



Cape Peninsula
University of Technology

**A FRAMEWORK FOR CLOUD-BASED PATIENT-CENTRED HEALTH AND WELLBEING
SERVICES IN AN UNDERSERVED CONTEXT: CASE OF MATERNAL HEALTH
INFORMATION SERVICES IN KENYA**

by

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Declaration

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Signed _____

Date__28/04/2021_____

Dedication

This thesis is dedicated to the Almighty God, who has promised that I can do all things through Christ who strengthens me (Philippians 4:13) and that with God nothing shall be impossible (Mat. 19:26).

To my late father, Simon Nyatuka – Dad, you always reminded me to work hard in school so as to become the best I should. I am grateful and will forever cherish your wise counsel.

To my wife, Gladys, and my daughters, Patience and Praise, who understood my situation, prayed and gave me moral support and encouragement throughout the preparation of this work.

Abstract

The United Nation's (UN) Sustainable Development Goals (SDGs) agenda recognises **health** as a key pillar for global development, hence the need to reduce health inequalities and inequity. Specifically, the aim of SDG 3 is to oversee the health and wellbeing of all people, and reducing maternal mortality. As part of various strategies to achieve global health reform, the World Health Organisation (WHO) proposes the implementation of an integrated and people-centred health services framework by member states. Consequently, in order to achieve this agenda, Target 9c of the SGDs emphasises the need to *increase the use of information and communications technologies (ICTs), particularly in the developing countries*. Despite these efforts, health systems continue to face the challenge of persistent failure to satisfy health care demands, hence the need to rethink the design of health care. Existing health care information systems (HISs), particularly in low-income and middle-income countries (LMICs), need to be adequately customised to make these systems more technically sound. However, there is a paucity of research whereby health systems are highly fragmented, while cloud infrastructures have not been utilised sufficiently to support health care integration to promote people-centred care. Furthermore, patients' voices have not been heard on their own health care, including the designing and development of health information technology (HIT) interventions, thus leading to a lack of meaningful use of HITs. Furthermore, health professionals are unable to make evidence-based decisions at the point of care due to the lack of sufficient patient information, thereby prompting medical mistakes. The need for innovative HIT solutions is therefore just as valid in underserved contexts to improve population health and wellbeing. The aim of this research was to develop a framework for ICT-facilitated patient-centred health and wellbeing information architecture to support maternal health care in an underserved context as a case of Kenya's health system.

While the research adopted an interpretive approach, the lens of both stakeholder theory and co-design-oriented Service Design Research (SDR) were used to create the proposed framework. As representative sample, 47 participants (n=47) were recruited from six public health facilities located in informal settlements within Nairobi City County, Kenya. The research was executed on two levels: the co-analysis phase and the co-design phase. The co-analysis process involved the gathering of data from a social perspective, namely: contextual inquiry using interviews, focus group discussions, and observation. The co-design process entailed interactive co-design activities to gather data about the service as the design object in the form of design concepts and constructs, design principles, architectures, the design process, and proof of concept, which involved the use of various design tools and techniques, including a case scenario, information flow, service blueprint, business modelling diagrams, and service prototyping.

The thematic analysis (TA) method was applied to analyse the collected data, whereby manual coding was performed, after which twenty (20) data themes were generated to inform the study. A framework for cloud-based patient-centred health and wellbeing information architecture (CPHIA) was developed to enhance the development of eHealth interventions for maternal health care in an underserved context. A cloud-based mobile web application prototype service (AfyaTab) was developed as proof of concept, and by so doing, the study contributes theoretical, discipline and methodological knowledge to health practice.

Keywords: Cloud computing, eHealth, health and wellbeing, health sector, maternal health, personal health records, people-centred care, underserved context.

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Publications

The following are the publications including one conference paper and two journal articles written and submitted during my study to complete this thesis:

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Terms and key concepts

Term	Definition of Terms
Cloud Computing:	A model for enabling ubiquitous, convenient, on-line demand network access to a shared pool of configurable computing resources, including networks, servers, storage, applications and services that can be rapidly provisioned and released with minimal management effort or service provider interaction.
Health Communication:	Health communication is the study and use of communication strategies to inform and influence decisions and actions to improve health.
People-Centred Care:	An approach to care which consciously adopts the perspectives of individuals, carers, families and communities as participants in, and beneficiaries of, trusted health systems that are organised around the comprehensive needs of people rather than individual diseases, and respects social preferences. It requires that people have the education and support they need to make decisions and participate in their own care, and is organised around the health needs and expectations of people rather than diseases.
Service Design Research:	A creative, human-centred and iterative approach to service innovation. It is an integrative research approach which is context specific, holistic and multidisciplinary towards innovating and/or improving current services so as to make them more useful, usable, and desirable for consumers, and more efficient and effective for organisations.
Stakeholder Theory:	The principle of 'Who or What Really Counts', that is, who are the key, or rather main stakeholders in the firm? And to whom do managers pay attention? In other words, for one to identify the relevant stakeholders in an eco-system, the issues at hand should first be identified, defined and mapped out to facilitate stakeholder analysis, which includes the identification, prioritisation and classification towards achieving organisational goals.
Underserved Context:	Communities and/or those groups of people who live primarily in informal settlements, that is, within inner city (slums) and/or rural areas, and who are of lower socio-economic status (SES), hence population groups who frequently experience difficulties due to resource constraints that include lack of, or inadequate health care coverage, particularly in developing countries.

Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
ANC	Antenatal Care
ARRA	American Recovery and Reinvestment Act
CC	Cloud Computing
CBHF	Community-based Health Financing
CDMI	Cloud Data Management Interface
CHW/Vs	Community Health Workers/Volunteers
CO	Clinical Officer
CPHIA	Cloud-Based Patient-Centred Health and Wellbeing Information Architecture
CSA	Cloud Security Alliance
CSP	Cloud Service Provider
CP	Cloud Provider
CWC	Child Welfare Clinic
DR	Design Research
DTP3	Diphtheria-Tetanus-Pertussis
DHIS 2	District Health Information Software 2
DSR	Design Science Research
EHR	Electronic Health Record
EMR	Electronic Medical Record
ENISA	European Network and Information Security
HIPAA	Health Insurance Portability and Accountability Act
GOK	Government of Kenya
GT	Grounded Theory
HIS	Health Care Information System
HIT	Health Information Technology
HIE	Health Information Exchange
HIV	Human Immunodeficiency Virus
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronic Engineering
IPCHS	Integrated and People-Centred Health Services
IS	Information Systems
ISR	Information Systems Research
ITU	International Telecommunication Union
ISO	International Organisation for Standardisation
MCDM	Multi-Criteria Decision-Making

MoH	Ministry of Health, Kenya
NCC	Nairobi City County
NCD	Non-Communicable Disease
NHIF	National Health Insurance Fund
NIST	National Institute of Standards and Technology
NGO	Non-Governmental Organisations
OCCI	Open Cloud Computing Interface
ONC	Office of the National Coordinator
OOP	Out-of-Pocket Expenses
OVF	Open Virtualisation Format
PDSR	Practitioner Design Science Research
PHO	Public Health Officers
PHR	Public Health Record
RAD	Rapid Application Development
SAB	Skilled Attendance at Birth
SES	Socioeconomic Status
SDGs	Sustainable Development Goals
SD	Service Design
SDR	Service Design Research
SLA	Service Level Agreement
SP	Service Provider
SSL VPN	Secure Sockets Layer Virtual Private Network
TB	Tuberculosis
UHC	Universal Health Coverage
UNDP	United Nations Development Programme
VM	Virtual Machine
WHO	World Health Organisation

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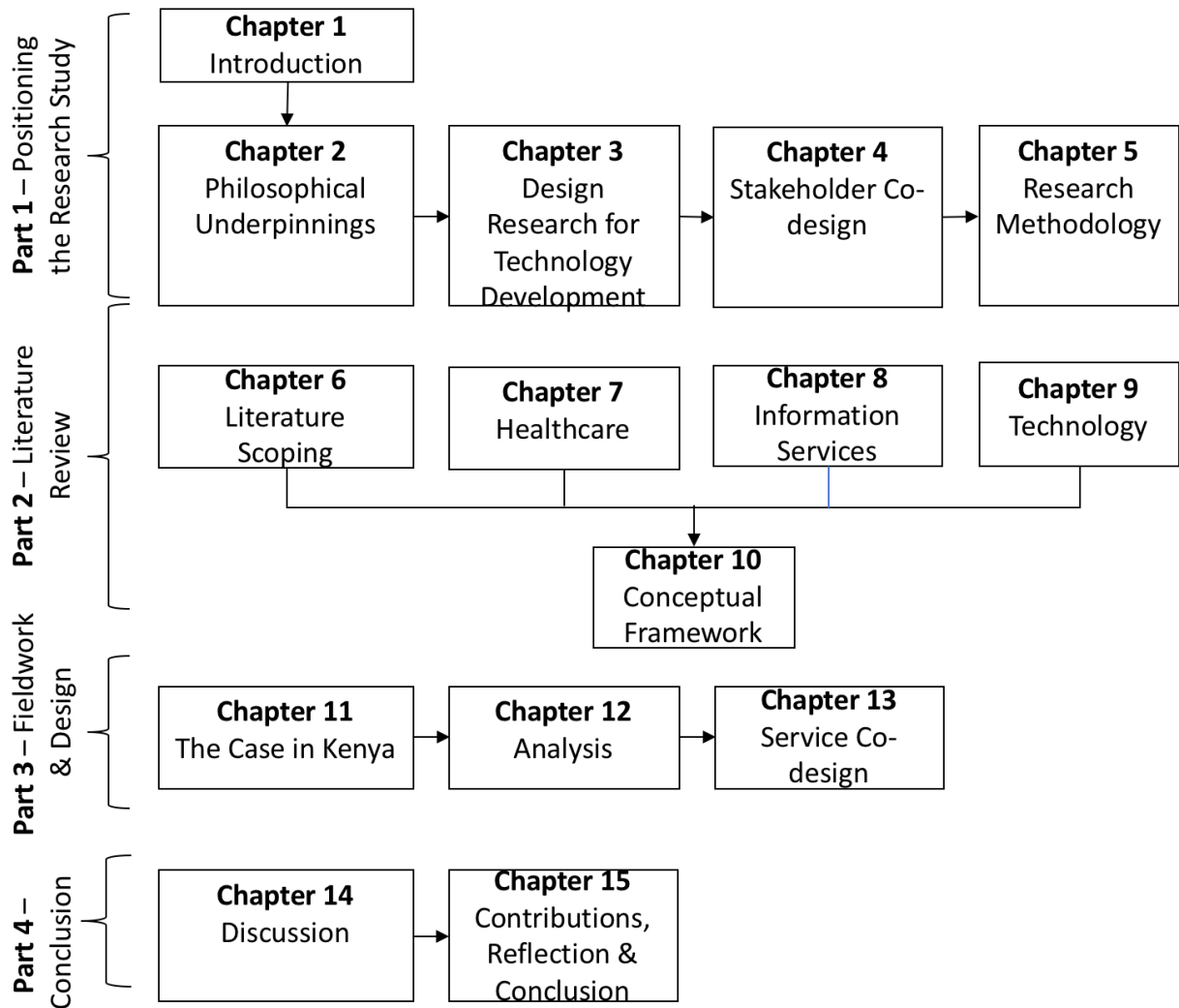
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Thesis Construction and Layout

Due to the complexity of this research study, the layout of the thesis was structured to guide the reader through the different aspects of the study. Below is a diagram that depicts the layout of the thesis as it was constructed.



The thesis comprises four parts namely part 1,2,3,4 respectively whereby each part deals with a specific aspect of the study. The first part orientates the reader to the researcher's adopted position for the study. The second part presents the aspects relevant to the study from related literature. The third part is a presentation of the fieldwork and design of the proposed service. The fourth part is where all the aspects of the study are integrated into the contributions.

The reason for moving the discussion on the philosophical assumptions and research methodology before the literature is to orientate the reader on how the adopted approach influenced the study.

PART I: POSITIONING THE RESEARCH STUDY

Chapter 1: Introduction

1.1 Introduction

This chapter presents the background to the study and the research problem. It also highlights the research objectives and questions, research methodology, justification, scope and delineation, ethics and the study's contribution towards knowledge.

1.2 Background to the study

The United Nations (UN) Sustainable Development Goals (SDG) agenda recognises **health** as a key pillar towards achieving global development (Clark & Wu, 2016). This prompts the need for governments to ensure better health and wellbeing for all populations, and to reduce health inequalities and inequity, both within and among member states. According to Radojicic et al. (2020), health systems are among the key indicators of a country's development. The targets of SDG 3 include the overseeing of global health and the wellbeing of all people. SDG 3 also aims to reduce global maternal mortality ratios (World Health Organisation, 2020). Therefore, in order to actualise SDG 3, there is a need to rethink the design of health care to create more strategic and more effective interventions.

As part of the SDG strategies to achieve global reforms in the health sector, the World Health Organisation (WHO) proposes an integrated people-centred care approach as a future trend in health care. The WHO proposes a strategy to guide the re-design of health care in order to improve health outcomes (World Health Organisation, 2015b; Hu & Bai, 2014). However, despite the efforts by governments and other entities to prioritise the SDGs, health care in underserved contexts still faces barriers such as maternal information services as well as geographical-, social-, economic-, political- and cultural challenges (Shuvo et al., 2015; World Health Organisation, 2016b; World Health Organisation, 2014). Underserved contexts are typical of low- and middle-income countries, and in the Global South, such contexts are often difficult to research due to geographical isolation and lack of connectivity (Dutta, 2019). In addition to inadequate provision of services, one of the challenges is that health information is inefficient for individuals to manage their own health (Miah, 2017; Runaas et al., 2017).

The narrow scope of existing health care information systems (HISs) in low-income and middle-income countries (LMICs) needs to be customised adequately in order to make these HISs more technically sound (Nabyonga-Orem, 2017). This may in turn help to provide person-centred eHealth services through self-management (Badawy et al., 2018), and supporting personal health and wellbeing (De Masi et al., 2017). Human-centred approaches and user-

centric technologies should be leveraged in order to deliver meaningful person-centred eHealth services in their context of use. In particular, design thinking, Service Design Research (SDR) and Cloud Computing (CC) have been identified as being vital in the creation and/or delivery of person-centred services by virtue of their user-centric ability (Malmberg et al., 2019; Miah, 2017; Hu & Bai, 2014) and serves as the motivation behind this research. Design considerations, processes and the service components of secure technology-enabled information services need to be integrated to facilitate personal health and wellbeing services to support maternal health care in an underserved context.

The point of departure for this research is that information systems (ISs) artefacts are driven and shaped by organisational context, hence the need for Information Systems Research (ISR) to consider social practices while designing and developing such systems (Rohde et al., 2009). When the information system (IS) forms part of an information service, the nature of a service needs to be considered for the research. This allows for considering the latent needs and experiences of the clients using the service where SDR is multi-disciplinary, rooted in Design Research (DR) about real-life problems, building on Service Research (SR) (Joly et al., 2019; Pekkala & Yirisku, 2017; Teixeira et al., 2019). Hence, SDR is adopted for this study and further details to substantiate this choice is provided in Chapters 2, 3 and 4, while its application in the research methodology is discussed in Chapter 5.

Three key concepts are combined to design a new ICT-facilitated health and wellbeing information service(s). These concepts include health care that is: (i) person-centred (Chapter 7); (ii) an information service (Chapter 8); and (iii) ICT-facilitated (Chapter 9). The aim of this research is to explore and explain design considerations for: (i) patient-centred care (Chapter 7), (ii) information service (Chapter 8), and (iii) cloud-based services as the enabling technology for the ICT-facilitated service (Chapter 9). These concepts are considered to facilitate personal health and wellbeing services to support maternal health care in an underserved context. The insights gained will guide the development of a framework for a personalised functional ICT-facilitated maternal health information service.

1.3 Background to the research problem

Health care is under pressure from an ever-increasing global demand to adopt better ways of responding to patients' needs, hence the need to integrate their resources (Malmberg et al., 2019). This is because **health** is recognised among the fundamental requirements of human capital, and therefore a critical ingredient for socio-economic growth and development (Bloom et al., 2004; Radojicic et al., 2020). According to the aforementioned authors, a healthier workforce is energetic, both physically and mentally sound, and hence more productive. Furthermore, people earn better wages as they are less likely to be absent from work for illness-related reasons. This, therefore, justifies the overall objective of SDG 3, which

is to “ensure healthy lives and promote well-being for all at all ages” (Nabyonga-Orem, 2017:2). In a bid to achieve this, the WHO proposes an integrated people-centred approach to care, which should be adopted by member countries according to their local needs and context, rather than predominant conventional biomedical models, as part of global health care reform (World Health Organisation, 2016b). Accordingly, the aim is to establish holistic trusted health systems organised around the comprehensive needs of the people rather than individual diseases as well as respect for social preferences. As part of the recommended strategies to actualise the same, SGD 9c emphasises the need to *increase access to ICTs significantly to provide universal and affordable access to the Internet in the least developed countries by 2020* (Clark & Wu, 2016). Implementation of ICT innovations, that is, eHealth by governments, is one of the means to enhance ongoing global health care reforms (Boore, 2018) towards improving population health outcomes. According to Miah (2017), proper utilisation of ICT can greatly empower individuals, organisations and communities to take control over their own health and wellbeing (Miah, 2017). This can only be achieved through freedom for patients to access their health information, patient engagement and participation in their care decisions, and also by utilising patient-reported outcomes or feedback (Girgis et al., 2017), hence person-centred care.

However, despite the efforts, implementation of the *person-centred care policy* remains a challenge to many organisations, and is therefore far from the reality in many countries (Malmberg et al., 2019; Ogden et al., 2017). This global directive seems to be at odds with traditional health care practices, and particularly in the dimensions of management and health care professionals’ attitude towards change. According to the authors, the means to achieve this transformation within the complex health care systems is not explicit, hence gaps in its implementation. Despite the existence of a variety of frameworks for patient-centred care, there still exist gaps in practical guidance of its implementation regardless of being a fundamental requirement for health care quality and safety (Santana et al., 2017). Furthermore, the nature of the requirements of SDG 3 poses a challenge to existing HISs in terms of monitoring of health indicators (particularly in LMICs), which hinders the realisation of the set health targets (Nabyonga-Orem, 2017).

The current HISs have a deficiency in meeting data requirements as they lack capacity to support the nature of multiplicity data collection and analysis needed to monitor health indicators adequately. Also, the systems are biased towards quantitative data as they mainly provide aggregated data while they lack the ability to provide disaggregated data, and are therefore inadequate for full health reporting (Nabyonga-Orem, 2017; Manya et al., 2016). There is a lack of proper understanding of the overall health domain, particularly large-scale ICT integration projects, most of which have failed to achieve their set objectives (Miah, 2017; Heeks, 2003) because of the tendency to underestimate the complexity of existing health

practices and different information infrastructures (Røed, 2012:2). This is because health care systems comprise various components such as hospitals, medical centers, patients, families, and government, among other players, who interact at different levels (Lipsitz, 2012). In addition, the co-existence of various stakeholders, including development partners/donors in developing countries, creates imbalances of power and, as such, leads to parallel reporting systems (Manya et al., 2016). Furthermore, some of the big hospitals have branches distributed across different geographical locations (Shakil et al., 2020), which accelerates the fragmentation of health systems that are otherwise not well funded. As a result, this increases data silos, which continues to harm patients by causing frustrations, especially within LMICs (Roehrs et al., 2017; Bukowski, 2016). The situation exacerbates the proliferation of traditional HISs where patients' health data are stored and maintained within the confines of individual health care institutions where it is generated (Vassilakopoulou et al., 2019). According to the authors, in this case, patients can only ask for paper-based copies of their medical record(s) on request, which they keep at home for purposes of tracking their medical encounters and for subsequent visits to a different hospital. Unfortunately, these paper-based records kept at home by patients deteriorate easily over time due to the fading of ink, staining as well as wear and tear (Vassilakopoulou et al., 2019). Furthermore, accumulating manual records can consume a significant amount of space and it is difficult to carry them when needed. In addition, retrieval of information from paper-based folders is slow, and making annotations on the documents can be difficult compared to electronic records. This situation continues to weaken HIT innovations; hence, they are unable to support health information needs of the users (Nabyonga-Orem, 2017). Therefore, both the patients and health professionals lack access to patients' medical data, particularly at the point of care since the patients receive care at different hospitals and settings throughout their lifetime (Zhou et al., 2019; Bantom et al., 2016; Pakenham-Walsh & Bukachi, 2009; Holmgren & Adler-Milstein, 2017). As a result, caregivers often rely on the information provided by their patients, which is typically not reliable since the accuracy of such data depends on the memory of the patient (Zhou et al., 2019), a situation that may hinder the provision of evidence-based treatment (Alyami et al., 2017). According to literature reviews conducted, the lack of quality patient information leads to medical mistakes, misdiagnosis, wrong drug prescription(s), care discontinuity and even death, among other challenges (Alyami et al., 2017; Sneha & Straub, 2017; Almoaber & Amyot, 2017; World Health Organisation, 2007).

Largely, end-users, and particularly the patients, are involved neither in the decision-making process concerning the design of their health care nor in the early phases of their eHealth development (Sieverink et al., 2019; Bantom et al., 2016). Patients are instead viewed as passive receivers of care, that is, they are treated as consumers rather than custodians and/or producers of their own information (Patrício et al., 2020) – contrary to the principle of

integrated people-centred health services (IPCHSs). This deny people their right to respect and dignity, information sharing, participation and collaboration as core concepts of patient-centred and family-centred care (Conway et al., 2006). Unfortunately, the voices of both the patients and their families have not been heard, including those of women, due to the paternalistic narrative of “patients seen but not heard” (Townsend et al., 2013:752). The WHO’s projection of target 3.1 of the SDGs is to bring global maternal mortality below 70 per 100,000 ratio of live births by 2030 (World Health Organisation, 2020; World Health Organisation, 2016a). As part of the global effort towards achieving universal health coverage (UHC), the WHO prioritises maternal health care through the implementation of person-centred antenatal care (ANC) guidelines within the confines of the IPCHS framework (Lattof et al., 2020). According to the author, however, little attention has been paid to practice regarding the provision of person-centred ANC as well as the provision of relevant and timely information. Women and girl’s voices are yet to be heard and acknowledged with the measurement of the quality and delivery of routine ANC (Lattof et al., 2020). In order to address these challenges, there is a need to collect high-quality ANC data to support policy decisions, particularly for vulnerable populations (Lattof et al., 2020). Among new opportunities that have been identified to address, this challenge in the post-2015 era includes the utilisation of ICTs to improve decision-making by stakeholders, that is, women, health care providers and policymakers (Kendall & Langer, 2015). However, existing health systems are faced with the challenges of data quality variation, unavailability and heterogeneity in terms of data types, data resources and data users, which compromises measurement of ANC coverage in general (Lattof et al., 2020). Integrated large-scale eHealth interventions a lacking among underserved populations (Miah, 2017), who are already devoid of basic health care that encourages the inequitable distribution of health care (Kaur, 2012).

In addition, the health care domain is under-researched particularly in the area of HITs towards supporting patient-centred care, which includes healthy lifestyle choices, monitoring individual’s wellness and providing general health information for self-management (Miah, 2017; Runaas et al., 2017). Specifically, according to Miah (2017), the author, cloud-infrastructures have not been sufficiently utilised in developing countries, as a large-scale ICT innovation to provide both effective and efficient HIT support tools to deliver quality health care service. Therefore, greater support for the implementation of digital registries and data platforms is needed to overcome the gaps in existing maternal health information services (Lattof et al., 2020). According to the authors, this will help provide better data to enhance evidence-based decisions towards improving maternal and newborn survival and health. Service is, therefore, a key context for applying IT, which digitises information interactions in service and thus facilitating value creation, which subsequently contributes to service innovation (Lim et al., 2018; Patrício et al., 2018). Efforts toward people-centred and integrated

care have been curtailed by traditional practices, whereby the role of patients is disregarded, and within a complex health system which is highly fragmented (Patrício et al., 2020; Holmgren & Adler-Milstein, 2017). In this case, the potential of new IT solutions remains unfulfilled, hence the need to rethink and re-design health care service systems. According to Patrício et al. (2020), this is to be achieved through SDR, which is a human-centred, holistic and repetitive approach; thus, it can leverage technology and empower people in co-creating their health hence integrated care. During their study to examine core areas that inform SDR, Joly et al. (2019) identified IS, which is related to IT, among the six dimensions that were noted to offer support and enablement of service innovation. Therefore, SDR is seen as a means to involve patients and their families in health care service development, thereby providing an opportunity for patients' voices to be heard (Malmberg et al., 2019).

This research, therefore, combines opportunities presented by both SDR and IT, with specific focus on CC technologies to design a patient-centred health cloud service to support ANC in underserved contexts. This research is motivated by the WHO's projection(s) for target 3.1 of SDGs to bring global maternal mortality below 70 per 100,000 live births by 2030 ratios (World Health Organisation, 2020; World Health Organisation, 2016a). Successful completion of this research will therefore go a long way in terms of contribution towards achieving SDG 3 as part of the efforts to improve global health outcomes.

1.4 Statement of the research problem

Health care is under pressure from an ever-increasing global demand to adopt improved ways of responding to patients. It is challenging to integrate patient needs and the available resources into one database or system (Lattof et al., 2020; Malmberg et al., 2019; Miah, 2017). According to Lattof et al. (2020), digital registries and data platforms are needed to overcome the gaps in existing maternal health information services. Malmberg et al. (2019) posit that the integration of patient data and the availability of resources are a challenge. Cloud-infrastructures have not been sufficiently utilised in developing countries, as a large-scale ICT innovation is needed to provide both effective and efficient HIT support tools to deliver quality health care service (Miah, 2017).

Health is recognised among the fundamental requirements of human capital and therefore, a critical ingredient for socio-economic growth and development (Radojicic et al., 2020; Bloom et al., 2004). The lack of a healthy workforce affects organisations in lower productivity and lower wellbeing issues of employees. Bloom et al. (2004) posit that the key components of human capital include work experience and health. The authors argue that higher life expectancy is associated with improved health status and low morbidity rates. Radojicic et al. (2020) posit that human resources are a critical requirement for the health

system and, therefore, countries ought to pay special attention, hence the need to develop and employ competent health personnel.

However, despite the efforts, implementation to integrate patient needs and resources into one database or system (person-centred care) remains a challenge to many organisations and in many cases far from the reality in many countries (Malmberg et al., 2019; Ogden et al., 2017). According to Malmberg et al. (2019) and Ogden et al. (2017) the means to achieve this transformation and integration in the complex health care systems are not explicit, hence the gaps in the implementation. Despite the existence of a variety of frameworks for patient-centred care, there are still gaps in practical guidance regarding its implementation. Bhutta et al. (2020) reviewed literature related to the implementation of health and health-related SDGs and found that, among other challenges, there seems to be a lack of coordination between stakeholders, limited financing, and high donor dependency. These gaps exist despite the fact for the fundamental requirements for health care quality and safety (Santana et al., 2017). Furthermore, the nature of the requirements of SDG 3 poses a challenge to existing HIS in terms of monitoring of health indicators particularly in LMICs), which hinders the realisation of the set of health targets (Nabyonga-Orem, 2017). The Health care domain is under-researched particularly in the area of Health Information Technologies that focuses on supporting patient-centred care, which includes healthy lifestyle choices, monitoring individual's wellness and providing general health information for self-management (Miah, 2017; Runaas et al., 2017).

The problem statement, following from the challenges described above, identifies the research gap that this study aimed to address as follows: It is unclear how design considerations, processes and the service components of secure technology-enabled information services can be integrated to facilitated personal health and wellbeing services to support maternal health care in an underserved context.

1.5 Aim and objectives of the study

This research aimed to explore and explain design considerations for (i) person-centred health care, (ii) information service, and (iii) cloud-based ICT-facilitated services to facilitated personal health and wellbeing services to support maternal health care in an underserved context. A further aim was to develop a framework for a personalised functional ICT-facilitated maternal health information service.

The following high-level objectives supported the research aim: (i) gaining sufficient insights into the latent needs of the stakeholders of maternal health information services in a specific practice situation as part of the problem understanding phase; and (ii) using these insights to design an ICT-facilitated information service for maternal health care based on the stakeholders' perceptions of what such a service could be, as part of the problem-solving phase. The specific research objectives have been aligned to the sub-research questions to

gain the insights needed to answer the research questions. The research questions are discussed next.

1.6 Research questions

Two main research questions were posed to guide this study in response to the research problem, with the focus on understanding the problem situation and designing a solution with the involvement of the relevant stakeholders in maternal care based on their needs and perceptions (see Table 1.1).

The answers to the research questions contribute to this study in terms of: (i) study knowledge claims in maternal health care as the application domain for this study; (ii) services as the focus of the study; and (iii) ICT as the enabler of the service. Contributions to practice include situational actions, contextual factors, as well as stakeholder perceptions and experiences informing the design of the proposed cloud-based personalised information service prototype.

Contributions to the design discipline include design concepts, constructs and principles for the knowledge claims, and the co-design service design process. The methodological contributions are depicted in the proposed co-design-oriented SDR framework. The outcome of the service design process research is the proposed cloud-based personal health and wellbeing service conceptual framework.

The contribution to the ICT discipline is the proposal of using a design research approach when designing ICT-facilitated services with the involvement of the relevant stakeholders. Contributions to the health care discipline entail the situational practice information needs and service experiences of the relevant stakeholder in maternal care.

The two research questions have sub-research questions to guide the research on the specific aspects being investigated. The first research question has four sub-research questions and the second research question comprises two sub-research questions. The objectives associated with the sub-research questions and the methods used to collect and analyse the data are presented in Table 1.1. The sub-research questions were derived from the related literature, each with an associated theme to guide the inquiry during the data collection. These are referred to as theory themes as opposed to the data themes derived from the thematic analysis process.

Table 1.1: Problem statement, research questions, methods and objectives

Research problem	It is unclear how design considerations, processes and the service components of secure technology-enabled information services can be integrated to facilitated personal health and wellbeing services to support maternal health care in an underserved context.

Research Question 1 (RQ1)	What are the characteristics of an integrated ICT-facilitated health and wellbeing service(s) for maternal care that could enable patients to actively participate in managing health information in an underserved context?	
Research sub-questions (RSQs)	Objectives	Research method(s)
RSQ 1.1: <i>How do the key stakeholders in maternal health information services influence the information services in maternal care in an underserved setting?</i>	To determine the perspectives of the relevant stakeholders in health information service provision in maternal care in an underserved context	Literature review Stakeholder analysis Context inquiry
RSQ 1.2: <i>What are the personal information needs of stakeholders in maternal care?</i>	To determine the information needs of relevant stakeholders in maternal information services	Literature review Information needs analysis
RSQ 1.3: <i>How do stakeholders in maternal care currently obtain and manage information relevant to their needs?</i>	To establish the current information practices of stakeholders involved in maternal care services	Literature review Situational inquiry of current information practices
RSQ 1.4: <i>What are the challenges faced in accessing and managing maternal personal health information?</i>	To identify challenges experienced when accessing and managing personal health information	Literature review Interviews Observations
Research Question 2 (RQ2)	What are the methods, constructs, propositions and definitions describing the design process of an integrated secure electronic personal health and wellbeing information service needed to enable patients to be more involved in their own health information services?	
Research sub-questions (RSQs)	Objectives	Research method(s)
RSQ 2.1: <i>How can stakeholders perceive a potential information service relevant to the needs of pregnant women in maternal care?</i>	To determine future information needs of potential personalised information service relevant to the needs of maternal care clients in consultation with the relevant stakeholders	Anticipated future information services Interviews Co-design-oriented service design
RSQ 2.2: <i>What are the considerations for the design of a functional ICT-facilitated maternal health information service that is personalised?</i>	To design and evaluate an ICT-facilitated cloud-based personalised information service (prototype) with the involvement of the relevant stakeholders in maternal care services	Literature review Interviews Co-design-oriented service design

1.7 Research methodology

This study adopted an interpretive research approach to investigate the problem field, as the research involved the investigation of complex interactions between various stakeholders in maternal health services, and the processes involved in a real-life situation. Specifically, the study sought to understand the nature of maternal health information services offered in an underserved context. The SDR strategy was applied to guide the data collection process whereby qualitative methods were employed to facilitate interaction between the researcher and the participants. Five different groups of stakeholders were identified for data collection to guide the study. Thematic analysis (TA) was used to generate themes emerging from the data. Therefore, an interpretive research approach was selected as the philosophical

stance since it facilitated the investigation of the subjective aspects of human activity to unearth the meaning. The two subjects (philosophical stance and research methodology) are discussed in detail in Chapters 2 and 5.

1.8 Justification for the study

This research contributes to the subject knowledge, specifically Health Informatics research in general, which is aimed at explaining the design characteristics, process, and service components of creating integrated and secure ICT-facilitated personal health information services. This includes cost-effective health care services and promotes patient-centric care (self-management). Ostensibly, the application of cloud computing CC technologies, and HITs in particular, is under-researched in underserved environments where many researchers have not validated cases (projects) in real-world environments (Bhutta et al. 2020; Hu & Bai, 2014).

Specifically, this research explored design characteristics essential in designing a cloud-based PHR service for maternal health care in an underserved context to promote patient-centred care (Seebode, 2013). Consequently, this research may assist in empowering patients in underserved communities to take control over their personal health information to promote their health and wellbeing (Seebode, 2013), which, in turn, may assist in the promotion of an improved lifestyle, avoiding additional diseases, unnecessary hospital admissions and complications. This is because health care providers and caregivers can make evidence-based decisions at the point of care, minimising medical mistakes and improving the quality of health care. Finally, new knowledge is generated as insights gained through an explorative study as well as prescriptive knowledge, i.e. as the design process properties to develop a novel framework for proposed services.

1.9 Scope and delineation of the study

This research explored design characteristics for secure integrated ICT-facilitated person-centred health and wellbeing (PHR) services in maternal health care. This was accomplished by gaining access to patient history and records with as much information related to health and wellbeing as possible from the patient(s) themselves and health professionals across various health facilities. SDR was the chosen research strategy, and the case study was Nairobi City County (NCC) whereby the researcher focused only on the information needs of the relevant stakeholders in maternal care. The study comprised two parts, namely: (i) the understanding of the specific problem situation as experienced by the stakeholders in maternal care in Nairobi City County; and (ii) the design of the proposed ICT-facilitated person-centred health and wellbeing information service for the solution design part. The information service was proposed to be in the form of a prototype service to be evaluated

as proof of concept as an ex-ante evaluation, thus not resulting in a functional service that could be deployed. The application of the DSR approach for the ICT-facilitated services determined the methods to be used for the data collection, analysis and design of the service. The benefits of SDR for ICT-facilitated services with the involvement of the stakeholders provided new insights from a design perspective. The value of SDR and features of cloud technologies have been combined to design cost-effective health care innovations/solutions (Patrício et al., 2011). It was customised for an underserved context, hence the study did not extend to developed contexts.

1.10 Ethics

The researcher observed the essential ethical requirements in the research process to avoid breaching the ethical guidelines. These encompassed seeking and obtaining the necessary ethical approval for the study as well as ethical concerns relating to the research stakeholders, including the researcher, the sponsoring organisation(s), and the participants (Kumar, 2011). Research ethics are discussed in detail in section 5.11 of Chapter 5.

1.11 Contribution of the study

The major contributions of this study include the theoretical contribution, contribution to discipline knowledge, methodological contribution, and contribution to practice (Iivari, 2007; Moritz, 2005; Ågerfalk, 2014). These contributions were influenced by both the philosophical stance (interpretive approach) and the research strategy (SDR) adopted by the study. The contribution of the study is discussed in detail in Chapter 15.

1.12 Chapter conclusion

This chapter introduced the study and positioned it in design research. The problem this study aimed to address was stated, and the research questions that guided the research were posed. A brief overview of the proposed research methodology was provided. The next chapters (2, 3 4 and 5) deal with the philosophical underpinning, design research as approach, the role of stakeholders in a co-design process, and the research methodology adopted for this study.

Chapter 2: Philosophical Underpinning

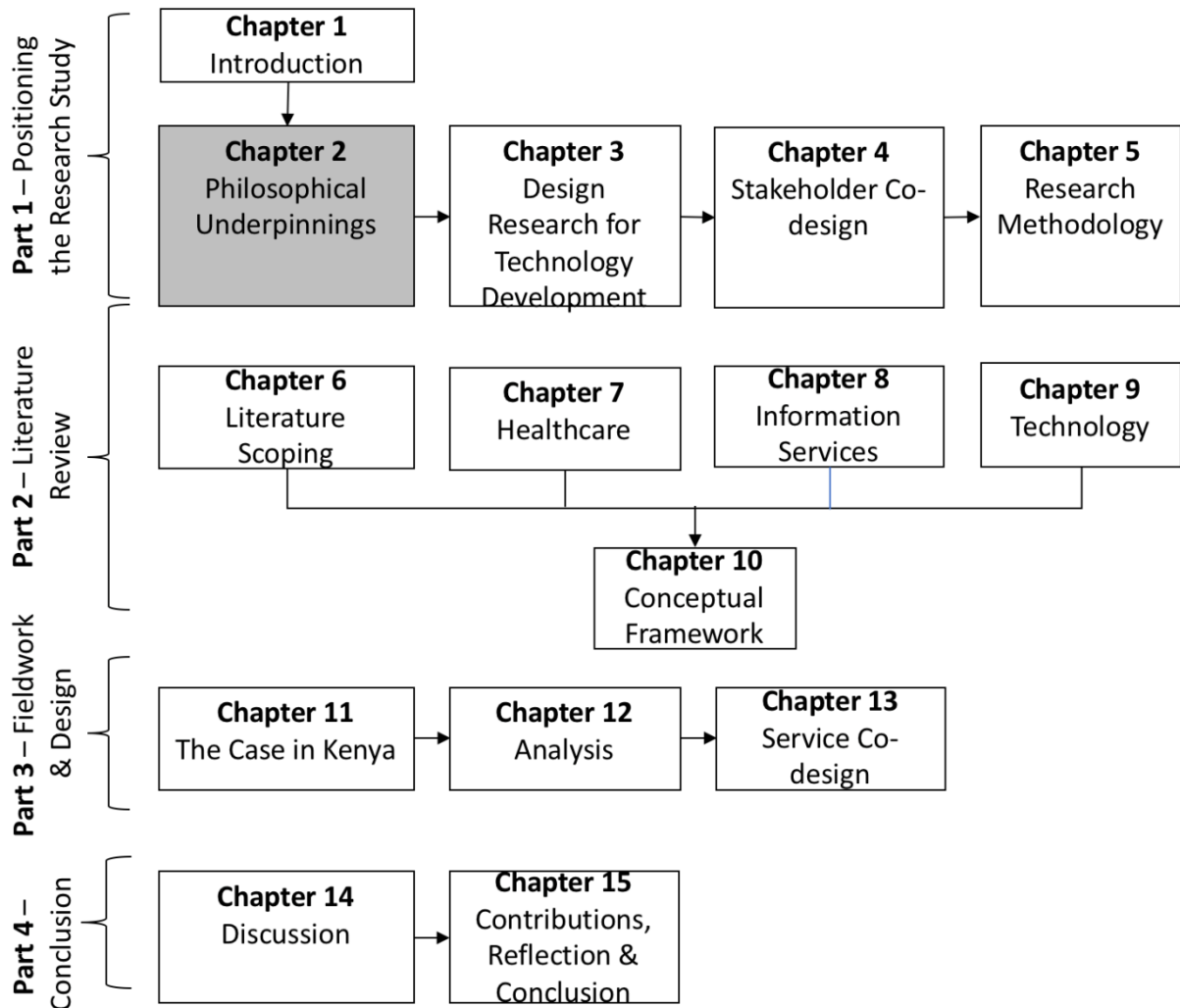


Figure 2.1: Thesis Layout - Chapter 2

2.1 Introduction

In this chapter, the philosophical assumptions adopted for this study are presented. The reasons for this specific focus are based on the view of the nature of design, departing from design as a discipline rather than design as applied in the science and engineering disciplines.

2.2 An overview of research perspective

This research used *“The Sciences of the Artificial”* book by Simon (1996) as a point of reference to demonstrate the intended research contribution during the process of designing proposed services using the SDR strategy. Simon explores the interrelationship between the natural, artificial and social world(s) to understand their co-existence. He argues that “natural science” is knowledge about natural objects in the world and phenomena, their properties and characteristics (Cross, 2001; Simon, 1996). According to Cross (2001) and Simon (1996),

natural science attempts to identify the components of the existing structure to describe how things are, that is, the truth about the natural phenomena, hence descriptive knowledge. On the other hand, the social world attempts to explain how people behave and/or interact with objects in the natural world, meaning descriptive knowledge may be either objective or subjective (Simon, 1996). Artificial science on the other hand involves describing how things could be, hence prescriptive knowledge. In this case, the author highlights four major distinctions between artificial and the natural worlds, which set boundaries for artificial sciences (Simon, 1996:5):

- Artificial things are synthesised (although not always or usually with full forethought) by human beings
- Artificial things may imitate appearances in natural things while lacking in one or many aspects, the reality of the latter
- Artificial things can be characterised in terms of functions, goals, and adaptation
- Artificial things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptives

The predisposition in this case is that some artificial things are mainly imitations that are “synthetic” as opposed to natural and that such imitation may use either the same basic materials as those of the natural object or quite different materials (Simon, 1996). Artificial is, therefore, produced by art (man-made) rather than nature hence unnatural since It is only a simulation of the natural phenomena, which is real. A combination of the two concepts, that is, “synthesis” and “artifice”, introduces us to the subject of engineering, whereby “synthetic” may be used to imply “designed” or “composed” (Simon, 1996:4). Designers, therefore, try to shape the various components of new structures (Cross, 2001) while they envision and realise alternative situations with both facts and values (Steen, 2013). This then, qualifies our view of engineering as a concern of synthesis, whereas science is concerned with analysis. As we already know, artificial objects with desired properties are a by-product of engineering activity and skill, hence the central objective. The engineer, therefore, who is the designer in this case, is concerned with how things ought to be so as to function appropriately to achieve a goal (Cross, 2001; Simon, 1996). In conclusion, the scientific method may be described as a pattern of problem-solving behaviour used to establish the nature of what exists while the design method may be described as a pattern of behaviour used to invent things that do not yet exist (Cross, 2001). Therefore, science is an analytic process while design is a constructive process (Cross, 2001; Gregory, 1966). While using the SDR strategy (explained in Chapter 3), this research will explore the interrelationships between the natural world, social world and the artificial worlds to demonstrate epistemological and ontological position(s) of this research as opposed to designing the proposed cloud-based personal health and wellbeing service (cloud PHR service).

2.3 Philosophical assumptions

Research philosophy is a belief about the way data regarding a phenomenon should be gathered, analysed and used (Blaxter et al., 2006; Gicheru, 2013). There are two main philosophies identified in the western tradition of science, namely positivism (scientific) and interpretivism (social constructionism/phenomenology), i.e. that which is being observed (Collis & Hussey, 2003; Thurairajah et al., 2006). While positivists argue that the world exists externally and that its properties should be measured through objective methods, social constructionists opine that reality is not objective and/or exterior but socially constructed and giving meaning by people. This then explains the origin of the term *epistemology* (the study of what is knowable) as opposed to *doxology* (the study of opinion or what is believed to be true) and encompasses the various philosophies of research approach (Gicheru, 2013). The purpose of science, then, is the process of transforming things believed into things known: *doxa* to *episteme*.

Positivists, therefore believe that reality is stable and can be observed and described objectively, without interfering with the phenomena under investigation (Gicheru, 2013). Positivists acknowledge that phenomena should be isolated and that observations should be repeatable. This involves the manipulation of reality with variations in only one single independent variable to identify regularities in, and to form relationships between some of the constituent elements of the social world (Corbin & Strauss, 2008). The role of the researcher, therefore, is limited to data collection and interpretation using objective approaches whereby research findings are observable and quantifiable. Therefore, predictions can be made based on the previously observed and explained realities and their inter-relationships. Research has shown that all empirical studies use a positivist approach, which has a successful association with both physical and natural sciences (Alavi & Carlson, 1992). However, the key disadvantage of a positivist approach is that it seeks to isolate a phenomenon from the complexities of the situation in which it is embedded, and abstracts generalisable principles from observation and experiment (De Figueiredo & Da Cunha, 2007). Furthermore, there is no insistent demand that findings of scientific inquiry should be useful (Gicheru, 2013).

Interpretivism on the other hand, according to Blaxter et al. (2006), contends that only through the subjective interpretation of and intervention in reality, can that reality be fully understood. From an IS point of view, interpretivism research may be defined as an approach aimed at producing an understanding of the IS context and a process whereby the IS influences, and is also influenced by its context (Walsham, 1993, 2006). The author argues that the interpretive research approach starts from the position that our knowledge of reality, which includes the domain of human action hence, a form of social construction by human actors. Therefore, our views and opinions concerning reality are a way of making sense of the

world around which the shared meanings are intersubjective rather than objective (Walsham, 1993, 2006). Interpretivism believes in understanding the complex world of lived experience from the point of view of those living it, which includes understanding meaning and the actor's interpretation of a situation (Schwandt, 1994). According to Klein and Myers (1999), seeking meaning of the context is one of the key tasks of interpretive IS research, whereby various contexts including those associated with informants and/or researchers, the choice which is largely dependent upon the audience, as well as the story the author intend to tell.

Qualitative research is a broader concept covering a set of techniques describing, decoding, translating, and somehow unearthing the meaning rather than the measurement or frequency of phenomena in the social world (Rowlands, 2005). Interpretive research theory is viewed as ontological and epistemological tools used in research, with an understanding of how individuals and groups create meaning in their everyday practices, communication, and lived experiences (Rowlands, 2005). The researcher, in interpretive research, therefore needs to see participants as producers of history, which should be reflected in the historical context of the study, according to Klein and Meyers (1999). Thus, a study of phenomena in their natural environment is key to the interpretivist philosophy, together with the acknowledgment that scientists cannot avoid affecting the particular phenomena they study (Gicheru, 2013). The interpretivist/constructivist paradigm approach is context-sensitive, hence helping researchers gaining a sense of the lived meaning of each description and relate them to what is known about the phenomenon of interest in general, and all traditions of interpretivism are no lesser than those of positivism, nor are they shorter (Kerr et al., 2010; Gicheru, 2013).

For this exploratory research, the researcher engaged with participants (relevant stakeholders) to gain insight into, and become familiar with the research context (Javanparast et al., 2009; Vom Brocke et al., 2020). While the researcher used the SDR approach, subjective interpretation was employed to understand how the people make sense of their actions in their context as they interact with health care service. The study sought to understand the nature and components of personalised ICT-facilitated maternal health information services. For instance, according to Fitzpatrick (2000), a working health record comprises of varying parts which may include different authors, intended audiences, intended life-spans, home locations and intended purposes and thus a complex scenario. On this basis, a pragmatic approach, which is a function of abductive reasoning (Reichert, 2013) is used to design the proposed new service (cloud PHR) as a composite service, which primarily emphasises an iterative process and continuous refinement of the design as pragmatic constructivism (Niehaves, 2007), also known as “designerly ways of knowing” rather than experience (Cross, 2001, 2006). The research, therefore, involved the investigation of complex interactions between various stakeholders in maternal health care and the processes involved in a real-life situation. This prompted the researcher to research the subjective aspects of human activity to unearth

the meaning rather than the measurement of health care phenomenon. This research adopted an interpretivist/ constructivist research approach to investigate the research problem as the appropriate philosophical underpinning.

2.4 Ontological and epistemological considerations in Design Research

Ontology refers to a particular view of the properties encompassing the world, and how these properties relate to each other (Miah et al., 2013). Epistemology, on the other hand, refers to the theory of knowledge which seeks to clarify what the conception of knowledge involves, how it is applied, and to explain why it has the features it does (Rescher, 2012). De Figueiredo and da Cunha (2007) argue that design knowledge is built into contexts where it is put to use, and its products and results, as they materialise, contribute to further theoretical advances. The inquiry process is much more contextualised and results-oriented than to first principles, hence the tacit knowledge of various partners plays a key role. In this case, the iterative processes tend to follow the principles of design, which is much more typical of the in-practice context than of traditional scientific inquiry. In their attempt to differentiate between the two main philosophical paradigms, positivism and constructivism, which are similar to interpretivism in the context of IS research (Schwandt, 1994), a conceptual framework with four key philosophical questions was developed by Guba and Lincoln (1994), as represented in Table 2.1, to demonstrate the scientific legitimacy of designerly ways of knowing and actioning research approaches.

In essence, SDR is similar to action research since both approaches share common characteristics as they talk about the creation of an innovation and purposeful development in a specific problem domain. According to literature, however, SDR mainly emphasises designing new and/or improving existing services to make them more useful, efficient and effective for organisations (Järvinen, 2007; Miah et al., 2013; Moritz, 2005). In SDR, the researcher becomes the designer, while also facilitating the design process, which is based on constructivist research. The Guba and Lincoln's (cited by De Figueiredo & Da Cunha, 2006) framework attempts to provide answers to the four philosophical questions, that is, ontological, epistemological, methodological and ethical questions, which will help in understanding the philosophical stance for this research as presented in Table 2.1.

Table 2.1: Positivism versus constructivism in light of the four philosophical questions
(Source: De Figueiredo & Da Cunha, 2006:12)

QUESTIONS	ANSWERS	
	Positivism	Constructivism / Subjectivism
<i>Ontological question:</i> What can be known?	<i>Realist hypothesis:</i>	<i>Phenomenological hypothesis:</i>

	We can know reality, which is external to us, independent from us, and driven by immutable laws.	We know the world by interacting with it in an emergent process that changes knowledge as we keep interacting.
<i>Epistemological question:</i> What is knowledge?	<i>Deterministic hypothesis:</i> Knowledge is what we learn by exploring the causes of the problems we face.	<i>Teleological hypothesis:</i> Knowledge is what gets us to an intended result.
<i>Methodological question:</i> How can knowledge be constructed?	<i>Principle of analytical modeling to explain reality:</i> We must divide each difficulty into as many parts as possible and necessary to resolve it better.	<i>Principle of complexity:</i> We build knowledge by recognising the world as complex and in constant flux, embodying stability, change, chaos, and order, the whole exceeding the sum of parts and the parts interacting in the shared, emergent and largely unpredictable construction of reality.
	<i>Principle of sufficient reason:</i> There is no effect without a cause and no change without a reason for change.	<i>Principle of intelligent action:</i> Human reason can transform intelligible representations of the dissonances to which it is confronted by creating responses in the form of “intelligent actions” adapted to reduce these dissonances.
<i>Ethical question:</i> What is the value of knowledge?	<i>Principle of value exclusion:</i> Values have no role to play in knowledge construction.	<i>Principle of value inclusion:</i> Values have an essential role to play in the emergent process of knowledge construction
	<i>Principle of extrinsic ethics:</i> Ethical behaviour is formally policed by external mechanisms.	<i>Principle of intrinsic ethics:</i> Ethical behaviour is constructed by each researcher in the persistent search for the collective good.

2.4.1 Ontological stance

The ontological stance adopted for this research is multi-pragmatic, moving between the problem understanding and problem-solving paradigms (Steen, 2013). To understand the paradigm, the researcher interpreted how humans, through their participation in social processes, enact their own realities with a specific meaning attached to constitute their actions in that situation. It can be regarded as ontology-in-situ (Jack, 2017), a concept that proposes to counteract the abstract nature of Giddens’s structuration theory. Ontology-in-situ considers the social processes and events at specific times and places. Sense making is the outcome of the researcher’s subjective interpretation when interacting with humans (Goldkuhl, 2012). In the problem-solving paradigm, the researcher and humans collaboratively design something to create new realities based on their needs and experiences within the constraints of a specific situation. The essence of pragmatist ontology is human actions guided by purpose and knowledge to change reality (Goldkuhl, 2012).

In the case of ontological positioning, therefore, the researcher should decide whether the reality is objective and external to the researcher, or socially constructed whereby reality is to be only understood through examining the perceptions and propositions of the participants

(Thurairajah et al., 2006). It is against this background that the two main ontological assumptions are referred to as realism (Johnson & Duberley, 2000) and idealism (Gummesson, 1991), as illustrated in Figure 2.2.

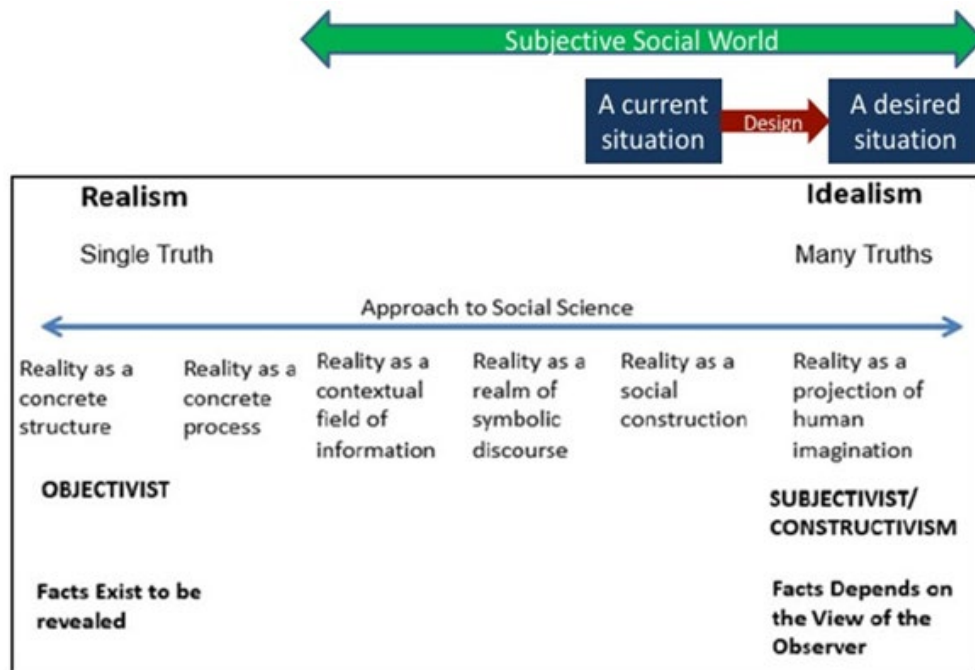


Figure 2.2: Continuum of core ontological assumptions
(Source: Collis & Hussey, 2003:51)

There are different paradigm classifications, for example, positivism, interpretivism, critical realism and constructivism (Hassan et al., 2018). For this study, the interpretivist and pragmatic paradigms were adopted. The pragmatic paradigm is to collectively create new designs relevant to the needs within the constraints of their particular situation. The interpretive paradigm is applied to study the human participants' needs and experiences in a particular situation and their sense making of their engagement with the design components and participation in the design process. Pragmatism allows for the use of multiple methods available to researchers who deem them suitable for the research problem in a particular situation. This is because the emphasis is more on the aim to achieve a specific outcome and consequences of the research than on the scientific merits of the methods (Kaushik & Walsh, 2019). Although pragmatism assumes there is an objective reality in which it is grounded, it can only be encountered through human experience (Kaushik & Walsh, 2019). For this study, the researcher assumed that knowledge is socially constructed as the service stakeholders, designers, and researchers made sense of the situation, design process, and design object.

The study started with Simon's (1996) view of the artificial world. When considering design as the preferred orientation for this research, the researcher agrees with You and Hands (2019), who reflected on Simon's work arguing that design is rather the understanding

of a liberal and integrative discipline combining theory with practice for new production purposes. In such a case, Schön's theory of reflection-in-practice (Schön, 1983) is better suited for Design Research (DR) than Simon's rational problem solving. Cross (2001) positions design as a discipline with its own terminology and rigor, which means that design should not be considered as a science (You & Hands, 2019). Research, through design, therefore, provides the epistemological means for a design discipline (Findeli et al., 2008). Given the philosophical approach adopted, that is, interpretivism as explained in the section above, the ontological position taken for this research is idealism. The researcher engaged with the participants to gain deeper insight into the current situation by interacting with the social world to create/deliver the desired situation, hence subjectivism/constructivism. Reality was based on the projection of human imagination and the researcher's observation as opposed to the objectivist approach whereby facts exist to be revealed.

2.4.2 Epistemological stance

The epistemological stance for this study, therefore, views knowledge as created based on:

- The knowing through observations and interpretations of human sense-making in their lived experience in a specific situation and their engagement during the design process
- The knowing through the collective making of the new design is associated with the design action, intervention and constructive knowledge as interplay between knowledge and action (Goldkuhl, 2012). According to Goldkuhl (2012), knowledge is constructive and has the potential to be useful in action while it is also based on experience (Kaushik & Walsh, 2019)

According to Guba and Lincoln (1994), the form and nature of reality is what can be known about it, as well as the nature of the relationship between the knower and what can be known. In science, new knowledge is continually being contributed in an attempt to understand reality whereas design knowledge is applied by building artefacts for human purposes (Azzam et al., 2018; Deng & Ji, 2018).

Design knowledge is gained from human-centred design solutions that only have meaning when they become part of the living experience of people (Trischler et al., 2018). Design knowledge is of and about the artificial world and its creation and maintenance. Design knowledge is inherent to the design activity by doing and reflecting on constructing the artefact, and the evaluation of its use in the situation (Cross, 2001) embedded in the designer's activities (Faste & Faste, 2012). During the design process, new knowledge is created through the making when the designer reframes different scenarios and possibilities with the users based on an increased understanding of the context of the problem situation and the conditions of the design process (Azzam et al., 2018; Ghajargar & Bardzell, 2019; Jones et al., 2016; Deng & Ji, 2018). Knowledge specific to the design is prescriptive (no truth value) about the design

object as well as the design process (Iivari, 2007). During the design process, Vaishnavi et al. (2019) acknowledge that insights can be gained of the problem situation as well as the theorising of the design object and process (Iivari, 2007). It is a challenge to develop, articulate and communicate design knowledge as highlighted by Cross (2001). Design knowledge is sourced from people, processes and products during the design process, according to Burns et al. (2016), and is used to create objects through evaluation, abstraction and reflection knowledge-building processes (Vaishnavi et al., 2019). Design knowledge therefore informs reflection, anticipation and projection of the designer to transcend from the present to enable projective actions (Bieling, 2010) and move beyond knowledge about a current situation.

Bahari (2010) argues that epistemological assumptions are based on the question, 'what should be recognised as acceptable knowledge in a given subject or discipline?' (Bahari, 2010). The key aspect of epistemology in social science is the question of whether the social world can and/or should be studied through the same principles and procedures applied in the natural sciences. The answer to this question, however, is dependent on the way the acceptability of the knowledge is created from the research process and the research methods used to acquire that knowledge (Bahari, 2010). According to the author, two main methods link theory and research, namely the inductive and deductive approaches, while the third alternative is abductive reasoning, which attempts to address the gaps in both deductive and inductive approaches (BRM, 2019).

Specifically, an inductive approach is applied in qualitative (interpretivist) research while the deductive approach is used in quantitative (positivist) research. The induction process involves moving from the specific to the general when making empirical observations, whereby concepts and theories are formed based on these observations. The deduction process, on the other hand, involves moving from the general (two or more premises) to the specific (a conclusion), which starts with a theory, from which a hypothesis is then derived, tested, and revised (Woiceshyn & Daellenbach, 2018; Steen, 2013). With abduction, one begins with experiencing the current problematic situation simultaneously and iteratively, in order to imagine ways to frame the situation towards coming up with a possible solution(s), hence design (Steen, 2013). Pragmatism is therefore regarded as a philosophy that justifies the mixing of quantitative and qualitative methods in one research (Maarouf, 2019), for example, using co-design.

The point of departure in this research, therefore, was the understanding that abductive reasoning (i.e. pragmatism) merely suggests that something *may* be; this is contrary to both the deductive and inductive approach, which believe that something *must* be and that something is operative (Steen, 2013). The aim of pragmatic constructivism is therefore to intelligibly build models that are functionally fitted to experience and to assist with ordering the

domain of experience (Avenier & Thomas, 2015). While making logical inferences and constructing theories, the research process begins with tentative explanations towards the best possibilities. In this case, researchers seek the *best* explanation from many alternatives to explain ‘surprising facts’ discovered at the onset of the research whereby both numerical and cognitive reasoning may be combined (Kolko, 2010). An abduction process mainly employs pragmatism, i.e. studying people’s practices and experiences rather than with a focus on abstract theory (Steen, 2013) to design artefacts to produce ‘true knowledge’ (Niehaves, 2007).

Therefore, pragmatism can be described as the philosophical assumptions involving the basic set of beliefs informing the actions and defining the worldview of the researcher (Kaushik & Walsh, 2019; Denzin & Lincoln, 2011). Pragmatism is a research paradigm that embraces a plurality of methods whereby a researcher should employ a methodological approach best suited to solve a specific research problem. In essence, design science involves the generation of instrumental knowledge towards producing and manipulating natural and artificial systems of which knowledge may then be applied in scientific design (Niiniluoto, 1993). According to Wang (1997), there are three types of design knowledge, namely: (i) conceptual knowledge (no truth value) e.g. system concepts and ontologies, conceptual frameworks, and classifications, among others (Wang, 1997); (ii) descriptive knowledge (truth value), e.g. ‘X causes A in situation B’; and (iii) prescriptive knowledge (no truth value), e.g. ‘in order to achieve A, apply X’ (Niehaves, 2007). Conceptual design involves the generation, evaluation and selection of the *best* design concepts for further refinement in the latter stages of the design process (Wang, 1997). Descriptive knowledge entails observational facts, empirical regularities and causal laws (Niiniluoto, 1993); while prescriptive knowledge includes design product knowledge, design process knowledge, that is, technical rules (Van Aken, 2005) and technical norms (Niiniluoto, 1993).

While this research used the inductive (interpretive) approach, part of it also applied a pragmatism (abductive) approach through the application of the co-design method to create a prototype service (cloud PHR system). Interpretivism is recognised as an *epistemology* that enables the researcher to comprehend differences in the roles between humans as *social actors* (Bahari, 2010). Interpretivism is therefore associated with phenomenology, a philosophy referring to the manner in which individuals make sense of the world around them, and also how the philosopher should set out preconceptions in his/her grasp of that world or phenomena, hence pragmatist inquiry (Wetter-Edman et al., 2018).

2.5 Chapter conclusion

In this chapter, the ontological and epistemological assumptions adopted for this study were explained in terms of how these assumptions influenced the research approach from a

design perspective. In the next chapter, the design research is discussed towards technology development.

Chapter 3: Design Research for Technology Development

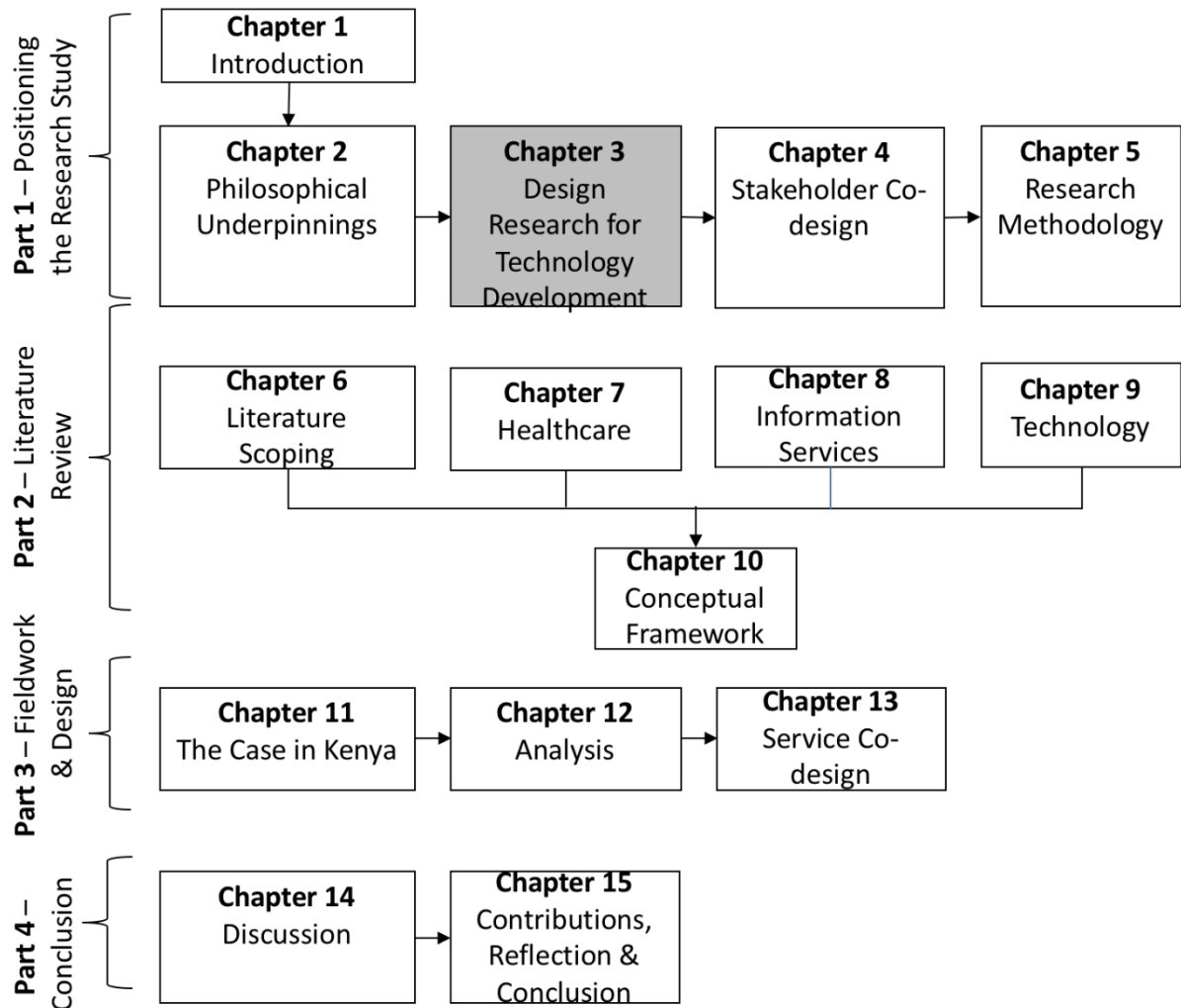


Figure 3.1: Thesis Layout - Chapter 3

3.1 Introduction

This chapter discusses the role of design in health services as foundation for the research methodology adopted in this study. Specifically, the role of Service Design Research (SDR) is discussed in detail for technology development in terms of relevance and understanding the research context better as opposed to design science research (DSR) being context specific while it recognises the role of the stakeholders.

3.2 Design and research

The problem this research aimed to address is that current eHealth interventions have a deficiency in delivering meaningful health and wellbeing services, particularly in an

underserved context since they lack holistic contextualisation (Boore, 2018; Korpela et al., 2013). The researcher proposed a design-oriented approach towards solving the research problem, focusing on the creation of user-centred ICT facilitated solutions that are useful in an underserved context (Househ et al., 2014). The researcher positioned the proposed framework in the related literature, drawing from ISR, DSR, SDR, co-design and DR. This chapter specifically considers the lessons shared by Azzari and Baker (2020), which include: (i) the importance of understanding the context of a research study; (ii) the need to be participant-centric and to co-create services with relevant stakeholders; (iii) the need to consider design, mechanics and technical elements; (iv) using different types of data and analysing iteratively; and (v) respecting different stakeholders' views from design literature. Thus, Design Research (DR) literature is explored with specific focus on design research, scientific versus design research, design as a discipline and design principles, design practice in a situation, co-design, and design in IS research.

A definition for design is needed for design as a verb, that is, to design as a human activity, and as a noun, that is, design as outcome represented in some form. Design is also perceived as a practice by anyone, and as a process to solve a particular problem (Langley et al., 2018). Additionally, it could mean the proposal of a novel idea to create/construct/build a new or improved object (tangible and intangible) to change an existing situation into a preferred one based on an identified need or opportunity. In science, the researcher needs to follow the rules and procedures of scientifically appropriate methodological standards in the search for truth, whereas design is more concerned with the outcome of what reality could be and where the success is in the intended use of the design in situations over time (Dalsgaard, 2014; Stolterman, 2008).

Design and science can be regarded as incommensurable based on Dewey's philosophical tradition of pragmatism, where for design, truth is in the utility value or changing of the reality of something that does not yet exist and therefore the design itself becomes part of the argument (Stolterman, 2008; Jordan & Stolterman, 2018). Design in practice deals with a range of problems from simple to complex, and scientific approaches may increase rather than decrease the complexity of the design process (Stolterman, 2008). This may be at the cost of gaining more insights where the understanding of the design process is needed (Stolterman, 2008). This understanding is needed to accommodate the specifics and unique conditions of the design situation (Stolterman, 2008) where the outcome of the design is not expected to be repeated or copied (Cross, 2001). Design knowledge is created through the design actions and movements between theory and practice by engaging in particular situations, and when dealing with complex problems, integration is needed between physical artefacts, knowledge and interactions (Windahl & Wetter-Edman, 2019). For designs to be useful, and desirable, designers need to have a good understanding of the situation to be able to envision alternatives

for an improved situation. Using appropriate research approaches can assist in a better understanding of the current situation, associated practices and experiences to allow the designer to design suitable alternatives that may lead to the improvement of the current situation. Design can therefore be regarded as negotiations between expectations of use within the constraints of the situation and the intentions of the designers as they perceive the anticipated use (De Mello Freire & Damazio, 2018).

Galle and Kroes (2014) argue that although a scientific theory may be considered an artefact, it does not represent or express an idea of the artefact in terms of how it can be instantiated. Instead, design is a proposed novel idea that can be constructed into a useful and desirable design (Galle & Kroes, 2014). Design and science can concur, but differs in aim in terms of studying or describing the world (descriptive knowledge) using cognitive descriptive theories versus designing something to change the world based on prescription on how to act (i.e. prescriptive knowledge that is practice prescriptive) (Galle & Kroes, 2014). Methodologically, science and design also differ in methodologically evaluating solutions to problems, that is, to address a research gap in science versus the design of something to address a real-life problem (Galle & Kroes, 2014). Even though scientific theories about design exist, the design paradigm lacks well-developed and articulated methods and vocabularies (Dalsgaard, 2014).

The strength of design lies in using methods to make ideas tangible and to deal with complex, ill-defined or wicked problems with the involvement of diverse stakeholders having different perspectives and where there is seldom a single correct or optimal solution (Langley et al., 2018). The nature of a wicked problem is that it is unique and therefore cannot have a single theory to determine a specific right practice (Rohde et al., 2009). As such, design can be explained as (i) an activity for planning and implementing new or improved objects (tangible and intangible), (ii) by a designer who intends accomplishing goals in a particular environment, (iii) using components that satisfy a set of requirements subject to constraints, (iv) to create a design that includes by-products of processes involved, such as drawings, models, plans or manufactured objects (Frankel & Racine, 2010; Ralph & Wand, 2013). This is based on Charles Eames's definition of design as "a plan for arranging elements in such a way as to best accomplish a particular purpose" (Faste & Faste, 2012:2) and implies "to invent or bring into being" something that does not yet exist.

Design is, therefore, a creative activity that results in a novel new or improved outcome based on a divergent set of possibilities versus certainties and possibly probabilities of science – it is not copying an existing idea or object (Galle & Kroes, 2014), hence, design can be regarded as something unique (Khan et al., 2020). The design evolves during the design

process as the different possibilities are considered within the use domain to explore its adaption towards the desired outcome (Dalsgaard, 2014).

The design process happens in a situation where its constructs (e.g. subjects, socio-cultural constructs, and technologies, among others) within the context of the situation require a good understanding of the design situation in which all these components may influence the design process (Dalsgaard, 2014). Therefore, the use of design methods can be seen as a form of inquiry that starts with a primary or empirical experience and is always in connection with a contextual whole, that is, a particular situation (Wetter-Edman et al., 2018).

3.3 Scientific versus design research

Science is about intelligent actions, consisting of forming a novel, non-trivial and well-supported belief about some part of the world for a better understanding (Galle & Kroes, 2014) and does not traditionally extend beyond knowledge into design (Azzam et al., 2018). Research, on the other hand, is defined as a systematic investigation that establishes novel facts, solves new or existing problems, proves new ideas or develops new theories (Faste & Faste, 2012), and assists in the understanding of a phenomenon that is of interest to the researcher (Vaishnavi et al., 2019).

Pragmatism as a philosophy of science has been suggested as an alternative paradigm to a rational functionalist problem-solving paradigm where actions and values are situated in a specific context (Hovorka & Germonprez, 2010). The authors base their view on the fact that in addition to the technological artefact, processes that enable human action also need to be considered. Design should therefore include how/when/why humans use services in their contexts with an emphasis on human actions and experiences in addition to value co-creation. Pragmatism frames designerly inquiry where the designer draws on the sources available in the situation to make sense of it and to be able to transform it through an iterative, experimental process into the desired situation (Dalsgaard, 2014). An inquiry, again, is an attempt to answer a question based on Dewey's concept of inquiry of the investigation into some parts of reality to create knowledge aimed at a controlled change of those parts of reality (Goldkuhl, 2012). Research inquiry requires a methodological decision-making consideration of likely consequences from actions to match or differ from specified research goals (Kaushik & Walsh, 2019). In pragmatism, an inquiry is a person's efforts to create knowledge through sense-making by reflecting on one's experience (Wetter-Edman et al., 2018) to improve a situation (Goldkuhl, 2012) and to create knowledge in the interest of change and advancement, and should be regarded as part of the human's ordinary initiatives.

The nature of the design object will determine its form (if it is a concrete object), and how it is designed. In the case of service design, the design object, the service, is intangible and it is important to consider the nature of the services, and the way this may influence the design

process. Further in this chapter (section 3.7), the SDR approach as one of the methodologies adopted for this research is discussed, but first, the view of design as a discipline as adopted for this study is discussed.

3.4 Design as a discipline

There is a need to develop design as a discipline with its domain-independent approaches to theory and research in design with its own terms, theories and methods (Cross, 2001; Teixeira et al., 2019; Trischler et al., 2018). The nature of design as a discipline is still under-researched (Dalsgaard, 2014; Jones et al., 2016; Ghajargar & Bardzell, 2019). Design can be regarded as a translation discipline where knowledge is a combination of knowledge creation and use (Langley et al., 2018). Design, although using methods from other disciplines, is always focusing on designing a solution relevant to its use in practice by interpreting the meanings of the designed elements (Langley et al., 2018; De Mello Freire & Damazio, 2018). Design can also be regarded as an interventionist and transformative discipline to deal with the introduction of an intervention to facilitate the need of transforming from a problem to the desired situation (Dalsgaard, 2014; Azzari & Baker, 2020) in the pretext of design principles.

3.4.1 Design principles

Schuler and Namioka (1993) argue that design knowledge is built in contexts where it is put to use as its products and results materialise, thus contributing to further theoretical advances. The focus of DR, therefore, is on how to establish meaningful interactions among individuals who are directly involved in processes of design and use of services. As a result, the process of SDR inquiry becomes much more contextualised, hence result-oriented whereby tacit knowledge emanating from various actors plays a key role in research. More so, the iterative design processes involved tend to follow the principles of design, which is much more typical of an industrial context as opposed to traditional scientific inquiry (De Figueiredo & Da Cunha, 2007). Thus, DR produces more innovative and purposeful services that are context-specific, because participants are engaged throughout the design process with co-design and co-creation activities, providing an audience to users' voices, thereby creating services with meaningful use that satisfy customer needs in their context of use. This subsection highlights the various design principles that may be applied in designing IT artefacts in DSR, including IS design research theory, among other design principles, which the researcher adopted to guide this research to deliver new services.

Gregor and Jones (2007) propose eight guidelines to guide IS researchers when designing IS artefacts, which are as follows:

- **Purpose and scope:** First, the aspects of purpose and scope of the prototype system were defined prior to development. Purpose and scope were determined during the project proposal stage, that is, to create integrated ICT-facilitated health and wellbeing information services for

maternal care within NCC. The requirements were identified during co-design and prototyping activities

- **Constructs:** Various entities of interest, i.e. constructs (actors), were identified using the business process model (use cases and flow diagrams) to visualise the intended solution before implementation
- **Form and function:** Regarding the abstract blueprint (form and function), a conceptual model and architectural design of the proposed system were developed to guide the system development process
- **Mutability:** An allowance was given to facilitate further development in terms of both the system state and structure or schema. This is because the artefact was mainly a prototype that did not have full functionality
- **Testable propositions:** While the artefact was developed based on user requirements as identified during data gathering, co-design and prototyping activities, the prototype service (system) was tested in practice as proof of concept (Nunamaker Jr et al., 2015). This enabled the researcher to evaluate the new services using IS design theory guidelines as a true representation of what the research promised
- **Justificatory knowledge:** Specifically, the SDR approach was used, with the main focus on developing new or improving existing services that are context specific (Schuler & Namioka, 1993), hence innovative, and on making them more useful, desirable and usable to the customer while enhancing efficiency and effectiveness for the service pro (Salgado et al., 2017). In terms of contribution to knowledge, the researcher used theories in “*Sciences of the artificial*” book by Simon (1996) to demonstrate the intended contribution of the research using SDR as a catalyst for creating person-centred care services in underserved contexts through active participation. It explores the interrelationship between the natural/social and artificial world(s) to understand their co-existence. In short, the author argues that artificial knowledge (design knowledge) emanates from the natural and/or social world
- **Implementation:** For purposes of implementing the new prototype service, the researcher used a piloting approach whereby the system was launched in a few health facilities first to give room for fixing errors, if any, before actual implementation for use
- **Expository instantiation:** After actual full physical system implementation was completed, performance testing was conducted in the context of use to confirm it as a true representation of the theory. Gregor et al. (2020), in their study on the anatomy of design principles, proposed a schema for specifying design principles for IT-based artefacts in socio-technical systems. The schema comprises various elements of design principles based on the goals in a specific context as well as the relevant mechanisms to achieve them. These include: (i) taking into consideration the varying roles of human actors involved; (ii) addressing issues regarding the complexity of IT artefacts through decomposition; (iii) establishing the distinction between different types of causation, that is, deterministic versus probabilistic; (iv) various mechanisms to achieve aims; and (v) the definition of justificatory knowledge which underlies the design principles as represented in Figure 3.2. The aim is to provide an understanding of the process of formulating design principles and mechanisms to be employed towards achieving the desired

outcome, hence prescriptive knowledge. It therefore involves making prescriptive statements on how to achieve a goal(s), that is, to ‘know how’ knowledge (Gregor, 2006), which plays a critical role in the design process

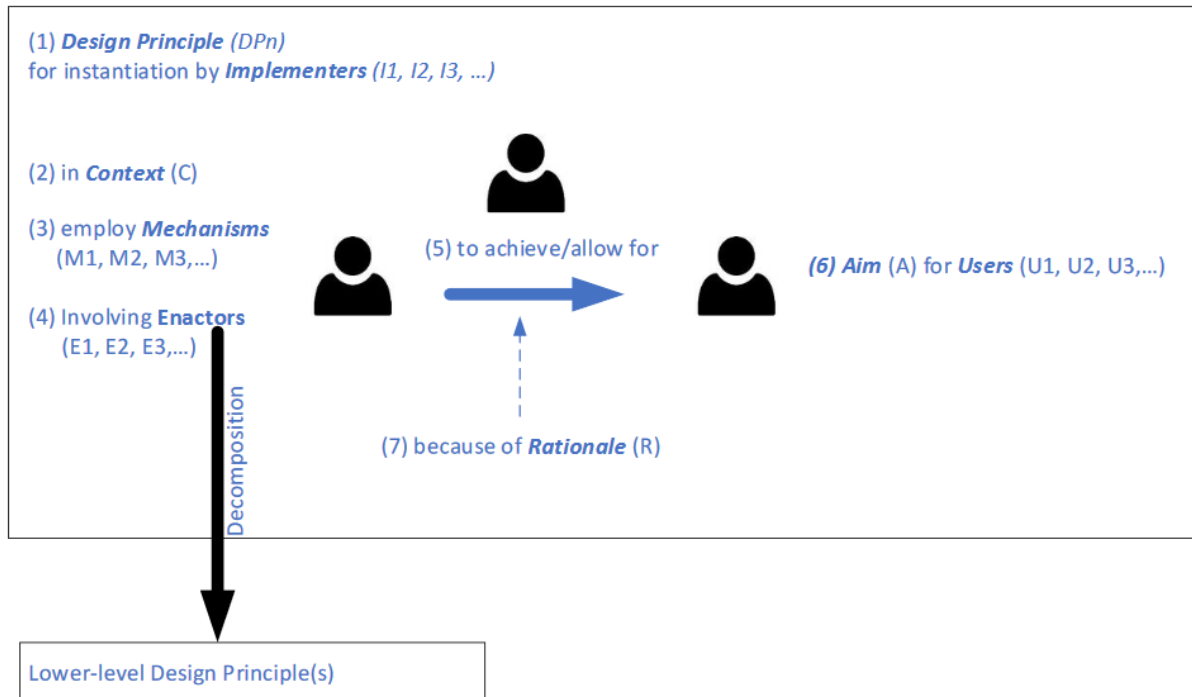
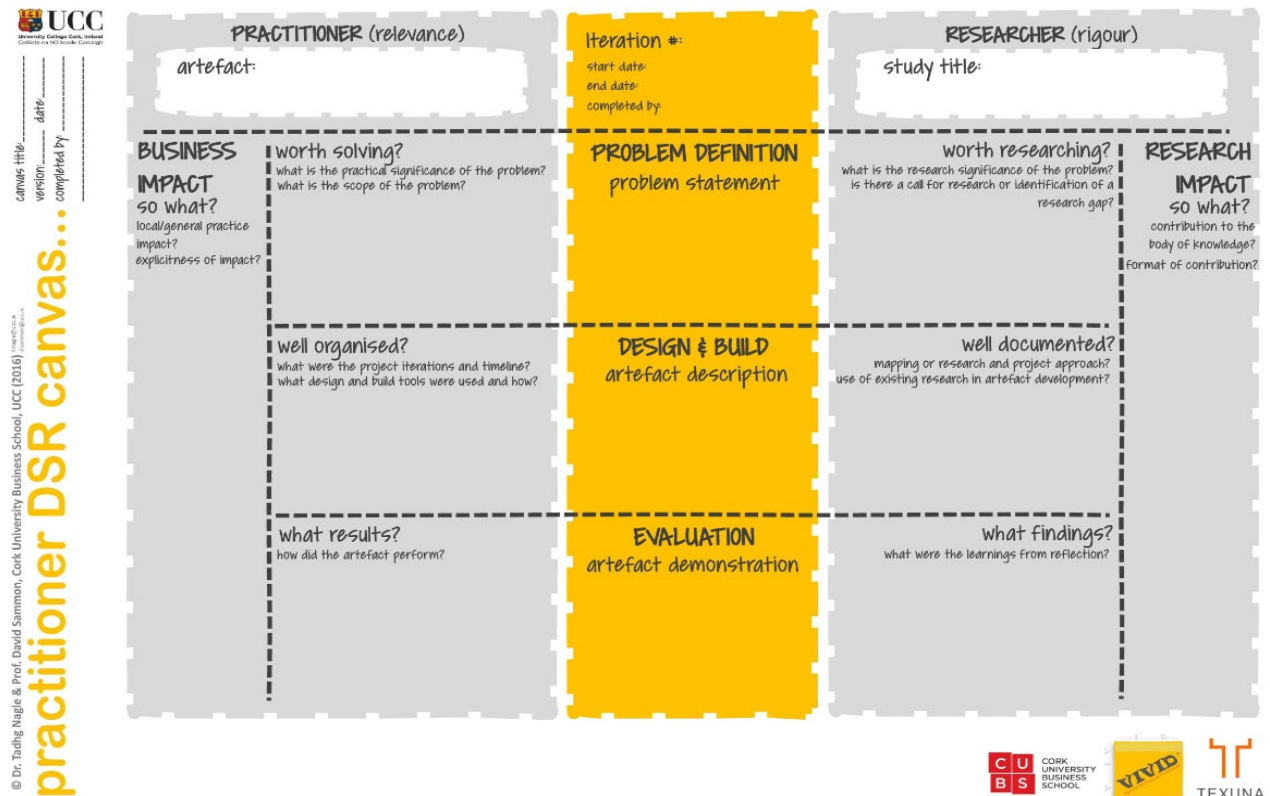


Figure 3.2: Conceptual schema for design principles
(Source: Gregor et al., 2020:1633)

According to Gregor et al. (2020), the common components of the schema include aim, context, and mechanism. The actors include implementers (to instantiate abstract context-specific concrete design); users (those whose aim is to be achieved); enactors (perform actions as mechanisms through which the aim is to be accomplished); and theorists (reflect on design context and capture the abstract design knowledge).

On realising a lack of adequate guidelines for conducting DSR for practitioners doing DSR related projects, Nagle and Sammon (2020) proposed an innovative design-oriented teaching approach. Specifically, they introduced a Practitioner Design Science Research (PDSR canvas) to help teach practitioners the problem-led/design-oriented research methodology of DSR. The approach aims to facilitate relevant and rigorous research, and it comprises three key pillars, namely: (i) the central pillar; (ii) the right pillar (academic rigor); and (iii) the left pillar (practical relevance), as shown in Figure 3.3. The central pillar emphasises the key activities of a DSR iteration, which incorporates three sections – problem definition, design and build (develop) – similar to the elements of the double diamond model of the SDR approach (Design Council, 2015). Also, while the practitioner side of the canvas outlines activities to be completed during a PDSR project to ensure relevance, the researcher promotes the rigor aspects of a DSR project by following the same principles. The PDSR

framework, therefore, encompasses the underlying design philosophy, that is, the SDR strategy which is adopted in this research.



Chandra et al. (2015) argue that the formulation of design principles is an important vehicle towards conveying design knowledge that contributes beyond instantiations in the specific context of use. In order to alleviate the gap concerning the variations in this process, the authors propose three orientations to guide the formulation of design principles in the context of IS, namely: action-oriented, materiality-oriented, and a combination of both action- and materiality-oriented design principles (Chandra et al., 2015). Specifically, action-oriented principles prescribe the actions that the IS artefact allows for, that is, what the system should allow users to do. The materiality principles on the other hand prescribe how an IS artefact(s) should be built or should comprise of, whereas the third dimension prescribes a combination of both the action and materiality-oriented principles. Specifically, the main aim of the canvas model is to provide practitioners with a visual conceptualisation of the components of a DSR-oriented project(s) and how they are amalgamated to facilitate rigorous and relevant design research.

While the co-design-oriented SDR strategy has been adopted, the researcher leveraged the various design principles to create meaningful ICT-facilitated PHR services in the context of use to achieve the aim of the users. This research borrows ideas and concepts from the

aforementioned design principles to conduct a rigorous co-design-oriented DSR research to deliver appropriate solutions.

3.5 Design practice in situations

Situated actions in practice are typically ad hoc influenced by the lived experiences of the people in the situation in the context of particular and concrete circumstances that are often not happening as planned (Ghajargar & Bardzell, 2019). Design is situated and its outcome is the result of the designer's interpretation of a specific situation and a problem experienced in that situation (Dalsgaard, 2014; Maedche et al., 2019). The design process and its outcome are influenced by the constraints of that situation to determine what is possible. The design outcome is based on the designer's interpretation of the desired result when the design is introduced in the use situation. A problem deals with the needs of people in a specific situation that informs the goals of the design to satisfy the specific requirements through the involvement of relevant stakeholders (Maedche et al., 2019). In this case, design practice is used as a concept (Windahl & Wetter-Edman, 2019) that incorporates different concepts such as design thinking, human-centred design and SD to provide for design activities and designerly knowledge by exploring the links of design practice to Service-Dominant (S-D) logic. The authors explored two central dimensions of design: firstly, where design practice "operationalise(s) service experience as situated and systemic", and secondly, how it "breaks institutions through interventionist and transformative action" (Windahl & Wetter-Edman, 2019:678), whereby these two dimensions are regarded as embedded in explorative inquiry. Based on their understanding of design practice and on Dalsgaard's (2014) view, their pragmatist view of design practice is as an action-oriented professional practice concerned with change and transformation.

According to Rohde et al. (2009), design practice deals with an intervention in a social practice that is reflective (situated) and confronted with wicked situations; therefore, truth and utility are inseparable. Cross (2001) views the design of IT artefacts for intended use as creative where its use in practice cannot easily be anticipated. Dalsgaard (2014) posits that theory-practice and reflection-action are intertwined in design where solutions are often constructed through iterative thinking in the form of a reflective conversation with the given situation, conducting and reflecting processes as the design process unfolds (Rohde et al., 2009). Designers depend more on the techniques of the artificial world as opposed to the science of the artificial (Cross, 2001).

3.6 The role of design in health care

In the last decade, the art of design has shifted from designing stand-alone products towards building holistic service systems that involve products, interactions, experiences and

services in different areas, including health care (Pamedytyte & Akoglu, 2019). In their quest to demonstrate the value of design in a health care environment, the authors, through their study, show how a human-centred design process with a bottom-up approach could help design researchers and developers challenge the hierarchical situations to create appropriate solutions for patients in vulnerable situations.

Tsekleves and Cooper (2017) argue that design has potential for immense contribution to the future of health care. During an analysis of 20 chapters in the *“Design for Health book”* and 26 case studies to determine the way forward regarding design in health care across different health care sectors, i.e. public health, acute health, chronic health care and aging well, the authors identified 18 themes regarded as critical to guiding health care design. These were grouped into three main thematic categories, namely: challenges, opportunities, and emerging trends.

The first category, **challenges**, revolves around seven immediate or current and emerging issues facing the health care sector that need redress by design (Tsekleves & Cooper, 2017). These include *long-term health care, ageing, social interaction and support, environment and lifestyle, non-communicable diseases (NCDs), wellbeing and mental health, and active living*.

Second is the thematic category, **opportunities**, which focuses on the application of various methods and approaches where design can offer value within the health care environment in terms of problem-solving (Tsekleves & Cooper, 2017) as depicted from the said book. Also, seven themes are identified under this group, which include *health communication, prototyping, co-design, evidence-based design, digital design, salutogenic design and holistic design*.

The third thematic category, **emerging trends**, revolves around both emerging and possible future directions of health care service in terms of both practice and provision (Tsekleves & Cooper, 2017). Five themes have been identified under this category, namely: *self-management, person-centric health care, holistic health care, community health care, and preventive health care*.

Figure 3.4 is a demonstration of the relationship(s) between the three thematic categories whereby challenges experienced in health care influence emerging trends, whereas opportunities offered by design provide solutions to these challenges.

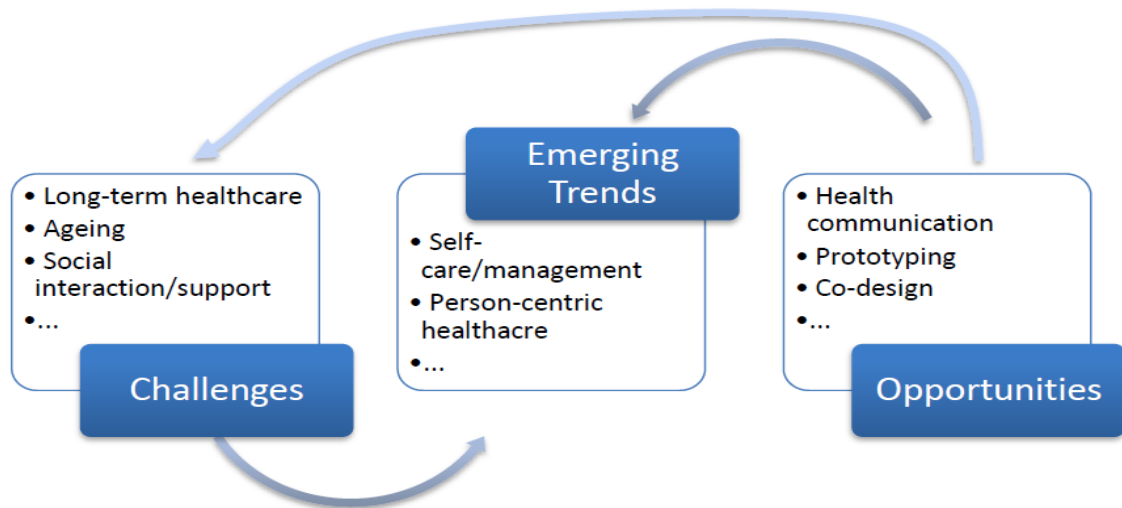


Figure 3.4: Main themes and groupings following thematic analysis of the book chapter
(Source: Tsekleves & Cooper, 2017:S2261)

However, DR in health care is not without challenges, which could be more prevalent, recurrent, or demanding (Groeneveld et al., 2018). According to the authors, there are three main clusters of the key challenges categorised into practice, managerial and generic challenges. Specific challenges occurring under **practice** include the processes of conducting fieldwork, involvement of end-users, and handling of sensitive situations. Challenges under the **managerial** cluster, on the other hand, include management of relations, building understanding among project stakeholders, and communicating the value of design to health care. The last cluster, **generic** challenges, includes time, budget limitations and building rapport (Groeneveld et al., 2018). Noticeable is that health care is moving from a disease-based approach towards preventive care models, which seek to support and empower patients in various ways. As a result, exciting opportunities are emerging from design to contribute to population health and wellbeing and a positive experience for stakeholders, especially to care recipients and providers (Groeneveld et al., 2018). Specifically, SDR is perceived to enable value co-creation through webs of interactions in health care, which involve both provider and customer networks, hence the need to adopt it in the re-design of health care (Patrício et al., 2020; Malmberg et al., 2019).

3.7 Service Design Research (SDR) approach

Design for services may be defined as activities involving the conception, planning, and building of an interactive system(s) or service architecture, with the primary goal is to provide resources to support interactions between the users and providers (De Mello Freire & Damazio, 2018). The service concept, therefore, plays a key role in SDR and development, not only as a core component of the design process but also as a means to ‘concretise’ the nature of the service (Goldstein et al., 2002). According to the authors, the service concept does not only define the *how* and the *what* of SDR, but it also ensures integration between the

how and the what of SDR while mediating between the needs of both the customer and those of an organisation's strategic intent.

The research problem is therefore investigated through the lens of the SDR approach, which can be defined as a creative, human-centred and iterative approach to service innovation (Malmberg et al., 2019; Teixeira et al., 2019; Wetter-Edman et al., 2014). In the context of SDR, **service** refers to a series of interactions between providers and users of service, hence participatory design (Thobias & Kiwanuka, 2018; Salgado et al., 2017). Services are intangible and dependent on each individual who uses them, and therefore the SDR approach attempts to understand the characteristics of the desired service(s) by engaging designers and stakeholders as well as users during the design and development process. This helps to facilitate understanding of end users' needs and their experiences with a particular service using various design methods and tools, including the co-design method, hence active participation (Huang et al., 2013; Hurley et al., 2018; Moritz, 2005). SDR, therefore, has the capability to generate new ideas through an iterative process while the designer explores users' experience towards creating new innovative services (solutions), which are then translated into prototypes, tested and implemented as a new service (Trischler et al., 2018).

In service design, knowledge is gained from the designer's intellectual reflection on the design activities and the phenomena representing the service situation investigated, similar to research through design (Sun, 2020). It seems that much effort is required to address challenges associated with the maintenance of electronic health records (EHRs), which are shared in digital form and therefore need to be accessed securely by different authorised users, whereby the main goal is to support continuous, efficient, quality, and integrated health care service (Häyrynen et al., 2008). In this case, EHRs are services involving a complex network of actors – hence interdependent health care – who co-create their value by facilitating many-to-many interactions among themselves (Thorbjørnsen et al., 2009). Therefore, to reap the benefits of EHRs, patients have to provide accurate information to health care providers and comply with the recommendations thereof. Similarly, health professionals can provide accurate diagnoses and treatments when they are able to access patient records compiled from clinical information, which can only work if different practitioners cooperate and capture patient information accordingly. To leverage the actors' potential for value co-creation, networked services such as a national EHR service should be designed to support interdependent interactions rather than individually (Edvardsson et al., 2014). Therefore, to address challenges associated with the creation of network-level services, Patrício et al. (2018) recommend the use of SDR for Value Networks (SDR4VN), which enables the designing of services as enablers of many-to-many value co-creating interactions among network actors.

Generally, research represents SDR as both a multidisciplinary approach and service innovation as a multidimensional phenomenon (Joly et al., 2019). It is against this background that design researchers in health care have tried to apply design approaches and techniques such as the SDR approach, which could help overcome issues, and which are human-centred and context-specific (Malmberg et al., 2019). In the context of this research, the focus is on *maternal health and wellbeing of information services*, whereby principles of SDR were applied to investigate the nature of the services in an underserved context to improve current services. According to literature, SDR is a multidisciplinary, human-centred, collaborative and iterative approach that promotes service innovation (Blomkvist et al., 2010; Ostrom et al., 2015; Sangiorgi et al., 2017), and is thus recognised as a catalyst for organisational transformation (Kurtmollaiev et al., 2018). On this basis, research recommends the involvement of patients through SDR to initiate cultural change (Malmberg et al., 2019). This approach promotes active participation in the design process, and has therefore the capacity to induce change in people's health behaviour (Wetter-Edman et al., 2018). SDR can be leveraged to engage both the patients and their family perspective(s) in the service development process whereby their voices are heard (Malmberg et al., 2019). This research, therefore, aimed to combine opportunities presented by both SDR and ICT to complement efforts towards person-centred care (Malmberg et al., 2019).

Integration of SDR principles and IT can tremendously improve both delivery and productivity in public sector operations (Karwan & Markland, 2006). The authors assert that existing service management models can be combined with IT solutions to deliver efficiency and effectiveness, particularly in public service operations. This follows the realisation that IT alone cannot deliver the desired outcome despite the promises thereof, hence the need to supplement it with the service concept to improve operational efficiency (Karwan & Markland, 2006). Specifically, this study attempted to create innovative patient-centric eHealth services to support personal health and wellbeing in an underserved context. The study, therefore, focused on health and wellbeing service delivery as a challenge in health care that needs to be addressed by design, whereby ICT is used as a preventive care strategy that supports human health and wellbeing (Rao et al., 2007; Codinhoto et al., 2009). Opportunities presented by both SDR and ICT were therefore leveraged to deliver patient-centred eHealth services as a future trend in health care practice (Hu & Bai, 2014).

3.8 Chapter conclusion

In this chapter, the role of design in health services is discussed to provide a foundation for the research methodology applied in this study. In the next chapter, the adopted research strategy and design process are discussed.

Chapter 4: Stakeholder Co-Design

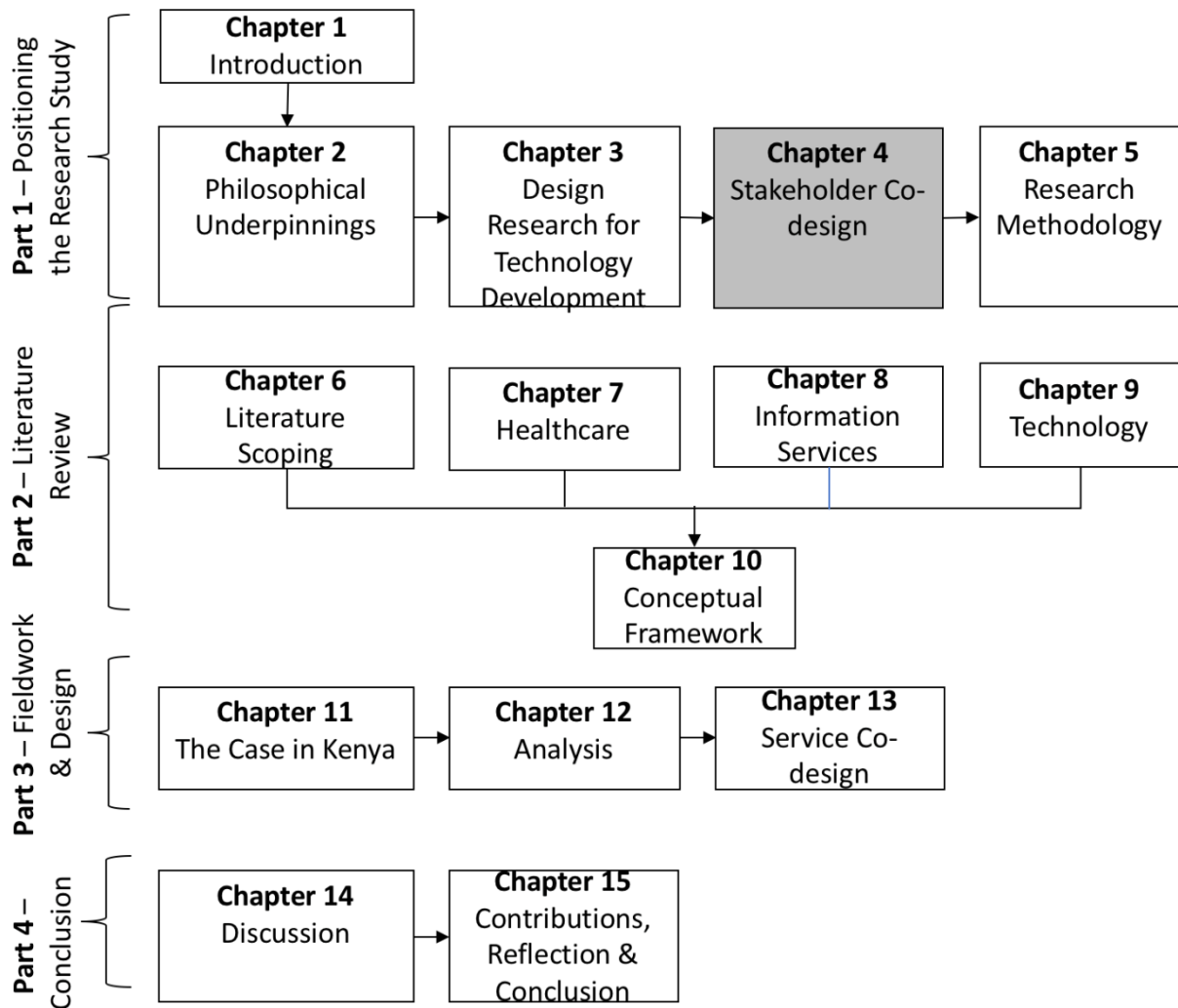


Figure 4.1: Thesis Layout - Chapter 4

4.1 Introduction

In this chapter, the research strategy, i.e. the co-design-oriented Service Design Research (SDR) approach is discussed, which entails the involvement of the relevant stakeholders in the research processes. The chapter is therefore organised as follows: first, the importance of involving the stakeholders as active co-designers of the proposed solution is indicated and secondly, the proposed design research strategy in terms of IS research before a co-design-oriented SDR framework is proposed.

4.2 Co-design

The co-design process is understood as a process of abduction, that is, pragmatism, which implies a type of reasoning different from both deduction and induction reasoning (Steen, 2013). The process involves the various approaches spanning from research-oriented to

design-oriented, where applied ethnography and generative tools are used. The main focus of the co-design process, according to Steen (2013), is to use various approaches whereby designers engage users through usability testing while the users also engage researchers and designers through participatory design. According to Slattery et al. (2020), co-design is meaningful, with active end-user engagement in the research design and design process. In service design, co-design allows for the combination of two sets of knowledge with customers: as experts of their situation to provide insights into the latent user needs, and the designer's ability to convert and align these needs with new ideas for new or improved service concepts (Trischler et al., 2018). The context of the situation determines the design, impact and implementation of the research study (Slattery et al., 2020). Current research studies focus on maximising rigor and completeness directed at an academic audience without considering co-design activities and with limited dissemination on how co-design can benefit researchers, practitioners and end-users in terms of the research process outcomes and impact for co-design (Dimopoulos-Bick et al., 2019; Slattery et al., 2020). Such misalignment between the aims of the research project and end-user needs could be regarded as research waste (Slattery et al., 2020). However, it is also important that the complexities associated with research do not frustrate the stakeholders involved in the co-design. In pragmatism, however, the emphasis is on shared meanings and joint actions.

4.3 Stakeholders

Stakeholder theory implies the principle of whom or what counts, i.e. who are the key or rather main stakeholders of the firm and to whom do managers pay attention? (Freeman, 1984; Mitchell et al., 1997). In other words, for one to identify the relevant stakeholders in an ecosystem, the issues at hand should be identified, defined and mapped out first to facilitate stakeholder analysis, which comprises identification, prioritisation and classification (Chung & Crawford, 2016). Freeman (1984) therefore defines the term *stakeholder* as any group or individual who may affect or is affected by the achievement of the organisation's objectives, and stakeholders may have a limited or significant influence on a project's expected outcomes. On the other hand, Javanparast et al. (2009) define the concept of *stakeholder analysis* as an approach used to understand a system by identifying the key actors or stakeholders in the system and assessing their respective interest in that system.

In 1984, Freeman proposed an organisation-centric view, arguing that a firm should manage relationships between its primary stakeholders (the narrow view) and secondary stakeholders (the broader view) for purposes of value creation (Freeman, 1984). The narrow view includes those parties (individuals, groups of people, organisations and institutions) directly associated with a corporation's economic interests, and without whom the corporation could survive. The broader view, on the other hand, focuses on those stakeholders who may

or may not have legitimate claims, but may be able to affect or are affected by the firm, thus influencing the interests of those with legitimate claims (Mitchell et al., 1997).

Sciarelli and Tani (2013) perceive the core goals of an enterprise as a type of combination of the interests that various stakeholders are caring for. In order to create value for stakeholders, therefore, the business must be seen as a set of relationships among groups having a stake in the activities that make up the business and how they relate in form of interactions and value-creation (Freeman, 1984; Chung & Crawford, 2016).

The salience model proposed by Mitchell et al. (1997:865) comprises three relationship attributes as highlighted in Figure 3.6, by which important stakeholders should be identified and classified to pay them adequate attention:

- **Power:** The concept of power is defined as the probability that one actor within a social relationship would be in a position to carry out his/her own will despite resistance to bring out the outcome one desires (Mitchell et al., 1997). On the other hand, Johnson et al. (2008) define it as one's ability to persuade, induce or coerce others into following certain courses of action
- **Legitimacy:** Refers to a generalised perception that the actions of an entity are acceptable, desirable, proper, and/or appropriate to social norms, values and beliefs (Suchman, 1995; Mitchell et al., 1997)
- **Urgency:** The degree to which stakeholder claims call for immediate attention, that is, time-sensitive and critical in nature (Mitchell et al., 1997)

In 2008, Johnson et al. proposed the power/interest matrix approach to stakeholder mapping, which categorises stakeholders into four segments: those to be treated with minimal effort (A); those to be kept informed (B); those to be kept satisfied (C); and the key players (D) (Johnson et al., 2008). The model is aimed at helping to determine the level of interest and degree of power stakeholders must have for their expectations to be met by the organisation. This, therefore, means that the greater the extent to which any party identified as a stakeholder possesses the attributes regarded as important, the more that stakeholder is seen as one to which direct attention should be given (Clifton & Amran, 2011).

The Net-Map approach to stakeholder analysis provides an interview-based mapping tool that helps to investigate, analyse, visualise, monitor, evaluate and understand in order to improve situations influenced by different actors (Schiffer & Hauck, 2010). The network approach can infer potential network evolutions to obtain a more dynamic approach to stakeholder management. Furthermore, network interventions tend to make networks more effective as they increase both the quantity and quality of relationships among network participants (Vance-Borland & Holley, 2011). Therefore, the network perspective facilitates a holistic view of the environment and the actors involved, thus letting them understand how the various stakeholders are related to each other (Sciarelli & Tani, 2013).

Clifton and Amran (2011) and Johnson et al. (2008) assert that stakeholder mapping is useful in identifying stakeholders' expectations by analysing them in terms of power, legitimacy, urgency, interest, and contribution. This enables various stakeholders to comprehend, monitor, evaluate and improve complex situations in which different actors are likely to influence outcomes, so that they may be strategically positioned to determine action(s) to be taken towards solving a problem (Schiffer & Hauck, 2010).

This research applied concepts of stakeholder analysis to select and recruit participants from the relevant stakeholder groups to adequately explore and analyse the problem. The information needs of different stakeholders were determined, and the outcomes serve as baseline study findings towards finding an appropriate ICT-facilitated solution for the research problem. Specifically, this research used the snowball sampling technique (Goodman, 1961) to identify the various stakeholder groups in maternal health care, which then assisted the researcher in nominating potential research participants (Marshall, 1996).

4.4 Design Research (DR) and Information Systems (IS)

In Information Systems Research (ISR), different paradigms, methods and approaches are used to underpin a research study, of which positivism, interpretivism, and a critical approach seem to be the more accepted ones (Dimopoulos-Bick et al., 2019). Since the beginning of the 21st century, Design Science Research (DSR) has garnered attention to deal with the lack of research on the design and development of artefacts in IS and has since become a well-established approach in the IS discipline. Behavioural science research is positioned for positivism, interpretivism and critical types of research studies as part of the problem understanding paradigm versus DSR as part of the problem-solving paradigm (Niehaves & Berndt, 2006). Niehaves (2007) argues that a diversity of epistemological stances could be possible and that research rigor, validity and quality should depend on the underlying epistemological stance adopted for the study. The author used the principles of both interpretive research (Klein & Myers, 1999) and DSR (March & Smith, 1995; Hevner et al., 2004) to support his argument. IS research uses different paradigms, methods and approaches. In their study, Peffers et al. (2018) propose five genres to assist with the evaluation of specific research studies, of which design-oriented ISR is the one considered as a departure point for this study. This genre is seen as the design of better IS solutions, where the utility value in practice is the important consideration for acceptance. The process of such design research studies aligns to typical system development with analysis, design, development, evaluation and diffusion based on a problem experienced in practice.

Deng and Ji (2018) reviewed related literature in the IS field to gain clarity on central ideas such as the definition, philosophical positioning, and research outcomes (pragmatic-design versus design-theory), among others, of DSR. The authors found that there is still not

a unified definition of DSR to contribute to the lack of agreement on the central ideas and objectives of DSR and propose a roadmap for further research. Although their literature review, extended through a snowball process that included more related publications outside the IS field, considered DSR, using the keywords *IS*, *artefact*, *theory*, *knowledge*, *concept* and *process* seemed not to have included publications from the design field, that is, outside the IS and Engineering disciplines (Deng & Ji, 2018). The authors considered Design Research (DR) as reported in the included IS-related literature and not as conceptualised in design disciplines such as Industrial Design, Service Design, and Interior Design. Their study aimed to consider the concept of design in DR versus DS versus DSR to propose a process model of design-oriented IS research. Similar to Deng and Ji's (2018) proposed process model, this research proposes a design-oriented, technology-enabled service design research process model (DOSDR) to clarify the role of the designer and researcher as well as the knowledge contribution in addition to the design outcome.

DSR is an attempt to reduce the gap between theory and practice (Deng & Ji, 2018), and although the researcher recognises the important work of many prominent researchers who contribute to developing DSR as a discipline, the approach used in this research resonates more with DR where design is not equated to science. This approach enabled the researcher to bring to the foreground practice-based research, where the situation in a specific context being investigated is the foundation of the proposed approach (Ågerfalk & Karlsson, 2020; Herriott, 2019). For this research, a new service refers to the design object and the outcome of the design process. Services are intangible and even though tangible objects such as the technology are used to facilitate the service and the interaction between the users and the service at the touchpoints, a service still represents a complex design object. At the same time, the researcher could not find the explicit articulation of design knowledge in related design research (Dalsgaard, 2014; De Mello Freire & Damazio, 2018; Faste & Faste, 2012; Jones et al., 2016; Jordan & Stolterman, 2018; Khan et al., 2020; Sun, 2020), similar to the way it is conceptualised in DSR and ISR (Chandra et al., 2015; Iivari, 2007; Iivari et al., 2020; Gregor et al., 2020; Niehaves, 2007; Vom Brocke et al., 2020; Winter & Aier, 2020). The design principle seems to be the concept most described in DR, DSR and ISR. The researcher therefore borrowed the conceptualisation of design knowledge contributions of DSR. PDSR and ISR informed the contribution of this research.

4.5 Service Design Research (SDR)

In SDR, the focus is on developing theories, SD methods and models, and conceptual frameworks for new services, based on the users' experience of the service, the use of the service, and the users' latent needs (Joly et al., 2014; Pekkala & Ylirisku, 2017). It is an evolving multi-disciplinary field rooted in DR and that builds on SR (Teixeira et al., 2019) with

a human-centred, collaborative holistic approach addressing real-life problems in organisations and/or in society as a whole (Joly et al., 2019; Pekkala & Ylirisku, 2017). For technology-enabled services, DSR also draws from Interaction Design (ID), Human-Computer Interaction (HCI) and Information Systems (IS) (Teixeira et al., 2019) based on the socio-technical nature of incorporating technology in solutions. Teixeira et al. (2019) map SDR as empirically grounded in the real-world on the relevance rigor framework of Hevner et al. (2004) using the DSR process for an SD knowledge base. It is, therefore, against this background that the researcher adopted SDR – to contribute new service ideas that enable new forms of value co-creation with the relevant stakeholders (Kimbell, 2011).

4.6 A co-design-oriented Service Design Research (SDR) approach

In this section, the research design for the proposed co-design SDR approach is presented. While ideas from Saunders et al.'s (2017) research onion were borrowed for the methodological research considerations based on the onion layers, this study adopted the interpretive and pragmatism paradigms as philosophical stance, and proposed a co-design-oriented SDR as research strategy in addition to the ones proposed by the authors, namely: experiments, surveys, case studies, ethnography, action research, and grounded theory, among others. Although Saunders et al.'s (2017) research onion does not provide for design research, it could be positioned on the onion's research strategy layer as an alternative to action research that also deals with the introduction of an intervention to improve a situation. The proposed research strategy for this research also used elements of ethnography through participant observation. The proposed strategy is discussed next.

4.7 Research strategy: Co-design-oriented SDR

This research study has been positioned in multi-paradigms where the researcher moved in and out of, and between the respective paradigms (Klein & Myers, 1999). Therefore, the ontological stance adopted for the problem-solving paradigm is pragmatism, informed by the nature of design rather than approaching it from a scientific position. On the other hand, a subjective position was adopted for the problem understanding paradigm to gain the necessary insights into how the humans make sense of their problem situation during the design and of the anticipated improved situation. The research participants were active co-designers of the proposed new service based on their needs and grounded in the body of knowledge whereby a conceptual framework developed from the related literature guided the research part of the process. The research outcomes include a conceptual framework as the research contribution and the new technology-enabled information service as the instantiation of the co-design process.

4.8 Proposed co-design-oriented SDR framework

The proposed research strategy that guided the study by combining three levels for the actual design process is unpacked and depicted in Figure 4.2. The three levels are: the lower level that comprises the double diamond of the design process (Design Council, 2015); the research process on the second level; and the worldview on the top level.

The design research process starts with an inquiry into the current situation, also seen as the problem situation to gain a better understanding of the problem. The problem is presented as a practical problem as experienced by the people who can benefit from a new service based on their needs and experiences. At the same time, the practical problem is framed as a research problem grounded in the relevant literature with a clear research gap that will be addressed by the study. This is followed by the four phases of the double diamond process of SDR, namely, Discover, Define, Develop, Deliver (Design Council, 2015; Nyatuka & De la Harpe, 2019) and is concluded with a proof of concept. The SDR strategy, in this case, enables the researcher (service designer) to employ a variety of design tools and techniques (Wetter-Edman et al., 2014) to discover the touchpoints, i.e. key moments of service to users while they access or interact with those services (Salgado et al., 2017). At the same time, the designer(s) is able to assess the degree and quality of users' experiences in those moments while interacting with the services. During this process, design tools are used to help minimise the dominance of the facilitator while it gives voice to the users, hence UCD services, thus empowering users to contribute ideas for new value propositions that are more supportive in their value creation processes (Hurley et al., 2018). The SDR approach, therefore, provides a broader view whereby social relations are examined, which necessitates the need for active engagement of both the service providers and service recipients/users (Vassilakopoulou et al., 2016). The actors in this process are therefore not mere service creators and/or service recipients; they are also viewed as resource integrators within the service ecosystem, which is instrumental for service innovation and thus co-creation of value in service development (Patrício et al., 2018; Vassilakopoulou et al., 2016; Vargo et al., 2008). Therefore, the users are equally central to the design process, as it helps to capture their unique knowledge and latent needs (taste and preferences) of customers, which is critical to innovation and the success of new services (Trischler et al., 2018).

Despite being presented in a linear manner, the nature of design is iterative with cycles of planning, designing, reflecting, and re-planning. The research level illustrates how the data from the situational inquiry process is collected and analysed; the research may provide methods that could be used for the design in practice; the observations and design constructs of the design in practice feed into both the next design step and the design research. The top level depicts the knowledge creation and use of the paradigms used. The co-design-oriented

SDR framework was specifically developed to guide this research as depicted in Figure 4.2 as the approach for this study.

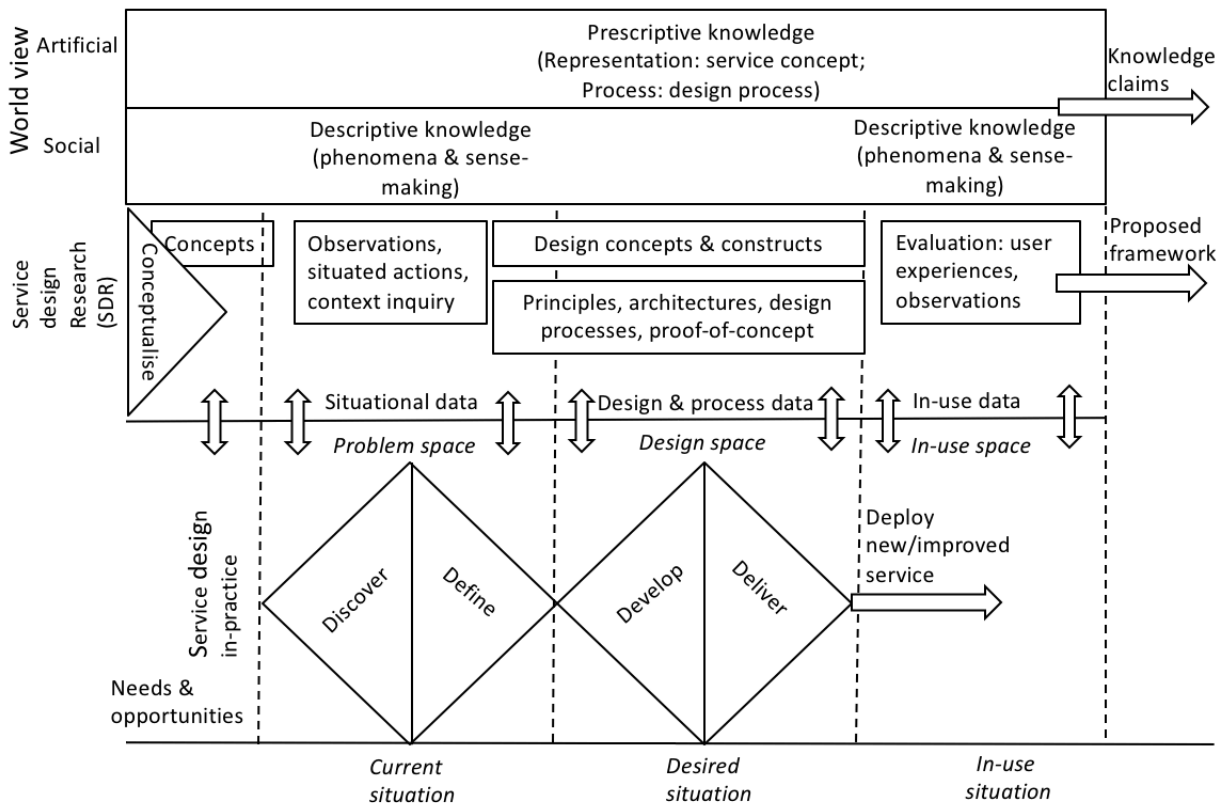


Figure 4.2: Paradigm representation of the co-design-oriented SDR framework
(Source: Researcher)

The SDR process in this case was used to create a new service through a co-design process based on sense making of the needs and experiences of people in a specific situation towards the desired situation. At the top of the framework are the two worldviews presented: (i) social for the problem understanding paradigm; and (ii) artificial for the problem-solving paradigm. The associated knowledge, descriptive associated with the social world and prescriptive associated with the artificial world gained during the co-design research process, is indicated. When the problem is conceptualised, the current situation is investigated to consider the needs and experiences of the relevant stakeholders and/or users to identify potential opportunities for solutions. The problem conceptualising process is abductive, moving from the concrete situation towards drawing from the existing body of knowledge to ground the practical problem also as a research worthy problem. Therefore, problem solving in pragmatism starts with the recognition of a problem in a specific situation for the researcher then to reflect on the nature of the problem and a suitable approach that leads to the reformulation of the problem. In the context of this study, the service is the design object, i.e. the technology-enabled information service. The service concept defines the ‘*what*’ and ‘*how*’

of service design while also integrating the two to mediate the stakeholder needs with the service provider's intent (Goldstein et al., 2002). Possible actions informing the design of the research are considered to solve the problem. The research methods selected are then considered through reflection that may again result in a further reformulation of the problem. This iterative process may be repeated through a process of abductive reasoning until the researcher is confident that the design will result in the expected outcome (Kaushik & Walsh, 2019). Hence, the outcome of the problem conceptualising is a conceptual framework that guides the research process. Ultimately, the conceptual framework is used as a lens to shape the analysis and findings and which can be changed to reveal different aspects (Jordan & Stolterman, 2018) as insights are gained.

The design process is a combination of the Nunamaker et al. (1991) process for system development research and the double diamond typically used for designing services (Design Council, 2015) to make the research part more explicit. The double diamond model proposes four phases to first discover the needs and experiences of people in the current situation through a divergent thinking process. The next phase involves defining the design challenge through a convergent thinking process. The develop phase is where the service concept is developed with the involvement of the relevant stakeholders and also considering inspiration from other sources. The last phase is to deliver the selected solution by testing different possibilities to match it as closely as possible to the desired outcome. The outcome of the service design process is a viable new or improved service that could be in the form of a prototype as a proof of concept (Nunamaker Jr et al., 2015) or service ready for deployment. The framework of Nunamaker et al. (1991) provides for an evaluation phase to evaluate the research output.

The *practical outcome* of this study is the instance of a technology-enabled information service prototype and the *research outcome* is the conceptual technology-enabled information service framework that has been refined during the design process to incorporate the insights gained from the characteristics of the service and the process of designing the service.

This research, however, only focused on the current situation and the design process to reach an improved situation towards the desired situation. It did not consider the in-use situation because the proposed service still needs to be further developed into a functional service for the particular situation. The data from the social aspect of the research were collected from observations, situational actions and contextual inquiry. Data about the service were collected during the design process, as the design object is in the form of design concepts and constructs, design principles, architectures, the design process, and proof of concept (Nunamaker Jr et al., 2015).

4.9 Proposed co-design SDR process

Figure 4.3 has been developed to illustrate the design process that maps the service design double diamond process (Design Council, 2015) to the detailed co-design process.

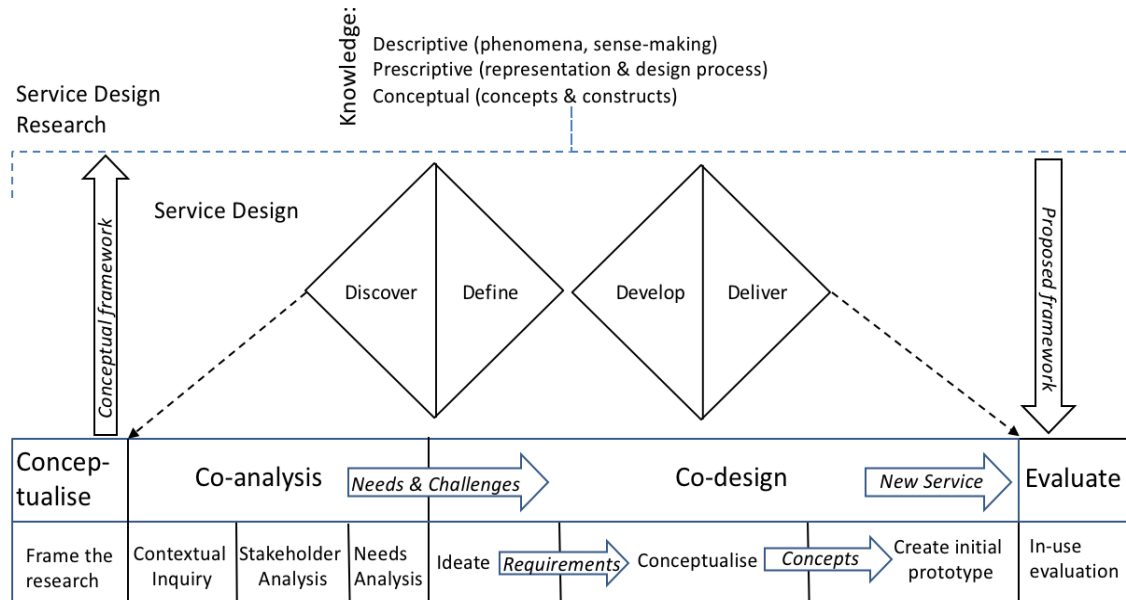


Figure 4.3: Co-design SDR process
(Source: Researcher)

The co-design process consists of two phases. During the co-analysis phase, the details about the context of the current situation are gained, the stakeholders involved in the study are identified and being consulted, and the needs analysis is done to determine the needs and experiences of the stakeholders involved in the current service and who would be interested in the proposed new service. During the design process, all the relevant stakeholders participate as active co-designers of the new service. The iterative design process is moving from ideating for possible ideas for the solution to conceptualising those ideas into possible solutions to create the prototype. As the process progresses, the outcome of the ideation process is the list of requirements that may be refined. After the conceptualisation, possible design and service concepts are created, from which the solution is built.

The research process can be regarded as one that informs and draws from the design process. The research and design processes are separate, each with its own methods and approaches but also integrated since they depend on each other. Prototyping allows for the use of a variety of design tools to identify the various data elements and design features to be included in the proposed ICT-facilitated design solution. According to literature, the advantages of prototyping include the ability: (i) to facilitate engaging, active participation among participants; (ii) for iteration of the design and development process until desirable results are obtained; (iii) to work better in situations where requirements are not known; (iv) to deliver

working solutions faster; (iv) to support customer experience; and (vi) to represent and test new services through co-design activity (Salgado et al., 2017; Teixeira et al., 2019; Peleg et al., 2008).

As part of the design process for this research, Rapid Application Development (RAD) methodology was used, focusing on developing different components of the prototype system. Advantages of RAD include: (i) minimal planning, thus saving time; (ii) the ability to minimise risk because of its iterative nature; and (iii) the ability for faster development and delivery of a quality working system at a lower cost and with greater stakeholder participation, thus creating a sense of ownership and satisfaction among stakeholders (Mattie & Webster, 2008).

4.10 Chapter conclusion

In this chapter, the research design was discussed, based on the involvement of relevant stakeholders in a co-design process. Figure 3.2 illustrates a proposed paradigm representation of the co-design-oriented SDR framework, based on the SDR strategy that depicts the design and research processes of this study. The co-design SDR process is depicted in Figure 4.3. In the next chapter, the research methodology for the study is discussed.

Chapter 5: Research Methodology

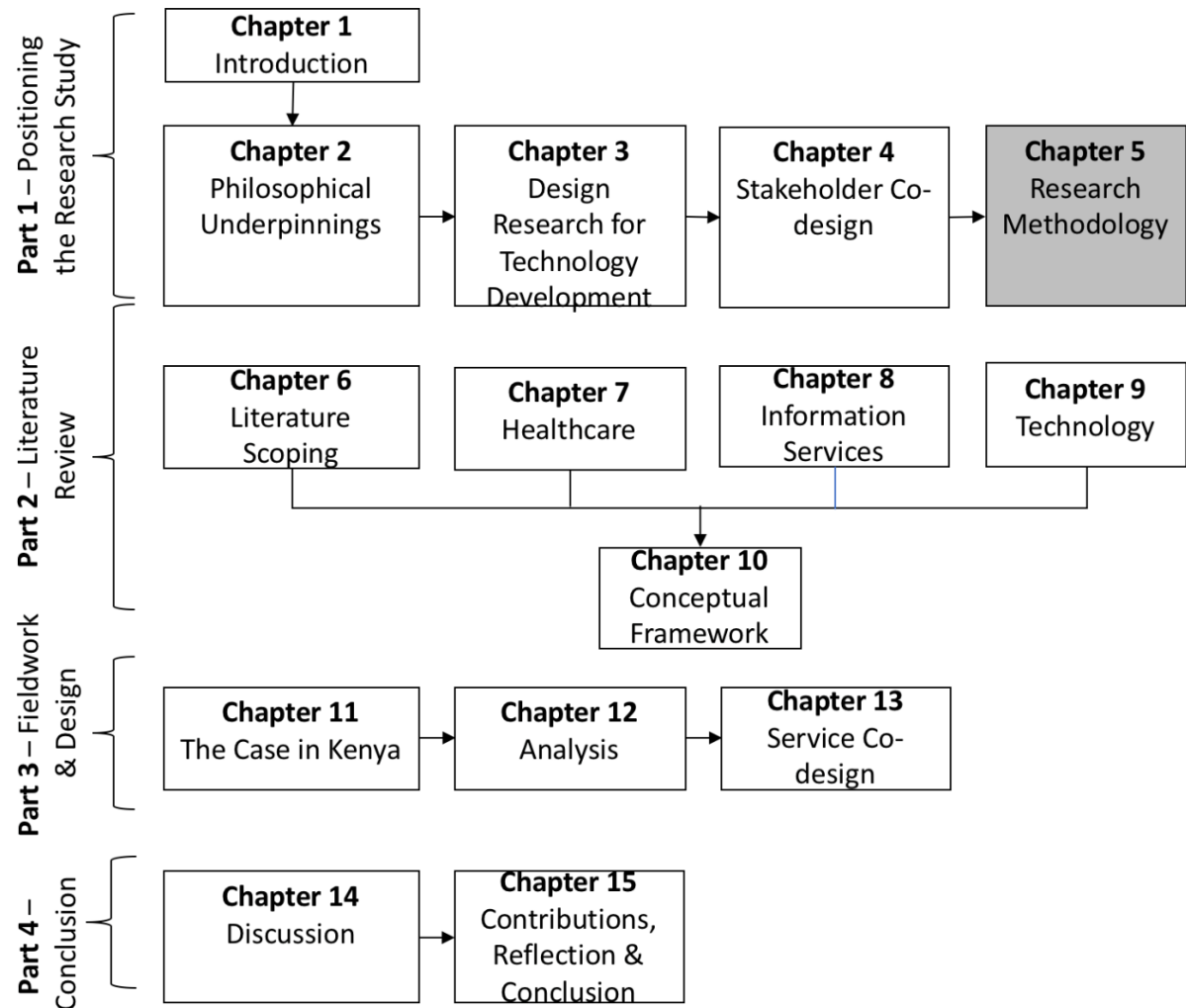


Figure 5.1: Thesis Layout - Chapter 5

5.1 Introduction

The chapter presents the detailed, systematic approach applied to carry out the research, including the philosophical framework, research design and strategy, population sampling, data collection process and tools, data analysis and interpretation, ethical considerations, and a conceptual schema for research.

5.2 Field research execution plan

The purpose of this research was to design integrated, secure, ICT-facilitated personal health and wellbeing information services to improve the delivery of maternal care in Nairobi County, Kenya. The researcher applied the concepts of stakeholder theory (Johnson et al., 2008) to identify the relevant stakeholders in maternal health care. The interpretive research approach was adopted through the application of principles of interpretive field research in IS

(Klein & Myers, 1999). The SDR approach was partly used in the design research (DR) process to create the desired design solution (Salgado et al., 2017; Moritz, 2005). The research process therefore involved two levels, namely stakeholder analysis and initial field research, comprising qualitative research (contextual analysis) and design research.

5.3 Initial field research

This research phase was undertaken in two stages: context analysis and design research.

i) Qualitative research

The aim was to facilitate analysis of the research context whereby individuals, groups, organisations and community contexts were investigated and described. In interpretive research, according to Klein and Myers (1999), facts are produced as part and parcel of the social interaction between the researcher(s) and participants, and that there will be little impact if the researcher does not interact with participants to understand the current situation and/or context. Particularly, interpretive field research in IS involves constant movement of understanding from the whole to the part and back to the whole, towards the harmony of all details with the whole as the criterion of correct understanding (Klein & Myers, 1999). This assisted the researcher with mapping issues to accurately determine the change objective, time and periodicity. Various qualitative methods were used to gather primary data to enable the researcher to forecast and assess various aspects in the research context (Amoako & Rivett, 2015). Among the aspects assessed were stakeholders' information needs, technical and economic feasibility capabilities around proposed solution(s), and the potential effects of the project on the beneficiaries.

ii) Design research

The researcher explored the health context and the women's maternity journey, which comprised touch points throughout pregnancy and childbirth, including their experiences, viewpoints, behaviours, and preferences (Salgado et al., 2017) related to information needs and services using the co-design-oriented SDR approach. The design process involved the use of various design methods and tools to perform context inquiry, which included service prototyping, among others (Salgado et al., 2017; Moritz, 2005). This assisted the researcher with discovering and defining concepts relating to the design characteristics and components of the proposed ICT-facilitated personal health and wellbeing services for maternal care. As such, contextual inquiry was performed to gain deeper insight into the research phenomenon, i.e. maternal health and wellbeing information services in public health facilities within NCC.

5.4 Research design (RD)

According to Kumar (2011), research design is a plan that enables a researcher to undertake research procedures and tasks to complete a study and to answer research questions accurately, objectively and economically. The author asserts that a good research design should state the name of the research strategy to be employed as well as the target population and sampling techniques to be used, and that through reviewing the existing body of knowledge, the researcher is then able to tackle the research problem with understanding. While the researcher adopted interpretive and pragmatic research approaches, this section highlights the theoretical themes used to guide the research, the target population and sampling, data collection methods and tools, data analysis techniques, ethical considerations and the conceptual schema for research.

5.5 Theoretical themes for research

Since the research was to use TA, the researcher used a predefined set of theoretical themes to guide the development of data collection tools, which subsequently enabled the inductive coding of the data (Elliott, 2018). Theoretical themes were formulated from the literature in line with the research question to explore six main areas of potential interest in the data (Braun & Clarke, 2006). The following themes, derived from a search of literature, were used to guide this study:

- Stakeholders in maternal health services (T1)
- Maternal health information needs of stakeholders (T2)
- Maternal health information practices (T3)
- Challenges facing management of maternal health information services (T4)
- Stakeholders' perceptions on potential maternal health information service (T5)
- Design considerations for ICT-facilitated maternal health information services (T6)

The researcher used a pre-defined set of theoretical themes (Elliott, 2018) derived from the research questions based on the literature reviewed to guide the research through thematic alignment whereby inductive coding was done. The theoretical themes were used to guide the data collection and to prompt the participants for their views. The interview questions (IQ) were mapped to the theoretical themes.

5.6 Target study population and sampling

The concept of *study population* can be defined as a complete set of individuals or objects that possess common observable characteristics (Mugenda & Mugenda, 2003), while sampling refer to the process of selecting a representative sample from a bigger group to serve as the basis of predicting the prevalence of a situation regarding the bigger group (Kumar, 2011). The target population represents the sample elements a researcher is interested in and

the group about which conclusions are derived (Boore, 2018). Also, a sample is a small set of cases a researcher selects from a large pool and generalises to the population. The target population in this study was drawn from potential stakeholders in maternal health care in the public health facilities located in informal settlements within NCC. Participants were selected from across six community health facilities in the slum areas where majority of the underserved population lives. Since the study was focused in the underserved context(s), the researcher targeted government facilities where majority of the city residents received health care services at subsidised rates because the government paid part of the cost which made it relatively affordable as opposed to private institutions where their privileged counterparts receive treatment. The selected facilities included Mathare North H/C, Embakasi Health Centre, Eastleigh H/C, Kibera South H/C, Mutuini Sub-County Hospital and Pumwani Maternity Hospital, from which the representative sample was obtained. To obtain a sample study population, the researcher conducted the sampling procedure on two levels: (i) firstly, the researcher sought to identify potential stakeholder groups in maternal health care in public health facilities; and secondly, (ii) the researcher sought to identify key stakeholders (as active participants) who would be selected to participate in the research by virtue of their roles in maternal health care.

On the first level, the researcher used snowball sampling, which is a chain-referral like interview-based tool to select potential participants through the help of Facility-In-Charge respondents. According to Goodman (1961), snowballing is defined as a non-probability sampling technique whereby a random sample is selected from primary data sources. A potential stakeholder nominates other potential data sources (individuals) within the target population to generate a sample (Marshall, 1996). The merits of snowballing include: (i) its ability to recruit hidden populations; (ii) a cost-effective way to collect primary data; (iii) a study is completed much faster, hence saving time; (iv) little planning is needed to commence collection of primary data. A disadvantage of this technique, however, is the possibility of bias among peers recruiting one another into the study while respondents may sometimes be hesitant to name colleagues due to ethical concerns (Bhat, n.d.).

The process was repeated until a sufficient sample was collected. This is the procedure the researcher followed to identify the relevant (key) stakeholder groups at the selected health facilities. The researcher then repeated the same procedure with emerging stakeholder groups, who recruited subsequent emerging groups to gain insight into the current situation, hence theoretical sampling whereby emerging data were used to select a new sample (Marshall, 1996). This approach enabled the researcher to understand the current situation, the relevant/key stakeholders and their roles, relationships, and the influence and interactions in relation to delivery of maternal health care services in existence. The sampling process continued until saturation of participant categories and their properties was reached (Guest et

al., 2014). The different actors (respondent groups) included women, CHW/Vs, health professionals (nurse/midwives, COs, doctors), facility administrators (managers) and ICT experts.

To address the aforementioned biases with the snowballing technique, the researcher further scrutinised the second level of sampling. The identified potential participants groups were subjected to a variety of criteria to select active participants (relevant stakeholders) to provide responses to interview questions as explained in the following section.

5.6.1 Sampling techniques

According to Marshall (1996), there are three main sampling strategies for qualitative studies and particularly in health care research, namely:

- **Convenience strategy:** Selecting the most accessible subjects and the most cost-effective method time-wise, effort-wise and money-wise; however, it may result in poor quality data and lacks intellectual credibility hence the need to use a more thoughtful approach to selecting a sample is usually justified (Marshall, 1996)
- **Judgment or purposive strategy:** The most common technique of sampling. The most productive sample is actively selected (key informant sampling) by the researcher to provide responses to the research questions (Kerr et al., 2010). This may involve developing criteria that might influence the contributions of an individual, including the researcher's practical knowledge of the phenomena under investigation, available literature, and evidence from the study itself. This approach is regarded as more intellectual, especially in cases where variables such as age, gender and social class might be critical. However, if the participants are known to the researcher, then stratified sampling may be used based on known public attitudes or beliefs (Marshall, 1996)
- **Theoretical sampling strategy:** An iterative process of qualitative studies whereby samples are mainly theory driven to a greater or lesser extent. This sampling technique facilitates building interpretative theories from subsequent emerging data and selecting a new sample in order to assess and elaborate on this theory, which is the principal strategy for the GT, but it can still be used in qualitative investigations to necessitate interpretation (Marshall, 1996; Kerr et al., 2010; Guest et al., 2014)

The general and most common sampling method applied in qualitative research is purposive sampling (Kerr et al., 2010). For purposes of this study, the researcher applied the above three techniques as they were vital for this research at both stage 1 and stage 2 of the sampling process. Specifically, theoretical sampling was applied in stage 1, where the snowballing sampling technique was used with iterations to identify relevant stakeholders, while convenience/purposive sampling was used to select key informants from potential stakeholders. Also, the researcher applied personal judgment to select individuals whose competence level he felt was sufficient, with an awareness of operations in their working

environment, and were willing to share information freely (Kumar, 2011; Guest et al., 2014). This process was guided by applying a variety of criteria, including age, level of education, profession/career, job position/rank, and corresponding experience which, according to Marshall (1996), is a more intellectual strategy whereby age, gender and social class are important variables. This assisted the researcher with determining the capability of individuals to answer questions relating to specific research objectives before including them in the study (Research-Methodology.net, 2016).

Pregnant women participants helped the researcher understand the information needs of mothers in maternal health care/services whilst the health professionals helped the researcher with understanding the information needs of the caregivers. The facility administrators assisted the researcher with understanding policy-related information needs, whereas the CHWs enabled the researcher with understanding the dynamics of community health care service and information needs. In addition, the ICT experts helped the researcher understand design characteristics and components for ICT-facilitated PHR services in an underserved research context.

5.6.2 Sample size

According to Kerr et al. (2010), the number of participants required in a qualitative study cannot be accurately estimated prior to the study, being a complex phenomenon involving many factors such as scope of the study, nature of the topic, study design, amount of useful data obtained from participants, and the sampling strategy and qualitative method(s) employed. The size of a sample is determined by the optimum number of research subjects needed to enable valid inferences to be made about a study population. Specifically, in qualitative studies, an appropriate sample size is one that is sufficient to answer the research question adequately (Marshall, 1996), and the optimum sample size is dependent on the parameters of the phenomenon under investigation, e.g. the rarity of the event or the expected degree of variations in the outcome between the intervention and control groups.

Kerr et al. (2010) further argues that the optimum number of required subjects evolves over time and becomes obvious as the study progresses until data saturation is reached when new categories, themes and/or explanations stop emerging from the data. Because of above reason(s), qualitative studies require flexible and iterative research design to facilitate a cyclical approach to sampling throughout data collection, analysis and interpretation processes, as opposed to quantitative studies. However, for the purpose of planning in terms of managing time and costs, the researcher made an initial estimate to interview 30 participants for the interviews and focus groups discussions (Kerr et al., 2010).

The concept of saturation is defined as 'data adequacy', meaning the point at which no new information is obtained from additional interviews and/or data (Marshall, 1996). It is

therefore a point in the data collection process where no new relevant information is being elicited from either individual interviews or focus groups or no new information is deemed missing. A sample size in qualitative research is dependent on “the completeness of information of the information obtained from analysis of the transcripts”, i.e. saturation (Kerr et al., 2010). During their study comprising 60 interviews to ascertain the number of interviews needed to achieve saturation among women at a higher risk of acquiring HIV in Nigeria and Ghana, it was concluded that at least 12 interviews would be adequate for most qualitative studies (Guest et al., 2006). They argue that qualitative research mainly seeks to understand common perceptions and experiences among a group of relatively heterogeneous individuals.

Generally, sample size(s) for qualitative research are said to lie between the ranges of 1-200 for individual interviews depending on the qualitative method used; 6-20 participants in situations where heterogeneous groups based on study objectives; and 3-5 groups comprising 6-12 participants each for focus group interviews (Guest et al., 2006; Kerr et al., 2010). In the case of this research, the researcher targeted at least 30 participants.

5.7 Data collection methods, tools and sources

Data collection is the process whereby the tools and/or instruments for data collection are identified (Boore, 2018). For this research, the researcher collected a variety of data, including qualitative data, design data and secondary data, gathered using a variety of methods as illustrated in Figure 5.2, developed by the researcher.

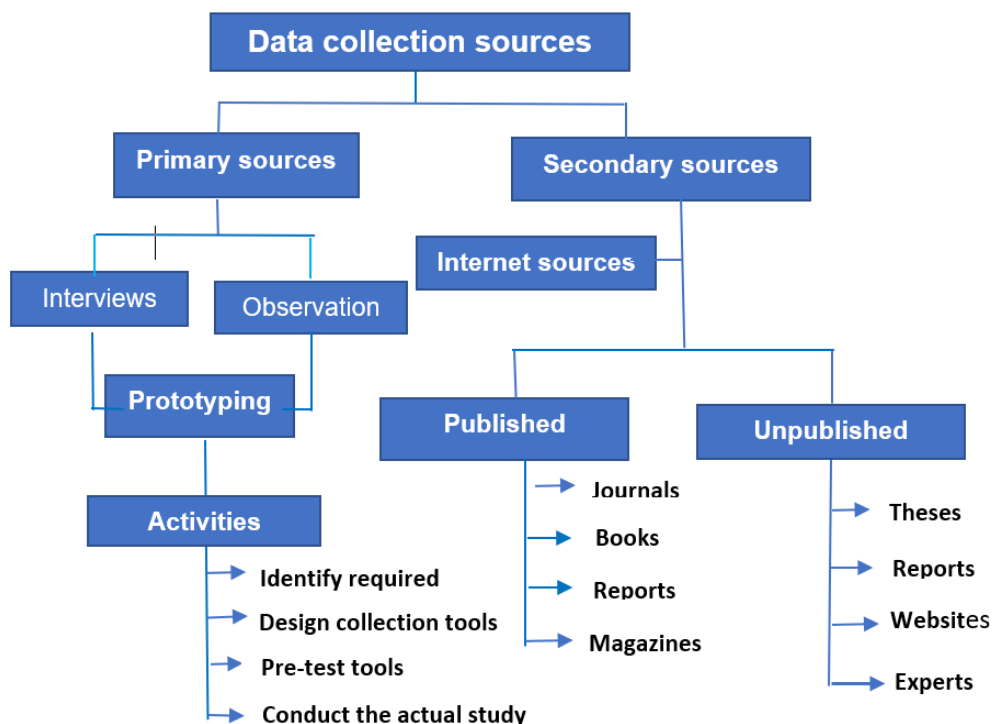


Figure 5.2: Data collection methods and sources

The aim of the data collection process using various methods is to enable the researcher to interact with participants whereby s/he will listen to their opinions, views, experiences and propositions to analyse and unearth various issues in the research context. For this research, design data were collected using service prototyping, which mainly involved the use of co-design methods (Salgado et al., 2017). The aim of using co-design-oriented SDR strategy was to facilitate discussions and communication between the research participants and the researcher to discover the relevant design requirements for the proposed services.

Secondary data, on the other hand, were collected from a variety of sources, including Internet sources as well as both publishes and unpublished material, which included journal articles, books, theses, and reports, among other sources. The key advantage of secondary data is that it can be used by a researcher(s) to compliment primary data, thus working towards greater insight and scientific understanding (Jones, 2010).

5.8 Qualitative research methods

The methods used in collecting qualitative data were interviews (personal interviews and focus group discussions), and participant observation (Salgado et al., 2017; Moritz, 2005), thereby enabling the researcher to interact with participants so as to listen to their opinions, views, experiences and propositions, and to analyse and unearth various issues in the research context.

5.8.1 Semi-structured in-depth personal interviews

The interview guide(s) included a demographic questionnaire for collecting demographic details (quantitative in nature) to supplement the qualitative data. Interview questions for various participant groups were formulated based on pre-defined theoretical themes for research (Appendix D). Interview questions contained both closed and open-ended questions, which enabled the researcher to identify perceptions, attitudes, beliefs, myths, and/or rumours from the respondents within the research context, and which included barriers towards the provision and/or accessing maternal health and wellbeing services. According to Moritz (2005), advantages of personal interviews include: (i) their ability to synchronise communication in both time and place; (ii) they give an interviewer (the researcher) an opportunity to obtain more information by observing the tone and body language of the interviewee; (iii) they are faster to undertake as data are collected there and then; (iv) they can be recorded for future reference; and lastly, (v) the interviewee is present to clarify any ambiguities on interviews questions during the interview. In fact, interviews are the most appropriate especially in situations where little is known about the study phenomenon, and therefore detailed insights are needed from the participants (Gill et al., 2008:292).

A major disadvantage of interviews, however, is that the visibility of the interviewer may intimidate and influence the behaviour of the interviewee (Opdenakker, 2006). The researcher, being aware of this disadvantage prior to the study, followed the ethics protocols and clarified issues regarding ethical concerns whereby he first introduced the purpose of the research and then sought consent from the participants before the study commenced.

5.8.2 Focus group interviews

The focus group discussions were conducted with the selected pregnant women. The researcher engaged with the participants through in-depth discussions concerning their experiences with the type of maternal health services offered in public health facilities. The main aim was to assist the researcher with having interactive discussions with participants to understand contextual issues (problems and/or barriers) that hinder the delivery of and/or accessing maternity services, and a possible remedy to address them. Discussions were recorded while the researcher observed the participants' body language at the same. The focus group method furthermore promotes participatory research through "active experimentation with focus groups" (Nyumba et al., 2018:21), whereby participants have an opportunity to fully participate in the research by giving their opinion and views.

Included in the advantages of the focus groups method is the attention on a specific research topic, thereby offering the collective view of the meaning behind those views based on participants' experiences and beliefs (Nyumba et al., 2018). In addition, focus groups assist a researcher with exploring a research topic and obtain narratives that can be used later in the research to test a narrative(s) in order to make concrete conclusions (Nyumba et al., 2018). A major disadvantage of the method, however, is overdependence on participants' dynamics hence participants may not be at ease with each other due to stigmatisation arising from disclosure (Harrison et al., 2015). The researcher, however, tried to create an atmosphere conducive to making participants feel free to share information, with the emphasis on the need to observe confidentiality in order to safeguard individual privacy.

5.8.3 Participant observation

For this research, participant observation involved field research whereby data were collected at the various sites, and particularly by observing activities and operations in the natural environment at the maternity wing/departments of the selected health facilities. This involved observing various activities as they happened, including client admissions, labour, baby delivery, and postpartum practices (Salgado et al., 2017). A key advantage of the observation method is that it provided the researcher with the opportunity to study and understand the research phenomena better (Hirsch 1985). This is primarily achieved through one's philosophy, attitude, and behaviour through observing body language, which is more revealing than what the individual would sometimes say verbally. The observation method

furthermore enables a researcher to observe participants in a natural setting hence providing insights which may not be possible through other methods.

5.9 Principles of interpretive field research in IS applied in the study

In order to collect quality data, the researcher employed various principles of field research in IS to evaluate and guide the research approach. These include hermeneutic circle, abstraction and generalisation, contextualisation, interaction, dialogical reasoning, multiple interpretations, and suspicion respectively (Klein & Myers, 1999:72). The hermeneutic circle involved grouping of interview transcripts. The abstraction and generalization principle entailed generating initial codes, categories and data themes (see appendices). Contextualisation principle involved adoption of SDR strategy which enabled the researcher to conduct contextual inquiry. Interaction principle involved facilitating interaction between the subjects and the researcher to make them part of the DR process through interviews, co-design and prototyping activities. The researcher applied dialogical reason by listening to the data collected to identify and report any surprises between the research findings and theoretical pre-conceptions. Multiple interpretations were made from mixed reactions by research subjects and were compared with the researcher's own observations and experience to ascertain the appropriate meaning(s) of what is to be observed during the study. Last but not least is the principle of Suspicion which the researcher applied to avoid errors that would alter the meaning of the data to yield false findings.

5.10 Data analysis

According to Kumar (2011), data analysis refers to the systematic process of applying statistical and logical techniques in describing, illustrating, condensing and evaluating data, while interpretation refers to attaching meaning to information that results from the data analysis. The concept of data analysis is defined as "a systematic process comprising three distinct phases of analysis flow, namely: data reduction (selection, focusing, simplifying, abstraction, and transformation of data contained in transcriptions) data displays (organising and assembling information in order to draw conclusion(s) for action) and conclusions and verification of data findings" (Miles & Huberman, 1994:10).

5.10.1 Qualitative analysis

Qualitative data may be in different forms, including hand-written notes or typed field notes, notes dictated after fieldwork, tape recordings of interviews and/or other events in the field setting (Miles & Huberman, 1994). To prepare for analysis, raw data must be processed and field notes must be converted into write-ups, which may either be typed directly or transcribed from dictation. Miles and Huberman (1994) argue that write-ups are an intelligible product(s) for the reader as they can be easily read, edited for accuracy, commented on, coded

and analysed. The point of departure here is that field notes are sketchy as they are mainly taken in point form, hence they contain half or less of the actual content covered during the interviews. In essence, write-ups provide an opportunity and thus stimulate the researcher to remember points said during the interview and add some of the missing content when field notes are being reviewed, and that such additions should be marked to avoid bias (Miles & Huberman, 1994). The same procedure applies in the case of transcribed dictation. In the case of direct tape recordings of the field events, the researcher processes data by listening or watching the video tape, make notes, select excerpts and then make judgments; however, the accuracy of the transcriptions depends on the knowledge and/or experience of the person conducting the transcription hence they should be done with caution (Miles & Huberman, 1994).

During the early steps of data analysis, i.e. pre-data analysis, the researcher used both memorandums and summarised information sheets to record the responses prior to actual data analysis (coding). These contained a summary of the main points derived from individual interview responses, which were recorded as answers against various questions in the interview guide. This helped the researcher reflect on the already collected data to device strategies to collect new or better and more meaningful data from subsequent interviews (Miles & Huberman, 1994). The process was meant to assist the researcher with making sense of the data collected and theorising ideas to derive propositions towards drawing conclusions for the study. According to Moghaddam (2006), memorandums are fundamental as they enable the data analyst to review ideas towards drawing conclusions about the emerging theory, while they also serve as a point of reference afterwards as they re-orient the researcher (Moghaddam, 2006). The author argues that the writing of memorandums is critical as it helps analysts to elaborate on emerging ideas, processes, assumptions, and actions indicative of the data, as well as initial categories to be generated (Miles & Huberman, 1994; Moghaddam, 2006). Memorandums also assist the analyst with trailing ideas and concepts hence the ability to manage possible conflicts that may occur during the data gathering process. This research therefore used memorandums to capture interviewees' impressions conveyed through the data and observations, which enabled the researcher to reflect, comprehend, and gain insight into the research phenomenon (Boore, 2018). Specifically, the researcher applied the thematic analysis approach to analyse the data, which facilitated inductive coding of the qualitative data (Elliott, 2018).

5.10.2 Thematic Analysis approach

Thematic analysis was used whereby the data collected were subjected to a process of identifying themes throughout the coding and categorisation of concepts in order to derive themes (Braun & Clarke, 2014). According to the authors, thematic analysis enables

theoretical freedom hence a flexible and useful research tool capable of providing a rich and detailed, yet complex account of the data. This revelation, therefore, makes the thematic analysis method well suited to the varying needs and requirements of a wide range of qualitative research projects, including in health research. The process involves identifying, analysing, and interpreting repeated patterns of meaning within the data, whereby text data are analysed and coded according to various segments line-by-line and word-for-word, which eventually become occurrences (Boore, 2018).

While using thematic analysis, the researcher mainly focused on identifying themes, i.e. patterns of meaning emerging from the data using the streamlined codes-to-theory model for qualitative inquiry (Saldaña, 2015). This involved generating initial codes, sub-categories, categories, and themes from the data as illustrated in Figure 5.3.

For the first level of analysis, initial codes were generated from the respondents' comments while categories were generated from the initial codes. Data themes were then derived from generated categories to inform the study (Marshall, 1996; Miles & Huberman, 1994).

For purposes of this study, however, the data analysis process stopped at theme level since the researcher's intent was to derive themes to inform the study towards developing a design model for ICT-facilitated health and wellbeing service rather than a theory.

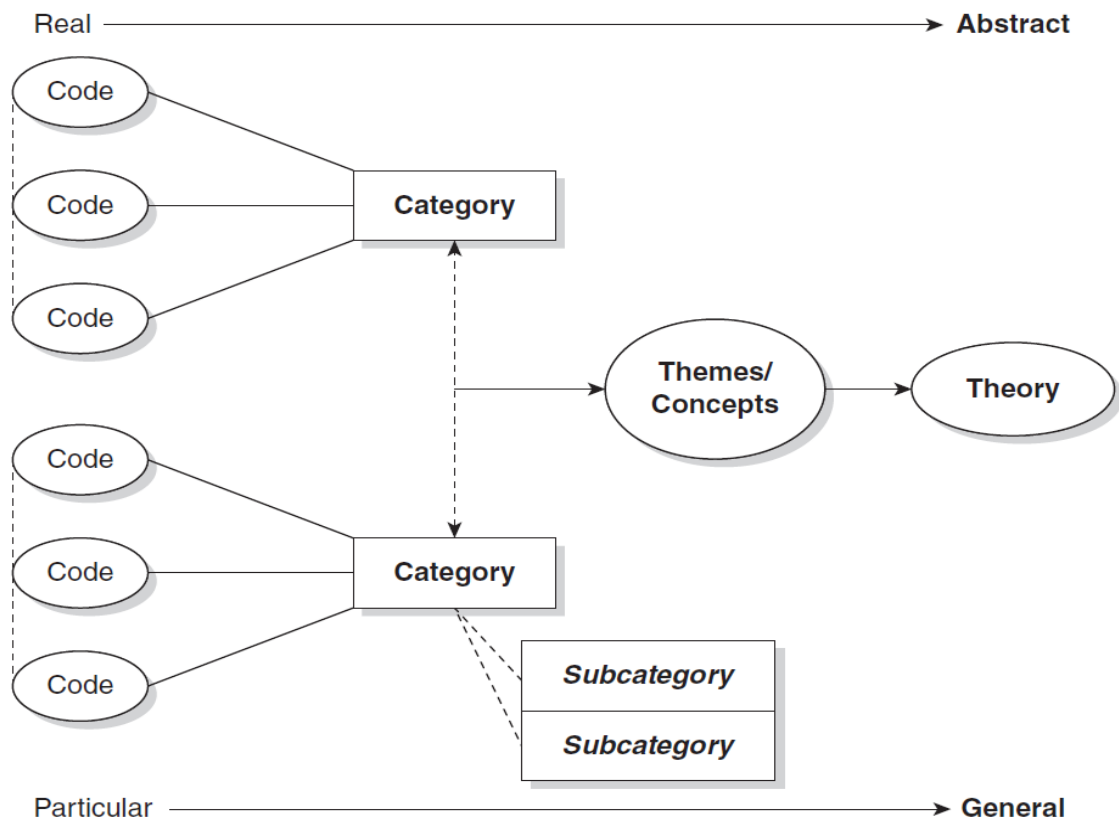


Figure 5.3: A streamlined codes-to-theory model for qualitative inquiry
(Source: Saldaña, 2015:12)

Braun and Clarke (2006) propose six phases for thematic analysis, which include familiarising oneself with data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; and producing the report. Similarly, qualitative researchers should be able to make sense of evolving themes in data; recognise the coding moment and encode the data consistently; develop codes; and interpret the information and themes in the context of a theory (Boyatzis, 1998; Braun & Clarke, 2014). Therefore, interview transcriptions were critically examined word-for-word and line-by-line to identify repeated codes, i.e. occurrences towards creating categories and related properties. During this process, the researcher asked personal and reflective questions about the data (Moghaddam, 2006), for example:

What is happening in this data? Is this data in line with the nature of the research context? What patterns are occurring here? What do this occurrence(s) imply? What is the current situation like? What does this response mean?

These questions helped the researcher to ensure consistency in generating and sorting various codes according to their corresponding properties, similarities and contrasts, including features associated with them (Moghaddam, 2006). The researcher used memorandums to navigate through the data easily, i.e. moving from empirical data to a conceptual level, refining and further expanding codes, developing key categories and displaying their relationships, and building towards a more integrated comprehension of events, processes and interactions in the case (Miles & Huberman, 1994). After creating memorandums through matching the various categories to their properties, the researcher was able to identify the main categories as well as similarities and differences between them. Consequently, the researcher began noticing data saturation in the various categories, since the repetition of occurrences was obvious and clear, after which a reorganisation of related concepts was done.

5.10.3 Data coding process

The concept of *coding* refers to the analysis of collected data through reviewing a set(s) of field notes which may be transcribed or synthesised, and dissecting them meaningfully, while at the same time maintaining and keeping intact the relations between the parts. It focuses on how the researcher differentiates and combines the data gathered and the reflections made about such data (Miles & Huberman, 1994). Codes are, therefore, tags and/or labels that assign units of meaning to the descriptive information compiled during a field study. In essence, codes are utilised for the retrieval and organisation of huge chunks of data, whereby some form of categorisation is applied to enable the researcher to quickly trace, pull out and cluster the various segments relating to specific research question(s), hypotheses or themes towards drawing conclusions (Miles & Huberman, 1994). Coding allows for direction

before becoming selective, and it breaks down the data into typical portions which can afterwards be raised to a conceptual point (Moghaddam, 2006).

Essentially, initial coding helps the researcher to explore and allow new ideas to emerge (Boore, 2018; Charmaz, 2006). This technique is defined as an “analytic process through which concepts and categories are identified and their properties and dimensions are discovered in data” (Matavire & Brown, 2013:120). The second level of coding is defined as the process of breaking down data into separate units of meaning, with the main purpose of conceptualising and labelling data (Moghaddam, 2006). The process commences with categorising different and/or many individual phenomena, of which concepts are clustered around a related theme(s) towards structuring categories that are more abstract.

This research used manual coding as dictated by the nature of the constrained research environment whereby available resources were used. Essentially, the choice of the coding method depends on many factors, including project size, availability of funds, time, and the researcher’s inclination and expertise (Basit, 2003). Furthermore, the main aim was to determine empirically the relevant data themes to inform the study rather than generating a theory, which would require a more rigorous analysis process hence the choice of coding. Activities such as naming, comparisons and writing of memorandums were conducted whereby interviews were analysed and coded according to the various segments word-for-word and/or line-by-line, which eventually became occurrences (Matavire & Brown, 2013; Birks et al., 2013; Boore, 2018). These occurrences were then contrasted with various occurrences in the database with the main goal to generate codes.

5.10.4 Observation data

Another source of data the researcher blended into the theory beside interviews was participant observations (Kerr et al., 2010; Moritz, 2005). A comparative analysis approach was applied whereby the meanings of indicators from the various data sources were carefully compared in a systematic manner to generate conceptual properties (Martin, 2006; Charmaz, 2006). These sources played a role in informing the development of the research model, and understanding, distinguishing and grouping the properties of various concepts that yielded into data themes.

5.10.5 Demographic data

According to the United States Census Bureau (2016), demographic analysis refers to a technique used to develop an understanding of a population’s characteristics, including age, sex, education, profession, occupation, and marital status, which are typical examples of demographics used in surveys. To understand the population characteristics of the various participant groups (Kerr et al., 2010), the researcher used the age, level of education/qualifications, profession, job position/rank and experience of participants, including CHWs,

health care professionals, managers, and ICT experts. For pregnant women respondents, the researcher used age, level of education, language of communicating, employment status, marital status, and affordability of medication, frequency of visit to hospital and pregnancy status.

In this study, the data collected from demographic questionnaires were quantitative, and it was analysed using descriptive statistics and mainly percentages. This technique was selected given its ability to effectively summarise vast amounts of data in an organised manner, hence a fairly straight-forward process to (i) translate data into results, (ii) enable easy comparison of results, (iii) identify further ideas of research, and (iv) observe noticeable patterns and trends of the phenomena under investigation, thereby facilitating easy interpretation of results (Mathur & Kaushik, 2014).

5.11 Ethical considerations

Ethical approval for this research was obtained from the Cape Peninsula University of Technology (CPUT) FID Research Ethics Committee. Three categories of ethical concerns relating to research stakeholders were considered for this research, namely ethical issues concerning research participants, the researcher, and the sponsoring organisation (Kumar, 2011). All of these requirements were essential in the research process, which the researcher observed diligently to avoid breaching the ethical guidelines. In respect to issues relating to research participants, Fouka and Mantzourou (2011) highlight five important concerns, all of which the researcher keenly followed. These include firstly the participants' informed consent, which require that a participant give consent voluntarily, knowingly and intelligently, through informed choice, and with an understanding of the benefits and risks thereof, which the researcher provided by introducing the purpose of the study and how it was to be conducted (Fouka & Mantzourou, 2011).

Second is the issue of beneficence, which refers to the Hippocratic Oath – “be of benefit, do not harm” (Fouka & Mantzourou, 2011:5). While the researcher engaged the participants to answer the research questions, he also ensured their safety against potential risks (Fouka & Mantzourou, 2011; Kumar, 2011). Third is respect for anonymity and concern for confidentiality, which is protected when the identity of the participant cannot be linked to his/her responses. In order to maintain the anonymity and confidentiality of participants, the data collected were coded such that their actual names and responses were kept anonymous and confidential. However, in cases where participant confidentiality had to be broken due to a moral obligation(s), it was justified to be for the good of society (Fouka & Mantzourou, 2011). Fourthly, the issue concerning participant privacy was considered, not to be shared without their consent (Fouka & Mantzourou, 2011). The researcher ensured respecting the decision of the participants whenever one declined to disclose certain information and/or refused to be

recorded during the interview and/or taking photos during the study. Finally is concern for vulnerable groups of persons, which, for some reason(s), are unable to protect their own rights, including mentally ill people, the aged and minors (Fouka and Mantzorou, 2011), as it is not ethical to experiment on vulnerable groups. The researcher did not engage with aforementioned persons in the study.

On ethical concerns regarding the researcher, malpractices such as bias, mistreatment, misreporting and/or the use of inappropriate research approaches were avoided (Kumar, 2011). In order to address the aforementioned issues, the researcher ensured that:

- Respondents only participated voluntarily, through elaborate introduction with a clear purpose of the study that enabled participation with full understanding
- The research questions did not contain offensive or unacceptable language and the information collected was kept confidential
- Participants' details remained anonymous and private
- All sources used in the research were acknowledged using the Harvard reference method
- The research process consistently demonstrated high levels of objectivity, and any form of bias (if any) committed during the study was reported accordingly
- The research process was conducted honestly and justly, and noticeable weaknesses throughout the research process were reported. No form of reward was considered for participation except assistance to facilitate travel to the venue where the data was being collected with some refreshments was provided during fieldwork.

5.12 Conceptual schema for research

Figure 5.4 illustrates a visual map of the research process, which was created to show how the research process would be executed. It demonstrates the mapping of the four phases of SDR strategy with the six research objectives, thereby guiding the research process towards answering research questions in order to obtain the study findings to facilitate discussions and the conclusion.

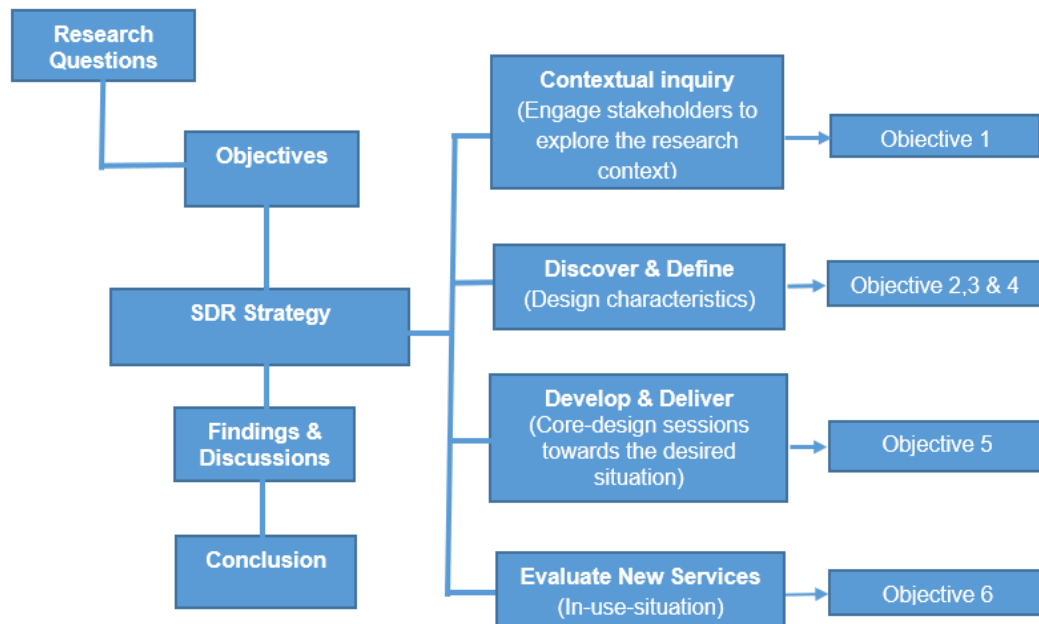


Figure 5.4: Conceptual schema for research
(Source: Researcher)

5.13 Chapter conclusion

In this chapter, the research methodology employed in the study was discussed. The qualitative approach, SDR strategy, and a conceptual framework derived from a review of literature were presented. The next chapter contains a detailed review of literature from a global viewpoint on the nature of health and wellbeing services.

PART II: LITERATURE REVIEW

Chapter 6: Literature Scoping

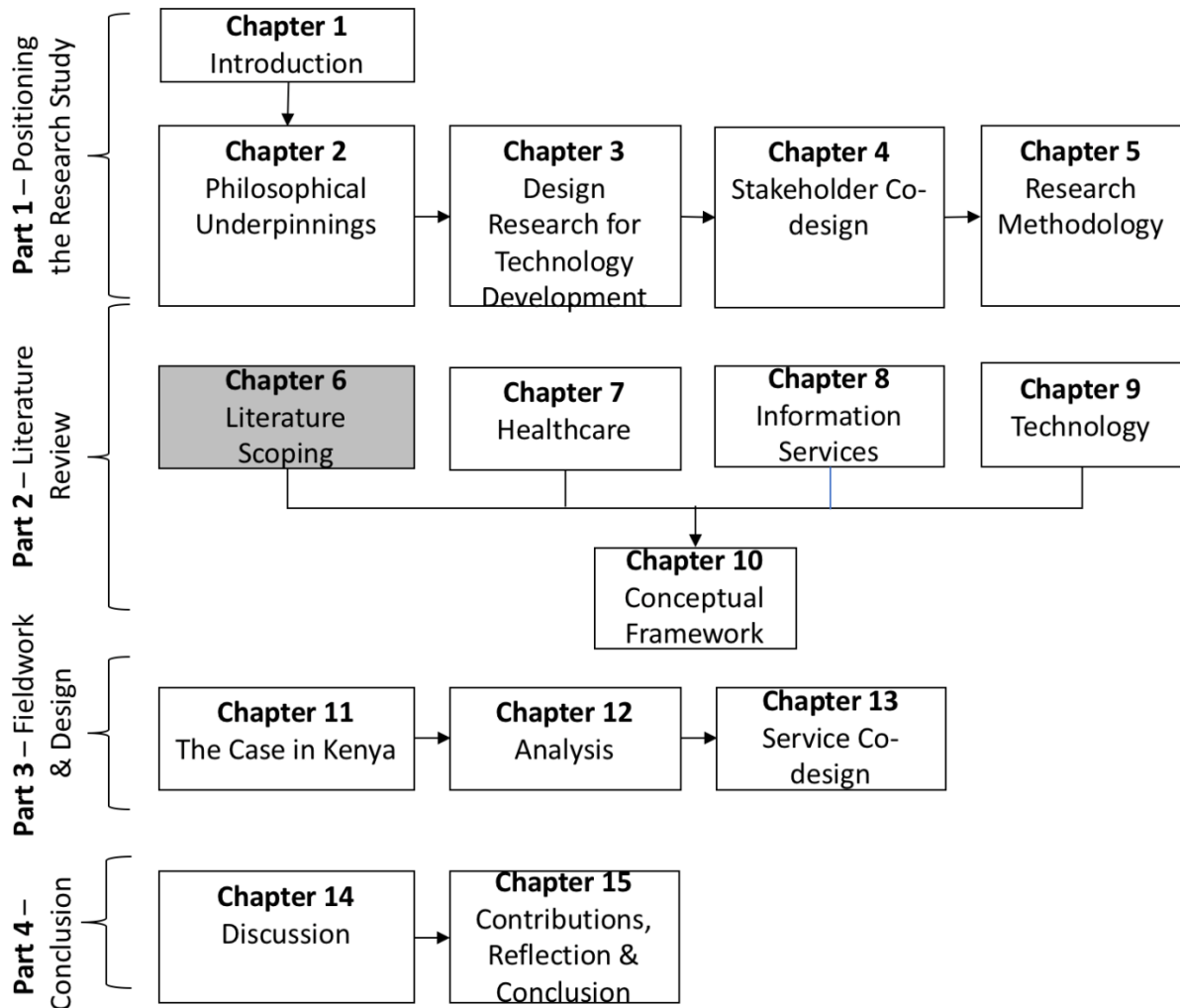


Figure 6.1: Thesis Layout - Chapter 6

6.1 Introduction

In this chapter, the literature on the nature of health and wellbeing services from a global perspective is evaluated and the issues that underlie its delivery in both developed and underserved contexts are discussed. Both theoretical and empirical studies are reviewed, including person-centred health and wellbeing services, service components, stakeholders, maternal health, information services, relevant HITs used and the health context, which is Africa, and specifically Kenya. From the review, the gaps are identified to inform the design of a general model for the study, followed by the chapter summary.

6.2 Definition of health and wellbeing

The WHO defines *health* as “complete physical, mental and social wellbeing and not only the absence of disease or infirmity” (Grad, 2002:981). *Wellbeing* refers to a positive rather than a neutral state that frames health as a positive aspiration as adapted by the 1986 Ottawa charter (Martino, 2017). The author therefore argues that health and wellbeing differs from one individual to the other according to their context(s) as well as their needs. Patients who are engaged and who understand their health status are more likely to participate more effectively in health care delivery, thus improving their experiences and health outcomes as opposed to disengaged patients (Seebode, 2013; Mishra et al., 2018). Individuals who do not fully understand the doctor’s decision(s) regarding their care in most cases demonstrate poor health outcomes, and their therapeutic options more often express non-compliance with prescribed medication (Sunyaev et al., 2010). This leads to high morbidity and mortality rates which result from lifestyle diseases, and especially chronic illnesses (Tsekleves & Cooper, 2017). The situation causes unnecessary hospitalisation, among other unpleasant eventualities, which would otherwise be avoided. There is thus a need to focus on new approaches towards promoting preventive health care, including person-centred care and self-care/management (Tsekleves & Cooper, 2017), which promote active participation by individuals in their own care. It is against this background that patients need to be empowered to take responsibility for their own health and wellbeing (Zhou et al., 2019; Househ et al., 2014), hence collective effort(s) towards promoting health and wellbeing globally.

6.3 An overview of global health infrastructure

The global health care service is subdivided into six regional grouping units of the WHO, which include Africa, Americas, South-East Asia, Europe, Eastern Mediterranean and Western Pacific regional offices (World Health Organisation, 2017). Through these offices, there have been major reforms in health care around the world that are gradually changing the way health-related activities are performed. This is geared towards empowering patients to take responsibility for their own health and to foster collaboration through integrated national HISs (Rodolfo et al., 2014). The aim of this global transition is to engage patients during their care activity in order to promote person-centred care and self-management through health education and literacy as well as collaborative health care delivery through the integration of health systems. According to the World Health Organisation (2016b), 400 million people lacked access to primary health care services globally in the year 2015, while the services were too much duplicated and of poor quality in those areas where these services were available. There have been disparities in people’s health and life expectancy among and within countries, whereby 6% of the population within LMICs were impoverished due to health spending (World Health Organisation, 2015b). For instance, in the case of maternal care, most countries

recorded over 90% coverage on skilled attendance at birth (SAB), while 97 out of 194 countries recorded above 98% coverage. Two thirds of the countries recorded over 90% coverage on SAB and diphtheria-tetanus-pertussis (DTP3), while over a quarter of the countries recorded less than 50% coverage rates on family planning and tuberculosis (TB) treatment. Furthermore, antiretroviral therapy (ART) coverage rates in most countries were below 50% (World Health Organisation, 2015b).

According to literature, many countries still experience challenges associated with the barriers of unequal geographical access to health care, fragmentation of health systems, and inadequate health infrastructure, including worker force shortages and weak supply chain systems (Patrício et al., 2020; Thobias & Kiwanuka, 2018; World Health Organisation, 2016b; Lade et al., 2014; Heeks, 2002). This situation prompts inadequate coverage of primary health care, thus making health systems wanting, which then leads to poor continuity of care (World Health Organisation, 2016b; Korpela et al., 2008). As a result, service providers lack of accountability in terms of the populations they serve, where people are not empowered to take control of their health. In an attempt to address this problem, health care partners, including the WHO, have proposed efforts to implement the Universal Health Coverage (UHC) initiative as part of the strategies towards achieving SDG 3.8 in 2015 (Nguhiu et al., 2017). This encourages member countries to develop and implement strategies to protect their citizens from financial risk(s) associated with seeking and accessing safe, effective, quality and affordable care. The Implementation of SDG 3 is guided by the WHO's eight principles of the global people-care policy, which are embedded in the five strategies for the IPCHS framework (World Health Organisation, 2015b; World Health Organisation, 2016b).

6.3.1 Health care in developed countries

In advanced economies, health systems, including clinics or hospitals, are supported by health professionals with various specialties (Kandelman et al., 2012). A conventional medicine health care model is used where doctors, nurses, pharmacists and other professionals deliver medications and surgeries to help make people healthier (Tauziac, 2020). This enables and promotes health stakeholders to cooperate using a multidisciplinary approach for the benefit of the patient(s). Health institutions are well-equipped with advanced medical and technical facilities, hence the provision of quality health care, which is contrary to the situation in developing countries where health services are merely provided on an emergency basis (Kandelman et al., 2012). The majority of developed nations in the world have well-structured and well-designed health systems in terms of research data, generated and obtained from within the country. However, this is not the case in developing countries where the structure and scope of health services are considerably limited by resource restrictions (Kandelman et al., 2012).

Through the Organisation for Economic Cooperation and Development (OECD), the majority of developed countries from across North and South America to Europe and Asia-Pacific are committed to ensuring efficient delivery of and equitable access to high-quality health care (Van Doorslaer et al., 2006). To achieve UHC, most OECD countries have facilitated access to physician services at affordable rates, and sometimes provided at zero financial cost at the point of delivery. This is occasioned by the availability of a variety of public insurance medical schemes aimed at ensuring equitable access for all (Van Doorslaer et al., 2006). While it plays a similar role as that of the WHO, the OECD monitors and compares the performance of member countries' health care systems as well as equity in access to care as the key objective, a scenario that is not yet possible in the developing world. In general, health care infrastructure in developed contexts is more advanced and well established hence they provide quality health as opposed to developing contexts, whereby poor infrastructure is the greatest challenge due to the scarcity of resources (Nabyonga-Orem, 2017). Generally, developed countries, have a bigger percentage of their national income going to health care as opposed to developing countries (Farag et al., 2012). Therefore, the major difference between developed and developing countries is resource availability such as funding towards infrastructure, skilled manpower, and education (Tauziac, 2020).

6.3.2 Health care in developing countries

Health care in developing countries refers to those nations with population groups that frequently experience difficulties due to resource constraints, including the lack of adequate health care coverage, hence underserved. According to Botts et al. (2011), underserved context may be defined as "those communities and/or groups of people who live primarily in informal settlements i.e. within inner city areas (slums) and/or rural areas, and are of lower socio-economic status". Developing countries mostly use naturopathic medicine, which focuses more on wellness and treating the whole person system as opposed to a conventional medical system (Tauziac, 2020). According to the author, developing countries have a greater likelihood of using traditional medicine, unlike in developed contexts. On a global scale, communities living in underserved environments are of low SES, which prompts inequalities in terms of living standards, life expectancy and inadequate access to resources such as health care services as opposed to developed contexts. The lack of continuous health care coverage puts them at more risk as opposed to other population groups who have access to continuous primary health care (Czaja et al., 2015; Botts et al., 2011). For instance, life expectancy in developing countries and particularly in sub-Saharan Africa has been dropping in past decades, whereby the context is not wealth but poverty (Drury, 2005). Disparities in health are complex, resulting from racism, ethnicity and people's SES. According to literature, the situation is compounded by political, social, cultural, economic, environmental/geographic and social factors, which compromise people's education, occupation, and economic potential such

as income and assets, which affect wealth, quality of life, and the quality of health care, among other challenges (Williams et al., 2010; Roztocki & Weistroffer, 2016; Ruxwana et al., 2010; Øversveen et al., 2017).

The aforementioned challenges lead to unequal resource distribution whereby vulnerable populations lack access to primary health care. Poor health care infrastructure leads to weak health systems with inadequate and ill-equipped facilities and the digital divide, thus the inability to optimise the benefits of HITs (Kenya, 2015; Nabyonga-Orem, 2017). Low education and health literacy levels as well as language barriers hinder people's ability and competency to self-manage themselves due to the ignorance of formal health care practices. As a result, the majority of the population uses traditional medicine as a source of their primary health care, particularly in the sub-Saharan African region (Czaja et al., 2015; Turin, 2010). Low-income levels prompt the inability to afford primary care services while unavailability of adequate skilled labour force compromises the quality of care (Lade et al., 2014). Strong cultural beliefs and norms such as traditional medicine practices continue to curtail efforts to promote clinical practice. Also, geographical barriers continue to remain an impediment towards accessing health care services, especially in rural areas where health facilities and personnel are scarce and where transportation services are poor (Kenya, 2015; Tang et al., 2006).

Furthermore, the majority of patients in underserved environments, including in rural areas, are older, with poor health and more disabilities (Effken & Abbott, 2009). The authors argue that ethnic minorities are faced with challenges of social, cultural, economic and language barriers, with low income, thus they experience limited access to quality health care. This situation attracts foreign donor influence hence conflict of interest among health care stakeholders, which leads to parallel health reporting systems, thereby causing further fragmentation of health systems (Manya et al., 2016; Manya et al., 2012; Bukowski, 2016; World Health Organisation, 2016b). This necessitates the need for the integration of health systems to transform health care, as the major difference between developed and developing countries is resource availability, which includes funding, infrastructure, skilled manpower and education, among other issues (Tauziac, 2020).

6.4 Health and wellbeing service components

A well-functioning health system should respond to the needs and expectations of the population in a balanced way, according to the World Health Organisation (2010). This section concentrates on the nature of health and wellbeing service infrastructure, with specific focus on the various components, which comprise health service providers, consumers, delivery channels, service integration and challenges faced; health stakeholders; maternal health services; and information services. According to the WHO, an effective health system should

have the following key service components: improved health status of individuals, families and communities; protection of the population against health threats; protection of people against financial repercussions of ill-health; provision of equitable access to patient-centred care; and engaging people in making decisions concerning their own health and health system (World Health Organisation, 2010). Based on this understanding, the researcher identified the following essential components in the provision of health and wellbeing services: health care providers, clients, delivery channels, system/service integration and the challenges thereof.

6.4.1 Health service providers

This category includes health care providers, health professionals and CHWs. Health care providers include health care institutions that provide special care services, which include hospitals, dispensaries, clinics, and health insurance companies (Pardamean & Rumanda, 2011). Health professionals on the other hand include physicians, doctors, specialists, clinicians, nurses, dentists, physiotherapists, pharmacists, and radiologists, among others. These professionals study, diagnose and treat illness, injury or other conditions and, as such, provide specialised health care services that are preventive, curative, promotional or rehabilitative (Bahga & Madisetti, 2013). CHWs support community health services to increase health access and reduce health inequities. They are hired by health care agencies to promote specific health care programmes such as immunisation, family planning, and HIV/AIDS, among others, and to advise on resources allocation, hence primary health care services (American Public Health Association, 2019).

6.4.2 Clients/health care consumers

With health care being a customer service industry, its clients are in this case considered to be an important component of health and wellbeing services, as they are the ones consuming these services. Clients specifically include individuals, families and communities (World Health Organisation, 2010) as the consumer of the services, hence stakeholder(s). Clients play a significant role in modern health care, and particularly in the context of patient-centred care whereby they are expected to play an equal role, just like health professionals, on decisions concerning health and care through interpersonal exchange (Donabedian, 1992). According to the author, customers play a significant role in terms of contributing to quality assurance as they set standards by which health care services are judged and/or evaluated, hence they are regarded both as evaluators of quality and as informants.

6.4.3 Delivery channel

The ultimate goal of any effective health care delivery system should be to focus on fostering optimal health outcomes through the provision of affordable and patient-centred quality care, with the emphasis on service (AAFP, 2020). Such a system should therefore be designed to motivate stakeholders, including patients and health care personnel, in order to

make decisions that are consistent with the aforementioned goal. However, the greatest obstacle facing the global health system is the failure of effective delivery (Kim et al., 2013) hence the need for better interventions. Because conditions vary from country to country, it is necessary to tailor delivery strategies to local situations in order to ensure their meaningful use. For instance, delivery of health care in developing nations in particular has not attracted much scholarly effort to discover and develop new resources despite efforts to improve capacity to deliver care in order to save lives (Kim et al., 2013). The focus on technological innovations has led to optimism among health care leaders and governments globally as most have begun committing resources towards improving health care delivery systems. Sustaining sound health systems demand both a strong sense of direction and coherent investment in order to provide the kind of services that can deliver on the desired outcomes (World Health Organisation, 2010). Given the nature of the aforementioned challenges facing health care globally, including fragmentation, it is imperative to use HIS-oriented delivery channels as they provide timely information/intelligence for good governance. Generally, this would facilitate access to health care services, epidemiological surveillance, and health education, among other services, in a cost-effective manner, leading to quality service (World Health Organisation, 2010).

6.4.4 Service/system integration

Health care is gradually changing from isolated episodes of treatment towards a continuous process, which involves various stakeholders, including health professionals and institutions (Lenz et al., 2007). This shift triggers new demands for IT applications to facilitate the integration of heterogeneous health systems to distribute HISs comprehensively. Heyeres et al. (2016) argue that health service integration is an important aspect for creating more efficient health-care systems that promote patient-centred care, thus yielding improved health outcomes.

More importantly, the integration of health services is critical in addressing the evident rampant fragmentation of health systems, and particularly in LMICs that experience resource constraints such as shortages in human resources (Many et al., 2012; Bukowski, 2016; World Health Organisation, 2016b; Heyeres et al., 2016), which adversely affect health care delivery on a global scale. The integration of health care is essential for increasing health coverage through primary health care, and for promoting community participation (Heyeres et al., 2016). This can be achieved through interventions that engage and empower individuals to adopt healthier lifestyles, and support self-management and community rehabilitation. In high-income contexts, the integration of health care systems is perceived as being critical in addressing the predominant challenges of aging populations and the burden of long-term chronic illnesses. According to Heyeres et al. (2016), this can be achieved through structural

and financial reforms in order to facilitate inter-sectoral action with social services, which include family welfare and disability support programmes. For instance, in Australia, efforts towards sustainable, integrated health systems are believed to be achieved through collaboration across jurisdictions in terms of joint initiatives and shared learning to better meet the needs of its citizens (Department of Health, 2014; Heyeres et al., 2016). In order to reduce unnecessary hospital admissions, the government, in collaboration with other partners such as Commonwealth workers, collaborate with multidisciplinary teams through National Primary Health Care programmes to raise a healthy population.

Unfortunately, health systems are constantly being subjected to powerful forces influencing and often overriding rational policy decision-making (World Health Organisation, 2010). Among the major challenges emanating from this situation is the fragmentation of health care as a result of competition among multiple programmes, projects, and institutions, leading to poor delivery of health care. It is therefore necessary to ensure system/service integration in order to provide balanced services. It is against this background that the World Health Assembly proposed the implementation of the principles of the IPCHS framework in May 2016 to address this global problem of health care integration (World Health Organisation, 2016b), and particularly LMICs.

6.4.5 Key global challenges facing health care

According to the WHO, current health services are not synchronised with the challenges of the 21st century. The key global concern is that approximately 50% of the global population does not have access to basic health care services. This is occasioned by challenges such as longer lifespans and the ever-increasing burden of long-term chronic diseases which require complex interventions over long periods and which gradually change demands on health systems. Despite efforts to provide advanced medicine in curative care, a myriad of challenges, including unequal geographical access to health care, poor governance, inadequate skilled personnel, and weak supply chain systems is still being experienced by many countries globally (World Health Organisation, 2016b; Silali & Owino, 2016; Shuvo et al., 2015). Care continuity is poor due to weak referral health systems because of service fragmentation and poor coordination among stakeholders, thereby compromising the quality of health care. Existing health systems mainly focus on institution-based, disease-based and self-contained curative models, leading to silos that compromise the capacity of health systems to deliver effective health care and to achieve universal coverage as well as equitable, high-quality and sustainable care (World Health Organisation, 2016b).

6.4.6 Health care service stakeholders

Health stakeholders are defined as players who either affect, or can be affected by the health system (Javanparast et al., 2009). These include individual citizens (health care

consumers), physicians (care providers), public and private employer organisations, i.e. hospitals, insurance companies, pharmaceutical companies and government health departments, among others (Institute of Catholic Bioethics, 2011; Korpela et al., 2008). For instance, insurance companies provide health coverage to patients while pharmaceutical companies manufacture and market drugs that are prescribed by physicians to treat patients. Government, on the other hand, provides national health policy decisions, guidelines, funding and subsidies on health care cost as the core responsibility towards its citizens. Among other stakeholders are non-governmental organisations and development partners such as the WHO, which plays a significant role in supporting health care materially, financially and policy-wise on a global scale. In a study to investigate the nature of intergroup relationships within the discourse on patient-centred care, health care managers, providers and patients were identified as key players in a typical health care system (Kreindler, 2015). The Ministry of Health (2014a) in Kenya highlights 10 registered cadres of health personnel in the health sector, namely: doctors, dentists, pharmacists, pharmaceutical technologists, registered nurses, enrolled nurses, COs, public health officers, and public health technicians. According to literature, pregnant women and community health workers/volunteers (CHW/Vs) are among the primary stakeholders in maternal care, serving as a link between the community and health facilities (performing the role of educating communities on health issues), nurses (midwives), doctors (gynaecologist, obstetricians) and managers (policy decision makers), representing government authorities (Thobias & Kiwanuka, 2018; Ten Hoope-Bender et al., 2014; Tamrat & Kachnowski, 2012; Vora et al., 2009; Fotso et al., 2008; Gerein et al., 2006).

In the context of eHealth, there are four key actors: policymakers, providers, patients and payers (Ritz et al., 2014). The policymakers represent the government/Ministry of Health, providing frameworks to guide health care delivery to citizens and to aggregate health data from different sources to develop population health indicators. Providers, i.e. health care institutions, coordinate and provide health services and keep health information records of patients. Patients are the citizens who benefit from providers' services and may want to access information about their care electronically. Payers, on the other hand, procure care services for patients as their customers and they report to policy makers. In the context of HIS/eHealth, Korpela et al. (2013) identify three key stakeholders and relations in the development of HIS, which are technology providers, health care providers, and the people as health care consumers (as shown in Figure 6.2). Gao and Sunyaev (2019) identify administrators, patients (people), policy makers, physicians (health care providers) and vendors (technology providers) as the key stakeholders in the decision-making process concerning the adoption of CC in health care.

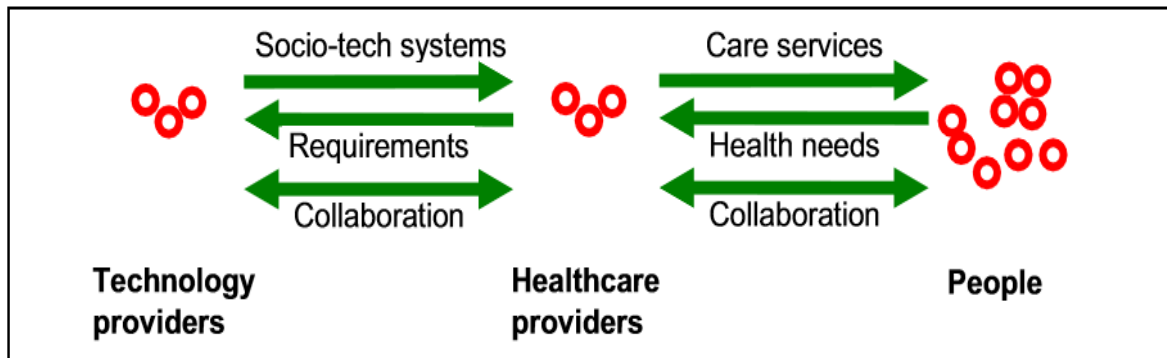


Figure 6.2: Main stakeholders and relations in HIS development
(Source: Korpela et al., 2013:127)

6.4.7 Maternal health care services

Since the inception of the 58th WHO Assembly and the 2010 World Health Report resolutions, the world has continued to witness an increased focus on UHC (Nguhiu et al., 2017). The significance of the UHC programme has been demonstrated in the recent past by the majority of UN member countries in terms of its inclusion in their health care strategy. This is in line with Target 3.8 of the SDGs whereby the countries have been urged to ensure adequate protection of their populations from financial risk associated with seeking care, and at the same time ensuring access to safe, effective, quality and affordable health care (Nguhiu et al., 2017; De Masi et al., 2017). Among the top priorities in the global health care agenda is maternal health care, as provided for in Target 3.1 of the SDGs, which is aimed at reducing the maternal mortality rate ratio (World Health Organisation, 2020; World Health Organisation, 2016a). In an effort to improve maternal health outcomes, many international strategies have been put in place under the leadership of the WHO as the UN agency responsible for global health. Specifically, the WHO has in the recent past prioritised the development of indicators, guidelines and measures for health, essential interventions, preventable maternal mortality, preventable newborn deaths and stillbirths, and quality maternal and newborn care in health facilities (Lattot et al., 2020). Among key initiatives undertaken is the *Every Woman Every Child Movement* spearheaded by the UN Secretary-General in 2015, a Global Strategy for Women's, Children's and Adolescents' Health 2016-2030 (De Masi et al., 2017). The aim of this initiative is to end preventable maternal, newborn, child and adolescent deaths and stillbirths, and to ensure their health and wellbeing (World Health Organisation, 2015c). The strategy provides a framework for countries to achieve the highest possible standards of health for all women, children and adolescents in order to 'Survive, Thrive and Transform'. Specifically, the framework emphasises country leadership, which should provide a multi-stakeholder engagement platform to address local issues unique to each country. Its key elements include supporting country planning and implementation efforts; engaging and aligning global

stakeholders' accountability (partnership); and financing for women's, children's and adolescent's health (World Health Organisation, 2015c).

To achieve universal health coverage (UHC), however, its implementation framework must be anchored in the IPCHS strategy, which recommends that countries consciously consider individual, family and community perspectives in terms of their specific preferences and needs so as to respond to them adequately (De Masi et al., 2017). The aim is to ensure that every pregnant woman and their newborn(s) receive quality care throughout their maternity journey. Also, in 2016, a new global guideline was introduced to help manage routine ANC, namely *ANC for a Positive Pregnancy Experience* (World Health Organisation, 2016c). The guideline is meant to prioritise person-centred health and wellbeing from a human rights perspective whereby it defines positive pregnancy experience as:

“Maintaining physical and sociocultural normality, maintaining a healthy pregnancy for mother and baby (including preventing or treating risks, illness and death), having an effective transition to positive labour and birth, and achieving positive motherhood (including maternal self-esteem, competence and autonomy)” (World Health Organisation, 2016c).

Specific interventions recommended for antenatal care (ANC) include: midwife-led continuity of care; group ANC; task shifting components of ANC; recruitment and retention of staff in rural and remote areas; community-based interventions to improve communication and support; women-held case notes; and a minimum eight ANC contact schedules (World Health Organisation, 2016c). More importantly, the ANC routine guideline is the prioritisation of integrated people-centred health and wellbeing (De Masi et al., 2017). The main aim is to provide pregnant women with a universal package to improve their quality care and to guarantee effective evidence-based practices alongside timely and relevant information, as well as communication to support women during pregnancy (World Health Organisation, 2016c). Another important global strategy recommended is the implementation of ANC Education (AE) to help deal with uncertainties associated with pregnancy, childbirth and parenthood towards reducing maternal and child mortality to improve the quality of prenatal care (Heim et al., 2019). The main aim of the AE initiative is to provide pregnant women with education programmes such as physical preparation, information on both physical and emotional changes during pregnancy, labour, childbirth, breast-feeding and puerperium. The ANC recommendations are therefore deliberately designed in a flexible manner to make them adoptable in different countries with varying health care settings, including burdens of disease, socio-economic status, and health systems structures to facilitate satisfaction of the needs of their citizens (De Masi et al., 2017).

6.4.8 Key global challenges in maternal health care

Maternal mortality, which is a result of complications during pregnancy and/or childbirth, is the second biggest killer among women globally (Mulauzi & Daka, 2018; Shiffman, 2017). Despite various efforts, maternal mortality rates still remain high, as approximately 800 women die every day during pregnancy and childbirth from largely preventable causes, and of which over 90% of the deaths occur in LMIC (Kendall & Langer, 2015). Among the major causes of maternal deaths is the ever-increasing burden of both communicable and non-communicable diseases (NCDs) such as Tuberculosis (TB) and HIV among pregnant women, particularly those of reproductive age; maternal health challenges associated with urban settings; and social and economic inequalities, among other demographic factors such as health behaviour. According to the WHO, in terms of the systematic analysis on causes of maternal deaths, there are two main categories of deaths, namely direct obstetric causes and indirect causes (Say et al., 2014). The authors report that approximately 73% (1 771 000 of 2 443 000) of all maternal deaths between the period 2003 and 2009 were as a result of direct obstetric causes, while indirect causes accounted for 27.5% (672 000, 95% UI 19.7-37.5) of all global deaths.

Haemorrhage, hypertensive disorders, and sepsis/obstetric infection and abortion are among the common direct obstetric causes of death (Say et al., 2014; Mulauzi & Daka, 2018), while indirect causes are mainly associated with pre-existing conditions such as HIV infection, mental disorder and diabetes, when aggravated by pregnancy (Storm et al., 2014; Mulauzi & Daka, 2018). According to the authors, a larger proportion of indirect causes are recorded in South Asia and sub-Saharan Africa. These causes vary across the board both regionally and nationally (Kassebaum et al., 2014). Noticeable is the fact that key global policy and strategy documents on maternal health, including those from UN organisations, have not focused much on indirect causes of maternal mortality apart from HIV infection (Storm et al., 2014). Also, existing ANC measures have limitations as they emphasise clinical practices such as hospitalisation rather than non-clinical interventions, hence the need to develop more comprehensive interventions to provide quality ANC, including the provision of relevant and timely information (Lattof et al., 2020). This will also help to increase knowledge generation and sharing, with improved availability, accessibility, acceptability, and quality of institutionalised labour and delivery services and other effective interventions such as contraception and safe abortion services (Kendall & Langer, 2015).

6.5 Chapter conclusion

This chapter described the scoping of literature on the nature of health and wellbeing services to identify issues underlying health care on a global scale. Both theoretical and empirical studies were reviewed, with the focus on Africa. The nature of health and wellbeing information services was explored, focusing on the maternal health care situation in Kenya as a case study. In the next chapter, health care aspects relevant to this study from the literature

review are discussed with reference to the importance of integrated people-centred health care service and patient-centred health and wellbeing services.

Chapter 7: The Nature of Health Care Service

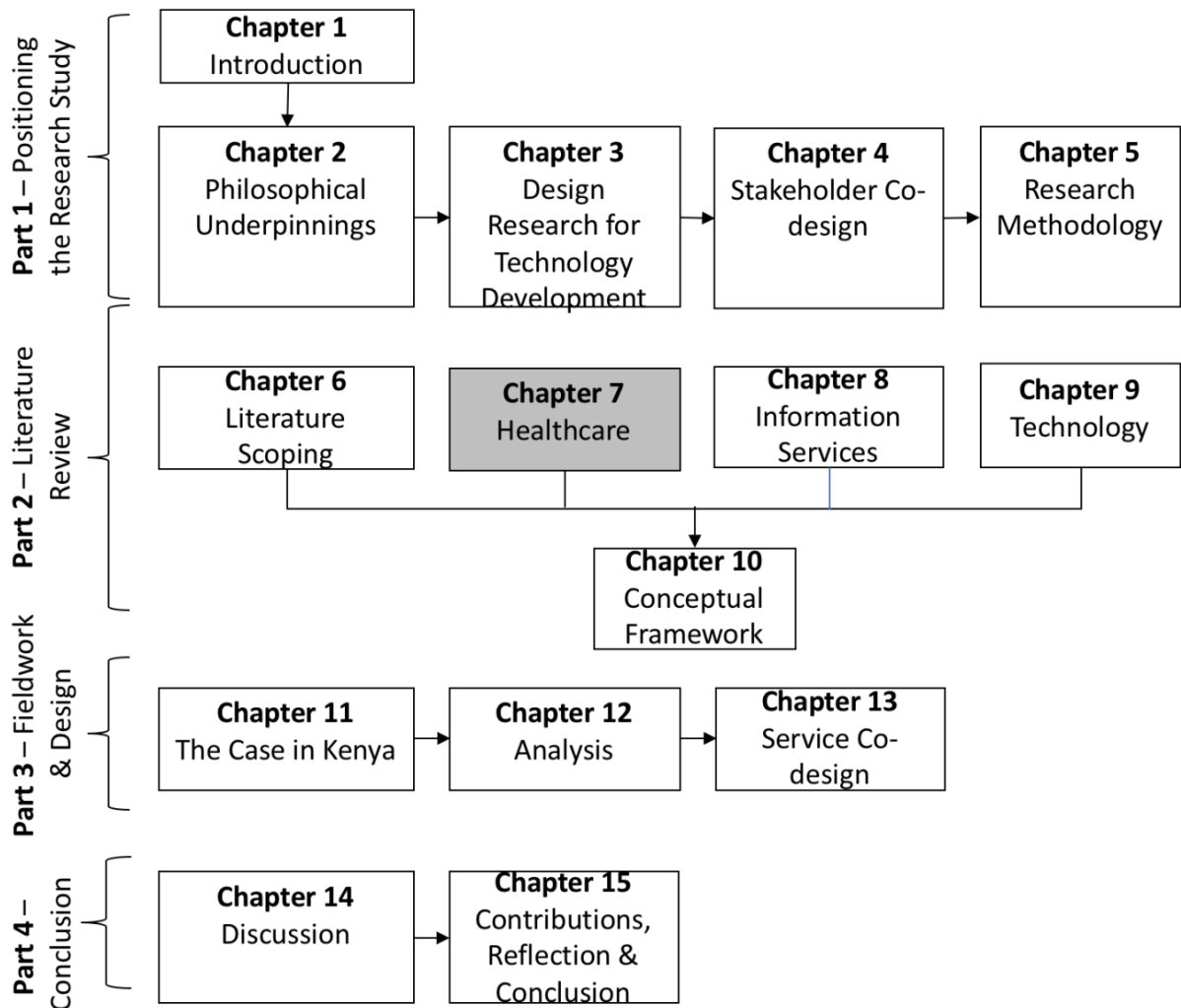


Figure 7.1: Thesis Layout - Chapter 7

7.1 Introduction

In this chapter, the specific health care aspects relevant to this study from the literature review are discussed. Firstly, health care as the domain in which this study was applied is considered, followed by aspects relevant to an integrated people-centred health care service. This is followed by patient-centred health and wellbeing as the central focus of the study.

7.2 The definition of health care

Health care is defined as “the maintenance or improvement of health via the diagnosis, treatment, and prevention of disease, illness, injury, and other physical and mental impairments in human beings” (Saravanan et al., 2016:9). According to Saravanan et al., health care refers to the various service(s) offered by different categories of health professionals, including physicians, dentists, midwives, nurses, and pharmacists, among other

related professions, cutting across different levels of health care, i.e. primary, secondary, and tertiary care (Saravanan et al., 2016). The authors argue that the ultimate goal of modern health care is to have a continuum of care for the patient(s), integrated on all levels. This led to the introduction of the *people-centred care policy* of the WHO, maintaining that individuals, families and communities be treated as active participants in their health care (World Health Organisation, 2015b; World Health Organisation, 2016b).

Key objectives of the policy are to: (i) engage and empower people and communities through active participation; (ii) re-orient and re-design care model(s); (iii) coordinate health care services; and (iv) create a supportive health care environment. These objectives focus on enhancing access and ensuring a holistic patient experience through the medical care and treatment process (Grisot & Lindroth, 2019). The *people-centeredness* concept, therefore, prompts the need to develop globalised non-medical therapeutic strategies and interventions, including the use of ICTs to promote health and disease prevention rather than treatment and/or cure (World Health Organisation, 2015b; World Health Organisation, 2016b). In pursuit of this agenda, governments across the globe have embarked on efforts to incorporate the Integrated and People-Centred Health Services (IPCHS) framework into their national health strategies, Kenya included (Ministry of Health, 2016).

It is against this background that the health care industry is undergoing a global paradigm shift, from institution-focused, disease-focused and clinician-focused health care systems to people-centred care models, which aim to achieve evidence-based treatment, continuity of care, and the prevention of medical mistakes (Drury, 2005; Alyami et al., 2017; World Health Organisation, 2016b).

7.3 Quality of health care

The quality of a service is defined as “the global overarching judgment or attitude relating to the overall excellence or superiority of the service” (Narang, 2010:171), and reflects the consumer’s perception of service-firm performance. According to Narang (2010), two main aspects are relevant to service quality: technical quality and functional quality. In the context of health care organisation(s), both functional and technical quality need to be monitored and managed effectively to guarantee success.

The technical dimension of quality refers to issues related to diagnosis and procedures, while the functional dimension relates to how the services are delivered to patients, who in this case are the customers. While technical knowledge is believed to originate from health personnel (Bopp, 1990), functional quality is considered as the primary determinant of customers’ perceptions about service quality, since technical quality is difficult to assess as it requires the assessor(s) to possess relevant education/professional knowledge (Narang, 2010). A sound health system, therefore, must deliver quality services to the people whenever

they are in need of service (Radojicic et al., 2020). However, the nature of these services varies across different countries, as a good health system requires a strong financing mechanism, a skilled and well-remunerated workforce, reliable information to support evidence-based decisions and policies, adequate health care infrastructure, and logistics for commodity supplies. In order to guarantee delivery of quality public health care services, components such as funding, resources (health care personnel, facilities, and medical equipment), efficient leadership, and governance of health systems must be in existence. Above all, there should be equitable and efficient allocation of resources to have a successful health care system.

In an effort to provide a global framework to promote the implementation of quality health care for adolescents, the WHO proposes a variety of criteria to be used. These requirements include: (i) health facilities having a signboard displaying operating hours; (ii) health facilities having up-to-date information, education and communication materials in the waiting area; (iii) health care professionals having the expertise to provide health education and to communicate about health and available services; and (iv) health facilities having outreach workers trained to conduct community health education (World Health Organisation, 2015d). However, there have been reported disparities globally between the developed and developing countries concerning the quality of health services offered. Generally, there are differences across the nations of the world in terms of structure and scope of health systems, which influences the quality of health services offered to citizens (Kandelman et al., 2012). For instance, developing countries are the most disadvantaged as the majority of them lack capacity and human, financial and material resources to ensure availability and access to quality health care services (Kandelman et al., 2012). This calls for the need to utilise current and emerging HIT opportunities in order to address these disparities in health care, particularly among the underserved communities (Gibbons, 2011).

7.4 Person-centred health care

Person-centred care is progressively gaining momentum as a modern approach to health care to establish more inclusive, resource-effective, and adaptive health care systems whereby the patient is seen as a person (Malmberg et al., 2019). According to literature, however, the concept of *person-centred care* is somehow used interchangeably with other related concepts such as patient-centred care and people-centred care (Seebode, 2013; Vassilakopoulou et al., 2016; De Masi et al., 2017; Larson et al., 2019; Koumaditis et al., 2015; Grisot & Lindroth, 2019; Godfrey et al., 2018; World Health Organisation, 2016b).

The following are definitions of the three concepts:

- **People-centred care:** The WHO defines people-centred care as “an approach to care that consciously adopts individuals’, carers’, families’, and communities’ perspectives as participants in, and beneficiaries of, trusted health systems that are organised around the comprehensive needs of people rather than individual diseases, and respects social preferences” (World Health Organisation, 2016b:2)
- **Person-centred care:** Is defined as “individualised care”, “seeing the person and not the medical condition” and “tailoring care around the person”, which is regarded as good practice, and which is the quality of care that the medical personnel should aspire to deliver (Godfrey et al., 2018). It is a form of care that accords respect, acknowledges people’s essential human dignity, treats people as individuals, and also attempts to find out what is important to them and relevant to their treatment and care
- **Patient-centred care:** Can be defined as the type of health care that involves partnership among practitioners, patients and their families (when appropriate) to ensure that decisions show respect towards patients’ wants, needs, and preferences, and that patients have the education and support they need to make decisions and participate in their own care (World Health Organisation, 2007; Naughton, 2018; Ogden et al., 2017). It may also be defined as “care provision that is consistent with the values, needs, and desires of patients and is achieved when clinicians involve patients in health care discussions and decisions” (Constand et al., 2014)

However, according to the WHO, the concept of *people-centeredness* is in this case broader than both person-centred care and patient-centred care, as it encompasses not only clinical encounters, but also includes paying attention to the health of people in their respective communities and their crucial role in shaping health policy and health services (World Health Organisation, 2016b). Nonetheless, the meaning attached to the two concepts, *patient-centred care* and *person-centred care*, is relatively the same (Godfrey et al., 2018). Essentially, both concepts refer to understanding the experiences of the patient(s) in terms of history, including their illness or disease holistically, and with the aim of empowering patients to become active participants in their care activity and/or processes (Reynolds, 2009). In the context of this study, the two concepts are used interchangeably.

Constand et al. (2014) argue that patient-centred care is perceived to have greater patient satisfaction and with reduced health costs, this could mean more improved health outcomes. Essential components include effective communication, partnership, and health promotion (Constand et al., 2014). Among the strategies of achieving effective communication are information sharing, compassion, empowering care provision, and sensitivity to patients’ needs. Partnership involves relationship building and inter-professional collaboration, hence decentralised and teamwork-oriented care. Health promotion on the other hand involves providing the best support in care, based on the patient’s history and circumstances (Constand et al., 2014).

Four distinct dimensions are identified to transform health care, that is, from the biomedical model to person-centred care. These dimensions – context, roles, processes and outcomes – are critical considerations towards actualising the shift (Malmberg et al., 2019) as shown in Figure 7.2.

- (i) **Context:** The context of dimension in this case represents the environment in which individuals experience health and illness as well as the nature of care delivered or provided in that particular context (Malmberg et al., 2019). In other words, different people with the same health condition can therefore react and function in different ways in the same situation. This then justifies the personal meaning associated with illness and circumstances in an individual's situation, which contextualises the experiences, hence holistic (Malmberg et al., 2019)
- (ii) **Roles:** PCC in this case entails a more humanistic relationship between the caregiver and the patient such that the sharing of power and responsibility in the care process means moving away from the paternalist approach, that is, where health professionals solely make decisions on behalf of the patient (Malmberg et al., 2019). The layman's knowledge and experience of the patient about their illness are regarded as equally important to the knowledge and experience of the medical practitioner, hence a more balanced relationship and role. This recognises the role of the patient as an active participant in his/her own care rather than a passive recipient(s), i.e. patient-centred care, hence a shift in power.
- (iii) **Process:** Contrary to the conventional biomedical model where the process of diagnosis and treatment is seen as the prerogative of the medical personnel whereby the patient is to observe compliance, the person-centred care approach embraces patient beliefs and values to establish what is important to them (Malmberg et al., 2019). This helps the patient to make sense of what is happening, hence, there is collaborative decision-making whereby the doctor can provide the relevant advice while at the same time assimilate the newly solicited perceptions into current practice(s) and, as such, it leads to a co-creation of value.
- (iv) **Outcomes:** While the biomedical model focuses on biological outcomes, curing patients, a proper diagnosis, and successful treatment as key factors towards achieving positive health outcomes, person-centred care focuses on broader and more subjective outcomes (Malmberg et al., 2019). In other words, the focus shifts from eradicating the illness towards supporting patients' feeling of wellness, whereby the key indicators of person-centred care include the satisfaction of patients and the degree of involvement of both patients and the caregivers in the care process, hence a focus on needs.

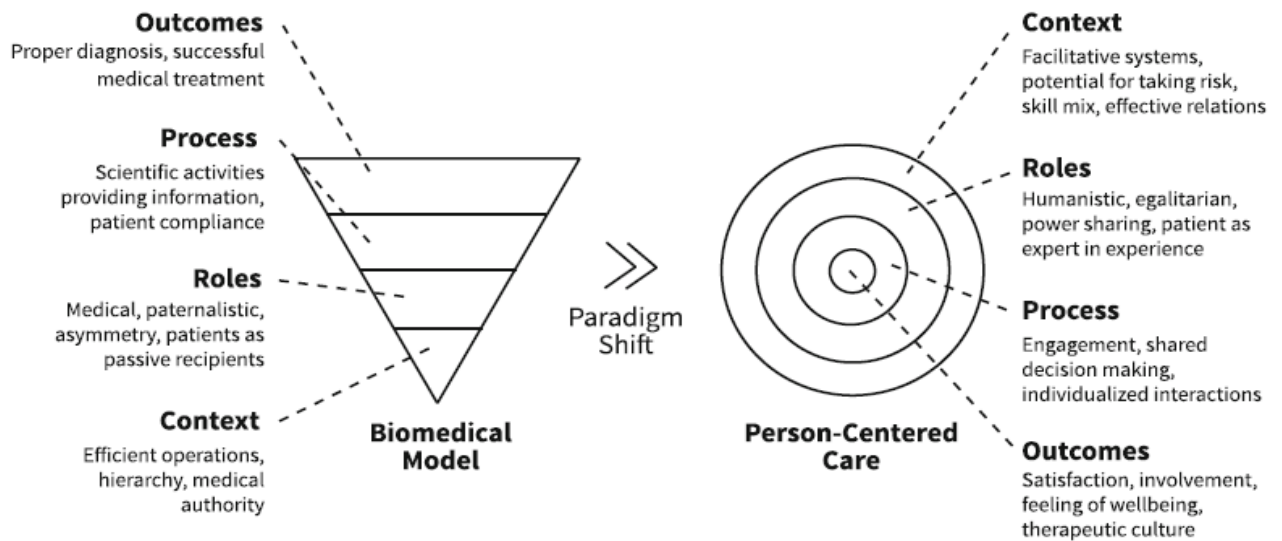


Figure 7.2: Paradigm shift towards person-centred care
(Source: Malmberg et al., 2019:5)

7.5 Integrated people-centred health services (IPCHS)

The WHO's introduction of the global IPCHS framework originated from the understanding and realisation that despite increased health budgets and advanced medicine, people are still not necessarily satisfied with the care they receive (World Health Organisation, 2015b). *Integrated health services* are defined as "health services that are managed and delivered so that people receive a continuum of health promotion, disease prevention, diagnosis, treatment, disease-management, rehabilitation and palliative care services, coordinated across the different levels and sites of care within and beyond the health sector, and according to their needs throughout the life course" (World Health Organisation, 2016b:2). This mode of care requires people to have the education and support they need in order to make decisions and participate in their own care, and it is organised around the health needs and expectations of people rather than diseases, hence holistic.

Implementation of the IPCHS framework illustrated in Figure 7.3 has to be guided by the following principles as recommended by the WHO (World Health Organisation, 2016b):

- **Country-led:** Countries need to develop strategies for pursuing integrated people-centred health services while they seek external support where necessary, but they should respond to their local conditions, situations and contexts
- **Equity-focused:** Efforts to enhance equity are a necessary part of people-centred and integrated health care strategies. Strategies must be sought to address immediate factors driving inequitable service utilisation, including fundamental social determinants
- **Participatory:** People-centred and integrated health service delivery places informed and empowered people at the centre of the health system. National-oriented strategies and

mechanisms should be put in place to ensure accountability to local stakeholders, especially to disadvantaged populations

- **Systems strengthening:** Service delivery relies on effective information and financing systems as well as the availability of skilled and motivated health workers. Any changes to service delivery system will trigger consequences across the entire health system
- **Evidence-based practice with iterative learning:** Decisions made should be based on available evidence founded on iterative learning and action cycles among stakeholders to monitor changes in the service delivery system and identify emerging problems to be solved
- **Results-oriented:** Emphasis should be on ongoing monitoring of progress through specific and measurable objectives and results
- **Ethics-based:** Ensuring that care optimises the risk-benefit ratio in all interventions; respecting individual rights to make informed and autonomous decisions; safeguarding privacy; protecting the most vulnerable; and ensuring equitable distribution of resources
- **Sustainable:** Well-planned, managed and delivered care that is equitable, efficient and effective with long-term development in a sustainable manner

The WHO describes patient-centeredness as an attribute and a global strategy towards ensuring quality health care service such as safety, timeliness, effectiveness, efficiency and equity (World Health Organisation, 2007). This strategy seeks to promote health care in the context of people-centric and integrated health services towards achieving universal health coverage (UHC), with the aim of ensuring that the entire global population in both developed *and* developing countries have access to quality health care services without any financial hindrances (Nguhiu et al., 2017).

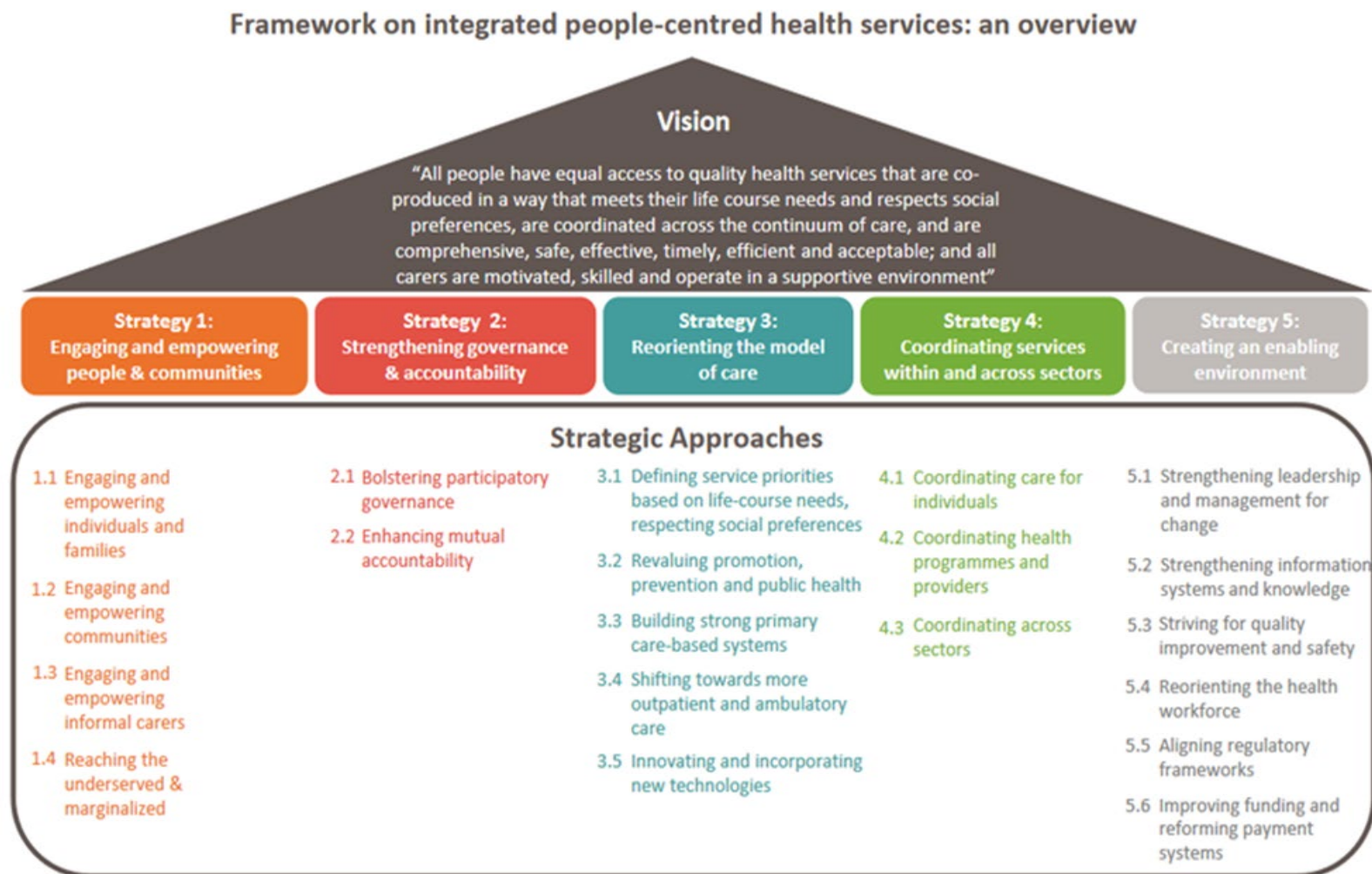


Figure 7.3: Framework for integrated people-centred health services (IPCHS)
(Source: World Health Organisation, 2016b:1)

7.6 Patient-centred health and wellbeing

This section focuses on the origin of the *patient-centred health care* concept, which is also known as *person-centred care*, and the fundamental principles around the concept. Various models and frameworks describing patient-centred care approach comprise of overlapping elements believed to form its foundation. In this section, four models will be summarised: the Picker/Commonwealth dimensions, the Institute for Patient- and Family-Centred Care (IPFCC), the Planetree model (Shaller, 2007), and the Caring Together framework (Frakking et al., 2020).

7.6.1 The Picker/Commonwealth dimensions

The term *patient-centred care* was first coined by the Picker Commonwealth Programme for Patient-Centred Care, which conducted a survey through focus groups and telephone interviews with patients and families (Shaller, 2007). The aim of the survey was to develop survey instruments for the Picker programme able to measure patient experience(s) of care across the following eight dimensions (Shaller, 2007):

- Respect for personal values, tastes and preferences; an awareness of issues regarding quality-of-life; involvement in decision-making; dignity; and paying attention to patient needs and autonomy
- Coordination and integration of care across health care systems, and support services in the context of receiving prioritised care
- Information, communication, and education on health status, progress, prognosis, and processes of care in order to facilitate autonomy and self-care towards health promotion
- Physical comfort, including pain management, help with activities of daily living, and a clean and conducive caring environment(s)
- Emotional support provision towards alleviating fear and anxiety concerning clinical status, prognosis, and the impact of illness on patients, their families and their finances
- Involvement of family and friends in the decision-making process; awareness and accommodation or concern for their needs as caregivers
- Transition and continuity of patient care with regard to information that will enable patients to care for themselves away from a clinical setting, including coordination, planning, and support to ease care transitions
- Access to care services, while considering the time spent on waiting to be attended to, which includes admission and placement in a room in the in-patient setting as well as an appointment or visit in the out-patient setting

7.6.2 Institute for Patient- and Family-Centred Care Model (IPFCC)

The IPFCC model was introduced in 1992 to facilitate the adoption of principles of patient- and family-centred care in all establishments providing care including health, education, mental health, and social services (Institute for Patient- and Family-Centred Care, 2020; Shaller, 2007). The institute views the patient- and family-centred care as an innovative approach towards planning, delivering, and evaluating health care that is based on mutually benefiting partnerships among patients, their families, and health care providers (Shaller, 2007; Conway et al., 2006). The core concepts of patient- and family-centred care include:

- Dignity and respect, where health care practitioners listen and respect patient and family views and opinions. Patient and family knowledge, values, beliefs and cultural beliefs are considered during the planning and delivery of care stages
- Information sharing whereby health care practitioners need to communicate and share complete and unbiased information with patients and their families in ways that are emphatic and useful. Information shared should be timely, complete, and accurate to effectively enable individuals to participate in care and decision-making
- Encourage participation, that is, where both patients and their families are encouraged and supported to participate in their care and decision-making at the level they choose
- Collaboration, that is, where patients and their families are included such that health care providers collaborate with patients and families in matters of policy and programme development, implementation and evaluation, in health care facility design, in professional education, and in the delivery of care

7.6.3 The Planetree Model

Having been founded in 1978, the Planetree mission was to serve as a catalyst for developing and implementing new models of health care that initiate the healing of mind, body, and spirit; that are patient-centric, value-based, and holistic; and that integrate the best of Western scientific medicine with time-honoured healing practices (Planetree International, 2020; Shaller, 2007). The nine elements of the Planetree patient-centred care model include the following:

- Explicit recognition of the importance of human interaction in the context of personalised care, kindness, and being 'present' with patients
- Informing and empowering different patient groups through customised health library services and patient education
- Integrating health partnerships with families and friends in all aspects of care
- Attending to aspects and/or issues associated with food and nutrition
- Incorporating spirituality and inner resources for healing into care of patients
- Incorporating massage and human touch

- Incorporating the arts, i.e. music and visual art forms, into the healing process
- Integrating both complementary and alternative practices into conventional care
- Creating healing environments through architecture and design

7.6.4 The conceptual Caring Together framework

The Caring Together framework for patient, family-centred care (PFCC) was developed by Frakking et al. (2020) to guide the development and implementation of PFCC services in small community hospital facilities within the Australian context. The model presents essential concepts which cut across priority areas of health organisations and is organised into three co-layers: (i) focusing on the experiences of consumers and staff; (ii) focusing on leadership, environment, service delivery, engagement and learning; and (iii) focusing on overarching fundamental values of being heard, respected, valued and supported by staff at all levels within an organisation (Frakking et al., 2020). The innermost layer of the model represents client and staff experiences, which are regarded as the central focus in the care process. The second layer presents four major elements: leadership, environment, service delivery, engagement and learning. The third layer introduces the fundamental values of PFCC, which include observing the individual's right to be heard, respected, valued and supported by staff at all levels in an organisation. The PFCC model was designed after the realisation of a paucity in the literature on how to embed PFCC practically on a larger scale across community hospital setting(s) offering holistic health care services such as paediatrics and adult services in acute and ambulatory settings of care to the underserved, i.e. the socioeconomically disadvantaged. The aim of the model is to address the limitation of evidence-based frameworks towards supporting the incorporation of PFCC into the operations of small Australian hospitals (Frakking et al., 2020).

Generally, the common goal of the aforementioned frameworks is to provide patient-centred care, i.e. empowering health care consumers in different contexts, also known as the *holistic patient view* (Nelson, 2015). Nelson further describes patient-centred care as:

- A learning health system where individuals are at the center of their care
- Where providers have ability to secure seamless access and use health information from different sources
- Where the individual's health information is not limited to what is stored in health records, but includes information from many different sources and portrays a longitudinal picture of his/her health, not merely episodes of care
- Where diagnostic tests are only repeated when necessary because the information is readily available
- Where public agencies and researchers can rapidly learn, develop and deliver cutting edge treatments

Despite their emphasis and focus on person-centred care, all the aforementioned frameworks have similar limitations, which may hinder their proper functioning in different settings. The models are mainly generic and theoretical rather than practical, which raises the question of their applicability in different specific health care contexts. Secondly, all four frameworks were developed within the developed context(s), which is different from the proposed research context, i.e. the African context, and as such, they cannot be generalised to the local situation. There is a huge difference between developed and developing countries in terms of resources availability, as pointed out by Tauziac (2020). This is mainly influenced by factors such as political and socioeconomic circumstances. Consequently, this causes differences in structure and scope of health care systems globally in terms of finance and human resources as the most important requirements (Kandelman et al., 2012; Radojicic et al., 2020). To address these gaps, this research adopted the SDR strategy to create context specific solutions while allowing active participation from stakeholders during the design process. This facilitated the designing of integrated patient-centred eHealth services for underserved urban populations in the Kenyan context. Also, a prototype system was developed as proof of concept of the design to test the functionality of the proposed solution (Nunamaker Jr et al., 2015).

7.7 Chapter conclusion

In this chapter, the aspects of health and wellbeing services related to this study were discussed as these formed part of the design considerations for the proposed service, that is, patient-centred health and wellbeing service. In the next chapter, key concepts regarding information services are discussed, with a specific focus on issues reported in the literature concerning maternal health information services.

Chapter 8: Information Services

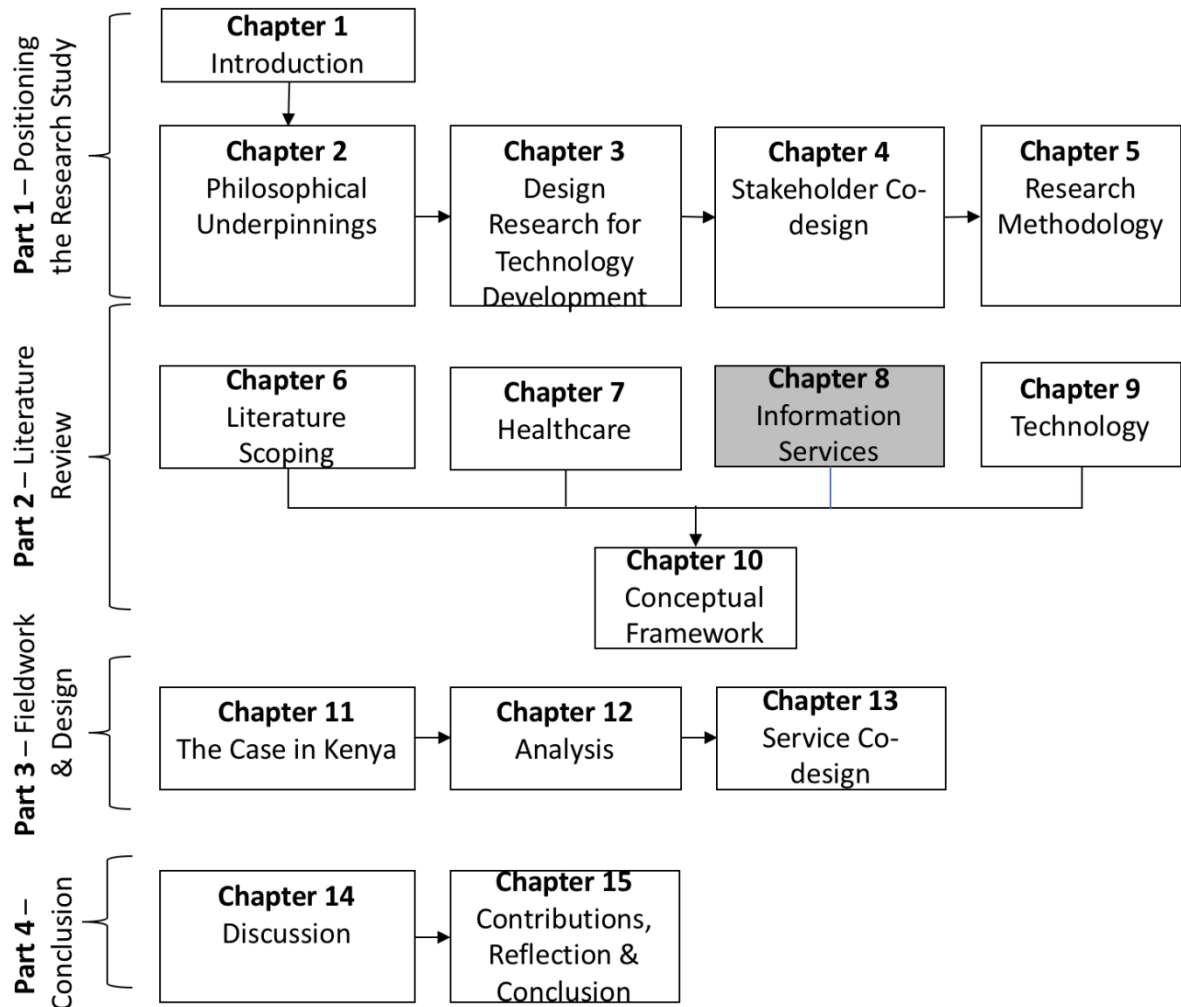


Figure 8.1: Thesis Layout - Chapter 8

8.1 Introduction

In this chapter, the focus is on the current status of the literature on information services. General issues of services reported in the literature are discussed first, followed by deliberating on information collected about the type of services for the proposed design. The issues specific to data access, the context of information needs, and the different information roles are also reviewed.

8.2 Services

Whaiduzzaman et al. (2014b) define the concept of *service* as a type of relationship between the service provider and the service user or customer of that particular service. Vargo et al. (2008) define service as the application of competences such as knowledge and skills by one party for the benefit of another, and is therefore the underlying basis of exchange.

According to Huang et al. (2013), service is regarded as the actual value offered to users (customers) of the particular service offering. A service therefore, creates value and provides benefits to customers at specific times and places, with customers often involved in the process. The focus of this research is on information services as example of a digitised service that can be enabled by technology. Specifically, the study focused on designing maternal health and wellbeing information services in an underserved context, thus, sub-sections in this chapter include discussions on information services, information service roles, information context, enabling technology, and maternal health information services.

8.3 Information services

There has been a shift towards information services rather than the use of IS, but there seems to be a paucity of suitable theories that explain the difference between IS and information services (Mathiassen & Soreness, 2008). A technology-enabled information service is where information is provided by the service provider to their customers to satisfy a need and where the interactions are supported by technology. In this case, an information service should therefore be viewed from a socio-technical perspective so as to consider how the various configurations of people and IT artefacts interact to support the information needs for a specific purpose in information environments (Mathiassen & Soreness, 2008). These represent mutable, loosely coupled and emergent interactions (Hovorka & Germonprez, 2010), although information processing is often associated with uncertainty and with different meanings and interpretations attached by the information user and/or seeker. The diffusion of technologies, with more attention given to interface design, ubiquitous use of processors and the use of commercial applications, has prompted an increase in digital services (Mathiassen & Soreness, 2008).

An information service is therefore a situation where information is provided as a product to the customer by the service providers. An information-intensive service therefore, is where value is created through the interactions between the customers and the provided information rather than physical and personal interactions with the provider (Lim et al., 2018). According to Lim et al. (2018), a number of factors characterise data-based value creation, which include data source, data collection, data itself, data analysis, information on the data source, information delivery, customer, value in information use, and provider network. Customers use specific processes to find suitable information from different sources. Therefore, understanding what their needs and processing preferences are will be critical in assisting service providers to provide useful information. This is based on the understanding that value is only created for customers once they use the information acquired for a specific purpose.

With reference to the value of the information service offered, a number of quality concerns should be considered as they may have an impact on the service. These are: level

of completeness (incomplete or too much information), representation (ease-of-use, understandability, and readability, among others), and accuracy and timeliness (Mai, 2013). The quality dimensions that affect the feeling of users being well informed include accuracy, completeness and timeliness (Zarraga-Rodriguez & Alvarez, 2015). It is important to note that information quality is subjective because it depends on the specific context (situation) and to what extent it helps the person to make sense of the information to satisfy a need (Andrade & Urquhart, 2009). Access to a diverse set of digital objects however depends on both economic and technological affordability as well as the accessibility of individual information users within a particular context (Chowdhury, 2013). According to Chowdhury, the key aspect relevant to sustaining digital information services is *integration* between environmental, economic and social sustainability.

The following are considered among the critical components of an information service: the customer as the information user; the information as the service, which includes content; and the medium or channel of communication. In the context of information, the focus revolves around where the two entities (people and technology) intersect, interact and/or integrate, which is the relation between the entities (Madsen, 2014). The following design challenges are important considerations for the design of a digitised information service: content, use feature, and revenue (Kraaijenbrink, 2008). The author proposes a product-oriented design theory for digital information services where he argues that provision of information services requires the sourcing/producing of suitable information, the flow of information, content use features such as content-creation options, and data analytics tools to facilitate use.

8.3.1 Information service roles

Among the human actors involved in health information service provision are the authors of the information content, information seekers as the information users, designers of database systems, human indexers, and selectors of information relevant to the service (Lim et al., 2018). This study however considered the following categories as proposed by Strong et al. (1997): information consumer – the person who seeks and uses the information; information producer – the person creating and authoring the information provided by the service; information custodian – the person who considers the quality and/or organisational aspects of the information provided by the service; and the information designer – the person who designs the information architecture, interfaces and applications.

8.3.2 Information consumer as the client of the service

Health consumers are increasingly taking up a more active role in managing their health and wellbeing (Tao et al., 2017). The information consumer is the customer of the information service and the person who seeks for information to address a specific need based on a situation that causes the need. This person is therefore regarded as a cognitive actor with specific interests, cognitive and emotional state, and perceptions (Robson & Robinson, 2013); all of these are influenced by the context within which the person is situated. Robson and Robinson (2013) propose three levels for using information: (i) first level, where the information satisfies customer need(s), meaning this information is relevant in the situation; (ii) second level, where the acquired information is understood and new knowledge is created, and whereby the information has a cognitive impact; and (iii) third level, where the information is applied to result in a lifestyle change, meaning the information was useful. Important aspects to take into consideration to understand the information needs of consumers include their demographic details, their experience in the area of their information interest, the significance, relevance and applicability of the information to the consumers, and their belief systems (Robson & Robinson, 2013). It is also important to establish how the aforementioned aspects manifest in the consumers' lived context.

8.3.3 Information producer, designer and custodian

It is critical for the health information service provider to provide information that is useful to their customers, and particularly in the health care space where it comes with a risk. Information that is not well moderated and the quality is assessed or presented in a manner that does not facilitate ease-of-use and understandability, has the potential to make the situation worse for the information seeker. The information service provider should use data produced by the system to determine user preferences, patterns of use, and trends, but most importantly, to gain insights into the information seeking behaviour of users (Lim et al., 2015). In this case, the information producer as a cognitive actor should also make sense of the suitability of information as perceived on behalf of the user. This person should act intentionally by continuously making sense through actions within the context of the service and should not regard information as passive objects (Jones, 2013), hence the reason this actor is also known as the *human sense-maker*. It is therefore important for the producer to 'know' the target group, their perplexities, fears and perceptions, and also in the case of underserved contexts, to consider their literacy levels, socio-economic status, digital divide (i.e. lack of access to information needed due to cost, technology and infrastructural constraints), and to display a cultural sensitivity. It is important to note that information producers who take up the responsibility of creating quality information, also appraise information differently from the information consumer, especially when they have different levels of expertise, for example, health professionals versus patients (Tao et al., 2017).

In an underserved context it is possible that the human sense-maker may be the same person dealing with the technological aspects of preparing and posting the information on the digital platform, i.e. the design and development process. In such a case, it is also possible that the same person is the author, creator, moderator, quality assurer and custodian of the information captured in the service provider's information repository. An information service, therefore, provides information created or authored by information producers to their customers; this process can also be regarded as an information communication chain Robson & Robinson, 2013).

8.3.4 Information context

Context is defined as “any [type of] information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves” (Dey, 2001:5). It is therefore important to unpack the circumstances as the context that leads to the information needs, to understand context as social defined setting rather than just the setting of use (Agerwal et al., 2009). The difference between a context and a situation is that contexts can be described as frameworks of meaning whereas settings are the dynamic environments within which humans operate that influence the manner in which they make sense of their circumstances for which information is needed (Agerwal et al., 2009). A context can have several settings, including location, social influences Robson & Robinson, 2013) and factors associated with underserved contexts; hence the information delivered should be contextually relevant to customers. Furthermore, it must be in a language understood by the information user, and be culturally and gender sensitive in underserved contexts, while at the same time considering aspects specific to contexts such as literacy levels, infrastructural constraints, and political and socio-economic factors influencing the situations of the people.

Despite the fact that human sense-makers operate within their own personal contexts, they have to make sense of the contexts of the users' own personal contexts Robson & Robinson, 2013). Information providers operating in underserved contexts, which are often resource-constrained, have to use resources available without the option to use resources that could improve the quality of their information (French & Williamson, 2016). The human sense-maker should therefore have knowledge about the nature of the information, tools and materials to produce and/or organise the information to deliver specific information need(s) as part of the provided service. Underserved communities are thus regarded as complex social ecosystems where the services available are inadequate for the needs of the people in these contexts (Joly et al., 2014). People from such communities often experience limitations of connectivity, electricity and digital literacy. In addition, cultural issues associated with specific contexts contribute to challenges experienced in service provision, especially within LMICs,

hence the design of such services should provide for sense making of the aspects important for the service provided in such contexts (Cipolla & Reynoso, 2017). The authors agree with Manzini and Coad (2015:35) that designers need to be regarded as “producers of sense, or sense-makers” where such persons integrate their own experiences and knowledge into their understanding of situations that could influence the service. One can therefore refer to the information user as a person-in-context since their information needs are motivated from a range of situations that influence their information needs and behaviour, which is in turn influenced by the wider context of the environment (Ormandy, 2011).

8.3.5 Health information services in maternal care

According to Mulauzi and Daka (2018), maternal mortality can be minimised if appropriate preventive measures such as access to health information during pregnancy, childbirth and the postpartum period were put in place. The authors argue that maternal health information is fundamental for women’s health during their maternity period as it can help to identify existing risks in women and their children to prompt prevention of future health problems. The next sections will therefore discuss important aspects of maternal health information services, including women’s information needs, information sources, information flows and practices.

8.3.6 Information needs

During their study, Mulauzi and Daka (2018) identified three stages of maternal health information needs: during the pregnancy, childbirth and postpartum stage. Needs during pregnancy include importance of regular check-ups, place of delivery, birth preparedness, the pregnancy period, nutrition, miscarriage, pregnancy complications/danger signs, sex, foetal development, expected child, labour, communicable and NCDs in pregnancy, medicines in pregnancy, family planning, and exercise (Mulauzi & Daka, 2018; Papen, 2013). Infant care, child immunisations, feeding of the infant, the mother’s recovery, hygiene, stillbirth, low birth weight, infections, care of the umbilical cord and diarrhoea were the needs identified during the childbirth stage (Mulauzi & Daka, 2018). Important needs identified in the postpartum stage include self-management (hygiene, nutrition and weight loss), sex, infant daily care, family matters, emotional support, physical rest and sleep (Mulauzi & Daka, 2018). Grimes et al. (2014), on the other hand, identified pregnancy care and complications, labour and birth, planning for care, neo-natal care and complications, breast-feeding, infant settling and sleeping, the mother’s postnatal recovery, managing psychosocial changes, home routine and expectations as important needs. Significantly, the understanding of maternal health information needs of women is indispensable as it helps to design appropriate interventions for health promotion (Mulauzi & Daka, 2018), thus ensuring that women’s health information needs are fulfilled and also building capacity for their health literacy towards improving

maternal and child health outcomes. Unfortunately, information is in most cases disseminated without understanding the needs of individuals, and/or the contexts in which they can access and use the information (Mulauzi & Daka, 2018).

8.3.7 Information sources

Discussions between women and midwives and other health care professional appear to be the most important source of information during pregnancy (Grimes et al., 2014; Aaronson et al., 1988). In their study to analyse the benefits of AE-related non-pharmacological techniques by pregnant women in Brazil to use during labour and childbirth, Heim et al. (2019) noted that the majority of the women acquired information from conversations, women colleagues, and various media. The women preferred to have AE meetings linked to ANC consultations to promote participation. AE group discussions were pointed out as one of the preferred ways to receive guidance on AE-related information on non-pharmacological techniques to manage pain during labour and childbirth (Heim et al., 2019). According to Grimes et al. (2014), other existing sources of information did not play a significant role in the women's information seeking behaviour since it did not meet their needs. These include Internet/online resources, written/book resources, group information sessions and other health professionals including doctors. The majority of women did not use both the Internet and book resources due to multi-linguistic challenge(s); hence they only used sources written in common languages such as English. Both authors observed that books were found to be the second most popular sources of information after discussions with midwives, while the women who received care from a doctor in ANC seemed to use the Internet as their most preferred source of information. It was observed that women of higher socioeconomic status (SES) have higher preference for books and less for family information sources as opposed to those of low SES (Aaronson et al., 1988). Also, according to Aaronson et al., women with prior pregnancy experience used this knowledge to manage themselves, thus using themselves as source of information.

8.3.8 Information flows

Information is a critical tool for the caregivers as opposed to their daily work of providing care, and thus IS should be seen as a socio-technical system of people working together, and with the use of technologies to achieve a common goal (Korpela et al., 2013). Therefore, work flows and information flows within the health care ecosystem(s) need to be developed hand-in-hand with software systems meant to support health care activities. There is a need for collaboration among stakeholders, including health care professionals and system developers. Patterson (2013) argues that contemporary (technology enabled) health information flows beyond the usual patient-to-physician or health care provider path to include flow from individual users to community groups, social networks, and companies to business partners

such as insurers and employers. In general, health information flows can be both multi-directional and multi-purposive in the context of data use and/or distribution (Patterson, 2013). Unfortunately, existing methodologies promote parallel development of health care work rather than collaboration, hence they are vague and fragmented (Korpela et al., 2013). This situation calls for the need to adopt a holistic approach to enable the co-development of services, work and ISs in health care to create collaborative health systems. In this regard, Korpela et al. (2013) propose a holistic IS development framework with five conditions that must be fulfilled to realise effective information flows in health care. These include understanding the contexts of health care providers, health care consumers (pregnant women) and technology providers; understanding the needs of people (health consumers); understanding the work activities of health care professionals; defining solution architectures; and co-designing interactions and usefulness of the required solutions among the stakeholders. However, despite advances in the use of ICT, consumer needs have not been addressed in the context of health information flows regarding privacy and security practices (Patterson, 2013). While this research applied the SDR approach to co-design new, ICT-facilitated maternal health information services, the researcher also engaged the relevant stakeholders to create secure services to guarantee individual privacy and data security, and meeting the users' demands in an underserved context.

8.3.9 Information practices

Information practice may be understood as a set of socially and culturally established ways to identify, seek, use, and share the information available in various sources, for example television (TV), newspapers, and the Internet (Eynon & Malmberg, 2012). It is an umbrella term referring to a variety of everyday information activities that individuals engage in according to their information literacy skills and the use of information within specific contexts influenced by factors such as age, gender, socioeconomic status (SES) and access (Eynon & Malmberg, 2012). This then determines an individual's ability to search for and recognise sources of knowledge they consider relevant (Papen, 2013). Therefore, the concept of information practice is precisely about what people think about particular knowledge as well as their actions and/or behaviour, and how they engage with it, i.e. finding, using, and sharing information in a specific context (Zimmerman, 2019; Eynon & Malmberg, 2012). In most cases, pregnant women receive advice orally and/or verbally from friends, family and caregivers, including midwives and doctors, alongside information from books or the Internet (Papen, 2013). During a study to explore information seeking, technology use and vulnerable population groups, it was observed that word of mouth was the most important source of information as opposed to technology (Newell et al., 2016). According to the authors, word of mouth is preferred to the use of cell phones because of perception that technology lacks trust, hence violating individual

privacy and confidentiality. Trust is therefore perceived to be a critical aspect in determining information seeking behaviour, and particularly in accepting a source of information.

Advice received orally has been found to be insufficient since the caregivers may not have adequate time to answer a client's questions hence the tendency to turn to other sources such as Internet/websites and books to seek more information (Papen, 2013). The search for information is not only a cognitive process, but also a practice that develops as the women interact with colleagues face-to-face or online. Mac McCullough et al. (2014) assert that health stakeholders, and especially health care providers, should consider both internal and external factors which include barriers and benefits to their organisation, in order to tailor the nature of information sharing and/or exchange to ensure meaningful use (Mac McCullough et al., 2014; Holmgren & Adler-Milstein, 2017). According to Mac McCullough et al. (2014), information practices are greatly influenced by context since each user operates in a unique personal context, their prior experience(s), and the context of antenatal care (ANC) service as part of the information provided and engaged with at a particular point in time (Papen, 2013). Holmgren and Adler-Milstein (2017) identified the four Key dimensions of HIE: What is exchanged? Who is exchanging? How is exchange occurring? Who governs exchange? This research engaged the SDR strategy, which is context-specific, to design meaningful digitised information services in the context of use.

8.3.10 Collaborative information service

The magnitude of a new set of challenges facing health care infrastructure is beyond the capability of any single institution, hence the need for effective collaboration of all stakeholders (Noran, 2015). These include challenges of rapid population growth, ageing, social security, and the increasing complexity of pandemics. Such a scenario therefore prompts the need for both inter-professional and inter-organisational collaboration on health care services. Collaboration information systems (CISs) are important as they help to improve information flow while also supporting optimisation of the scarce resources between organisations, hence cost-effectiveness (Smaradottir et al., 2016; Holmgren & Adler-Milstein, 2017). Collaborative information behaviour, according to Reddy and Jansen (2008) is a critical ingredient of organisational work. This promotes collaborative information seeking, which is defined as "any activity that collectively resolves an information problem taken by members of a work-team, regardless of the nature of the actual retrieval of information" (Hertzum & Hansen, 2019:142). Therefore, the act of information seeking is fundamental to collaborative activities as teams of professionals seek and interact with information in various fields and contexts, including in health care (Hertzum & Hansen, 2019). During their study to investigate the significance of health telematics, Prokosch et al. (2006) pointed out the development of collaborative HISs as a contribution of telemedicine. According to the authors, telemedicine supports physicians'

work while also assisting with incorporating patient participation towards their wellbeing. This can be achieved through teleconsultation or teletherapy, thus promoting the development of joint electronic patient records among health care providers. More importantly, CIS provides a platform that actively incorporates stakeholders while empowering patients in the care process using various ways, including email communication and web-based information services (Prokosch et al., 2006). Therefore, CIS plays a critical role in engaging patients in their care because they are able to freely access and track their health information, status and treatment by themselves (Mishra et al., 2018). According to Noran (2015), collaboration between health care stakeholders is a mandatory requirement in the modern health care environment since it replaces legacy siloed health care models, which are no longer useful.

Unfortunately, planning collaborative health care faces serious challenges, as there are only a few frameworks to guide and/or implement this service (Korpela et al., 2013; Gudes et al., 2010). Literature on the collaborative aspects of information seeking is scarce since the research in this area is relatively young while most models of information seeking depict the concept as an individual information seeking activity rather than a form of social interaction between individuals, teams and/or groups (Hertzum & Hansen, 2019; Reddy & Jansen, 2008). During a study to investigate aspects of collaborative information behaviour (CIB) from prior empirical studies in organisational settings, Reddy and Jansen (2008) found that CIB differs from individual information behaviour (IIB) in terms of how individuals interact with each other, the complexity of the information need, and the role of IT. According to the authors, IT plays an important role in the transitioning of CIB, and particularly from the perspective of information retrieval technologies, which act as important supporting mechanisms. They then developed a model of CIB along the axes of behaviour and context, which takes into consideration the aspects of participant behaviour, situational elements, and contextual factors (Reddy & Jansen, 2008). The study also presents characteristics of CIS, namely searching, chatting, and sharing information. In order to provide conceptual clarity on important related activities, CIB is defined as “an umbrella term to connote the collaborative aspects of information seeking, retrieval, and use” (Karunakaran et al., 2013). The authors then summarised CIB into three phases of component activities, namely problem formulation, collaborative information seeking, and information use. In their study, Shah et al. (2019) identified two important dimensions of information seeking, namely social information seeking and collaborative information seeking. The authors argue that the two concepts have been largely separated from one another despite the potential value in their connection to support human information behaviour. In order to develop better solutions, there is a need for better understanding the social, practical and professional contexts within which information is sought (Shah et al., 2019). This will help to improve the possibilities and motivation for developing relevant systems

and services to bolster information behaviour towards accomplishing a task (Hertzum & Hansen, 2019).

From the above revelations from literature, context plays a critical role in the design and development of collaborative information service, including HIT systems. This involves taking into consideration contextual aspects such as individual participant behaviour, situational elements, and prevailing circumstances. In order to provide collaborative health information service, this research employed the SDR strategy to design a patient-centred ICT-driven framework with ability to support CIB among service stakeholders, which include patients and health professionals. Specifically, the principles of SDR, which are both a context specific and human-centred approach, and those of ICT were combined to deliver value in terms of promoting CIB in health care delivery.

8.4 Maternal health information services

Maternal health information can be defined as information that women require during maternity, including pregnancy, childbirth and postpartum period(s), as well as knowledge communicated regarding particular situations of preventive, curative or palliative health care (Silali & Owino, 2016). It may also be described as the health and wellbeing of women during pregnancy, childbirth, and the postpartum period (Mulauzi & Daka, 2018). Sound maternal health care is viewed as economic empowerment as it prevents maternal-related deaths, complications or disabilities among women at a productive age, and is hence more cost effective as opposed to cure (Mulauzi & Daka, 2018). Despite various global efforts to improve maternal health care, large numbers of women continue to die of maternal-related complications, hence the need to curb the trend. Solutions include delivering person-centred care whereby women should be empowered through both information literacy and health literacy skills to promote the quality of life through preventive maternal health care (Zimmerman, 2019; Mulauzi & Daka, 2018). The National Institutes of Health defines *health literacy* as “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” (Ratzan & Parker, 2000:vi). The concept of health literacy therefore revolves around possessing a variety of skills such as information-seeking, decision-making, problem-solving, critical thinking, and communication alongside social, personal, and cognitive skills that are vital in for effective functioning of the health-system (Zimmerman, 2019). Based on the above definition and revelations, both concepts of information literacy and health literacy skills have therefore been tied to quality of life, hence a requisite for better health outcomes.

An information literate individual therefore not only requires the relevant skills to find information, but also needs the skills to analyse the information, that is, interpret, evaluate and then use the skills (Zimmerman, 2019). According to the author, research links increased

information literacy to improved quality of life, because the increased ability of an individual to access and process relevant information, including health education, financial wellbeing and health, is a vital lifelong learning skill. According to Mulauzi and Daka (2018), the significance of information to women's maternal health care needs is, therefore, innumerable. On a global scale, over 80% of households experience limited access to quality maternal and child health information with the Sub-Saharan Africa region – the most affected region –where women almost entirely depend on health professionals and community health workers (CHWs), which may not be sufficient to satisfy the women's information needs (Silali & Owino, 2016). Generally, it has been observed in literature that the majority of women lack information concerning danger signs of pregnancy, delivery and related complications (Mulauzi & Daka, 2018). Furthermore, existing ISs only provide information services that are not demand-driven; local knowledge is therefore overlooked and the role of intermediaries is misunderstood. It is against this background that the researcher sought to investigate current maternal health care services in order to design patient-centred information services so as to promote preventive health care towards improving health outcomes.

8.5 Data access

The immense opportunity presented by HIT tools and large-scale innovations such as CC services enables individuals to manage personal health data in centralised repositories over the Internet, including storage, access and exchange of the data in a cost-effective manner (Li et al., 2010). For instance, among the most popular cloud-oriented PHRs are Google Health and Microsoft HealthVault, which provide flexible access to users at their own convenience, using any kind of device connected to the Internet (Liu et al., 2017). However, according to the authors, given the nature of the sensitivity associated with medical data, access to such information revolves around security and privacy concerns, which is a major concern, thus making PHRs closely tied to patient privacy (Wang & Jin, 2019; Liu et al., 2017).

During a study to examine the perspectives of CHWs and their clients regarding the aspects of data security and privacy in the context of mHealth in Tanzania, Hackett et al. (2018) observed that the use of new technologies has both positive and negative perceptions towards personal privacy and confidentiality. According to the authors, women's concerns regarding privacy were closely associated with the belief that leaking their pregnancy-related information would render women vulnerable to witchcraft by jealous neighbours. Participants also expressed their concerns that male partners of the CHWs could access their private information. Hence, there is a need for community participation from the onset when designing and developing eHealth interventions in order to integrate beliefs and gender dynamics, which play a central role in the acceptability and adoption of new technologies (Hackett et al., 2018).

Furthermore, users lack physical control over their own data; there is thus an increased chance of the adoption of such tools being jeopardised (Li et al., 2010; Botts et al., 2011). This situation calls for the need to ensure proper access control measures in order to guarantee the trust of patients. Particularly, seamless access to integrated HIT tools for citizens still remains a challenge and is therefore far from becoming a reality (Kouroubali & Katehakis, 2019). The issues of interoperability, usability, security, ethics and regulation need to be overcome first to pave way for successful implementation of tools such as EHRs and PHRs to manage personal health data effectively. The authors argue that interoperability plays a big role in promoting the sharing of information among stakeholders in terms of health and illness experiences, hence coordination of care and research, which empowers patients towards improved health outcomes (Kouroubali & Katehakis, 2019). It is thus essential to adopt the relevant principles to guide the design and development of safe and secure eHealth services to support portability.

During their study to investigate the role that the new European Interoperability Framework (EIF) can play in benefiting the implementation of eHealth services, the authors proposed 13 principles, including security, privacy, and accessibility of patient data, among other considerations (Kouroubali & Katehakis, 2019). For instance, according to Rosenbaum (2010), regulations of the United States health policy require that serious considerations be taken on access to health data, and particularly the circumstances under which such data are accessed due to confidentiality and privacy concerns. The aim is to ensure a safe and secure environment against unauthorised access to health data while at the same time maintaining set security and ethical standards such as HIPAA regulations as part of health care reform. Peleg et al. (2008) assert that access control to patient data through such HIT tools is a major challenge in terms of privacy management as they rely on role-based access control. This is because the role-based access approach is limited in terms of taking into account the conditions under which access to such sensitive data is requested or accessed (Peleg et al., 2008).

To overcome the problem of predominant bureaucratic regulation which results in inefficiency, Azaria et al. (2016) argue the need to increase innovation on electronic medical records (EMRs). This will enhance medical data exchange between patients and health care providers through the utilisation of personalised data science tools to fully engage patients in their health care (Azaria et al., 2016).

8.6 Chapter conclusion

In this chapter, the aspects relevant to maternal information services towards the new proposed service design as identified in the literature, were discussed. These aspects inform the design of the new proposed service. In the next chapter, the enabling technologies as identified in the literature review are discussed.

Chapter 9: Enabling Technologies

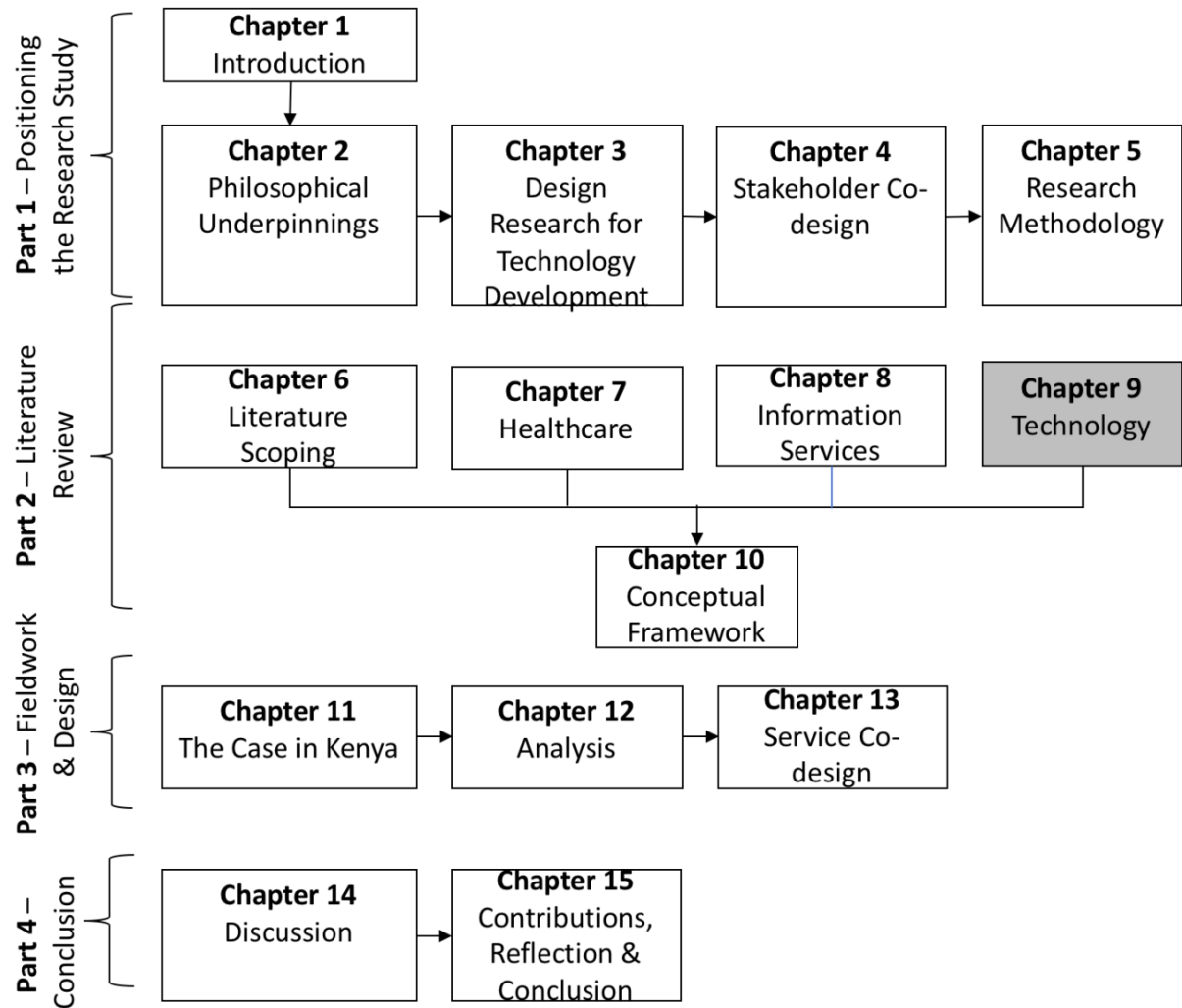


Figure 9.1: Thesis Layout - Chapter 9

9.1 Introduction

In this chapter, the focus is on the current status and the role of the enabling digital technologies and/or ICTs that have been adopted to support health care delivery on a global scale. Specifically, such technologies including Cloud Computing (CC), Health Information Technologies (HITs), mobile computing and related issues reported in the literature and their significance in health care.

9.2 The role of ICT in health care

Digital services are defined as “services, which are obtained and/or arranged through a digital transaction (information, software modules, or consumer goods) over Internet Protocol (IP)” (Williams et al., 2008:506). The service experience is thus influenced by the social interaction between users over an IT platform (Hofemann et al., 2014). Technologies such as

computers, the Internet, and smart devices can be seen as service enablers that provide services in new ways. The introduction of digital technologies in service provision creates many new innovative opportunities; however, a holistic understanding is needed across the dimensions of the service provider's services, digital environment and/or organisational properties (Nylén & Holmström, 2015).

IT digitises the information and interactions between the information user and information within a service to facilitate value creation (Lim et al., 2018). An information service requires a set of informational, human and technical components to facilitate the creation and/or organisation of information and the touch points for the information user to interact with the information service. The information channel used to transmit the information has an influence on the quantity and quality of the information. In information services, information will also be carried as content (Agerwal et al., 2009). In an underserved context, the enabling technology for accessing and utilising a service is often limited by infrastructural, connectivity, device and application constraints. This will largely influence the design of the interfaces to the information service. Failure to consider the experiences of the information users will therefore compromise the quality of the information, which makes the user's experience unsatisfactory.

Introduction of ICTs into the health care domain, which is otherwise known as eHealth, has demonstrated great potential towards making health care more digital, more data driven, more accessible, more error free, more collaborative and more patient-centric, and with reduced costs, among other benefits (John & Shenoy, 2014). Thus, there is a need to focus comprehensively on priority areas of ICT in health care as some of the most effective approaches to improve the quality of health care (Røed, 2012). The role of ICT in health care should therefore be understood as vehicle for a national approach for countries to reduce poverty towards achieving the SDGs (Drury, 2005). According to the author, ICT creates opportunity to support governments in improving health care delivery to citizens towards achieving improved health outcomes. According to literature, ICT has revolutionised people's interactions with each other as well as their daily life and work, for example, through telemedicine, electronic medical records, HISs that promote decision support, mHealth and eLearning tools (Boore, 2018; Findikoglu & Watson-Manheim, 2016; Drury, 2005; Bantom et al., 2016; Shiferaw & Zolfo, 2012).

The use of ICT will ensure the availability of up-to-date information, including patient history for health professionals to make proper medical reviews and diagnoses (Drury, 2005). Therefore, ICTs, and particularly HITs, are perceived as a remedy to overcoming access and resource related barriers in health care, which are prevalent in underserved contexts, specifically in the developing countries (Findikoglu & Watson-Manheim, 2016; Chan & Kaufman, 2010). According to literature, the common major challenges that characterise health

care services, particularly in underserved environments, include duplication of services, which greatly hinder health care collaboration due to the lack of HIS interoperability (Sneha & Straub, 2017; John & Shenoy, 2014; Miah, 2017; Manya et al., 2012; KPMG, 2014). As a result, underserved communities frequently lack access to primary health care and the opportunity to utilise ICTs due to this digital divide (Watkins et al., 2018; Botts et al., 2011). The consequences of this include delayed clinical decisions, discontinuity of care, and generally weak referral systems that compromise the quality of health care (Sneha & Straub, 2017; Pustišek, 2017). Existing HISs should therefore be improved in developing countries through the use of modern and affordable technologies such as CC (Miah, 2017), in order to guarantee sustainable health cyber infrastructures (Botts et al., 2011; AbuKhoussa et al., 2012).

9.3 Cloud computing technologies

CC is an emerging field of ICT that envisions a new model of providing computing services, namely *everything as a service*, whereby physical resources, infrastructure and applications are virtualised and provisioned in the cloud as a service (Whaiduzzaman et al., 2014b). It is a distributed model that avails computing resources to clients (users) on an on-demand basis, i.e. a pay-as-you go model, whereby resources are hosted as hardware, software (applications), databases, virtual servers and complete workflows (Whaiduzzaman et al., 2014b; Qi et al., 2014). The National Institute of Standards and Technology (NIST), on the other hand, defines CC as a model that enables ubiquitous, convenient, on-line demand network access to a shared pool of configurable computing resources, including networks, servers, storage, applications and services that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011). CC architecture comprises two main models, namely deployment and service models. Deployment models include public, private, hybrid and/or community cloud models. The service models include Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Jadeja & Modi, 2012). According to Whaiduzzaman et al. (2014b), Security as a Service (SecaaS) is another emerging cloud service model that is critical for the protection of data in health cloud storage.

9.3.1 Cloud service models

The following is a highlight of the main service models of CC: IaaS, PaaS, SaaS and SecaaS, as illustrated in Figure 9.2 (Mell & Grance, 2011; Whaiduzzaman et al., 2014b; Lupse et al., 2012):

- **SaaS layer:** Provides business applications, which are delivered online as a service through the web, for example, email, virtual desktop, communication, CRM, and games. Clients are then

able to access these services through a web browser, mobile applications, thin client, and terminal emulator, among others

- **PaaS layer:** Delivers platform as a service whereby it offers an integrated set of software that provide programs required by the developer to build an application(s) online for quick development of web applications
- **IaaS layer:** Provides infrastructural services (hardware and software), including virtual machines (VMs), servers, storage, load balancers, and networks as a service
- **SecaaS layer:** Is where the cloud service provider provides security applications and services both within a cloud environment and from the cloud to the clients on premise systems. SecaaS is a new method allowing customers to make use of cloud-based security services in new ways as opposed to when the services are provisioned locally, which would be more costly

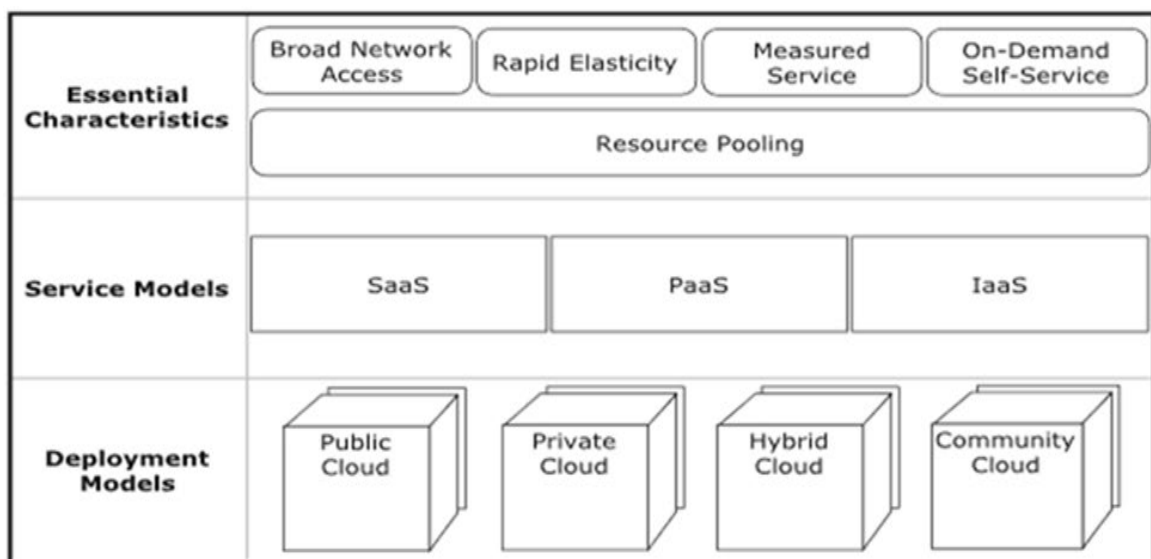


Figure 9.2: NIST visual model of cloud computing definition
(Source: Mell & Grance, 2011:2)

9.3.2 Cloud deployment models

According to literature, there are four primary cloud deployment (implementation) models (Weerasiri et al., 2017; AbuKhoussa et al., 2012; Mell & Grance, 2011; Lupse et al., 2012):

- **Private clouds:** The cloud infrastructure is created, managed and owned by one entity that is normally the client, or a third-party organisation, or a combination of both. Services are provisioned for exclusive use by a single organisation or industry with multiple consumers. This type of cloud may be hosted either from within or off the premises
- **Community clouds:** The cloud infrastructure is owned by a group of organisations, i.e. clients that share computing resources, which can be managed by third-party providers or organisational-based IT resources. Services are provisioned for exclusive use by a specific community of consumers with similar requirements including security, policy and other compliance requirements. The cloud may be hosted from within or off the premises

- **Public clouds:** The cloud infrastructure is owned, managed and provisioned for open use by third party organisation(s) that offer cloud infrastructure (services) to many users, i.e. the general public, with varying computing needs such as Google, Amazon, and Microsoft, among others. This type of cloud is hosted from within the premises of the cloud provider
- **Hybrid/federated clouds:** The cloud infrastructure comprises a mix of two or more of the aforementioned cloud deployment models, i.e. private, public and community clouds. They are independent entities bound together by standardised technologies to enable data and application portability by means of load balancing

9.3.3 Cloud computing reference architecture

NIST identifies components of a generic CC reference model in order to promote the understanding of cloud requirements, uses, feature (characteristics) and standards. These include key actors and their associated services and roles, various service layers/structures and related taxonomy within a cloud environment. Actors include the cloud provider, cloud consumer, cloud broker, cloud auditor, and cloud carrier, which may be an individual or an organisation participating in the transaction process (Mell & Grance, 2011; Liu et al., 2011). Figure 9.3 is a visual representation of NIST's detailed CC reference model (Bohn et al., 2011; Hogan et al., 2011):

- **Cloud consumer:** An entity or organisation that engages a business relationship using services provided by a CP. A cloud consumer (user) selects a service(s) from the SP's catalogue and requests an appropriate service based on his/her business needs through signing a contract and service level agreement (SLA) with the cloud provider to use the service
- **Cloud provider:** An entity or organisation that avails a service(s) to interested parties
- **Cloud auditor:** An individual or organisation that performs independent assessments of cloud services in terms of IS operations, cloud performance, cloud security and implementation aspects
- **Cloud broker:** An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between cloud providers and cloud consumers
- **Cloud carrier:** An intermediary that provides connectivity and transport of cloud services from cloud providers to cloud consumers (Liu et al., 2011)

According to the literature review, among the important features of CC in the delivery of health care services are ubiquitous network access, agility, rapid elasticity, metered pricing, on-demand self-service, scalability, integration, mobility and interoperability (Romero et al., 2016; John & Shenoy, 2014; Hu & Bai, 2014; Hamdaqa & Tahvildari, 2012; Mell & Grance, 2011). CC allows the use of the latest technologies at a lower cost, with the least resources as is necessary by clients (Lupse et al., 2012).

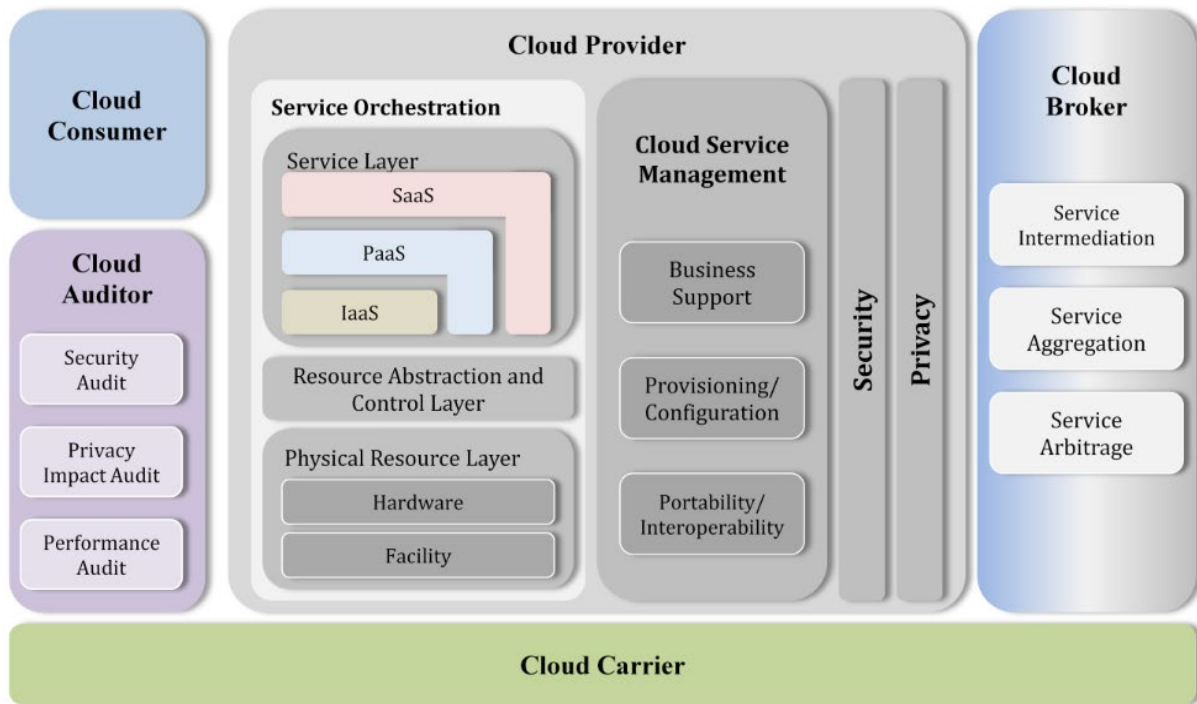


Figure 9.3: NIST conceptual cloud reference model
(Source: Hogan et al., 2011:42)

Given the potential of CC as a catalyst for integrating health systems in developing contexts (Manya et al., 2016), as well as its capability to converge with both web and mobile-based technologies, this research sought to create a paradigm shift from organisation-, clinician- or disease-focused to person-centred HIT models to improve health care delivery (Chong & Matchar, 2017; Kim & Bates, 2011). Specifically, a private cloud model is perceived as the most suitable in supporting medical applications due to the requirements of security, confidentiality and privacy concerns over patient data (Lupse et al., 2012).

9.4 ICT design and development process

The concept of design can promote the development of new competences; hence it can help an organisation(s) discover new technologies and business opportunities through exploring new modes of cooperation either at departmental, company or industry level (Pekkala & Ylirisku, 2017). Accordingly, this discovery of new opportunities then helps to translate and shape the organisation in diverse ways including in language and culture. According to the authors, initial product concepts in innovation such as stories, new vocabulary, and prototypes provide a starting point in the product development process whereby the concept components change during the development. Therefore, new concept components help in the initiation and reinforcement of a new course of development and description of a concept, which enables the commitment to development. This section highlights the design process to be used by the designer to design, develop and test proposed ICT enabled services, i.e. person-centred health cloud service. System development requires

a thorough investigation of activities of involved, context(s), and target group(s) concerned (Huang et al., 2013). This helps designer(s) gain insights into designing tangible artefacts, and to support intangible experiences as well as emotional needs. This study made use of a combination of methods, including the co-design method, agile approaches of system development, user experience design, and software engineering (Huang et al., 2013). The general perception is that engaging in co-design research enhances meaningful involvement of end-users in the research process, which may help address the problem of wastage of research resources (Slattery et al., 2020). In this research, the co-design process commenced with a contextualised inquiry involving interviews and participant observations (Salgado et al., 2017). Specifically, concepts related to DR, business analysis, and software engineering models were applied. A model-oriented analysis and system development techniques were used to demonstrate knowledge and also to elicit ideas from participants to inform the design process, since graphic presentations made it possible and easy to deliver complex emerging concepts (Huang et al., 2013). More so, a case diagram, data flow diagram and service system architectural design diagram were used alongside other design methods and tools to illustrate service requirements, as it helped the designer to construct, visualise, and document the proposed service system design solution at a more conceptual level (Group Object Management, 2010), hence conceptual knowledge. This was necessary to facilitate the identification of users' experiences, motivation and value(s) to designing a service.

To produce user-centric services, stakeholder insights were incorporated into service development whereby a variety of SDR tools and techniques was used. This was to assist the designer with capturing customer activities, propositions, motives and general user experience towards producing the desired services (Patrício et al., 2011). The designer capitalised on the users' experiences and opinions in order to capture and represent the service requirements through their activities and the context (Patrício et al., 2011). Therefore, a user experience-based approach was employed to enhance human-computer interaction whereby concepts and notation related to software engineering and SDR were used to create user-centred services (Huang et al., 2013). According to the author, this models the service concept as the actual value offered to the customer in terms of various resultant service offerings. This study used a variety of SDR tools and techniques to create a service prototype, that is, the design solution. These included co-design, service blueprint, case scenario, sketches, wireframes and prototypes, among other techniques (Salgado et al., 2017; Teixeira et al., 2019; Lupse et al., 2012; Moritz, 2005).

9.5 Person-centred health care cloud service

This sub-section explains the relationships between the interceptions of the three circles representing key concepts for research, including person-centred care, information services

and cloud records, which then lead to the creation of various services in the cloud platform as illustrated in Figure 10.1.

9.6 The role of HIT in transforming the health care sector

HIT, also known as eHealth, involves the design, development, creation and use of interoperable ISs; it minimises fragmentation of health systems to improve medical care, and it lowers costs, increases efficiency, reduces errors and enhances patient satisfaction (Holmgren & Adler- Milstein, 2017). HIT may be defined as the cost effective and secure use of ICTs in support of health and health-related fields, including accessing health care services, health surveillance, health education, knowledge and research (Hu & Bai, 2014). This is attributed to the tools having the capability to embrace the emotional needs of patients, and, as such, represents support for patient-centred care (Runaas et al., 2017). Therefore, the main aim of HIT is to promote cooperation and coordination of health care so as to enhance the quality of health care while reducing the cost of care at the same time (Hu & Bai, 2014). Common HIT tools include EMRs, EHRs and PHRs, which have mostly been researched and adopted in developed countries such as America, Europe and Asia as opposed to developing nations, according to literature (Heart et al., 2017; Caligtan & Dykes, 2011; Lehnbohm et al., 2013; Hu & Bai, 2014).

9.6.1 Electronic medical records (EMRs)

According to Caligtan and Dykes (2011), the concept of EMR is a legal record created in hospitals and ambulatory settings, whereby the data are sent to the EHR. The tool is used by physicians to track patient health data and history for the referencing, monitoring and evaluation of health care services in a single health facility (Heart et al., 2017; Garrett & Seidman, 2011). The content of EMR includes patient demographics, progress notes, medical problems and diagnosis, prescriptions and medications, and vital signs, among others (Heart et al., 2017). Key functionalities of an EMR include patient charts, order entry, results retrieval, appointment scheduling and registration, electronic prescribing, clinical decision-making support, patient portal, electronic messaging, note taking, and image management (Caligtan & Dykes, 2011; Heart et al., 2017).

EMRs, according to Net Health (2016), emerged in the 1960s whereby clinicians could record medical diagnosis and treatments for their own reference, while third parties would independently verify the diagnosis, leading to a breakthrough in medical recording. The computer era saw the emergence of a new, portable medical record model in 1980, thus easier communication of health information and improved coordination of care. Large hospitals adopted EMRs in the 1980s and 1990s, unlike smaller facilities where they were hardly used. Entry of the Internet to clinical practice early in 2000 saw the rise of EMRs, leading to improved communication of prescriptions to date (Net Health, 2016). Advantages of EMRs include

enabling clinicians to view and track complete patient history in order to facilitate clinical care decisions, and seamless access to medical records by medical professionals within a single facility (Garrett & Seidman, 2011; World Health Organisation, 2007). There is improved productivity of physicians since they can understand patients' condition and profiling of cases before treatments. As such, they are able to provide for better care, check patient drug consumption by cross-referencing prescriptions, and identify illnesses based on symptoms and patient characterisations, thus making evidenced-based clinical decisions (Heart et al., 2017). However, the disadvantage of EMR is that they are clinician-centred rather than personal, thus no support for patient self-care management (Garrett & Seidman, 2011). Furthermore, as EMRs progress to maturity, concerns have been raised by physicians about its efficacy, particularly doctor-patient privacy. The tools are too generic; it does not support care across all specialties, hence low adoption rates (Net Health, 2016; Heart et al., 2017). However, with the application of appropriate design and technologies, better specialty-oriented solution(s) can be developed to bridge this gap, especially between software and the practitioner. While using the SDR strategy and CC technologies, tailored solutions can be developed with respect to context(s) of use in order to guarantee effective practice-specific documentation, which this research confirmed.

9.6.2 Electronic health records (EHRs)

An EHR system is an extension of EMR functionality (Grant & Thomas, 2017). EHR is defined as a repository of health information gathered across the longitudinal electronic record of the patient (Caligtan & Dykes, 2011). For EHRs, data can be generated from different health care settings (Heart et al., 2017), and the record can be owned by the health care organisation, provider, or patient. EHR is an inter-organisational system that enables digitisation and sharing of patient data (Heart et al., 2017). The key functionality of EHR is similar but not limited to those of EMRs, which comprise patient demographics, progress notes, problem lists, vital signs, medical history, laboratory data, and radiology reports, among others (Caligtan & Dykes, 2011). Contents of EHRs are similar to those of EMRs, except that it supports seamless access to patient data by stakeholders beyond a single facility (Al-Nassar et al., 2011).

The concept of personal care marks the beginning of EHR systems around 2004, after the publication of care re-design recommendations in the USA in 2001 (Caligtan & Dykes, 2011). Initial objectives were formulated to recognise patients as the sources of control of their care through sharing knowledge, evidence-based clinical decisions, transparency in care, and cooperation among clinicians (Caligtan & Dykes, 2011). To address problems of health information fragmentation and paper-based documentation, the Office of the National Coordinator (ONC) set strategic goals for the adoption of EHR systems to ensure availability of EHRs to the majority of Americans by 2014. Government and other institutions began to use

EHRs, but only a few tools could adequately support health data interoperability (Caligtan & Dykes, 2011).

In 2009, the American Recovery and Reinvestment Act (ARRA) and Center for Medicare and Medicaid Services introduced incentives to encourage “meaningful use” of EHRs to promote the quality, safety and effectiveness of care (Caligtan & Dykes, 2011). Standards were established to enhance information exchange, with objectives such as ability to maintain active medication lists, sending reminders to patients, sharing reportable laboratory reports, and maintain updates to patient care and self-management (Caligtan & Dykes, 2011). EHR information is more accurate and complete, with minimal medical errors (Kleynhans, 2012; Ruxwana et al., 2010; Al-Nassar et al., 2011; Botha et al., 2015).

The advantage of EHRs is that they are more beneficial to modern clinical practice and they support specialisations to provide specific therapeutic treatments, thus improving patient care unlike generic models of EMRs (Heart et al., 2017). However, implementation barriers of EHRs include lack of universal terminology, resistance to adopting computer technology, illiteracy, non-involvement of stakeholders, and lack of expert knowledge on disease classification systems, among others (Kruse et al., 2016; Al-Nassar et al., 2011). Therefore, organisational context is essential to understanding organisation-wide vulnerabilities (Menon et al., 2014; World Health Organisation, 2006) in order to justify variations in EHR tools in different settings (Menon et al., 2014; World Health Organisation, 2006). To improve EHR success, Sinsky et al. (2014:728) drafted four principles for EHR design, implementation and policy, including user-centred design (UCD), health care professionals, efficiency as well as regulation and payment as shown in Table 2.9, which marked the onset of the EHR era.

Despite positive outcomes from EHRs, there are indications of negative perceptions among clinical practitioners’ concerning productivity and use patterns (Lanham et al., 2013). Also, perceptions regarding the benefits of EHRs differ across medical specialties, where psychiatrists have expressed no interest at all (Heart et al., 2017). The authors recommend further research to understand specific functionalities of EHRs in consideration with the principles of improved care delivery. Given the evidence of dissatisfaction with EHRs, it would be important to design solutions aligned to the context(s) of use, with a thorough understanding of the service components, work processes and service touch points to ensure their efficacy. This research used contextualised inquiry with a qualitative approach to understand appropriate design considerations. Designerly methods were used by employing the SDR strategy to deliver the desirable solution (Moritz, 2005). Specifically, the concept of *designerly methods* in this research implies the study of designing whereby design activity is viewed as a subject of scientific investigation (Cross, 2001).

Table 9.1: Principles of EHR design, implementation, and policy
(Source: Sinsky et al., 2014:728)

Table. Principles of EHR Design, Implementation, and Policy	
Patient-centered design	
1. The use of an EHR should add value for the patient.	
2. The primary function of an EHR is clinical care.	
Health care professionals	
3. The use of an EHR should improve, or at a minimum not reduce, the well-being of health care workers.	
4. The use of an EHR should align the work with the training of the worker.	
5. The EHR is a shared information platform for individual and population health.	
Efficiency	
6. The use of an EHR should minimize waste.	
7. Electronic workflows should align with clinical work.	
8. Various methods of communication, including nonelectronic forms, will be necessary for optimal patient care.	
Regulation and payment	
9. Sufficient resources should be available for the new work associated with the advanced use of an EHR.	
10. Policies around EHR use should reflect the strength of the evidence base supporting them.	
11. Regulatory balance between often competing values (i.e., clinical quality vs. security or efficiency vs. performance measurement) should be sought.	

9.6.3 Personal health records (PHRs)

A PHR system is defined as a patient-oriented computer-based tool allowing patients to access and manage their lifelong health information gathered from different sources and to make appropriate parts of it available to those who need it at any point in time (Romero et al, 2016; Tang et al., 2006). In the recent past, PHRs have become popular as a patient-centric model for exchanging health information, given its ability to merge data from different sources while it allows health care practitioners to access full patient medical history online (Liu et al., 2017). A PHR is an extension an HER, but it is tailored specifically for the patient's inputs, hence more patient-centric (Rodolfo et al., 2014; Househ et al., 2014).

PHRs are essential in terms of care transition intervention, particularly for aged patients, to fulfill patient experience. The tool has the potential to manage health data emanating from multiple sources, thereby assisting users to organise and interpret patients' experiences (Kouroubali & Katehakis, 2019). According to literature, the functionality of PHRs includes: capturing and updating data on patient demographics; finding health information; medical management; preventive care; laboratory test/results; provider selection; insurance and payment; allergies; family history; appointment scheduling with physicians; drug-drug

interactions; accessing laboratory results; prescription renewals; authorising referrals; doctor appointments; radiology reports; and supporting communication such as email alerts with physicians (Heart et al., 2017; Caligtan & Dykes, 2011; Botts et al., 2011; Thompson et al., 2016; Czaja et al., 2015; Liu et al., 2017). The history of PHRs can be traced back to the 1960-1970 period, although a number of studies claim that discussions on PHRs began around the year 2000 (Kim & Bates, 2011; Heart et al., 2017). PHR discussions first appeared in a German academic journal as *record linkage*, a tool for medical history taking.

More papers on PHRs for young female students were published under “*Saskatchewan adventure*” between 1973 and 1974 in Japan, marking the starting point of research motivated social interest (Kim & Bates, 2011). In 1982, problems of data collection triggered re-thinking the importance of records, and another paper known as “*Pocket-size health record*” was published, followed by a government publication, “*Health record for public health nursing activities*” in 1883 (Kim & Bates, 2011). Following the arrival of the Internet in the early 2000s, the PHR concept was revived in the USA for customised health care solutions to make health records more accessible to the consumers. The 2005 report entitled, “*From cancer survivor: Lost in transition*”, prompted the need to build a long-standing relationship between health care provider and the patient, leading to PHR products such as Google Health and Microsoft HealthVault in 2007 in US market (Caligtan & Dykes, 2011).

Recommendations for health information management systems (PHIMS) were proposed for worldwide adoption during the 10th International Nursing Informatics Conference (N12009). An advantage of PHRs includes the ability for data sharing and care coordination; hence, care providers are no longer the sole creator and/or custodians of patient health data (Heart et al., 2017; Caligtan & Dykes, 2011). Consumers take responsibility of their health records since they record health experiences in their PHR, and authorise access to the records at their own discretion (Caligtan & Dykes, 2011). PHRs enable users to import data from different sources including institutions and home monitoring devices, making it convenient for patients (Alyami et al., 2017; Caligtan & Dykes, 2011). The tools promote personal policy, which is the current global standard for health management (Czaja et al., 2015; World Health Organisation, 2016b).

According to Botts et al. (2011), PHRs have the potential to create opportunities to reduce some of the disparities in health care delivery. The value of PHRs include patient empowerment, enabling relatives to become more involved in patient care, positive health outcomes from joint decision-making with health care providers, and better access to patient health information for both the patient and doctor (Bantom et al., 2016). However, financial and health benefits may not be realised in underserved contexts due to the barriers of digital divide, issues of patient privacy and security, and individual factors such as an individual’s work flows. According to literature, issues associated with the digital divide include accessibility, usability,

literacy, health education, technology and health care in general. Also, little is known about the structure and actual functionality of a working PHR system for consumers, hence poor and/or low usability across the board. Also, according to literature, the usability and structure of a working electronic PHR system would probably be different from those created elsewhere, thereby confirming the need to contextualise the design and development of these tools (Czaja et al., 2015; Genitsaridi et al., 2015; Vincent et al., 2008; Fernández-Alemán et al., 2013; Salgado et al., 2017). More so, there is no agreed upon universal definition of a PHR system among the HIT research community (Thompson et al., 2016; Czaja et al., 2015).

The aforementioned facts have been confirmed in a study by Sieverink et al. (2019) to assess the fidelity of a PHR service in chronic care such as diabetes. The study sought to explain the found effects that could not be discovered by solely looking at the effectiveness of the technology in an experiment-oriented trial. Mere experimental evaluation(s) on eHealth interventions does limit the use of the tools (Sieverink et al., 2019). Recent literature reviews on the implementation of eHealth interventions, including PHRs, emphasise that the perceived fitness of eHealth technologies with current job tasks and the interoperability with similar systems are key factors towards their successful implementation. As a result, despite their potential to induce effectiveness on outcomes, that is, improved self-management skills, clinical outcomes, and the organisation of care, exploitation of the benefits remain scarce due to difficulties in their implementation, hence the proposed study.

9.7 Theories, models and frameworks of PHR systems

This section discusses the theories, distinct models and general frameworks for PHR models. Specific PHR models include stand-alone, tethered (Institution-specific) and integrated (hybrid web-based) model PHR systems, which are described in the subsequent sub-sections.

9.7.1 PHR system models

9.7.1.1 *Stand-alone PHR model*

An independent record does not connect with other HISs (Tang et al., 2006). It is mostly PC-based; enables the consumer to organise, copy, and store medical data onto portable devices; is flexible to access; is maintained under the physical control of the patient; and facilitates the sharing of information with care providers. Their key disadvantage is that data are entered manually, thus, the accuracy and completeness of the data are questionable (Detmer et al., 2008).

9.7.1.2 *Tethered PHR (Institution-specific) model*

This model is a PHR with a patient portal linked to a single health care provider's EHR (or database) to offer access to parts of the patient's EHR. It is internet-based, with the patient

data under the physical control of the provider, although the patient can access information to parts of their record (Detmer et al., 2008).

9.7.1.3 Integrated PHR (hybrid web-based) model

This is a web-based type of PHR fully controlled by the patient, collecting health data from various sources, i.e. EHRs, insurance claims, pharmacies, home monitoring, and diagnostic devices (Tang et al., 2006). It allows data entry to specific parts of the record, enables consumer access to the provider's records, eliminates manual entry of data, serves as communication channel for the patient, minimises medical errors, and minimises duplication (Detmer et al., 2008).

During a study to analyse design tensions in the implementation of a hybrid PHR system in Norway, Vassilakopoulou et al. (2019) involved various design teams to compare their deliberations concerning the design requirements for both the patients and the health care providers in two PHR systems, *MyBook* and *MyHealth*. Specifically, *MyBook* is a web-based application used to store personal health data, while the *MyHealth* application is part of the government's national eHealth platform. The study identified three themes, namely: control allocation, to be viewed as a patient owned system; content origination, to consider the acceptable data sources; and user environment localisation, considering the user interface (Vassilakopoulou et al., 2019). According to the authors, all the three dimensions of tensions were geared towards decisions related to regionalisation. The regionalisation of areas within a common collaborative space enabled the various design teams to protect their views, hence service contextualisation, which was relevant in the design decisions regarding hybrid information spaces, and which was in this case PHRs that were partly communal and partly private (Vassilakopoulou et al., 2019).

9.7.2 PHR frameworks

In a study to establish the factors influencing patients' use of ePHR services to counter implementation failures of these systems, Abd-Alrazaq et al. (2019) identified a total of eighteen (18) factors. These factors were then categorised into personal factors (13), human-technology interaction factors (4), and/or organisational factors (1). Key personal factors observed include gender, ethnicity, and income. Perceived usefulness and ease of use were found to be among the key human-technology factors, which revolve around the perceptions and expectations of individuals about a technology. The organisational dimension was mainly associated with facilitating conditions, including the processes of implementation, and/or organisational structures as well as the perceptions of end-users regarding the ePHR services (Abd-Alrazaq et al., 2019). However, a major limitation of the study is that it was based on a literature review rather than primary data. Therefore, the validity of the findings is questionable to some extent, thus compromising the adoption of the study's findings. Consequently, the

study is not context-sensitive, which makes the applicability of the findings in different health care contexts difficult. While this research considered explore the aforementioned factors, qualitative approaches were employed to investigate the research context in order to deliver a PHR solution with meaningful use in the context of its use.

In an effort to address the information gap concerning the lack of the patient's full access, viewing and tracking of important medical data stored in hospital created EHR systems, Zhou et al. (2019) developed a mobile-based PHR application to facilitate easy management of various types of personal health data. To achieve this, a user-centred development approach was used whereby participants were actively involved throughout the needs assessment, system design and development, and evaluation. A new mobile PHR service known as PittPHR was delivered comprising six modules, namely: health records, history, trackers, contacts, appointments, and resources. The system's architecture demonstrates the various technologies used while it is organised into two major parts: the mobile client and the back-end sides. The mobile client application side runs on the user's mobile device and contains the system modules and related services. The back end on the other hand comprises the database, security, and API services, whereby the two sides interact using Hypertext Transfer Protocol (HTTP) and JSON Data exchange protocols as shown in Figure 9.4.

The application allows users to customise the records as per individual information needs, hence supporting patient-centred care. However, while the study is based on empirical observations, the aspect of context has not been addressed based on the understanding that the overall health care context plays a central role in the design and implementation of patient-sensitive interventions (Waweru et al., 2019; Tsekleves & Cooper, 2017). The proposed solution is therefore generic and may therefore not be applicable in different health care contexts. This research employed context-sensitive approaches and techniques to deliver a PHR service that is meaningful in the context of use in order to offer adequate support for patient-centred care.

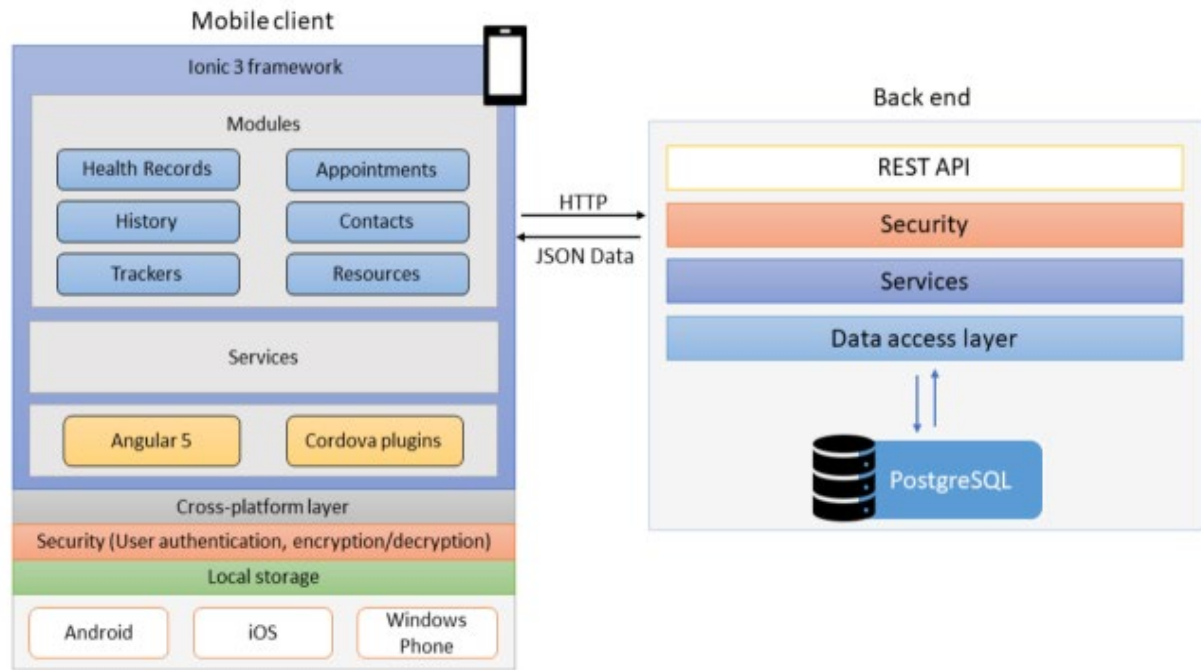


Figure 9.4: System architecture of the mobile PHR application (PittPHR)
(Source: Zhou et al., 2019:4)

Upon realising a lack of a unified view of patients' health history, Roehrs et al. (2017) embarked on a study to provide an architectural model for a distributed PHR system to facilitate integration of the service for both the patients and health care providers. Specifically, an OmniPHR was developed, enabling patients to have a full view of their health data scattered in different institutional databases (data silos). Also, the solution offers health care providers seamless access to up-to-date patient records even if changes were made to the data source(s) (Roehrs et al., 2017). According to the authors, patients can be empowered to maintain their personal health history in a unified viewpoint regardless of the type of device used. Consequently, health organisations will have patient data from different institutions interconnected with elasticity and scalability of the solution.

Figure 9.5 represents the authors' partitioned PHR in data blocks solution, which is then distributed in a network comprising twelve nodes grouped into four sub-networks for different user groups, including hospitals, health professionals, first aid stations, and clinical examination laboratories (Roehrs et al., 2017). The various user groups can use different devices to access the PHR system either as providers or as consumers due to the solution's capability for OmniPHR, that is, present everywhere irrespective of the user's location.

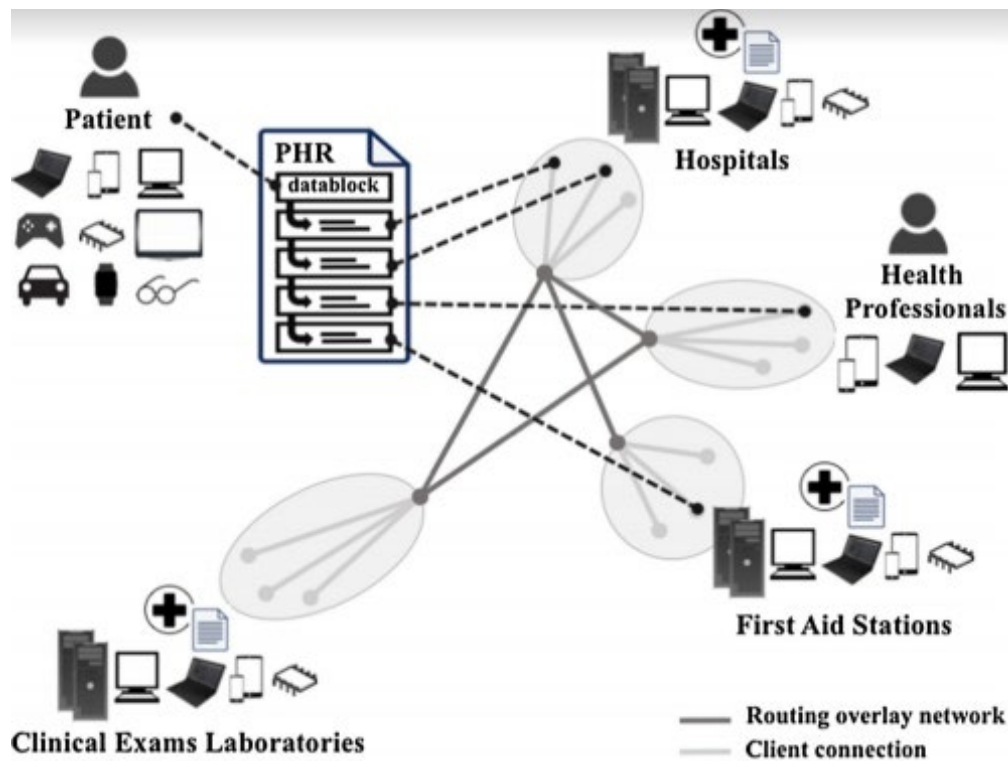


Figure 9.5: An OmniPHR distributed in the network
(Source: Roehrs et al., 2017:74)

To achieve this, a P2P network is used with routing overlay, i.e. an application server with defined roles in a cloud-based environment with scalability and elasticity features. Among the strengths of the model is that it demonstrates compliance with the principles of patient-centred care to a larger extent, which is key in modern health care. These include the ability to provide seamless access to personal health data and management, thereby empowering the patient. In addition, the model provides various modules and business components as well as relevant data security features for each data block, given the sensitivity associated with patient data.

However, while the study attempted to provide a robust solution to address most of the technical challenges associated with the design and implementation of eHealth interventions, the framework is based on a literature review rather than on empirical observations, and as such, is not context sensitive. According to Chan et al. (2010), the selection of patient-oriented health technologies particularly in developing countries should be based on three factors: (i) situational factors; (ii) existing technology in relation to health interventions and target patients; and (iii) empirical evidence. Given the nature of complexity associated with health care delivery, the proposed solution may not be generalised outside the original context, meaning it needs to be validated. To counter these limitations, this research used context-sensitive methodologies and approaches to gather empirical data to understand the research context better to deliver meaningful eHealth services in the context of use.

During their study to analyse the functionalities for a mobile-based PHR application specific to pregnancy monitoring, Bachiri et al. (2016) identified the estimated due date and weight tracking as the most common functionality features in literature. According to the study findings, the due date information feature was considered crucial for expectant mothers as it helped in following the evolution of the pregnancy and awareness of the remaining days. The weight tracking information feature on the other hand provides details related to a woman's health, including waist measurements and the body mass index (BMI) calculator among and other variables such as glucose levels and blood pressure (Bachiri et al., 2016). This informational feature of the application enables women to become aware of the various changes taking place in their bodies during the gestation period, for example the growth and size of the foetus and problems or related risks at each stage. However, just like most of the other reviewed literature, the study was a literature review and therefore not context-sensitive. The findings are based on theory rather than empirical observation, which render the study weak in terms of validity, hence the current research to engage an empirical approach.

According to Thompson et al. (2016), PHR system outcomes are influenced by interactions between users, tasks performed, tools used to accomplish those tasks as well as the physical, social, and/or organisational environment or context in which users operate. Figure 9.6 shows different categories of sub-factors that cause barriers affecting the usability of PHRs among the patients, providers and caregivers. However, the framework fails to consider stakeholder engagement as well as the technical barriers towards meaningful use of PHRs, hence not holistic.

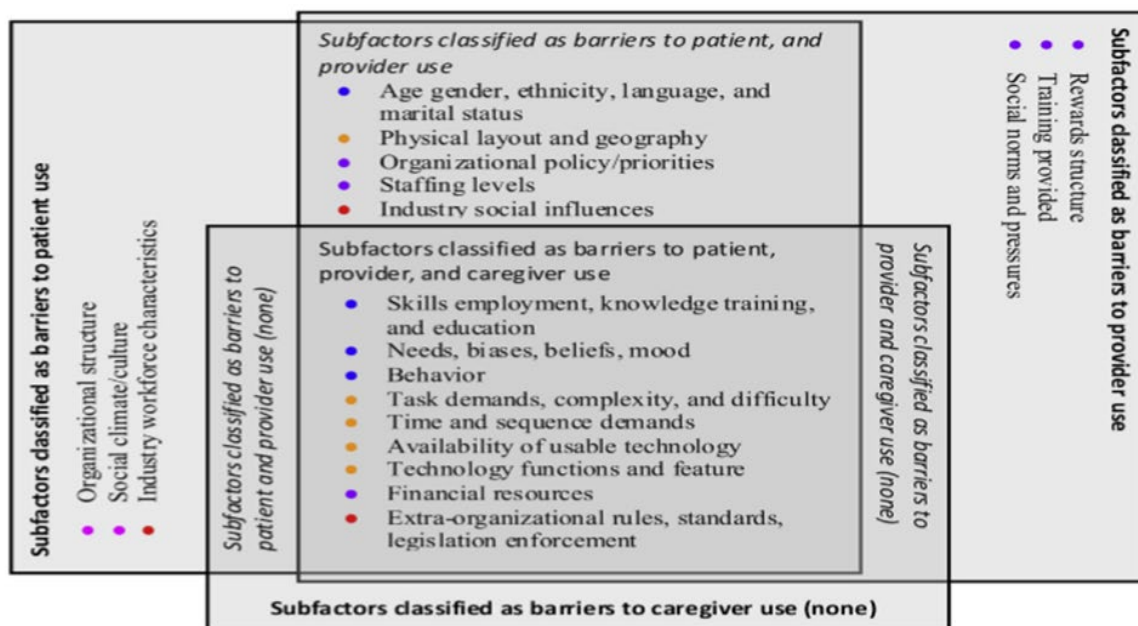


Figure 9.6: Categories of barriers to using the PHR service for each population
(Source: Thompson et al., 2016:223)

In their effort to provide a framework for the meaningful use of PHRs, Househ et al. (2014) observed that it is vital to design tools that meet the expectations of physicians, i.e. using computerised direct entry of medical orders, maintaining an up-to-date list of current and active diagnoses, maintaining active medication allergy lists, and recording patient demographics and vital sign changes. The authors, however, argue that it is necessary to understand the socio-technical effects on a patient's use of PHRs, while the patient should be extensively involved in the process to ensure meaningful use of the tool(s) towards health management. Despite an increased demand in the use of PHRs, Househ et al. (2014) during their study observed that the existing tools are mere extensions of the EHR, with limited patient input in their design. Therefore, as more patients and health consumers use PHRs, there is an increasing need to understand the manner in which patients use them. A framework was proposed to promote the understanding for meaningful use, as shown in Figure 9.7. According to the study, the key challenges hindering meaningful use of PHR systems were found to be associated with policy/regulation, managerial, multiple institutions, societal, cultural, and economic-oriented challenges. These challenges were then grouped into two broad categories, namely health system challenges and socio-technical challenges, which could then be used to understand the meaningful use of PHRs from the perspectives of both the patient and the physician. However, the model is generic, and may therefore not be applicable in certain environments with different circumstances. Also, the solution was developed on the basis of secondary data rather than an empirical study, which could have facilitated a better understanding of the meaningful use of PHR tools in the immediate context of use.

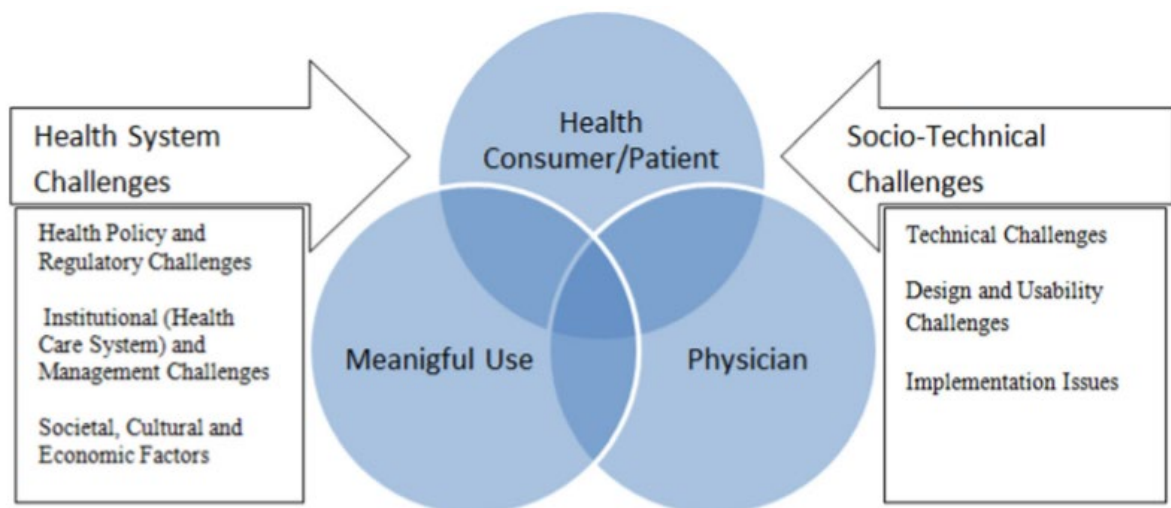


Figure 9.7: Framework for the meaningful use of PHR service
(Source: Househ et al., 2014:274)

While applying the lens of both stakeholder theory and SDR strategy, this research endeavoured to conduct contextual inquiry to gain insight into health care stakeholders' experiences to design a solution relevant within the context of its use. While using qualitative

approaches to analyse the research problem, “designerly ways of knowing” were followed to understand user experiences, particularly through service interaction points (Salgado et al., 2017). This informed and guided the design of a user-friendly PHR framework suitable for an underserved context, and with specific reference to communities living within Nairobi’s informal settlements. As observed in literature, however, the greatest challenge faced is the slow adoption of these technologies due to factors such as usability security, i.e. privacy and confidentiality (Li et al., 2010), which appears to be a major determinant in terms of adoption of the tools.

Generally, existing solutions have limitations, hence deficiencies that hinder successful implementation. Specifically, contextual issues have not been adequately addressed to address user needs accordingly. In addition, the majority of these solutions are mainly built on theoretical rather than empirical evidence, which does not factor issues related to the context of use. For instance, during their study to determine the usability of PHR systems among an underserved adult population in the USA, Czaja et al. (2015) identified a number of barriers, including low education, low health literacy and limited technology skills. The authors argue that little attention has been given to PHR usability issues and human factors among the underserved communities. To achieve a wider adoption of PHRs among these vulnerable groups, diverse consumer needs should be taken into consideration, which include their circumstances and experiences with using HITs, existing health systems management, and government regulations and policies (Czaja et al., 2015).

During a research project to establish the reasons behind the demise of Google Health, it was noted that the PHR application failed to demonstrate clear and desirable health outcomes for user-centred care as well as the workflows in the health care service delivery process (Mora, 2012). The system was mainly adopted by tech-savvy patients, high risk patients and their caregivers; subsequently, there was little impact on the majority of Americans. The innovation did not foster considerations for ecosystem development, including the co-creation of new interactions, laws and policies, and cost reduction, among others. Therefore, there is a need for further research to gain a better understanding of the nature and use of these tools from experts and stakeholders in different contexts, to guide the development and adoption of these tools (Househ et al., 2014; Kim & Bates, 2011; Czaja et al., 2015).

This study adopted context sensitive methodologies to deliver meaningful eHealth solutions the context of use to deliver desired health outcomes.

9.7.3 Other eHealth frameworks

There exist several eHealth implementation frameworks; however, none of these address the actual requirements in developing countries holistically (Boore, 2018). This can be attributed to the complex nature of the health care environment, which is characterised by overlapping strategic issues and interests among different stakeholders (Manya et al., 2012; Manya et al., 2016), which then hinders efforts towards the growth and maturity of eHealth in most developing countries, Kenya included. Challenges mostly experienced in eHealth include standards, policies, legislation, infrastructure and ICT capacity building, according to the authors. Noticeable is that existing eHealth frameworks are not context sensitive, hence they do not support people-centred care; they are more non-technological rather than technical, while their development is informed by secondary data. This renders them deficient in terms of meeting individuals' real needs in underserved contexts (Boore, 2018; Korpela et al., 2013).

During her study to investigate existing eHealth implementation frameworks for developing countries, Boore (2018) applied the Grounded Theory (GT) approach by using primary data to develop a framework comprising five factors towards holistic implementation of eHealth innovations. These factors include regulatory, society and political e-readiness as well as managerial practices and information systems (IS) capability. The regulatory aspect deals with laws, policies and standards to govern eHealth implementation process. The societal aspect involves designer and developer understanding of people's attitude, culture, economic potential and IT training or literacy skills. The political aspect involves authorities' goodwill to provide an enabling political environment. The managerial aspect involves ensuring support from the top management, effective change process management, engaging the IS leadership, organisational politics and self-interests. The IS capability aspect includes connectivity, ICT competency, system/service integration, online safety and a robust infrastructure.

Similarly, Du Preez (2018) conducted a study using a constructivist grounded theory (CT) method to investigate perceived interaction barriers among the South African ageing community of users to generate new insights into the socio-technical context. The study developed a theory to guide the designing of practical online interactions for the aged, i.e. Ageing User Decision-Determined Engagement (AUDDE). Three key-points were identified with *interaction*, namely decision to interact, outcome of interaction, and reflection on interaction, which acted as constructs linking core categories to represent relationships between core categories. According to Du Preez (2018), the decision to interact was based on two factors: perceived benefits and online user context. However, despite similarities in DSR and action research (i.e. GT and CT), the proposed frameworks are mainly theoretical, hence they only generate behavioural/design theories as opposed to an IS artefact, which has utility characteristics and is therefore more meaningful or beneficial (Baskerville et al., 2009).

Therefore, while this study employed the SDR strategy, which was equally developed from primary data and similar to both the GT and constructivist approach, the researcher explored stakeholders' perceptions and views to gain insights into developing a design solution (framework). A prototype system for the proposed ICT-facilitated PHR service (IS artefact) was developed as a proof of the concept of the design.

9.8 Essential features of cloud computing

CC has become a popular service platform today for service providers who offer different types of services to clients from a single web portal (Weider et al., 2011:223). There are five essential characteristics of CC technologies, of which services are deployed on a service-oriented architecture (SOA) as shown in Figure 9.8. These services include (Lupse et al., 2012).

- **On-demand services:** Users connect to a website to access computing resources at their convenience
- **Wide network access:** Ubiquitous web services are provided from within the cloud environment, hence they can be accessed using different network devices anytime and anywhere
- **Pooling resources:** Users share computing resources which are dynamically reallocated and/or hosted anywhere
- **Elasticity:** User flexibility is enabled to scale systems and costs accordingly
- **Measured (metered) services:** Resource usage is monitored and recorded, thus enabling pay-per-use mode unlike other models of computing

According to Weider et al. (2011), SOA refers to a business-centric IT architectural approach that supports the integration of businesses and provides a variety of loosely integrated services that are re-usable, platform independent and can communicate with each other. The CC architectural framework comprises a variety of both development and service models, as shown in figure 9.8.

The concept of SOA motivates developers to adopt design principles that allow the development of domain specific and independent applications, including in health care, hence business-centric (Weider et al., 2011). This capability promises huge potential in establishing sustainable HIT infrastructure, hence the rapid trend of adopting CC that has been witnessed in the health sector in the past few years (Hu & Bai, 2014).

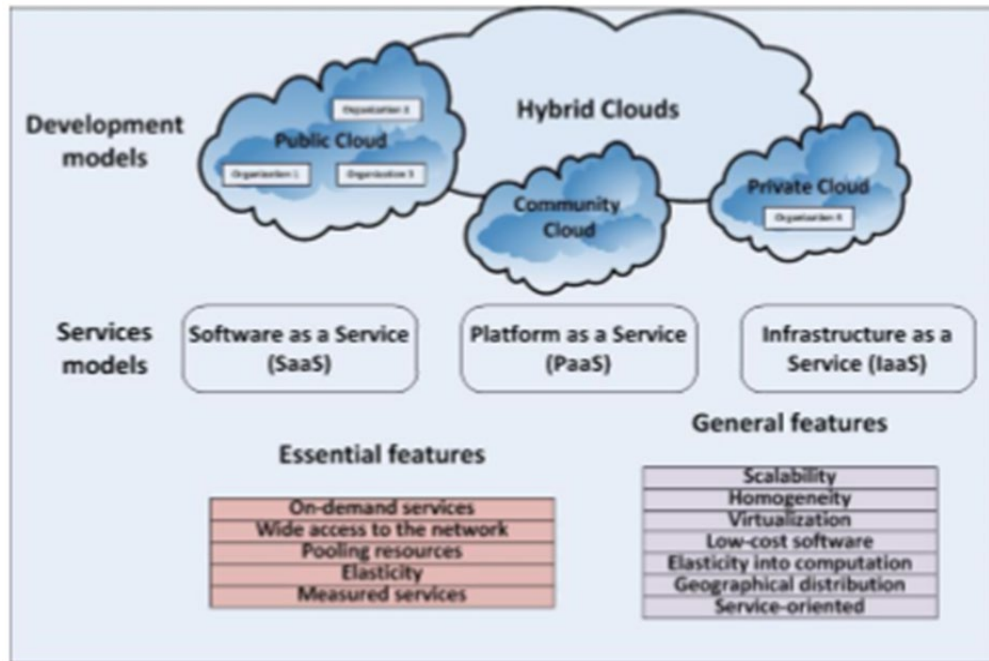


Figure 9.8: Elements and characteristics of cloud service
(Source: Lupse et al., 2012:81)

In their study to investigate the selection of different CC products, Arianyan et al. (2016) proposed a hierarchical cloud taxonomy engine, enabling developers and consumers to choose cloud services based on their needs and real capabilities of different CC products. The authors also presented a new evaluation mechanism to facilitate sorting of the cloud products according to customer needs and requirements as well as a model for classifying cloud features. The taxonomy comprises eight elements, namely: deployment model, backup and recovery, technical features, management features, legal issues, service features, financial features, and security features (Arianyan et al., 2016). Specifically, the deployment element involves cloud implementation models, platform models, and connectivity, that is, connection topology of cloud centers. The technical features, on the other hand, focus on the cloud platform, virtualisation through the hypervisor technology, hardware and software support, resource allocation, standards for interoperability, billing, technical limitations, and green computing support (Arianyan et al., 2016).

Key security features highlighted include levels of security (tiers 1-4), data safety through encryption locality and isolation, security reporting and monitoring of servers, network and storage devices, access control and reporting (Arianyan et al., 2016). The service element covers service types such as IaaS, PaaS and SaaS, compatibility, user friendliness, and QoS (Arianyan et al., 2016).

The management component addresses issues to do with architecture, management support, policy enforcement, SLA monitoring, and service orchestration, among other features (Arianyan et al., 2016). The backup and recovery dimension comprises both data and system

backup, termination of services, and an automatic recovery system for easy resuscitation of cloud services in the event of a system crash (Arianyan et al., 2016). The aspects of legal and guarantee/support focus on license type, support policy, guarantee type, language(s) to be supported, law enforcement and compliance to regulations (Arianyan et al., 2016).

While Arianyan et al.'s (2016) study provides a robust cloud taxonomy engine for the selection of cloud products, this research used the study as a pointer to borrow relevant ideas and concepts in order to design appropriate cloud-based eHealth services that will meet and support the users' requirements. Given the variations in terms of different health care contexts, this research only adopted features relevant to the research context.

9.9 The significance of cloud computing in health care

Health care institutions, that is, both private and public including hospitals, medical research centers, and health professional are seeking alternative approaches to increase efficiency in service delivery at a lower cost. One of these alternatives is implementing CC technologies, which, if well implemented, can address challenges faced by the health care industry (Ali et al., 2018; Reddy & Reddy, 2014). In the recent past, an increased demand for CC technologies has been witnessed in the health care sector due to the rapidly changing health care environment (Reddy & Jansen, 2008). This has been triggered by the need to provide effective and low-cost medical services, hence competition among health care providers to make this dream a reality. Cloud technologies offer immense opportunities to the health care industry through improving the quality of services to health consumers, operational facilities, accessing and sharing of information irrespective of distance, and to reduce health care costs (Ali et al., 2018; Reddy & Reddy, 2014). The following include some of the key factors that have accelerated the adoption of CC in health care:

- **User-centric features:** CC has user-centric features that enhance the development of patient-centric health care solutions, thus promoting the personal health care model (Hu & Bai, 2014). According to the authors, this encourages care receivers' involvement in their own health care, provision of technical solution(s) for social networking and health education to facilitate patients' self-management. According to Botts et al. (2011), CC is an example of health cyber infrastructure that provides greater opportunities in accessing disparate health data and enhances user experience in managing their health. Medically underserved populations, and individuals with chronic diseases in particular, will more frequently experience positive outcomes from freely accessing their health information (Botts et al., 2011)
- **Cost effectiveness:** CC provides ubiquitous, convenient and on-demand network access, pay-as-you-go mode of pricing (metered service), and interoperable health care services over the Internet, thus sharing health data. This enhances coordination and creates a co-operative economic environment that reduces health care integration costs for health care organisations and optimises resources (Hu & Bai, 2014; John & Shenoy, 2014; AbuKhoussa et al., 2012). CC

has several benefits, particularly for small businesses as they do not have to buy expensive hardware and software to compute and manage data internally, thereby minimising HIT investment costs (Nkosi & Mekuria, 2010). Opportunities exist for designing eHealth solutions that provide health care consumers with seamlessly accessible and low-cost tools to address the needs of individuals, communities and/or populations (Botts et al., 2011)

- Secure use of ICT services:** The continuous and rapid growth of technology comes with security challenges that have an impact on users (i.e. individuals, organisations and communities). CC can provide SecaaS, which comprises a variety of secure eHealth services, including data storage, data mining and health surveillance, and health education and research, among others (Hu & Bai, 2014). This can be achieved through the use of access control techniques, including identity-based encryption (IBD), attribute-based encryption (ABE) and role-based access control (RBAC), to protect the integrity of data. CC security services enable the controllability and traceability of data as well as health resource access authorisation through authentication, which enhances security and privacy of health care clouds (Hu & Bai, 2014). Health organisations can benefit from cloud-based security services by adopting appropriate cloud-based security management framework(s) as shown in Figure 9.9 by Nkosi and Mekuria (2010), which provides SecaaS as a service for mobile health applications that have limited computational power in untrusted computational infrastructure(s)

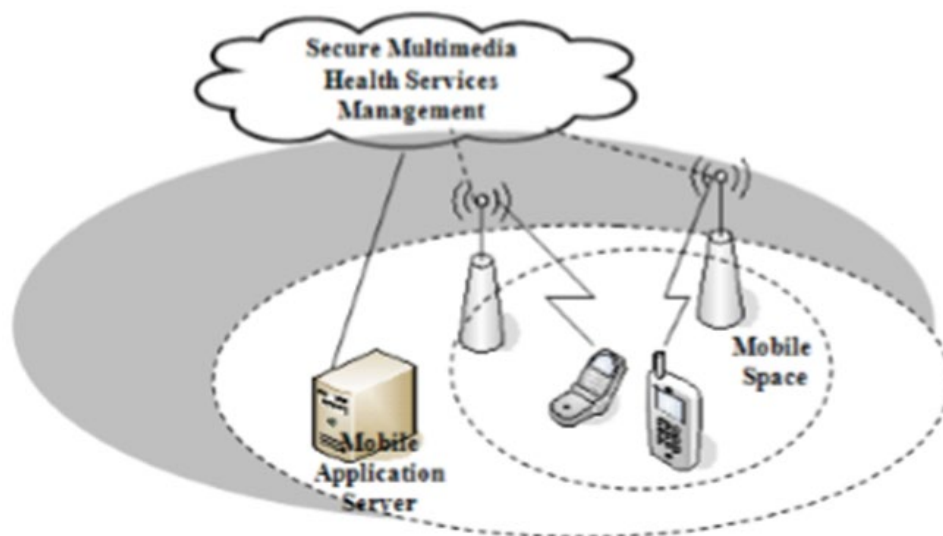


Figure 9.9: Cloud-based mobile health security management
(Source: Nkosi & Mekuria, 2010:630)

- Health interoperability:** The high accessibility, availability and reliability of services makes CC technology an ideal solution for health care interoperability and integration problems, hence the ability to offer a unified patient medical record containing patient information from different care episodes, being the main goal of eHealth towards quality health services (Hu & Bai, 2014; AbuKhoua et al., 2012). Through the use of application programming interfaces (APIs), third party systems are able to access health data and functionality from remote servers, thus

creating customisable applications which enable seamless data accessibility anytime and anywhere in the world (Botts et al., 2011; John & Shenoy, 2014; Nkosi & Mekuria, 2010). More so, health cyber infrastructures can offer better solutions to fragmented health care systems, thus minimising duplication of medical data and services, hence care coordination, which enhances preventive care services, and reduces hospitalisations and hospital emergency cases, among others. This increases the pool of information resources from different clinical data sources, including EMRs, EHRs, PHRs, and health information exchange (HIE) initiatives (Holmgren & Adler- Milstein, 2017), which can improve operational excellence of hospitals and registries as shown in Figure 9.10 (Botts et al., 2011). Subsequently, health care stakeholders, including care providers such as doctors, nurses and patients, enable themselves to minimise medical mistakes, preventable readmissions, and health care costs (Hu & Bai, 2014; Alamri, 2012)

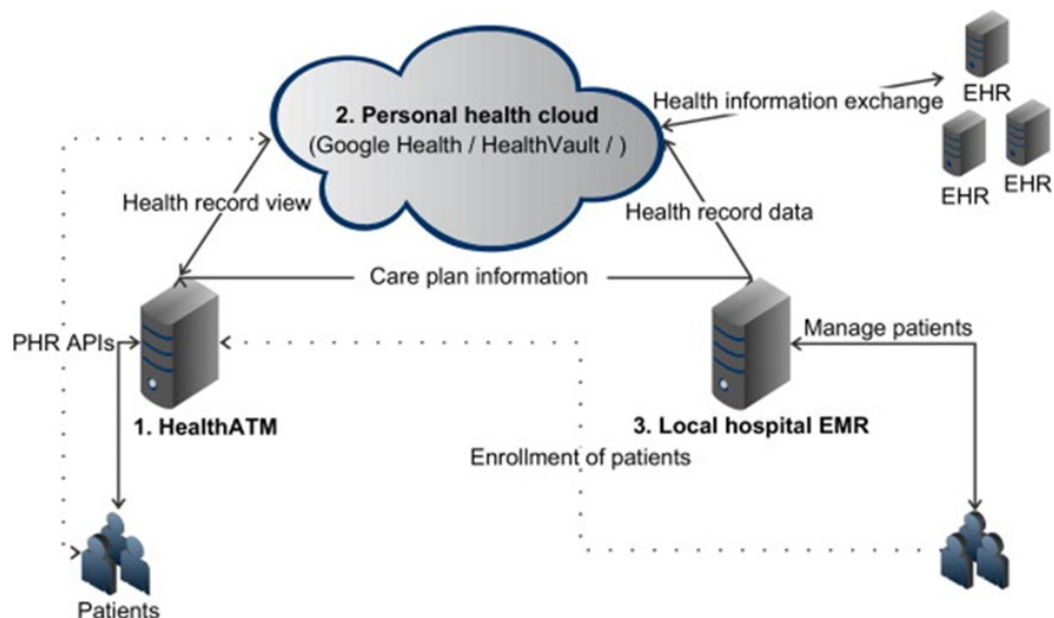


Figure 9.10: Health ATM architecture
(Source: Botts et al., 2011:118)

- Big Data storage capacity:** CC provides better data storage and processing services for huge amounts of digital health data, which can be seamlessly accessed, exchanged and/or shared across the health care system (including health institutions) using EMR, EHR and PHR systems through sensors and a variety of home monitoring devices as well as third party research institutions at local, national and international levels (Hu & Bai, 2014; John & Shenoy, 2014). This is attributed to a variety of health care services that need be offered to patients and the fact that traditional HIT infrastructure cannot accommodate massive amounts of health data generated and may need to be archived for many years. For instance, the Health Insurance Portability and Accountability Act (HIPAA) obligates health care providers in the USA to keep medical records for a period of six years from the date of discharge. Traditional HIT models cannot manage these volumes of data, thus causing a burden to health care institutions (John & Shenoy, 2014). Cloud-based data can be accessed directly by authorised medical personnel for evidence-based decision-making through remote diagnosis, remote monitoring and care,

and emergencies, among other services (Alamri, 2012). Furthermore, CC's capacity for enormous data storage promotes the development of Big Data mining solutions in health care, including disease surveillance, diagnosis, and treatment and policy decisions

- **Facilitation of medical research:** eHealth CC's interoperability and its ability to accommodate huge patient data repositories which can be accessed across the board, promote medical research (Shakil et al., 2020; AbuKhousa et al., 2012). Data mining tools can be created and used to detect new disease trends and patterns to enhance medical research, diagnosis and treatment. Also, clinical trials can be undertaken through partnerships between cloud owners, medical research and academic institutions and pharmaceutical companies to discover new medicines

However, the use of CC in health care is not without challenges. These challenges are grouped into three main categories: technological issues; security and privacy issues; and legal issues (Ali et al., 2018). Technological issues involve risks associated with: (i) lacking the necessary ICT infrastructure such as Internet connectivity in health care organisations to support CC-enabled services; (ii) possible intrusion into cloud-based platforms for medical device(s); and (iii) the inability to clearly define scalability requirements for cloud-enabled health care service and related technical complexity. The security and privacy dimension of cloud health include data integrity, confidentiality of data in cloud storage, and privacy risks concerning trustworthiness and data sharing (Shakil et al., 2020; Ali et al., 2018). The legal category involves policies and regulations associated with the use of CC technologies in health care (Ali et al., 2018). These include the aspects of contract law, intellectual property rights, and jurisdiction(s) of information, among other factors (Ali et al., 2018).

This research comprised an empirical investigation involving the relevant stakeholders to gain deeper insight into the research context. This helped unearth critical design issues to adequately address the aforementioned issues through the proposed cloud-based PHR solution.

9.9.1 Cloud-based health and wellbeing services

Demand for health data and computing power in health care remains critical since stakeholders need ubiquitous access for evidence-based decision-making (Pundo et al., 2013; Karuri et al., 2014b). CC promises a feasible health care computing infrastructure to provide better health care solutions (AbuKhousa et al., 2012; Haskew et al., 2015). Cloud-based technologies can effectively optimise computing resources pertaining to data collection, processing, storage, sharing, interoperability, Big Data analysis and self-care/management (Kaur & Chana, 2014; Kumar & Chaithra, 2015). HIT infrastructure is quite complex, thus, health organisations should take advantage of additional measures available in CC such as

data security services, and particularly considering the requirements of HIPAA (Lupse et al., 2012).

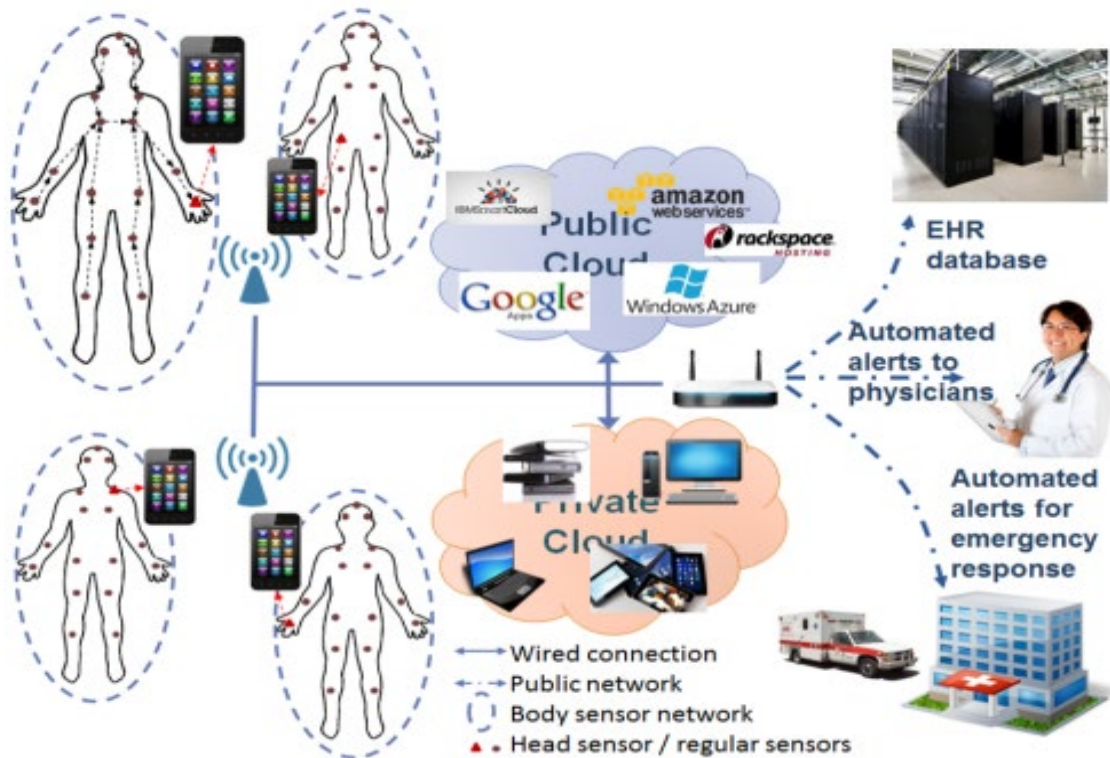


Figure 9.11: Mobile cloud computing for health care infrastructure
(Source: Wang & Jin, 2019:66775)

In a study focusing on mobile cloud computing, Wang et al. (2019) performed a comprehensive review on the advances and state of the art of pervasive HITs. Mobile cloud computing technologies play a big role in supporting the delivery of health care service. Ideally, mobile cloud services in health care should be categorised into two dimensions: mobile cloud computing and mobile cloud storage services (Wang & Jin, 2019). The mobile cloud computing dimension deals with offloading and executing intensive computational tasks from mobile to the cloud, which relieves a mobile device(s) from handling complicated, energy-consuming tasks (Aceto et al., 2015). This helps with addressing some of the major concerns in mobile cloud computing, including prolonging the limited life span of the battery of mobile devices. However, the unpredictability associated with these communication networks causes much faster energy consumption by the wireless communication module of mobile devices, hence, time and energy overheads (Deng et al., 2014). At the same time, despite mobile cloud computing being an ideal HIT service solution for exchange, transmission, processing, and storage of EHR and PHR data as illustrated in Figure 9.11, there are many factors associated with these services that may hinder optimum performance of the technology (Wang & Jin, 2019). Noticeable is that this situation may easily lead to dire consequences in health care,

particularly in terms of data security and privacy. It is on this basis that Wang and Jin (2019) attempt to describe the general architecture as well as the relevant design considerations to be factored in when designing mobile cloud computing services in health care. Specifically, Wang and Jin's (2019) study presents popular state-of-the-art optimisation methods to meet various computational and data security demands, which may be used to leverage mobile cloud computing technologies.

The nature of computing tasks performed on the enormous amounts of health data in a cloud environment attracts the manifestation of potential risks of data leakage, thereby compromising privacy. At the same time, security attacks have become a nightmare to the stakeholders, and particularly to the service providers (Wang & Jin, 2019), which limits optimisation of pervasive health care in mobile cloud computing technologies. To pave the way for future research towards enhancing the effectiveness of mobile cloud computing, the authors provide a general discussion on: (i) mobile cloud for health care applications utilising HERs, PHRs, picture archiving and communication; (ii) a taxonomy that summarises health care mobile cloud architectures, including sensors and mobile devices, cloud computing, and communication networks; (iii) leveraging mobile cloud computing and storage for pervasive health care; (iv) optimisation strategies used in mobile cloud health care today; and (v) security and privacy concerns and how to manage these in mobile cloud health care.

Thus, CC is one possible solution to effectively address challenges associated with the integration of modern technologies such as the Internet of Things (IoT) into health care (Dang et al., 2019). However, challenges include storage, management, and data exchange between devices as well as security and privacy issues. CC enables seamless access and sharing of medical data and related infrastructure in a ubiquitous and transparent manner while offering on-demand services over the network and performing operations that meet the growing needs of health care organisations. Important computing services offered include virtual servers, databases, networking, software, and data analytics tools over the Internet, hence faster service deployment, flexibility of resources, and reduced costs through economies of scale. CC therefore guarantees a solid foundation for the advancement of IoT in health care to transform human lives (Dang et al., 2019).

According to Hu and Bai (2014:17), cloud Big Data storage seems to be the most ideal solution in managing huge amounts of patient health data, which can be easily shared among hospitals and third parties such as government and research institutions. Cloud ability to support ubiquitous network access, Big Data mining, disease diagnosis and treatment, as well as reduced cost for health care organisations are among the key drivers for cloud adoption in the health care domain (Hu & Bai, 2014). The authors further argue that person-centred care model(s) will be the future trend for patients as active participants in their own health care.

There is thus a need to design cloud-based health care innovations with user-centric features to provide technical and social networks as well as health care education solutions to promote health and wellbeing (Hu & Bai, 2014). However, the application of CC in health care is still very immature, while most related studies have been conducted in developed contexts (Hu & Bai, 2014).

Figure 9.12 presents a generic architecture for eHealth cloud, which focuses on services to improve the quality of patient care with increased operational efficiency (AbuKhoussa et al., 2012).

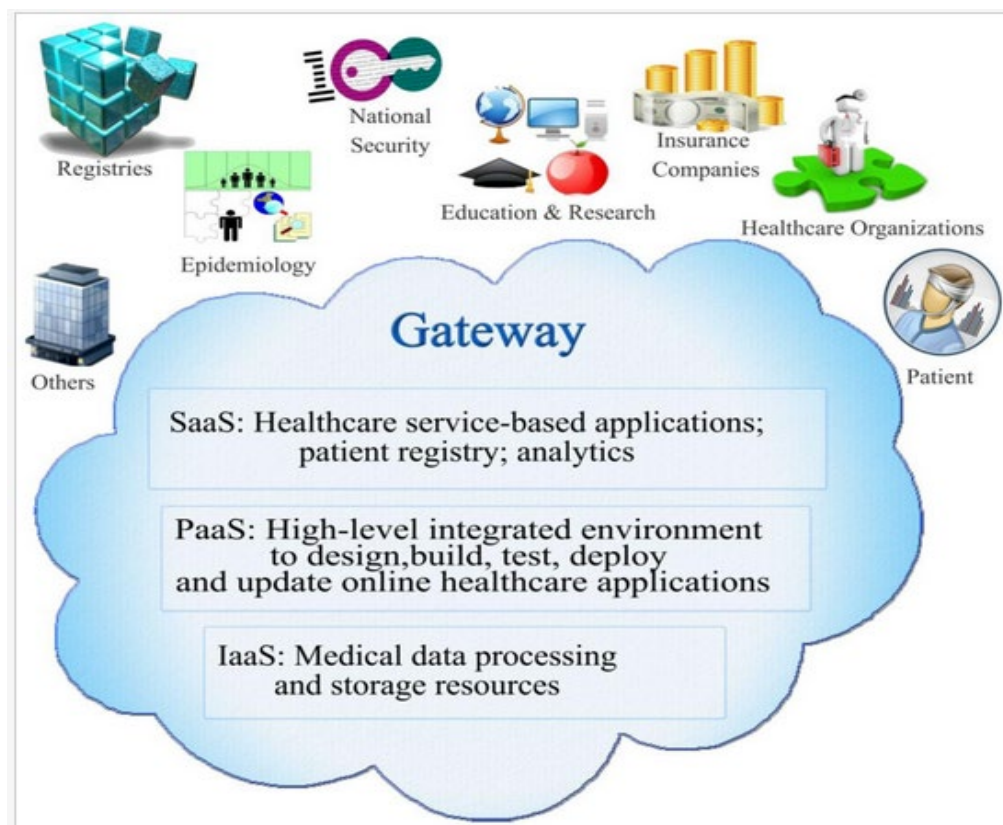


Figure 9.12: Generic architecture for eHealth cloud
(Source: AbuKhoussa et al., 2012:627)

Figure 9.12 is a diagram of an eHealth cloud consisting of an array of service layers ranging from the IaaS layer for storage and service infrastructure, to the PaaS layer for application development and SaaS for applications and communication (AbuKhoussa et al., 2012). The services may be implemented as a private cloud, public-cloud or hybrid cloud. The various eHealth cloud layers facilitate optimisation of the cloud environment for health care data management by providing a platform to create pre-built software tools for HIT providers, software designers and HIT solutions for health care stakeholders, including health care providers, patients, insurance providers, and research institutions.

Faster access to medical records from any location can accelerate the quality of diagnosis and treatment, thereby avoiding complications and saving lives, which CC can guarantee. More importantly, health care collaboration among stakeholders is enhanced through the use of cloud health, given its flexibility in the mobility of individuals for work or holidays (Lupse et al., 2012). With a cloud-based model, heavily loaded health care demands are met, thus, making it a viable approach towards providing better health care solutions by health care providers, which is pre-requisite to timely prediction, detection, communication, diagnosis and treatment of medical problems (Poppe et al., 2013). It ensures availability of the right information at the right time to save lives, hence the need to harness technologies and opportunities to foster sustainable health care ecosystems (Manya et al., 2016; Yang et al., 2015).

To address network resource limitations in transmitting eHealth multimedia services over heterogeneous networks, Alamri (2012) proposed a CC-based framework that uses Scalable Video Coding (SVC) to enable heterogeneous devices to use database storage when executing heavier multimedia applications and/or delivering m-Health services over limited bandwidth resources. However, Alamri's study has not addressed the issue of data exchange format(s) for heterogeneous cloud health data types, i.e. patient data, given highly fragmented health care systems despite spirited efforts in search of appropriate health care solutions.

In an attempt to alleviate limitations of ubiquitous mobile devices as service platforms, (Nkosi & Mekuria, 2010) proposed a CC-based framework to improve ubiquitous mobile device utilisation in order to enhance health care service delivery to the marginalised rural communities. However, while the authors demonstrated that multimedia and security operations could be performed in the cloud using CC-based protocol management techniques to address the challenge of mobile device limitations, the study noted non-involvement of medical professionals and users in the design of health monitoring innovations (Nkosi & Mekuria, 2010).

9.9.2 Cloud service provisioning strategies and considerations

The ever-increasing adoption of CC technologies and its variety of services is evidence of its distinct promises and benefits to the health care industry, which was expected to grow to \$5.4 billion by 2017 (Reddy & Reddy, 2014; Whaiduzzaman et al., 2014b). Service may be defined as a special type of relationship between the service provider(s) and the service user(s) (Whaiduzzaman et al., 2014b) whereby the cloud service provider (CSP) may provide services in two forms: as service provider and as cloud provider. A service provider (SP), in this case, is an entity that creates and avails services for running business operations on behalf of the client and recording (publishing) them in the cloud. A cloud provider (CP) on the other hand is an entity that owns the cloud and may offer cloud services internally on the cloud (Zhao et al.,

2013; Shamshirband et al., 2015; Whaiduzzaman et al., 2014b). Therefore, CC service provisioning is a process that provides customers with access to predefined computing resources according to customer needs. However, to satisfy users, the quality of service (QoS) rendered by the CSP must be compliant with the SLA. This means a contract between the customer and CSP must be drawn up that specifies the terms and conditions of the contract, and which includes on-demand availability, pricing, security, data privacy, integrity, authentication, scalability, elasticity and energy efficiency (Garg et al., 2013; Yassa et al., 2013; Shamshirband et al., 2014). Given increasing numbers of cloud providers (CP) and service offerings, clients should compare the various cloud services offered by different CSPs according to their predefined needs, policies and compliances in order to select the best option (SP), such as client data protection, security and confidentiality/privacy, among others, according to various international standards and authorities (Rahimi et al., 2012).

Therefore, QoS, SLAs, standards and customer requirements are crucial ingredients for providing services, as they will enable the client to compare, predict and rank provisioned services as per the client's needs (Whaiduzzaman et al., 2014b). Figure 9.13 is a representation of a taxonomy to visualise the concept of cloud service provisioning in a more holistic manner, which includes the objective(s), services, topologies, user requirements, indicators (metrics) and approaches, that is, models, methods and techniques that may be employed (Whaiduzzaman et al., 2014b).

Fair comparison, compliance, ranking and competency prediction of CSPs are considered among the most important objectives of a service user besides determining a suitable cloud topology (Whaiduzzaman et al., 2014b). While a single cloud is limited to provision of services to a user by a single CSP or CC data center, an InterCloud facilitates on-demand reassignment of resources and transfer of workload(s) through federated cloud systems of different CSPs based on various user needs in accordance with the SLAs and standards (Whaiduzzaman et al., 2014b). Consequently, a client should know and identify the ideal cloud service model(s) needed to run their business operations, i.e. IaaS, PaaS, SaaS and SecaaS (Weerasiri et al., 2017). More importantly, understanding user requirements is critical while choosing an optimal CSP(s) whereby factors such as agility, availability, pricing, security, trust, and general QoS should be considered (Jinno & Tsukishima, 2009; Rosenthal et al., 2010; Whaiduzzaman et al., 2014b; Mouratidis et al., 2013; Salama et al., 2012).

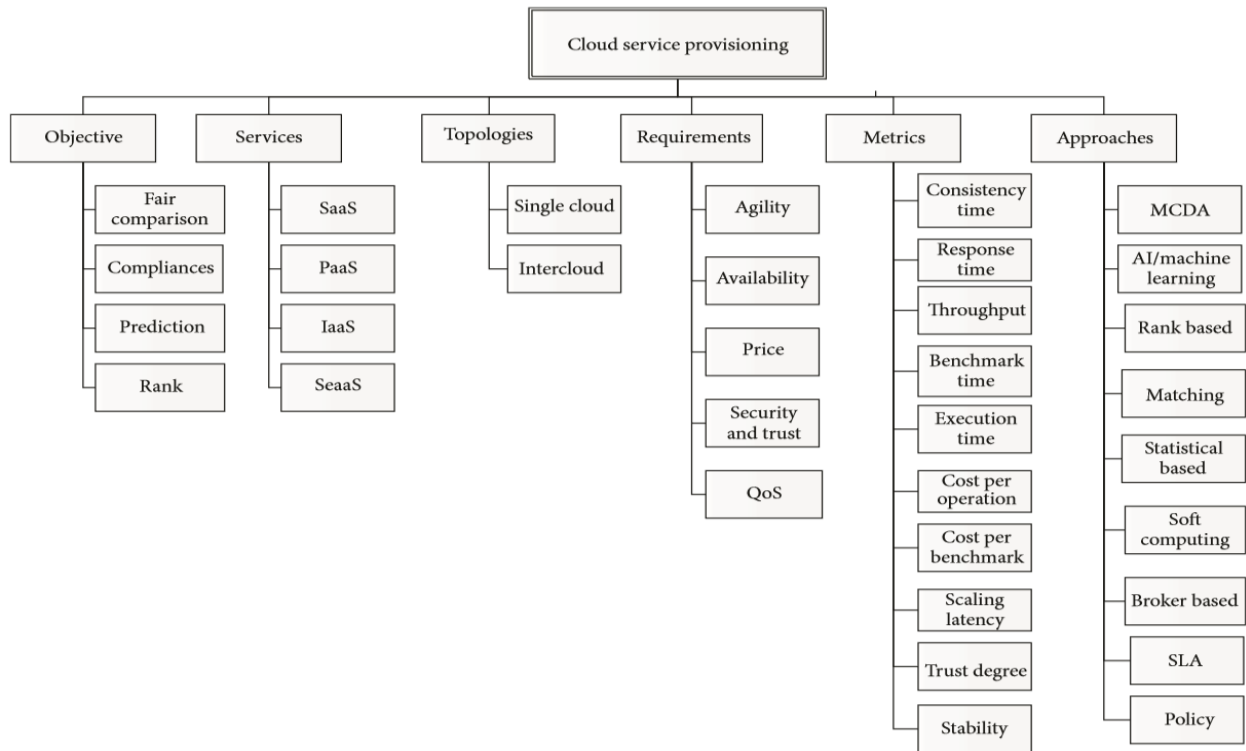


Figure 9.13: Taxonomy of cloud service provisioning
(Source: Whaiduzzaman et al., 2014b:3)

In their study involving a taxonomic survey of cloud resource orchestration, Weerasiri et al. (2017) proposed a unified and comprehensive analysis framework to enhance an understanding of the orchestration of cloud resources from the perspective(s) of concepts, paradigms, languages, models and tools. The aim was to provide a cloud resource orchestration technique from a holistic point of view. The model is based on the life cycle model similar to that of cloud resource artefacts, which include consumers' selection of resources; configuration of resources description attributes and relationships; deployment to instantiate cloud resources; monitoring compliance with QoS and SLAs; and controls to curb possible violations (Weerasiri et al., 2017). Cloud orchestration reference architecture is devised through the categorisation of processes and services based on their corresponding functionalities. These include the resource provision layer to support basic operations such as creation, reconfiguration, and deletion of cloud resources; the resource management layer involving the automation of complex management tasks; the description layer providing resource, orchestration and policy descriptions; and the user layer involving interaction with cloud resource consumers. For a user(s) to be able to determine and select appropriate cloud service(s) from a variety of choices available, Whaiduzzaman et al. (2014a) proposed a taxonomy of multicriteria decision analysis (MCDA) with eleven techniques to facilitate this process. The techniques are: Analytic Hierarchy Process (AHP); Analytic Network Process (ANP); Technique for Order of Preferences by Similarity to Ideal Solution (TOPSIS); Elimination and Choice Expressing Reality (ELECTRE); and Preference Ranking Organisation

METHod of Enrichment Evaluations (PROMETHEE), among others (Whaiduzzaman et al., 2014a).

While this research borrowed ideas and concepts from the aforementioned cloud service frameworks, the SDR strategy was employed to create context specific cloud-based solutions that would be meaningful in the context of use. Besides looking at stakeholder/ consumer requirements, the researcher also considered the technological, security, and legal perspectives (Ali et al., 2018).

9.9.3 Cloud standards

According to the Institute of Electrical and Electronics Engineers (IEEE), standards are published documents that establish specifications and procedures designed to ensure the reliability of materials, products, methods, and services people use every day. These include various protocols and guidelines that help ensure product functionality and compatibility, facilitate interoperability, and support consumer safety and public health (IEEE Standards Association, 2011). Likewise, cloud standards provide guidelines to organisations for selecting of various cloud services and models, i.e. online provisioning of storage services for applications and data in the cloud (ICT Authority, 2016). Various international authorities have published inventories of specific standards to guide and support the functions and requirements of CC. These authorities include NIST, International Organisation for Standardisation (ISO), European Network and Information Security (ENISA), Health Insurance Portability and Accountability Act (HIPAA), International Telecommunication Union (ITU), and Cloud Security Alliance (CSA), among others (Whaiduzzaman et al., 2014b). Key standards for CC include cloud interoperability, cloud portability and cloud security (Mell & Grance, 2011).

9.9.3.1 Cloud interoperability standards

Given the nature of cloud technology, there exists a variety of capabilities and functions among different cloud provider interfaces, hence the need for consolidation. The use of good standards should therefore be a primary goal (Parameswaran & Chaddha, 2009). The harmonisation of standards for cloud interfaces among provider interfaces is crucial in understanding key interoperability requirements and features to ensure compliance and user satisfaction, hence attempts to unify various cloud APIs and abstract it behind an open and standardised cloud interface (Parameswaran & Chaddha, 2009). According to the author, a key driver for a unified cloud interface (UCI) is the creation of an API about other APIs. This applies to each of the primary service models (IaaS, PaaS and SaaS) whereby two categories of interfaces should be provided in each of these for cloud users, namely Self-service Management API and Functional Interfaces. The self-service management API enables the cloud consumer to manage and control their use of the cloud services while the functional interface is for managing the contents of the cloud.

- **IaaS cloud:** The functional interface represents virtualised computing resources, namely the central processing unit (CPU), RAM/ROM or memory and input/output (I/O), which are used by an operating system upon which a stack of software runs. The main standards used in IaaS management interface are the Open Cloud Computing Interface (OCCI) standard for IaaS resource management, and the Cloud Data Management Interface (CDMI) standard for storage management and storage functional interfaces
- **PaaS cloud:** The functional interface for PaaS comprises a set of libraries and components within its runtime environment upon which operations are developed in various languages and executed whereby J2EE and/or .NET application platform standards may be used. The self-service management interface of PaaS oversees the life cycle of applications and the corresponding resources that depend upon on the platform
- **SaaS cloud:** The functional interface of SaaS facilitates access and utilisation of the SaaS application through a web browser. The self-management interface oversees administration and customisation of application functionality for each consumer, such as adding users, user authentication, and monitoring each user's consumption or resources. Interoperability between a web server and the user's browser is achieved through web standards and/or protocols such as TCP, HTTP, SSL/TLS, IP (v4, v6), HTML, XML, AtomPub, RSS, and JavaScript/JSON, among others. The standards can be used in a variety of web browser-based management interfaces since they are not cloud specific. In situations where SaaS services are utilised by another cloud or system as a service, interoperability is achieved using domain specific standard canonical data content formats which mainly use XML standards. Examples include OAGi BODs, which apply in business documents, while ODF and OOXML are applicable in office documents. Also, SOAP, WS-* and ebXML are used as interoperability standards across stack interfaces for packaging and transport. Specifically, SaaS management interface interoperability on web service interfaces should be guided by Identity and Access Management (IAM) security standards whereby the "principle of least privilege" is applied, that is, only the minimum necessary access should be granted to a user(s) to perform an operation for the minimum possible amount of time (Popovic & Hocenski, 2010)

9.9.3.2 *Cloud portability standards*

The virtual (cloud) infrastructure involves packaging, transporting/movement and deployment of pre-configured systems ready to run on demand, which include applications, data and the operating systems from one cloud to another via the Internet. Portability standards for the distribution of VMs to and between cloud platforms are crucial in facilitating the portability of inter-cloud workloads, which may be either single VM or multiple VMs. In this case, the Open Virtualisation Format (OVF) standard is used to handle portability issues between different virtualisation platforms. It contains metadata on virtual machine image(s) to be deployed as one unit, known pre-package configurations of a virtual machine image(s), details concerning the number of CPUs as well as memory needed to run optimally, network

configuration details and digital signatures to guarantee the integrity of the VM images to be deployed with corresponding End User License Agreements (EULAs).

Cloud storage requirements for both metadata and actual data should be considered to facilitate data and application portability using canonical data formats and protocols for secure data interchange and migration such as JSON and XML. More importantly, portability standards serve as a safeguard against vendor lock-in, hence flexibility for the cloud consumer to move into and out of a cloud. Portability of data is important because the data itself exist in different types, formats, and volumes, among others, and it may flow across various platform (inter-cloud) environments.

9.9.4 Cloud security standards

Data confidentiality, data integrity and the availability of information are three cyber security priority concerns, perceived as risks associated with cloud computing. Cloud data, therefore, are exposed to physical and logical threats, which include: calamities of nature, for example, fire outbreaks and flooding; organised crimes, such as hacking (intentional unauthorised system access by intruders); denial of service; compromised data confidentiality and integrity; and accidents (Mell & Grance, 2011). Given the nature of CC and specifically the aspect of multi-tenancy, there is a need to ensure data and system protection in terms of both logical and physical security. NIST highlights seven categories of security standards that may be used to guaranteed data security in a cloud environment:

9.9.4.1 Authentication and authorisation standards

Standards applicable to this level include: (i) RFC5280: Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile, used in Internet protocols such as HTTPS to secure browsing the World Wide Web and offline applications such electronic signatures; (ii) RFC 3820: X.509 Public Key Infrastructure (PKI) Proxy Certificate Profile used for the Internet to describe a certificate(s) originating and signed by X.509 Public Key End Entity Certificate to provide restriction on proxying and delegation within a PKI-oriented authentication system; (iii) X.509 and ISO/IEC 9594-8: Information technology, open systems interconnection; (iv) The Directory: Public-key and attribute certificate frameworks to facilitate communication between application entities, people, terminals and distribution lists; (v) RFC 5849: Open Authorisation Protocol (Oauth), used for sign-on and identity provision on the Internet. Other standards include: OpenID Authentication; eXtensible Access Control Markup Language (XACML), which is an XML-based standard to express fine-grained policies for information-access in XML documents and other electronic resources; Security Assertion Markup Language (SAML);, FIPS 181, i.e. Automated Password Generator; FIPS 190, i.e. guidelines for the Use of Advanced Authentication Technology Alternatives; and

FIPS 196, i.e. Entity Authentication Using Public Key Cryptography (Mell & Grance, 2011; Naedele, 2003; Cornwall et al., 2004).

9.9.4.2 Confidentiality standards

Standards applicable to this level include: (i) Key Management Interoperability Protocol (KMIP) which comprises a set of customised attributes to enable users to add metadata for improved key provisioning by the server (Rich et al., 2013); (ii) RFC 5246: Secure Sockets Layer (SSL) and Transport Layer Security (TLS) protocol which facilitate communication between client/server applications in such a way to prevent sniffing of data, and altering, corrupting or forging messages (Dierks & Rescorla, 2008); (iii) FIPS 140-2: Security Requirements for Cryptographic Modules, i.e. for the communication of requirements and the certification of products to verify compliance with the security standard in order to win customers' confidence; (iv) FIPS 185: Escrowed Encryption Standard (EES); (v) FIPS 188: Standard Security Label for Information Transfer to regulate user access and to provide protective measures and additional restrictions needed as part of a communications security policy; (vi) FIPS 197: Advanced Encryption Standard (AES), i.e. a symmetric block cipher used to encrypt classified, sensitive information in both software and hardware; (vii) XML Encryption Syntax and Processing (Caddy, 2011; Good & Benaissa, 2005).

9.9.4.3 Integrity standards

Data integrity refers to ensuring the reliability and accuracy of data in cloud storage that remain unchanged or altered by unauthorised entities. Some of the common protocols (standards) used to verify the integrity of data include: (i) XML signature (XMLDSig), which defines an XML syntax for digital signatures in XML documents; (ii) FIPS 180-3: Secure Hash Standard (SHS) used to generate a digital signature for verification alongside the signed data by the intended verifier; (iii) FIPS 186-3: Digital Signature Standard (DSS), which provides guidelines for the process of generating a digital signature to authenticate electronic documents; (iv) FIPS 198-1: The Keyed-Hash Message Authentication Code (HMAC), that is, a Message Authentication Code (MAC) using a cryptographic hash function and secret key (Mell & Grance, 2011; Jensen et al., 2009; Chandrasekaran & Simpson, 2013).

9.9.4.4 Identity management standards

This refers to protocols and standards that help manage verification and authentication through the use of Directory-as-a-Service (Daas), with capabilities to manage network access for cloud users, resources, and policies, to contain security concerns on data (Shah et al., 2019). Common protocols used in such a case include: (i) Service Provisioning Markup Language (SPML), that is, an open standard for integration and interoperability of service provisioning requests between users; (ii) X.idmcc–Requirement of IdM in CC for improving identity management as a service; (iii) Security Assertion Markup Language (SAML), that is, a

standard protocol that allows identity providers (IdP) to give and pass authorisation credentials to SPs; (iv) OpenID Authentication protocol used to facilitate decentralised authentication of users from various unrelated websites; (v) FIPS 201-1: Personal Identity Verification (PIV) of employees and contractors (Mell & Grance, 2011; Khan et al., 2011).

9.9.4.5 Security monitoring and incident response standards

These are protocols that protect organisational computing resources (assets) from cyber-attacks by creating a collection of forensic tools (Kent et al., 2006). Such standards include: (i) NIST SP 800-126: Security Content Automation Protocol (SCAP), that is, a set of specifications to standardise formatting and concepts by which security software tools communicate details on software identification, flaws and security configurations; (ii) NIST SP 800-61 Computer Security Incident Handling Guide; (iii) X.1500 Cybersecurity information exchange techniques, that is, a detailed description of how data should be exchanged in cyber-space; (iv) X.1520: Common vulnerabilities and exposures; (v) X.1521: Common Vulnerability Scoring System; (vi) PCI Data Security Standard (DSS) to guide organisations on how to handle branded credit cards to avoid identity theft in online transactions; (vii) FIPS 191: Guideline for the Analysis of Local Area Network Security (Kent et al., 2006; Mell & Grance, 2011; Waltermire et al., 2011; Rutkowski et al., 2010; Morse & Raval, 2008).

9.9.4.6 Security policy management standards

This refers to an Internet protocols (IP) layer for protection of organisations' IT assets through a firewall, which is a cyber-security rulebook (Stockwell et al., 1999). (i) Extensible Access Control Markup Language (XACML), that is, an XML-based open standard to provide security policies and access rights for web-based information services; (ii) FIPS 199: Standards for Security Categorisation of Federal Information and IS in terms of confidentiality, integrity and availability; (iii) FIPS 200: Minimum Security Requirements for Federal Information and IS (Mell & Grance, 2011; National Institute of Standards and Technology, 2006).

9.9.4.7 Availability standards

These include ISO/PAS 22399:2007 guidelines for incident preparedness and operational continuity management to ensure service availability and performance at agreed levels to customers on a 24/7 basis (Tangen, 2008).

9.9.4.8 Cloud computing context

Adoption of CC in health care has the potential to influence a fundamental change in the development, deployment, maintenance and payment for IT services (Marston et al., 2011; Gao & Sunyaev, 2019). According to the authors, CC can greatly enhance traditional HIT approaches if used meaningfully, thus enabling the health care industry to leverage important

benefits. CC adoption in this sector is however faced with a myriad of challenges that may hinder its meaningful use within health organisations (Marston et al., 2011). Among the common challenges experienced, include the inability to conduct adequate IT audits, technological issues such as data transfer bottlenecks, and data security issues and legal implications associated with service agreement/contracts (Kuo, 2011). Health care organisations are perceived to be very complicated in terms the operational complexity of medical services (Singh & Wachter, 2008). Furthermore, according to the authors, the health care context comprises different stakeholders who possess industry-specific features (Standing & Standing, 2008). According to Gao and Sunyaev (2019), the aforementioned issues render the health care phenomenon for CC as complex. Therefore, in order to guarantee its meaningful use, certain conditions must be met prior to CC adoption by health care organisations. Organisations should thus seriously consider relevant industry-specific factors prior to the adoption of CC services (Gao & Sunyaev, 2019). According to the authors, the existing literature has merely focused on CC adoption in general; it has not yet addressed the industrial specificities that inform the decision(s) on the adoption of CC in the health care context.

To bridge this gap, the study by Gao and Sunyaev (2019) sought to investigate determinant factors that influence the decision by health care organisations in the adoption of CC and related industrial specificities. The study identified five major categories of factors, which include technology, organisation, environment, data/information, and stakeholders. The technology category summarises the key variables associated with the characteristics of technologies to be adopted and their resultant effects. The key variables identified are compatibility and associated advantages, which include improved quality of care and finances in terms of better cost management. The organisation category of factors focuses on the health care organisation's context in terms of attributes and status. Key variables include available internal resources for IT adoption and the size of the organisation, while the determinant factors identified include IT culture and for-profit status (Gao & Sunyaev, 2019).

The third category of factors, which focus on the environment, describes the characteristics and status related to the health care context in terms of the surroundings and industry within which the organisation adopting CC operates. Among the key variables identified are competitive pressure and ruralness, while determinant factors include industry standards, market maturity, IT penetration, and special funding (Gao & Sunyaev, 2019). The data/information category focuses on key considerations related to the health care organisation's data/information requirements, and the key variables identified include security, privacy and interoperability (Gao & Sunyaev, 2019). The stakeholder category describes the relevant stakeholders in terms characteristics, attitudes and behaviours as opposed to the adoption of IT innovations by the health care organisation. The key stakeholder groups

identified include health care administrators, patients, policy makers, physicians, IT service providers/vendors, and IT users (Gao & Sunyaev, 2019).

Based on the above revelations from the literature, it is evident that an understanding of the overall context is a critical requirement when it comes to adopting CC by health care organisations. Context plays a significant role towards influencing the creation and development of meaningful cloud-based services in health care delivery. Specifically, the Whaiduzzaman et al. (2014a) MCDA taxonomic techniques framework plays a significant role here. This research therefore applied context-specific methodologies and approaches to engage the relevant stakeholders in order to gain insight and a better understanding of the research context to deliver meaningful cloud-based eHealth solution(s). This will go a long way in facilitating the delivery of quality health care service, thus improving population health outcomes.

9.10 Chapter conclusion

In this chapter, all aspects relevant to enabling technologies identified in the literature review were discussed. In the next chapter, all aspects relevant to the study are integrated into a conceptual theoretical framework to guide the study.

Chapter 10: Conceptual Framework

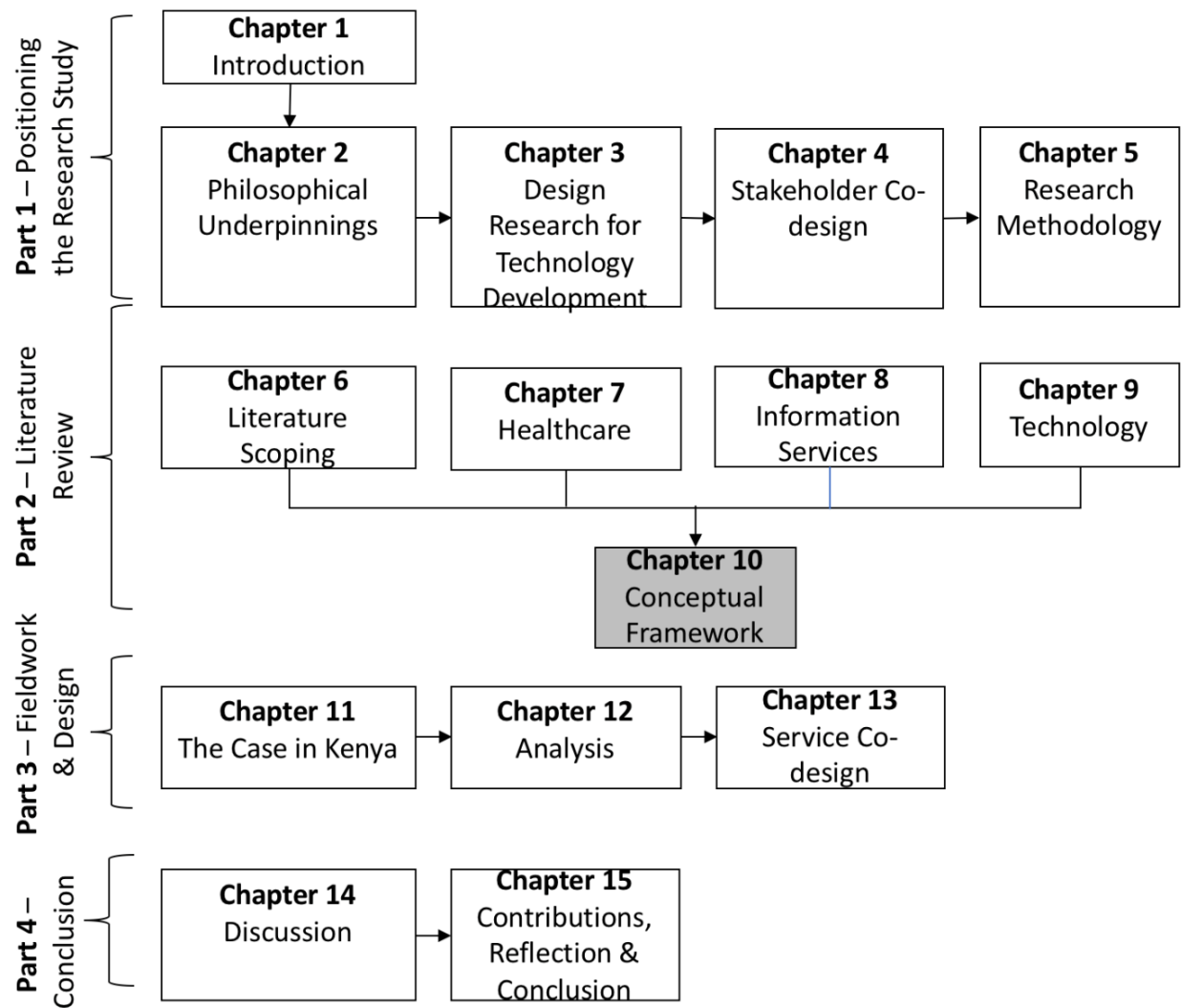


Figure 10.1: Thesis Layout - Chapter 10

10.1 Introduction

In this chapter, the philosophical underpinnings relevant to this study are reviewed and the philosophical assumptions for design research (DR) informing the proposed conceptual frameworks are explained. The proposed research approach, based on different disciplines, should result in contributions to the health care, services and ICT disciplines. Once the positioning of the study within the relevant disciplines is completed, the proposed conceptual framework guiding the fieldwork is discussed.

10.2 Summary of challenges and gaps identified from the literature

In Table 10.1 below, the main findings of the literature relevant to this study are summarised.

Table 10.1: Identified gap(s) in literature

Reference	Aim/objective	Challenges and gaps
Abd-Alrazaq et al.(2019)	To review the evidence regarding factors that influence patients' use of ePHRs	- The study is merely based on a literature review rather than primary data, hence it is context insensitive - Applicability of the findings in different health care contexts have to be verified
Zhou et al. (2019)	To develop and evaluate a new mobile PHR application that can easily be used to manage various types of personal health data	- The proposed solution is generic, it may therefore not be applicable within different health care contexts as presumed - The solution may have a deficiency in providing adequate support for patient-centred care
Boore (2018)	To develop a holistic framework for eHealth implementation in developing countries using the GT approach	The GT-oriented framework is only theoretical, it can therefore only generate behavioural and/or design theory, hence non-technical as opposed to developing an IS artefact, which could be more meaningful and proven
Du Preez (2018)	To design more effective online interactions for ageing population users	The constructivist grounded theory (CT) framework, limited to theoretical concepts in the design of online interactions for aged community and thus deficient of the practical aspect; hence, the proposed solution cannot be validated technically
Roehrs et al. (2017)	To develop a distributed model that integrates PHRs for patients and health care providers' use	- The study is based on a literature review rather than on empirical observations and is therefore not context sensitive - The solution cannot be generalised outside its original context, hence it must be validated first
Bachiri et al. (2016)	To analyse the functionalities of mobile PHRs that are specific to pregnancy monitoring	- The study is based on a literature review rather than on empirical observations and is therefore not context sensitive - The findings cannot be generalised to various contexts and must hence be verified
Thompson et al.(2016)	To identify work system barriers to patient, provider, and caregiver use of personal health records (PHRs)	- The study only focuses on non-technical barriers while ignoring stakeholder engagement and the technical aspects of implementation - The model is derived from secondary data and is therefore not fully context sensitive - The study was conducted in a developed context (USA), hence the findings may not be generalised or applied in a local developing context
Czaja et al. (2015)	To identify the demands associated with using electronic PHRs and to evaluate the ability of adults of lower socioeconomic status (SES) and low health literacy to use PHRs in order to perform health management activities	- The study relies on secondary data and is therefore not context-sensitive - The study lacks the element of stakeholder engagement as a possible strategy to enhance PHR adoption and usability - The setting of the study (USA) may not necessarily be similar to the local context (Africa)

As observed in the literature, the existing HIT innovations, including models and frameworks, have a deficiency in terms of ability to deliver patient-centred care service. Most of these solutions are based on theoretical rather than empirical evidence and is therefore not context-sensitive for meeting stakeholders/users' needs such as data security, privacy,

accessibility, and system usability to guarantee delivery of meaningful innovations. Furthermore, they are conceptual rather than practical, which raises questions about their validity.

To address these gaps adequately, this research employed context-sensitive research approaches to explore the design characteristics for proposed ICT-facilitated personal health and wellbeing services in an underserved context. Specifically, this research integrated the underpinnings of SDR strategy and stakeholder theory whereby the relevant stakeholders were engaged through active participation. To achieve this, a human-centred approach was followed, which included qualitative techniques and the co-design method in a real-world situation. A patient-centred PHR service framework was developed to empower individuals to have seamless access and control over their own health data from different sources (Zhou et al., 2019), hence patient-centred health care. In this case, the patient is empowered with super rights to control and allow access to their own personal health data to third parties through personal consent (Alyami et al., 2017), including at the point of care. The aforementioned steps were implemented in such a way that a context-sensitive PHR service framework was delivered to meet the users' needs in the Kenyan context. Consequently, a prototype PHR system was developed as proof of concept of the design (Nunamaker Jr et al., 2015).

10.3 Conceptual framework for the research contribution through DR

This sub-section highlights and illustrates the process through which the proposed *person-centred health cloud service* was delivered using the SDR approach. The selection of this research approach was based on the perceived potential of design science as a possible solution to address the problem towards creating an effective and efficient IS in the past (Rohde et al., 2009). According to literature, design knowledge is embedded in the theory types in IS research (ISR) design principles, which is generally classified under the theory for design and action (Chandra et al., 2015; Gregor & Jones, 2007; Gregor, 2006; Hevner et al., 2004). IS design theory gives explicit directions, including methods, techniques, and principles of form and function for the design and construction of an artefact, hence design knowledge. Design theory, therefore, involves many component parts, i.e. the principles of form and function that define the structure, organisation, and functioning of the design product or method (Chandra et al., 2015). Design knowledge thus revolves around means-end relationships, that is, between problem and solution spaces (Maedche et al., 2019; Venable, 2006).

In general, the aim of DSR is to generate prescriptive knowledge regarding the design of IS artefacts, including software, methods, models or concepts (Vom Brocke et al., 2020; Maedche et al., 2019). During a study to bridge the practice research divide through Practitioner Design Science Research (PDSR) towards innovative teaching, Nagle and Sammon (2020) made a massive contribution with this initiative to the Data Business through

its capability of developing business management skills and evidence-based decision-making. The study found the PDSR approach to be quite useful, particularly to practitioners who were guided by DSR to develop rigorously evaluated solutions that contributed towards research and practice communities (Nagle & Sammon, 2020; Van Aken et al., 2016). A further strength of PDSR is that it focuses on wicked and messy problems that cannot otherwise be addressed by DSR research alone. Therefore, a substantial opportunity is opened up whereby practitioners' unique access and insight into complicated problems is leveraged to conduct both rigorous and relevant research (Nagle & Sammon, 2020; Van Eijk et al., 2006). More importantly, the key success factor in DSR is gaining an adequate understanding and description of the underlying problem, including stakeholders, needs, goals, and requirements (Maedche et al., 2019).

The aim of this research was therefore to contribute to the current discourse on design-centred IS research by embracing the social practices in health care for which IT artefacts are created to guarantee meaningful use. Both the theoretical and methodological contributions in this research are geared towards strengthening organisational relevance from a DSR perspective in terms of ISR. The point of departure therefore, is that IS artefacts are driven and shaped by organisational context, hence the need for ISR to consider social practices while designing and developing such systems (Rohde et al., 2009).

Figure 10.2 was created to illustrate and visualise epistemological and ontological propositions of the research. The three key concepts that were combined to create new ICT-facilitated health and wellbeing service(s) are health care (i.e. patient-centred care) and service (i.e. information service), both representing the social world, and ICT (i.e. cloud health records), representing the artificial world (Simon, 1996). Patient-centred care, including health promotion and wellbeing services, is regarded as being part of the social world as a social construct, and clinical care as being part of the natural world. The interception(s) of the three concepts in the diagram illustrates how *personal health cloud service*, which offers multiple digitised health care services, can be delivered, namely: person-centred health and wellbeing services; technology enabled (cloud-based services); and health care technology tools (PHR service).

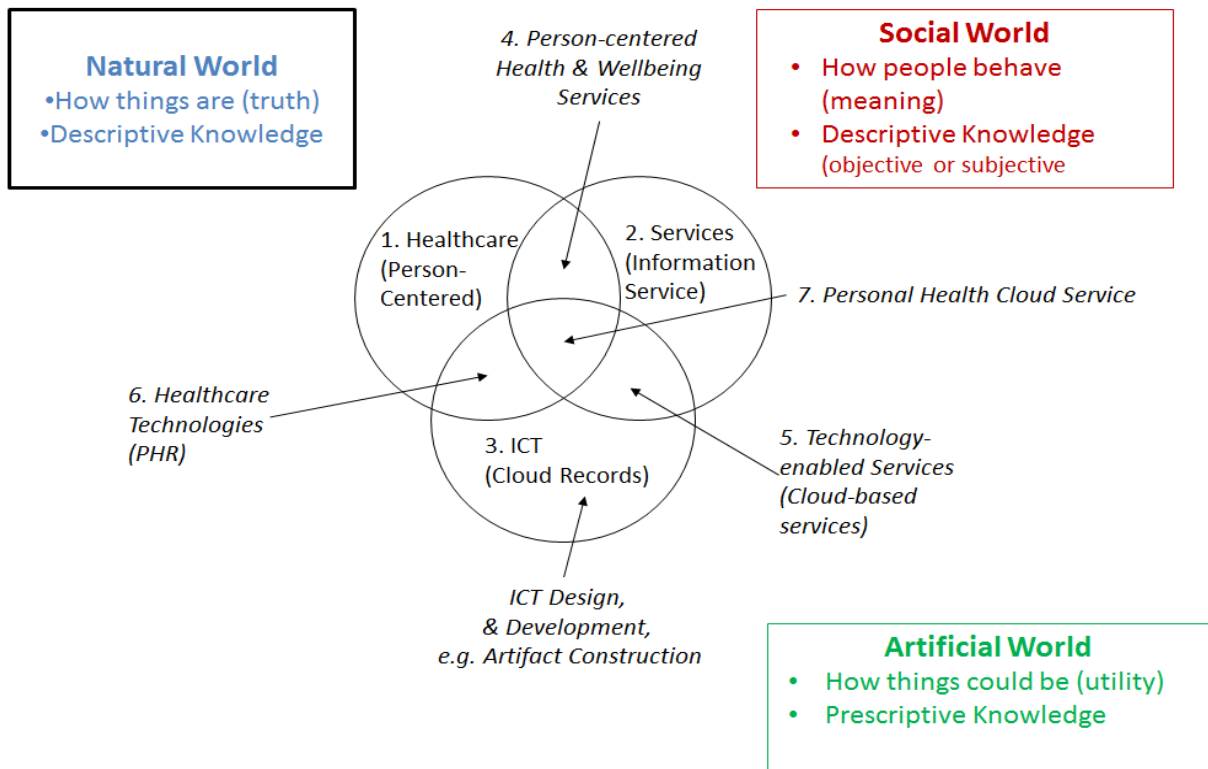


Figure 10.2: Conceptual framework for contributions to the respective research fields

10.4 Interceptions between the three disciplines

The circles, representing a combination of the three key concepts, provided focus for the research and helped maintain boundaries during the research process. These include person-centred care, information services, and cloud records, of which the proposed *patient-centred health cloud service* was created as the core of the study. This was achieved through co-design, which was used in this case as both a process of joint inquiry and a method of design (Steen, 2013). According to Steen, the concept of *co-design* involves co-operative creation of desired services, which may also be interpreted as collaborative design thinking. It therefore refers to organising open innovation processes whereby the designers, users/customers and stakeholders of a service from different organisations jointly share ideas and knowledge as participants in the design process.

10.4.1 Health care (Person-centred care)

Circle no. 1 represents the current health care practice, which was the research context under investigation. The current health care practice is where things are described as they are (the truth), representing the *natural world* (Simon, 1996). In this research, health care was to be re-designed towards providing better services (i.e. person-centred care), to deliver the desired situation. Principles of patient-centred care were observed during the research/design process for an accurate description of the research phenomena to ensure that the change objective would be achieved.

10.4.2 Services (Information services)

Circle no. 2 represents the information dimension of health care service, which, in this research, involved understanding the types of information service(s) offered and how people interact with these services, thus representing the *social world* (Simon, 1996). Various methods and tools were observed and/or applied during the processes of inquiry, design and development of the proposed services. This helped the researcher identify the various touch points of maternal health information service and users' experiences while interacting with the services, including pain points that informed the design for new, improved services (Salgado et al., 2017).

10.4.3 ICT (Cloud records)

Circle no. 3 represents the technological dimension, i.e. the role of ICT in health care (eHealth), which involves the use of various technologies such as CC, including hardware and software tools. Design principles, methods and tools, including co-design and prototyping (Salgado et al., 2017), were applied to design technology enabled services such as cloud records (IT artefact), which, in this research, represented the *artificial world* (Simon, 1996). In general, the new *person-centred health cloud service* provides a variety of services, including person-centred health and wellbeing services to facilitate access to and control over personal data by individuals; cloud-based services, for example provision of data storage and data security services in the cloud; and health care technologies/HIT tools (PHR service). To deliver these service(s), the SDR strategy and CC technologies were combined to design and deliver patient-centred, cost-effective, secure and interoperable health care service (John & Shenoy, 2014; Hu & Bai, 2014) to users in the research context.

10.5 Conceptual framework for research

The idea demonstrated through the conceptual framework for research in Figure 10.3 involves various components, including different stakeholders, with the focus on the clients (pregnant women) and health care providers (hospitals, CHWs, nurses, doctors) as the people offering supportive care services to the clients. In addition, government/the Ministry of Health (MOH) in Kenya and medical research institutions are involved as third parties, as they need health data for decision-making and for research. The service is based on the CC platform as the main technology towards promoting patient-centred care, given its user centric features.

Various hardware and software tools and applications, including servers, databases, and PHR services, among others, will be used to deliver the desired service. Locally generated EMR data (community/referral facility) will be pushed to the cloud to update PHR history in the central server. Health personnel will have restricted access to client PHR; however, they should have full access to client EMR in the local facility server. They can however view PHR data in the cloud through client consent during a care activity such as booking appointment,

doctor's consultation, treatment, health education talks, promoting health and lifestyles, and making an e-prescription, among others.

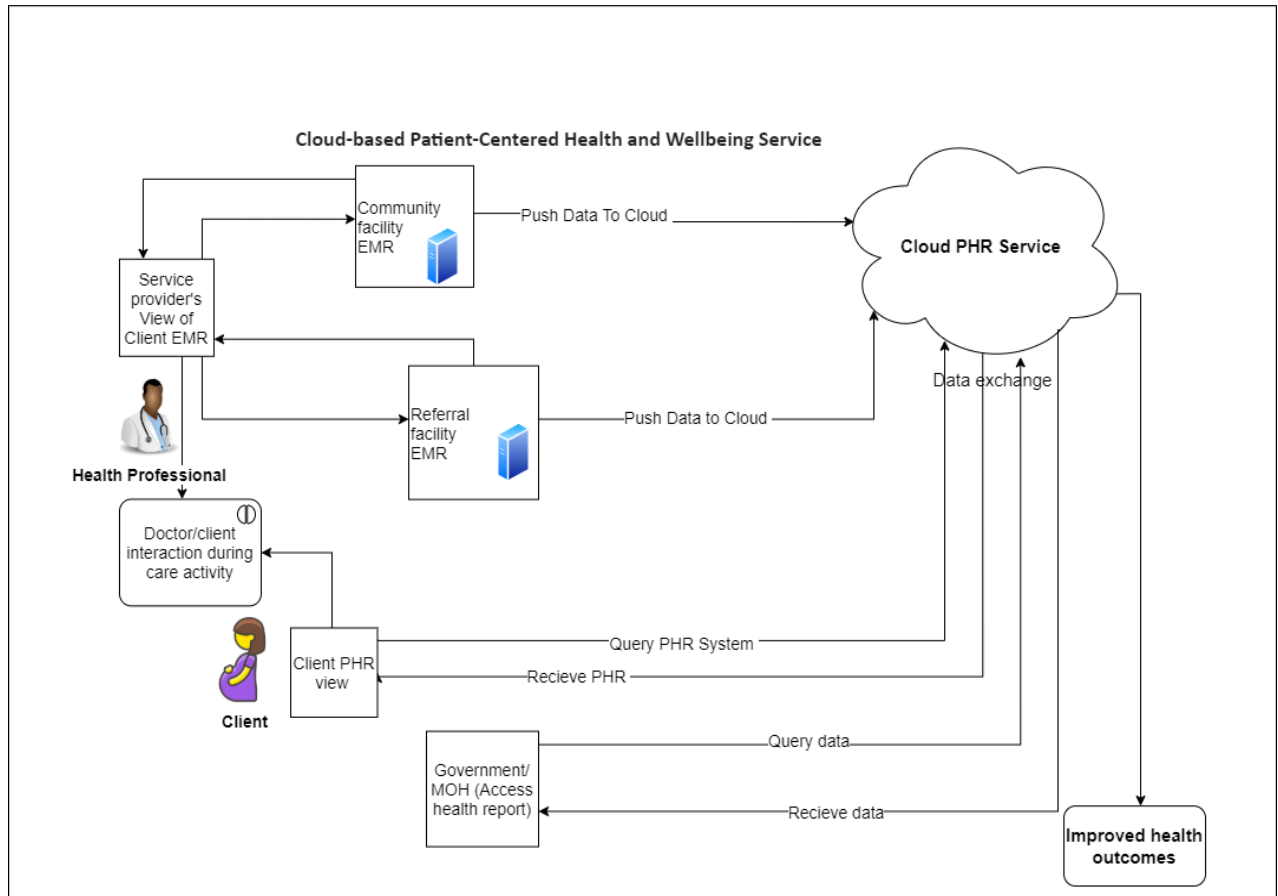


Figure 10.3: Conceptual framework for research based on the literature review

10.6 Chapter conclusion

In this chapter, the proposed conceptual framework based on the literature as informed by the relevant disciplines was discussed. This concludes the first two sections of the thesis. In the next chapter, the case study and the data collection and analysis are discussed.

PART III: FIELDWORK AND DESIGN

Chapter 11: The Kenyan Case

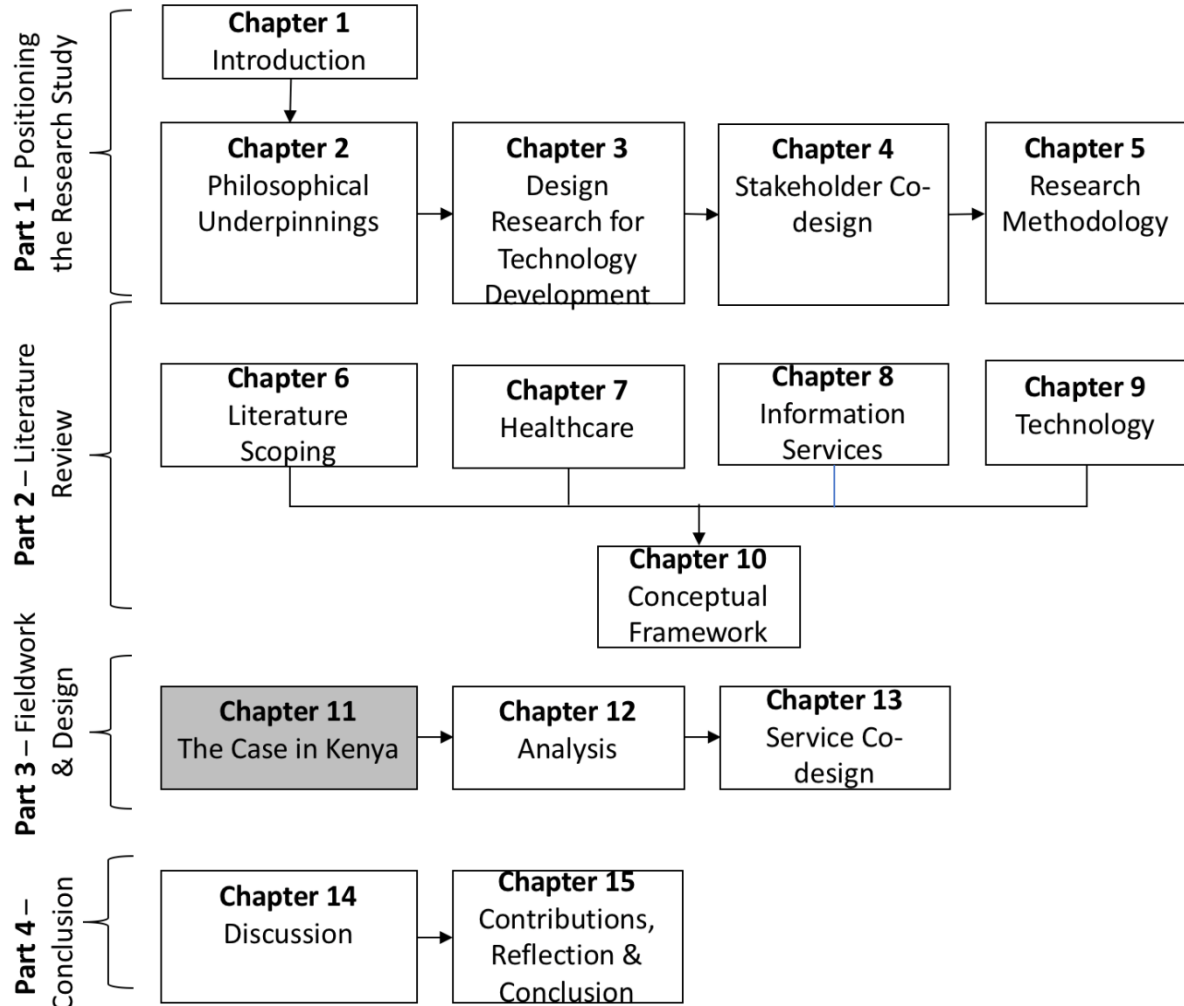


Figure 11.1: Thesis Layout - Chapter 11

11.1 Introduction

In this chapter, the case used for this study is discussed to contextualise the study.

11.2 Health context

Context may be defined as “location, identities of nearby people and objects, and changes to those objects” (Dey, 2001:4). It thus refers to an environment or situation concerning a particular phenomenon. The next section provides an overview of the status of health systems in Africa and explores Kenya’s health care system, with specific focus on Nairobi County’s informal settlement(s) as a typically underserved context.

11.3 Health care in an underserved context – Africa

The health care sector in Africa is faced with challenges that are generally prevalent within LMICS, including a high burden of disease due to scarcity of resources. Because of this, the majority of the population (about 90% in sub-Saharan Africa) relies on traditional medicine as their source of primary health care (Turin, 2010). People walk several miles in search of health care services, particularly in rural areas (Kenya, 2015). HIV infections, violence and injuries, early marriage and initiation of sex as well as the limited access to family planning services are the major challenges facing the youth (World Health Organisation, 2014; World Health Organisation, 2015a).

HIV continues to top mortality rates in sub-Saharan Africa, and it is the most affected region in the world, with 25.6 million people living with the virus, that is, two-thirds of the global total new HIV infections (World Health Organisation, 2017; World Economic Forum, 2015). About 69% of deaths on the continent are caused by HIV and malaria. Health care for older people with chronic diseases and disabilities remains a challenge as the numbers continue to grow. In 2010, the number of people above 60 years of age was estimated at 43 million, which is projected to reach 67 million by 2025 and 163 million by 2050 (World Health Organisation, 2014).

Inadequate funding, fragmented health care systems, ill management of health facilities, high health care costs, and an unskilled health worker force are among the major challenges faced in Africa (Turin, 2010; Kenya, 2015; World Health Organisation, 2014; Bukowski, 2016). Therefore, there is a need to improve the health care infrastructure and adopt beneficial health care practices and interventions to address these challenges. This can be achieved through implementing effective and affordable eHealth interventions in most African settings to improve health outcomes. While this study focused on Africa in general, it explored the Kenyan situation in detail in subsequent sections as a typical example of an underserved context.

11.4 Kenya's health sector

In efforts to improve its national health status, the Kenyan government's commitment towards improving the quality of health services is stipulated in various policy documents including Vision 2030, the Kenya Health Sector Strategic Plan (KHSSP II), the Kenya Health Policy (NCAPD, 2011) and the 2010 constitution. In 2014, the country's estimated total population was 45,010,056, projected to be more than 50 million by 2020, with 75% of the population living in rural areas (Kenya Health Care Federation, 2016). Table 11.1 below depicts a summary of the geographics of Kenya. The average life expectancy is 61 years, with child mortality rates caused by HIV/AIDS at 16.29%.

Table 11.1: Summary geographics of Kenya

(Source: Kenya Health Care Federation, 2016:16)

Summary Demo- and Geographics Kenya ⁵	Statistics
Population (in millions)	46 ⁶
Population living in urban areas	25%
Population under 15 years	42%
Population over 60 years	4%
Median age (years)	19
Life expectancy 2014 (years)	61
Female	50%
Total fertility rate (per woman) ⁷	3.9
Under 5-year mortality 2014 (per 1000)	52
Gross national income per capita (in USD)	2250

Table 11.2: The top 10 diseases causing death in Kenya

(Source: Kenya Health Care Federation, 2016:18)

The top 10 diseases that cause deaths in Kenya ¹³		
	<i>Deaths</i>	<i>Percentage</i>
1 HIV/Aids	54 518	16.29 %
2 Influenza and Pneumonia	45 441	13.58 %
3 Diarrheal diseases	23 374	6.98 %
4 Protein-energy malnutrition	15 253	4.56 %
5 Birth asphyxia and birth trauma	14 853	4.44 %
6 Stroke	14 609	4.37 %
7 Low birth weight	13 528	4.04 %
8 Malaria	11 970	3.58 %
9 Tuberculosis	9 379	2.80 %
10 Ischemic Heart disease	9 163	2.74 %

11.5 Health care service delivery structure

Kenya's health care service delivery is structured into six hierarchical levels – 1, 2, 3, 4, 5 and 6 – as shown in Figure 11.2 (Kenya Health Care Federation, 2016:33; Muga et al., 2005). According to Chen et al. (2016), increasing investment in health in developing countries needs to focus on quality improvement to yield better results in health services and emphasise the six WHO health care dimensions: effective, efficient, accessible, acceptable/personal, equitable, and safe services. According to the Ministry of Health (2013a), investments in Kenya's health care sector have increased in the recent past, following a devolution of health care services in Kenya's counties, which has led to the expansion of service delivery and improvements in the quality of health services. However, in the absence of proper management of the transition, the successes already achieved may be lost, particularly in maternal and child health (Chen et al., 2016). The country has an estimated total of 4,700 health facilities, comprising both public (51%) and private health facilities, through which health

services are delivered. Privately owned facilities, including faith-based hospitals, supplement government health care services with between 30% and 40% of hospital beds in Kenya (Ministry of health, 2013b; Boore, 2018).

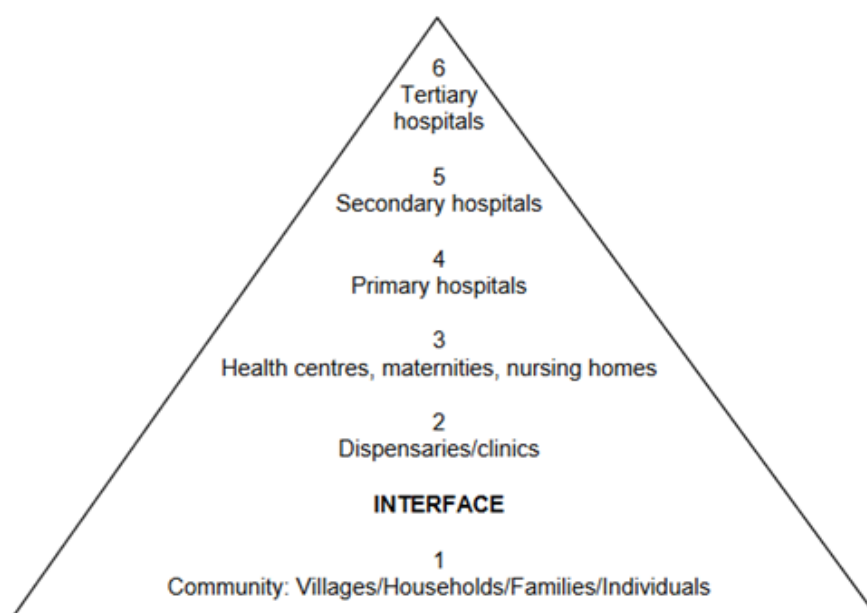


Figure 11.2: Levels of health care delivery in Kenya
(Source: Muga et al., 2005:21)

11.5.1 Devolved health services and financing

The promulgation of the 2010 Constitution of Kenya has led to the establishment of two levels of government: National Government and County Governments. Health is entrenched into the Constitution as a basic right of the citizens. The Constitution provides for the devolution of health services into 47 County Governments, including Nairobi City County (NCC), which has executive and legislative authority to generate revenue, to establish policies, and to plan and create their own budgets for the delivery of services to the people. While the management of the public national referral health services (level 6) remains under the National Government, authority and responsibility over the lower levels (1-5) were transferred to the County Governments, which include community, primary and secondary health services (Kenya Health Care Federation, 2016). Table 11.3 represents various types and levels of the public health facilities in the health sector. Specifically, the National Government is in charge of managing and providing health care services at the four (4) national hospitals (level 6), which are the highest hospitals within the public health care continuum and which provide the most extensive types of health care services within the sector. These include: Kenyatta National Hospital, Moi Teaching and Referral Hospital, the National Spinal Injury Hospital in Nairobi, and the Mathare Teaching and Referral Hospital. Lower-level health care services are managed by 47 County Governments, which include county referral hospitals (level 5), sub-county hospitals (level 4), health centers (HCs) (level 3), dispensaries (level 2) and community

health services, i.e. villages/households/individual services (level 1) (Kenya Health Care Federation, 2016; Ministry of Health, 2014b; Boore, 2018).

Table 11.3: Categories of health facilities in the Kenyan public sector
(Source: Kenya Health Care Federation, 2016:33)

Type of service level	Description	Services offered
National Referral Services (level 6, former level 5 hospital)	Intended to serve all Kenyans and act as a referral center for lower-level hospitals. They offer a full range of specialised services: sophisticated diagnostics, therapeutic and rehabilitative services.	Surgical services, internal medicine, and specialty services such as emergency obstetric care (EmOC) and anaesthesiology
County Referral Services (former Level 4/5 and district hospitals / sub-county referral hospitals)	The intermediary between National Referral Hospitals and District Level Hospitals. They oversee the implementation of the health policy at district level and coordinate district health activities. These types of hospitals provide some form of specialised care.	Surgical services, internal medicine, and specialty services, including emergency EmOC and anaesthesiology but less extensive than National Referral Hospitals.
Primary Care Services (District and sub-district hospitals / sub-county referral hospitals)	These are primary hospitals and serve as the main referral centers for HC, offering different services such as out-patient care, maternity and in-patient services, emergency surgery, blood transfusion, laboratory and consultative services in relation to community-based programmes.	Antenatal care (ANC) and routine birthing services, the majority of hospitals had formal immunisation programmes (98%, with only one tertiary hospital reporting that it did not host an immunisation programme), HIV/ AIDS care (96%), paediatric services (93%), and EmOC (78%). Over 80% of all facilities provide HIV/AIDS services.
Community Health Services	All community-based demand creation activities, namely the identification of cases that need to be managed at higher levels of care, as defined by the health sector.	A range of preventive and curative services with the focus on primary care services.

11.5.2 Health care financing

The national health care budget expenditure was estimated at KES 1.7 billion (USD 166 million) during the 2014/2015-2016/2017 period. Funding comes from tax, the National Health Insurance Fund (NHIF), private health insurance, employer self-funded schemes, community-based health financing (CBHF), out-of-pocket (OOP) expenses, development partners, and non-governmental organisations (NGOs) (Kenya Health Care Federation, 2016). In the recent past, the Kenyan government implemented health-financing reforms through the NHIF to ensure that citizens realise their constitutional right to health. For instance, the government now gives compensation to public health facilities for revenue losses incurred due to user-fee waivers or the removal on health services provided to citizens, including primary health care services and free maternal care. Other programmes include the civil servants' health insurance scheme, a comprehensive cover for all civil servants and their dependents, full health insurance subsidy for the underprivileged elderly people, the poor and the disabled (Nguni et al., 2017).

11.6 Challenges facing Kenya's health sector

Numerous challenges continue to hinder the utilisation of health care in Kenya, emanating from a variety of factors, including social, economic, political, and cultural issues (Turin, 2010; World Health Organisation, 2016b). According to literature reviews conducted (Boore, 2018; Turin, 2010; Fotso et al., 2008; Fotso et al., 2009; Wanjira et al., 2011), key challenges facing the health sector include: inadequate health care infrastructure; inadequate skilled worker force; lack of equipment and medicine/drugs; inadequate health facilities, electricity, and ambulatory services; disease burdens (both communicable and NCDs); high health care costs; geographical barriers and poor transport services; cultural beliefs and traditions (traditional medicine); low education/literacy levels with a larger elderly population. Better services are however found primarily in urban areas and specifically in private health facilities where skilled health workers prefer to work, hence doctors competing, which causes shortages of qualified health personnel in public/government health facilities (Kenya Health Care Federation, 2016; Fotso et al., 2008). This is occasioned by financial constraints whereby the government is not able to pay attractive salaries and incentives to retain health workers. On the other hand, urban areas do not face worker shortfalls despite health workers lacking certain levels of capacity and efficiency (Lade et al., 2014; Turin, 2010). On average, 74% of medical doctors, 69% of nurses, and 62% of clinical officers (COs) work in the private sector (Kenya Health Care Federation, 2016).

Table 11.4: Health worker breakout per sector in 2007-2008
(Source: Kenya Health Care Federation, 2016:33)

Cadre	Total Registered (2007)	Public Sector (2008)	Private sector (2008)	Private Sector (% of total)
Doctors	6,271	1,605	4,666	74
Dentists	631	205	426	68
Pharmacists	2,775	382	2,393	86
Pharmaceutical Technologist	1,680	227	1,453	86
Nursing officers	12,198	3,013	9,185	75
Enrolled Nurses	31,971	11,679	20,238	63
Clinical Officers	5,797	2,202	3,595	62

Patient per doctor/nurse ratios are low, i.e. one (1) doctor and 12 nurses/midwives per 10,000 persons, contrary to the recommended WHO standard ratio of 23 doctors/nurses/midwives per 10,000 people (Kenya Health Care Federation, 2016; Lade et al., 2014). Also, the health care system is highly fragmented, with many vertical disease programmes (such as HIV, TB, Immunisations, and Malaria, among others) under various donors, causing parallel health reporting systems and the need to harness ICTs to support collaborative efforts among

health care stakeholders towards quality and affordable health care services (Manyara et al., 2016; KPMG, 2014; Boore, 2018).

11.7 Maternal health care services

Kenya has generally made slow progress in improving the delivery of maternal health care, and particularly in reducing maternal mortality (Tama et al., 2018). High numbers of maternal deaths are still being recorded in the country, according to the authors. Currently, the country experiences 362 maternal deaths per 100,000 live births and 22 neonatal deaths per 1000 live births (Anderson et al., 2020). According to the authors, 75% of these deaths happen during labour, delivery, and the postpartum period(s) of which hypertension, haemorrhage, and infection are among the major causes.

The above scenario is associated with the lack of access to appropriate maternal health care services for mothers during pregnancy, delivery and the postpartum period(s) of which 57% of the women delivered in the absence of a skilled birth attendant (SBA) as at 2013. To curb this trend, the Jubilee government introduced a maternity care policy in 2013 to abolish user fees for maternity services in government health facilities so as to alleviate the financial burden to the consumer of the services (Anderson et al., 2020; Tama et al., 2018). To complement this effort, the First Lady's *Beyond Zero Campaign* towards eliminating maternal and neonatal deaths through increased in-facility-based deliveries was launched at the same time. According to literature, however, despite the efforts, no significant improvement has been realised since many deliveries continue to occur at home, whereby about 37% of the women deliver without the supervision of SBAs (Anderson et al., 2020; Grépin et al., 2019; Ochieng & Odhiambo, 2019; Gitobu et al., 2018).

Among the reasons for this failure is poor implementation of the policy, which was not effective enough to trigger maximum impact as the process was hurried without proper consultation with stakeholders, whereby important aspects were overlooked (Tama et al., 2018). This, therefore, presented several challenges to health care providers, health facilities and service consumers/patients. According to the author, there was poor communication of the policy, that is, a lack of clear guidelines on what services were to be provided for free; insufficient planning to contain supply-side constraints; increased pressure on health workers hence compromised quality of care; inconsistent disbursement of funds to health facilities as well as weak governance and accountability structures. Also, according to literature, among other reasons for the above, are the unaffordability of delivery costs due to structural and infrastructural barriers as well as long geographical distance and lack of transport to health facilities (Anderson et al., 2020; Essendi et al., 2015; Wanjira et al., 2011; Ziraba et al., 2009; Fotso et al., 2008; Fotso et al., 2009).

A study by Ochieng and Odhiambo (2019) found that there is generally a lack of understanding among Kenya's rural-based women on the role of regular ANC clinic visits. The authors argue that women with no complications during their pregnancies have a tendency to skip ANC clinic visits, leading to missing subsequent clinic appointments, including postnatal care. This attracts a negative attitude/criticism and denial of care by health care staff, which instils fear among the women, thus making them shy away from seeking further treatment at the health facilities. Common infrastructural challenges include the lack of: (i) essential equipment; (ii) electricity to operate medical equipment; (iii) skilled personnel; (iv) commodity supplies; and (v) water at the health facilities, as well as poor road networks especially in rural/remote places, hence home-based deliveries.

A study by Jepkosgei et al. (2019) noted two main factors of why women who seek childbirth services at Moi Teaching and Referral Hospital in Eldoret, Kenya, bypass county public health facilities. These factors are individual characteristics and facility characteristics. Individual factors include old age, first time birth experience, and a history of pregnancy complications while facility related factors include distance to the nearest facility and the nature of available services such as waiting time, service charges, water, ambulance, theatre, and commodity supplies (Jepkosgei et al., 2019). These findings confirm previous facts established in literature, particularly the general perception of a lack of adequate health care infrastructure in the rural-based health facilities located in the counties. As a result, women opt to seek the services of traditional birth attendants who are unable to handle high-risk pregnancy-related complications during delivery, leading to death due to the lack of relevant skills and information (Anderson et al., 2020; Wanjira et al., 2011; Ziraba et al., 2009; Van Eijk et al., 2006).

Figure 11.3 is a statistical representation obtained during a study conducted by Tama et al. (2018) to assess the success of the implementation of free maternal care in Kenya in three (3) of the 47 counties. Specifically, the study analysed maternal deaths per 100,000 live births between 2008 and 2014; the percentage of pregnant women who made at least 4 or more visits to antenatal clinics (ANC); the percentage of women who delivered in a health facility; and the percentage of post-natal (PNC) check-ups within 48 hours after birth in 2014 alone.

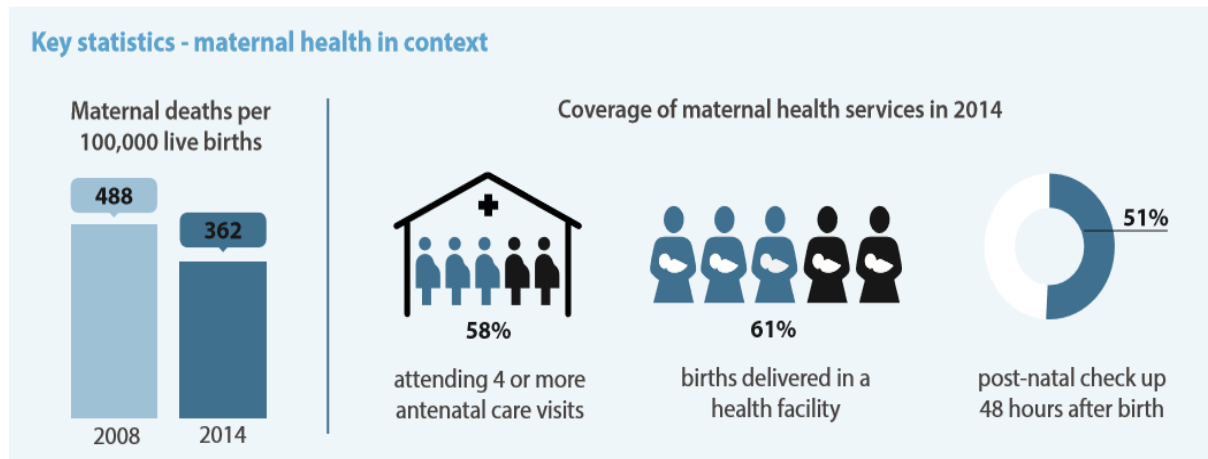


Figure 11.3: Coverage of maternal health services in 2014
(Source: Tama et al., 2017:2)

There exist inequalities in the quality of mother and child health (MCH) services that need to be improved to increase access to maternal care in underserved environments. The complexity of barriers to accessing the maternal care of formal providers indicates that current narrow-focused interventions are unlikely to improve the situation (Ochieng and Odhiambo, 2019). This prompts the need to adopt broad-based interventions to improve ANC services, including the adoption of meaningful ICT-based solutions to address challenges of geographical distance and inadequate health care personnel in particular. Unfortunately, existing HIS systems in developing countries are generally deficient to deliver the expected results because medical records are poorly managed and incomplete in most cases, which makes their usage difficult (Nabyonga-Orem, 2017; Ziraba et al., 2009).

Currently, the *District Health Information Software 2 (DHIS2)* is mainly used to collect routine data from health facilities across the country and analyse it for national reporting in aggregated form for decision-making (Braa & Sahay, 2012; Manya et al., 2016). No government-approved electronic medical record (EMR) systems have been implemented to manage patient medical data, except paper-based systems, thus limiting reliable sources of patient medical data at the public health facilities (Kariuki et al., 2016). This has led to inaccurate statistics, hence the need for increased adoption of standard EMRs to capture data directly to DHIS2 at the facilities to improve the accuracy of routinely reported data in order to minimise human errors during the compilation of monthly reports. Also, patients and health care professionals will be able to access patient health data to provide better medical diagnoses and decision-making at the point of care.

11.8 Kenya's health policy framework

The government, in conjunction with other stakeholders, developed two national policy documents for health in 2012 and 2014, namely: Health Policy 2012-2030 and Health Policy

2014-2030. These two pieces of legislation spell out the overall policy goal, policy objectives (policy directions) and policy orientations, which relate to the outcome of health services that needs to be realised in order to achieve the overall goal (Ministry of Health, 2012). Figure 11.4 is a representation of the 2014-2030 health policy framework.

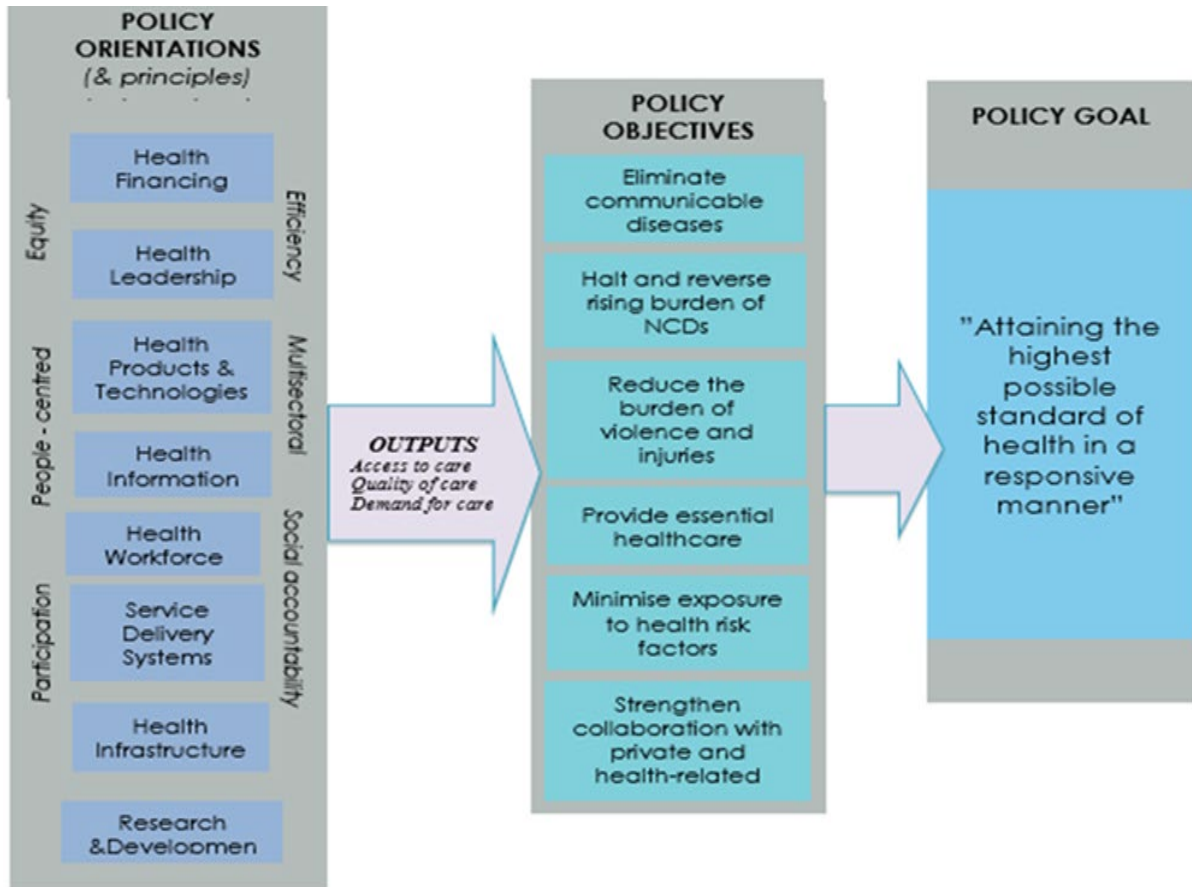


Figure 11.4: Health policy framework 2014-2030
(Source: Ministry of Health, 2014b:26)

11.8.1 National Health Policy Framework (2012-2030)

The policy provides guidelines to accelerate improvement of health care in Kenya, as envisioned in the 2010 Constitution of Kenya, and Vision 2030, among other global commitments. The policy highlights the mandate of Kenya's health sector under the supervision of the National Government to ensure attainment of the highest possible standards of health, as opposed to the needs of Kenyans. The policy is designed to be all-inclusive, balanced, and rational (Ministry of Health, 2014b; Mwaniki et al., 2015). The policy aims to achieve two major health obligations: firstly, contributing towards economic development as per the provisions of the new 2010 Constitution of Kenya and Vision 2030, and secondly, ensuring equity, efficiency, and socially accountable health care service delivery (Mwaniki et al., 2015). While appropriate strategies were implemented, the following policy objectives and/or orientations were also pursued for this research:

- **Policy goal:** “Attaining the highest possible standard of health in a manner responsive to the needs of the population” (Ministry of Health, 2012:15). Its aim is to provide support towards ensuring equitable, affordable and quality health and other related services at the possible highest attainable standards to all citizens
- **Policy objectives:** To eliminate communicable conditions; to stop and/or reverse the increasing burden of NCDs; to reduce the burden of violence and injuries; to provide essential health care services through ensuring universal health coverage (UHC); to reduce exposure to health risk factors through education and public awareness on preventable conditions; and to strengthen collaboration with stakeholders in other sectors that have an impact on (Ministry of Health, 2012; Mwaniki et al., 2015)
- **Policy orientations:** Service delivery systems on how to organise health care service delivery; leadership and governance on how to manage health care service delivery; a health workforce to determine and acquire the required human resources to provide health services; health financing that puts in place systems to ensure adequate resources for health care service provision; health products and technologies to ensure the availability of essential commodities including medicines, medical supplies, vaccines, health technologies and public health; health information, i.e. a system for generating, analysing, distributing and utilising information related to health care; and a health infrastructure that ensures proper physical infrastructure, equipment, transport and ICTs needed for health care service delivery (Ministry of Health, 2012; Mwaniki et al., 2015)

11.8.2 National Health Policy Framework (2014-2030)

The policy was formulated and launched in 2014 based on the requirements of the 2010 Constitution of Kenya, among other commitments, namely that every person has a right to the highest attainable standard of health, including reproductive health rights (Ministry of Health, 2014). According to the policy, a person shall not be denied emergency medical treatment and the state shall provide appropriate social security to persons who are unable to support themselves and their dependents. Specifically, the 2014-2030 health policy focuses on objectives of the devolved health care system, including health functions of both the National Government and the 47 County Governments, and improving on the goals and objectives of the 2012-2030 health policy (Ministry of Health, 2014:3; Mwaniki et al., 2015:13). These objectives include the following:

- Promoting democracy and accountability in the delivery of health care
- Fostering seamless service delivery both during and after the transition period
- Facilitating powers of self-governance to citizens and enhancing their participation in making decisions on matters affecting their health
- Recognising the right of communities as opposed to managing their own health affairs and to further their development

- Protecting and promoting health interests and rights of minorities and the marginalised communities, including informal settlements, and particularly slum dwellers, as well as underserved populations
- Promoting social and economic development and providing proximate and easily accessible health services throughout the nation
- Ensuring the equitable sharing of both national and local resources targeting health care delivery throughout Kenya
- Enhancing the capacities of the two levels of governments to effectively deliver health care services in accordance with their respective mandates
- Facilitating the decentralisation of state departments and/or organs that are responsible for health functions and services in Nairobi, the Capital of Kenya
- Enhancing checks and balances, including the separation of powers, between the two levels of government in a devolved health care system

The specific functions allocated to the National Government are: to offer leadership in the development of health policies, to manage national referral health facilities; and to build capacity and technical assistance to County Governments. County Governments, on the other hand, are charged with the responsibility to deliver health services at county level, including pharmacies, ambulatory services, primary health care, licensing and control of undertakings that sell food to the public, veterinary services, cemeteries, and solid waste disposal, among other functions (Ministry of Health, 2014; Mwaniki et al., 2015).

11.9 Kenya's readiness for eHealth

According to Alamri (2012:448), eHealth is defined as “the cost-effective and secure use of ICTs in support of health-related operations including service delivery, surveillance, literature, education and literacy, knowledge and research”. It may also be defined as “an evolving field of medical informatics, referring to the organisation and delivery of health services and information using the Internet and related technologies” (Boore, 2018). In a broader sense, the term symbolises not only technical development, but also a new mode of working, an attitude and a commitment for networked global thinking to improve health care locally, regionally and worldwide through using ICT.

In the context of this study, eHealth is viewed as the application of a wide variety of medical information and applications towards promoting health care delivery as well as the distribution and sharing of health data. This is achieved through clinical data storage and exchange of medical information by means of interpersonal communication, computer-based systems support, patient-provider communication, health education, health service, community health and telemedicine (Boore, 2018). Therefore, the implementation of eHealth innovations is regarded as a pointer towards economic development whereby a number of

initiatives have been put in place by the Kenyan government to promote eHealth infrastructure development through the Ministry of Health (MOH), in conjunction with health care stakeholders as part of ongoing health care reforms (Boore, 2018). Among such efforts are the formulation and adoption of the National Health Policy, the District Health Information System 2 (DHIS 2) as the National NHIS, and both the National eHealth strategy and the National eHealth policy, among other initiatives, towards facilitating successful implementation of eHealth in the country (Ministry of Health, 2016; Karuri et al., 2014a). Noticeable, however, is that the challenges experienced in the implementation of eHealth in underserved contexts are mainly associated with social, economic, technical and political factors, which have continually kept the development of eHealth in Kenya at the infancy stage (Ministry of Health, 2016). According to literature, common challenges experienced include: the violation of patients' privacy and confidentiality; ICT illiteracy and poor capacity management of health information among the health workforce/users; high costs of implementing eHealth innovations; fragmentation of health systems and donor initiatives; poor infrastructure; the lack of interoperability of the eHealth systems; and weak regulatory/policy frameworks (Manya et al., 2012; Xu et al., 2013; Mwaniki et al., 2015; Ministry of Health, 2016; Mburu & Kamau, 2018).

11.10 Adoption of DHIS2 as the National HIS

The vision of Kenya for the health sector is “to provide equitable and affordable quality health services to all Kenyans” (Karuri et al., 2014a:39). This is pegged on the Vision 2030 blueprint, hence the need for strengthening the national HIS to enable adequate provision of information to monitor health goals and to empower individuals as well as communities with timely information on health (Karuri et al., 2014a). Therefore, a properly functioning HIS is a critical tool for generating, analysing and disseminating/reporting quality health information in order informed decisions. This includes surveillance of diseases to prevent outbreaks as well as strategising to ensure adequacy in terms of service delivery. Also, health care professionals may use HIS for sharing data, training and research, among other uses. However, health assessment surveys carried out between 2000 and 2010 revealed the existence of serious issues on the integration of Kenya's HIS (Karuri et al., 2014a). Furthermore, despite increasing user demand for health information, the HIS was too weak and poorly integrated to meet this need. According to the author, routine health data were deficient in terms of quality, timeliness and level of analysis, which was hardly accessible to stakeholders for decision-making.

It is against this background that the DHIS2 free open-source web-based software was adopted and rolled out countrywide in 2011 by the HIS Division/Ministry of Health in Kenya as the National HIS to replace the traditional paper-based system (Karuri et al., 2014a; Manya et al., 2012).

According to Manya et al. (2012), specific objectives for this project were:

- To establish a central database with health facility level reporting
- To define standard health facility, district, and national report outputs
- To link service delivery and other health system input databases
- To scale up ICT infrastructure countrywide in order to support the new software
- To build staff capacity to support the system
- To achieve critical stakeholder support

The main aim of the project (DHIS 2) was to generate, analyse and disseminate quality health information towards ensuring availability of understandable, accurate and timely data for decision-making by health authorities. To contain the increasing demand for computing needs for health data, the system (DHIS2) is hosted in a central server in the cloud. The use of cloud-based infrastructure is aimed at enabling users to access the system via the Internet for purposes of data entry and use of health information (Braa & Sahay, 2012; Many et al., 2012). The system collects data from health facilities country-wide, through a paper-based system of registers, tally sheets, and data collation forms in aggregated form on a monthly basis, whereby data are either keyed directly into the DHIS2 or forwarded to the district headquarters to be captured and then analysed in the system.

However, despite country-wide implementation of DHIS 2, recent evidence has shown very little demand for data and its use by the intended users (Karuri et al., 2014a), because current approach takes longer to send and collate the paper-based reports such that surveillance of public health is still poor. DHIS2 does not automate important business and routine processes at the health facilities, hence essential information encounters such as electronic medical records (EMRs), inventory management, caregivers, equipment, and billing are not captured (Boore, 2018). Therefore, the information needs of citizens have not been met, since individuals do not have direct electronic access to their health data as stipulated in pillar no. 3 of Kenya's eHealth strategy, i.e. "health information for citizens", hence the dilemma facing eHealth services (Karuri et al., 2014a; Ogara, 2012).

11.11 National eHealth Strategy 2011-2017

Adoption of ICT in Kenya's health sector is making progress through efforts to implement the five key pillars that represent the conceptual framework of the National eHealth strategic plan 2011-2017, as represented in Table 11.5. These include telemedicine, HIS, information for citizens, mHealth and e-learning, which represent areas whereby technology allows the development of health care interventions that were not possible before. The HIS pillar includes technology-enabled modifications and transformations to current health systems, e.g. managing medical records and monitoring the supply of commodities (medicines and equipment) to health facilities (Ogara, 2012; Kenya Health Care Federation, 2016).

Table 11.5: Comprehensive definitions of proposed HISs to be implemented by MoH
(Source: Kenya Health Care Federation, 2016:48)

	Definition	Location	Users	Data Entry
Telemedicine	The use of telecommunication and information technologies in order to provide clinical health care at a distance. ⁸⁵	Public (MOH) and private sector	Healthcare providers	Healthcare professionals at provider level
Health Information Systems	A comprehensive and integrated structure that collects, collates, analyses, evaluates, stores disseminates health and health	DHIS – public (MOH and in the public facilities)	MOH, health providers, private sector (limited) and other interested parties	At Facility level (nurses/data clerks)
related data for information and use by all. ⁸⁶				
Information for Citizens	Health information that is accessible and understandable for Kenyan citizens.	MOH	Kenyan citizens	N/A
mHealth	Mobile Health used for the practice of medicine and public health with support of the mobile phone (system).	Public (MOH) and private sector	Kenyan citizens, NGOs, Private Sector, Public sector	Implementing partners or if MOH project MOH data clerks
eLearning	The effective use of technologies in learning and education systems.	Public (MOH) and private sector	Health workers, general public (potential)	N/A

The goal, objectives and principles of the eHealth strategy are stated as follows:

i) Overall goal

To have “equitable and affordable health care at the highest achievable standard” for the citizens

ii) General objectives

- To support more informed policy, investment and research decisions through access to timely, accurate and comprehensive reporting on the Kenyan health system activities and outcomes
- To improve the quality, safety and efficiency of clinical practices by giving care providers better access to consumer health information, clinical evidence, and clinical decision support tools
- To enable the Kenyan health sector to operate more effectively as an interconnected system overcoming the current fragmentation and duplication of service delivery
- To create linkages between health research and information technologies

iii) Principles

The following are the identified factors of success towards implementing the strategy, which includes the need to:

- Support strong leadership and governance mechanism(s)

- Support collaboration and partnerships for shared information and services among stakeholders
- Leverage available human, financial and technical resources
- Safeguard privacy and security
- Harmonise disparate health and technological expertise
- Use phased implementation of prioritised eHealth initiatives in line with the
- Check for redundancy in mission-critical aspects of the eHealth system's strategic framework

There is high mobile penetration in the country, with 88% of 37.8 million subscribers in 2015, thus making mHealth more established than telemedicine services (Tomlinson et al., 2013). Generally, mobile technology-based ICT services are increasingly becoming significant in health care management, particularly in resource-restricted settings (Thobias & Kiwanuka, 2018). Noticeable is that mobile-based PHR (mPHR) applications have obtained a large market in the recent past when more powerful mobile devices such as smart phones appeared (Bachiri et al., 2016). According to the author, this is as a result of mPHR applications' ability to empower users to manage their personal health data as well as easy communication with health professionals, thereby improving health care quality and efficiency.

A study conducted by Watkins et al. (2018) to investigate mobile phone usage among patients with long illnesses, pregnant women, and health workers in rural South Africa found that both health workers and patients used their own mobile phones at their own cost to manage their health care. Patients relied on voice call reminders from their mobile phones to take medication and also to attend clinic appointments. Health workers and some patients also used their mobile phones to access various websites and social media to gather health information despite the barriers of a poor digital infrastructure and low digital literacy, thereby hindering access to health care services (Watkins et al., 2018).

A study conducted to improve the knowledge of mothers in Reproductive and Child Health (RCH) services in rural Tanzania and to remind those who do not have access to phones to attend ANC clinics, revealed three key challenges in relation to the dissemination of information through mobile phone technologies, namely: ownership and access to mobile phones by mothers; the nature of vertical coordination of health services; and low staffing of health workers in public health facilities (Thobias & Kiwanuka, 2018).

In the Kenyan context, however, it has been difficult to build health care interventions that make economic sense and meet real needs of health consumers. Furthermore, in the Kenyan situation, there is no legislation on patient data confidentiality and, as such, discourages the use of these services (Tomlinson et al., 2013). Another major setback of mHealth projects is that they are mainly donor-funded and lack a clear scale-up strategy for

sustenance as well as consensus among stakeholders regarding design requirements (Tomlinson et al., 2013). Furthermore, these interventions rely on smart phones whereas most subscribers own basic mobile phones without Internet-based features. In addition, power supply is limited in rural areas. Furthermore, existing eHealth innovations are mainly controlled by private health care providers (Kenya Health Care Federation, 2016; Wallis et al., 2017).

During a study to assess the situation regarding eHealth development in Kenya, a total of 69 projects were identified, of which 49 were mHealth-based and most focused on primary care and HIV/AIDs (Njoroge et al., 2017). Kazi et al. (2017) conducted a survey to understand the demographics, phone usage and ownership characteristics among the ANC patients and the caregivers at ANC clinics in Northern Kenya, which is considered to be among the most marginalized regions in the country. The study revealed that an average of 90.5% of 284 participants has access to mobile phones. It is against this background that the MOH in Kenya coordinated the development of the eHealth policy framework (Figure 11.5) to address the situation.

11.12 National eHealth Policy Framework 2016-2030

While concerted efforts are being made globally to leverage the benefits of eHealth in order to transform health care and patient experiences, the situation is to the contrary in Kenya. It is against this background that the current National eHealth policy framework 2016-2030 was formulated – to provide strategic direction to facilitate sustainable adoption, implementation and efficient utilisation of eHealth at all levels of health care delivery in the country. To achieve the aim of attaining “the highest standard of health through adoption and use of ICT” (Mwaniki et al., 2015:129), the policy is anchored in various legislative and regulatory documents, including the Constitution of Kenya 2010, Vision 2030, ICT Policy 2006, Health Policy Frameworks 2012-2030 and 2014-2030, the Data Protection Act 2012, strategic/action plans and global/local eHealth standards (Ministry of Health, 2016; Mwaniki et al., 2015). Specifically, the 2012-2030 policy framework clearly outline strategic directions comprising of: the policy goal, three objectives, six guiding principles, and ten orientations which are geared towards improving health outcomes to accelerate the attainment of SDGs. Figure 11.5 graphically depicts the eHealth Policy Framework.

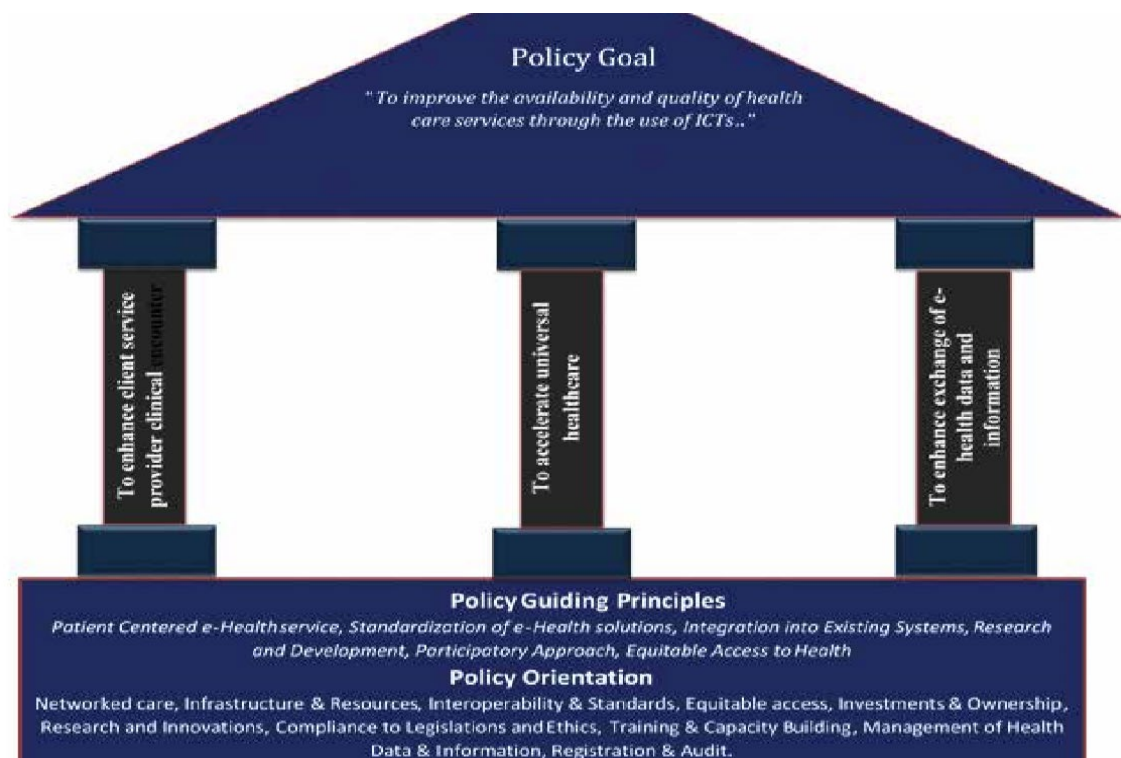


Figure 11.5: Framework for eHealth Policy
(Source: Ministry of Health, 2016:13)

Figure 11.5 is an illustration of the eHealth policy framework showing the various components needed towards achieving the overall policy goal (Ministry of Health, 2016):

- **Policy goal:** Outlines the overall focus and impact the policy is meant to achieve concerning the adoption of eHealth practices and service provision to improve the availability and quality of health care services in Kenya, i.e. *“to improve the availability and quality of health care services through the use of ICTs”*
- **Policy objectives:** Serve as the key pillars for the realisation of the overall policy goal. Specific objectives are: to enhance interaction between the patient and health service providers; to accelerate achievement of UHC; and to enhance the electronic exchange of health data and information (Ministry of Health, 2016)
- **Policy guiding principles:** Serve as the foundations of the eHealth policy to provide guidance on the type of investments necessary to realise the policy objectives and goal. These include: equitable access to quality care; a participatory approach; patient-centred health care services; standardised eHealth solutions; the integration into existing health systems; and research and development (Ministry of Health, 2016)
- **Policy orientations:** Provide direction regarding investment priorities and interventions to be implemented to attain the overall eHealth policy goal. These include: networked care and professional practice; infrastructure and resources; interoperability and standards; equitable access to health care; investment and ownership; research and innovations; compliance to legislations and ethics; training and capacity building; management of health data/information; and the registration and audit of eHealth systems (Ministry of Health, 2016)

11.13 Demographics of Nairobi County and health services

The NCC Government took office in April 2013 after Kenya's general elections, with the vision to make Nairobi "the city of choice for all to invest, work and live in". Under Legal Notice Number 137 of 9 August 2013 and in line with the County Governments Act 2012, the Transitional Authority formally transferred several health service functions to the NCC Government, including: the promotion of primary health care; County health facilities and pharmacies; ambulance services that include the emergency response and patient referral system; licensing and control of undertakings that sell food to the public; enforcement of waste management policies, standards and regulations; and veterinary services to carry out, coordinate and oversee these services. To deliver the aforementioned health service functions, the NCC Government designed a service delivery strategy based on the Kenya Health Policy Framework (2014-2030) and the Kenya Health Sector Strategic plan (KHSSP 2013–2018) to guide the delivery of health services in line with the Constitution and Kenya's Vision 2030.

Due to its strategic location and attractive physical, social and economic features in the region, NCC attracts masses, including residents, workers and investors. Being the host of the country's capital city, which is one of the largest cities in Eastern Africa (EA), NCC has the highest trade and industry concentration with 80% of the industries in the country (Mutisya & Yarime, 2011), including financial institutions. More importantly, the County hosts two major airports, namely: Jomo Kenyatta International Airport (JKIA), with Wilson Airport as the second airport in the county. JKIA is the largest Airport in East and Central Africa, hence the focal point for major aviation activity in the region, a factor that makes Nairobi City one of the primary commercial hubs in Africa with both local and foreign investments. Figure 11.6 presents an aerial view of Nairobi City Centre, which is the capital city of Kenya.

The County covers a total area of 696.1 km² and is located between longitudes 36o 45' East and latitudes 1o 18' South, while it lies at an altitude of 1,798 meters above sea level, and is made up of 17 sub-counties and 85 wards (administrative units) under the devolved system. According to the 2009 Kenya Population and Housing Census, the county currently experiences a rapid urbanisation growth at a rate of 4% (Mutisya & Yarime, 2011:200; Bakibinga et al., 2014). For instance, the Kenya National Bureau of Statistics (2013) projected a population growth in Nairobi City from 3,517,325 in 2012 to 4,253,330 by 2017, with an annual growth rate of about 3.8% as cited in the County's Annual Development Plan (CADP) 2018/2019 (Nairobi City County, 2017a) (Table 11.6).

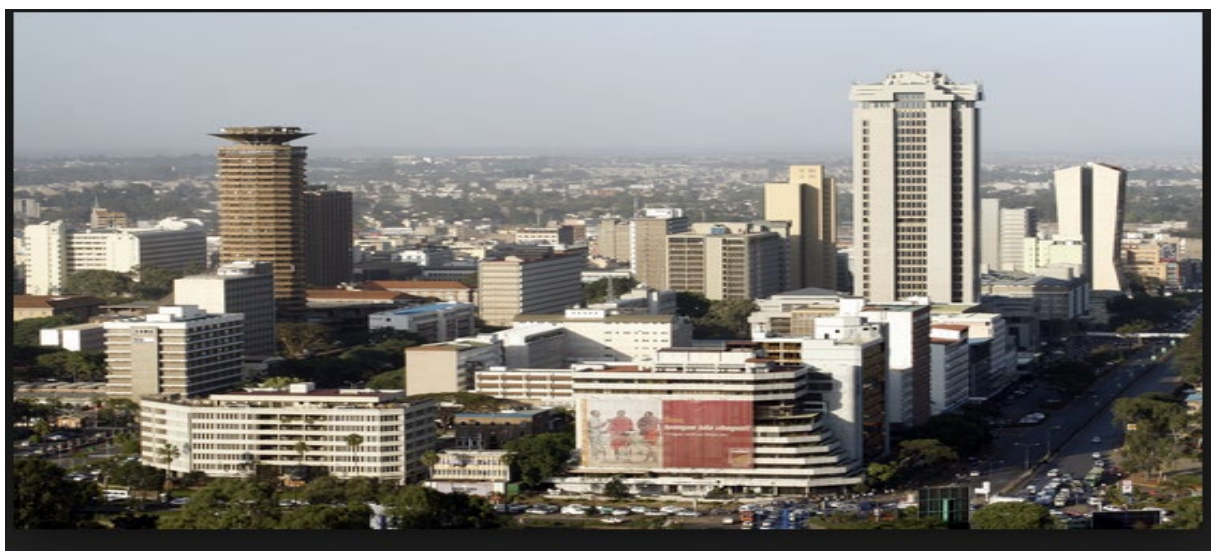


Figure 11.6: Aerial view of Nairobi Capital City Centre

Table 11.6: Population projection by age cohorts in Nairobi County
(Source: Nairobi City County, 2017a:6)

Age Cohort	2009 (Census)			2012 (Projections)			2015 (Projections)			2017 (Projections)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-4	199,381	197,780	397,161	223,457	221,662	445,119	250,439	248,429	498,868	270,214	268,045	538,259
5-9	151,900	154,977	306,877	170,242	173,691	343,933	190,799	194,664	385,463	205,865	210,035	415,900
10-14	119,951	127,014	246,965	134,435	142,351	276,786	150,669	159,540	310,209	162,566	172,138	334,704
15-19	115,772	154,292	270,064	129,751	172,923	302,674	145,419	193,804	339,223	156,902	209,107	366,009
20-24	211,089	266,307	477,396	236,578	298,464	535,042	265,146	334,504	599,650	286,082	360,918	647,000
25-29	234,596	228,157	462,753	262,924	255,707	518,631	294,672	286,585	581,257	317,941	309,214	627,155
30-34	182,623	141,506	324,129	204,675	158,593	363,268	229,390	177,744	407,134	247,503	191,779	439,282
35-39	134,459	95,173	229,632	150,695	106,665	257,360	168,892	119,545	288,437	182,228	128,985	311,213
40-44	89,109	57,492	146,601	99,869	64,434	164,303	111,928	72,215	184,143	120,767	77,917	198,684
45-49	65,901	41,102	107,003	73,858	46,065	119,923	82,777	51,627	134,404	89,314	55,704	145,018
50-54	41,682	24,894	66,576	46,715	27,900	74,615	52,356	31,269	83,625	56,490	33,738	90,228
55-59	24,304	14,981	39,285	27,238	16,790	44,028	30,528	18,817	49,345	32,938	20,303	53,241
60-64	15,061	10,105	25,166	16,879	11,325	28,204	18,918	12,692	31,610	20,412	13,695	34,107
65-69	7,358	5,664	13,022	8,246	6,348	14,594	9,242	7,115	16,357	9,972	7,676	17,648
70-74	4,462	4,240	8,702	5,000	4,752	9,752	5,604	5,326	10,930	6,047	5,746	11,793
75-79	2,424	2,519	4,943	2,716	2,823	5,539	3,045	3,164	6,209	3,285	3,414	6,699
80+	3,348	5,175	8,523	3,752	5,800	9,552	4,205	6,500	10,705	4,537	7,014	11,551
Age NS*	1,810	1,761	3,571	2,028	1,974	4,002	2,273	2,212	4,485	2,453	2,386	4,839
TOTAL	1,605,230	1,533,139	3,138,369	1,799,058	1,718,267	3,517,325	2,016,302	1,925,752	3,942,054	2,175,516	2,077,814	4,253,330

11.13.1 Population distribution

Over 34% of Kenya's total population lives in urban areas, of which more than 71% is based in informal settlements (slums), with an annual growth rate standing at 5% – the highest in the world (Mutisya & Yarime, 2011; Ziraba et al., 2009). The majority of Nairobi residents, 60-70%, live in slums where the population has exploded (Nairobi City County, 2013; Ziraba et al., 2009;

Bakibinga et al., 2014; Beguy et al., 2015). Figure 11.7 shows a projection done by the UN Secretariat of the population growth in Nairobi County between 1900 and 2040.

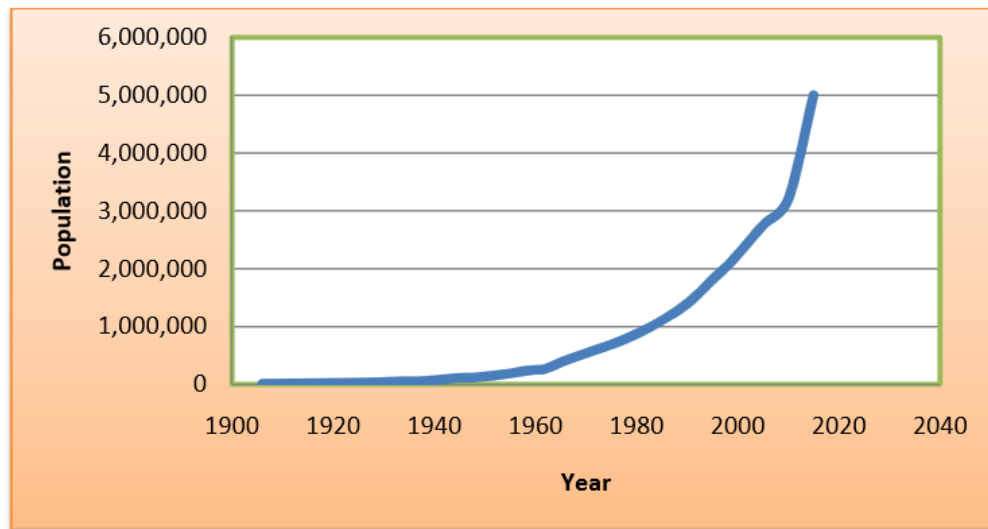


Figure 11.7: Projection of Nairobi's population growth between 1900 and 2040
(Source: Mutisya & Yarime, 2011:199)

Rapid urban poor population growth has led to the proliferation of slums in Nairobi city where people are devoid of basic needs and services, hence they live in deplorable conditions characterised by abject poverty and inadequate social amenities (Ziraba et al., 2009; Bakibinga et al., 2014; Beguy et al., 2015). The population has surpassed the available capacity in providing social services, which include health care, a situation that remains a continuous challenge to the planners. As a result, slum dwellers continue to experience cost challenges and congestion in public facilities to utilise government services (Mutisya & Yarime, 2011; Ziraba et al., 2009). Slum dwellers are, therefore, subjected to a myriad of challenges, including inadequate health services, clean water supply and sanitation, energy, solid waste management, housing and educational facilities, among other services, according to the authors. Furthermore, unemployment, poor drainage systems, high rates of crime and insecurity contribute to mass poverty and contagious diseases witnessed in these environments, which negatively affect the population's wellbeing. Slums in NCC include Kibera, Mathare, Korogocho, Mukuru Kwa Njenga and Majengo. Kibera slums, a section shown in Figure 11.8, is among the largest slums on the African continent, with a population estimated over 900,000 as it was standing in 2010 (Kenya National Bureau of Statistics. 2013). The slum covers an area of 2.5 square kilometres and is located approximately 5 kilometres away from the Central Business District (CBD) of Nairobi City (Mutisya & Yarime, 2011:202).



Figure 11.8: Aerial view of Kibera Slums in Nairobi City

11.13.2 County health services

This section provides a highlight of health care services within NCC, including disease burden; maternal and neonatal care; health infrastructure, i.e. number of health facilities; human resources; administrative structure; and challenges facing the sector.

11.13.2.1 Disease burden

According to NCC's *"Health Sector Working Group Report: Medium Term Expenditure Framework Budget for the period 2014-2015/2019"*, communicable diseases such as HIV/AIDS and TB are the main challenges facing the county's health sector (Nairobi City County, 2013). HIV is the main cause of mortality and morbidity, with the average prevalence standing at 8% (male at 5.3% and women at 8.4%), compared to the National rate of 6%, according to 2014 estimates. To address the situation, interventions have been put in place, including: the management of Sexually Transmitted Infections (STIs) and opportunistic infections; HIV Testing and Counseling (HTC); Voluntary Counseling and Testing (VCT); Prevention of Mother to Child Transmission (PMTCT); Comprehensive Care Clinic (CCCs)/ART clinics; and Voluntary Male Medical Circumcision (VMMC). The County Government has adopted strategies to facilitate the availability of drugs to prevent mother-to-child transmission of HIV in all public health facilities while implementing the Kenya AIDS Strategic Framework 2014/15-2018/19 to counter the HIV menace. TB is the most common opportunistic infection and the leading killer among people living with HIV/AIDS. The County experiences a high TB prevalence of 490 per 100,000 population with more than 15,000 TB patients. The cure success rate of TB for the year 2014 was 84% against the recommended 90% national target. More importantly, TB infection is more common in informal settlements

where the majority of the residents live (Mutisya & Yarime, 2011). Multidrug-resistant TB cases are on the rise, which presents another challenge – it demands a longer treatment period and is much more expensive to treat. Other communicable diseases include respiratory diseases such as pneumonia, which accounted for over 60% of clinic visits in 2014, especially among those over 5 years old, whereas diarrheal diseases, which is correlated with low hygiene and sanitation levels, account for 16% of clinic visits, among other diseases (Nairobi City County, 2013).

11.13.2.2 Maternal and neonatal child health services

According to the County Integrated Development Plan (CIDP) report for 2014, the average first to fourth ANC visit coverage was 93%; however, the ANC fourth visit coverage was the lowest at 48.6%. About 74% of the mothers delivered in health facilities, while 26% delivered elsewhere (Nairobi City County, 2014). During the same period, i.e. 2014, the top ten leading causes of illness among the under-five year olds were respiratory, diarrhoea, skin (including wounds), pneumonia, eye, ear, malaria, intestinal worms and urinary tract infections. An estimated 73% of children younger than 5 years were immunised, of which 3% among those attending a Child welfare Clinic (CWC) were suffering from stunted growth, and 0.32% of them were underweight (Nairobi City County, 2014). The County's Vitamin A coverage for children younger than 5 years was 34% against the national target of 80%. In particular, the County continues to experience a high burden of disease, including HIV/AIDS, TB, reproductive health (maternal), neonatal, environmental and NCDs such as cervical cancer and diabetes (Nairobi City County, 2014).

11.13.2.3 County health infrastructure

Nairobi City County reports on 495 health facilities offering services at various levels of care (Nairobi City County, 2014). The health facilities comprise hospitals (10%), nursing homes (7%), clinics (55%), dispensaries (20%) and HCs (8%). In total, 52% of the facilities are privately owned, 21% are Government (GOK/NCC) owned, while the remaining 27% are owned by faith-based organisations (FBOs), i.e. not-for-profit and non-governmental organisations (NGOs) as shown in Table 11.7.

The health sector has been and still is expanding its services in Nairobi by upgrading existing ones while constructing new health facilities. These include Beyond Zero clinics in Kibera slums, the Paediatric unit at Bahati H/C, the upcoming Mathare-Korogocho and Mutuini hospitals, and the expansion of Mama Lucy Kibaki hospital to increase access and ensure quality and high standards of care (Nairobi City County, 2013).

Table 11.7: The number of health facilities per category in Nairobi County

(Source: Nairobi City County, 2013:17)

Ownership	Functional Community Units	Clinics	Dispensaries	Health Centres	Nursing /Maternity Homes	Hospitals	Total	%Category of Total
Public (GOK/CCN)	121	14	61	27	1	3	106	21%
Sub Total	121	14	61	27	1	3	106	
FBO/ NGO	0	82	28	11	3	8	132	27%
Private	0	177	8	4	31	37	257	52%
Sub Total		259	36	15	34	45	389	
Grand Total	121	273	97	42	35	48	495	100%
% Category of Total		55%	20%	8%	7%	10%	100%	

11.13.2.4 Human resources

Nairobi County's public health workforce comprised 3,695 (in post) of the 6,629 (required) workers, with a variance gap/shortage of 1,979, according to 2014 statistics. The available staff mainly comprise medical officers/specialists (191), nurses (1,376), COs (270), and public health officers (PHOs) (222) among key cadres of the health personnel (Nairobi City County, 2013).

11.13.2.5 Staff/patient ratios in Nairobi County

The recommended nurse/patient ratio, according to the Nursing Human Resources of Kenya-Case Study of 2010 is 2.5 nurses for 1,000 patients that is, 1 nurse per 400 patients. However, as evident from available statistics in Table 11.8, the current County Health staffing levels fall far below the recommended threshold by the above authorities hence the need for more staff.

Table 11.8: Staff/patient ratios compared to the WHO's recommended ratios

(Source: Nairobi City County, 2013:18)

S/No	Cadre	County Ratio	Recommended Ratio	Authority
1	Doctors	1:17000	1: 1,000	WHO, 2006
2	Nurses	1:2,500	1: 400	Nursing Human Resources in Kenya, 2010 Case Study
3	Dentists	1:42,000	1: 2,000	WHO,2006
4	Pharmacists	1:16,000	1: 2,000	WHO, 2006

11.13.2.6 Administrative structure

The mission of the NCC Health Services sector is to "provide quality health care services that are accessible, equitable and sustainable to the population of Nairobi City County and beyond" (Nairobi City County, 2017b:24). The core-values include respect for human dignity and for cultural diversity, professionalism, innovativeness, integrity, responsiveness and social accountability.

The County's Health unit has three departments with clearly defined mandates and heads of departments for efficient delivery of health services. The departments are: Preventive and Promotive Health Services; Curative Care; and General Administration consisting of planning and support services. Service delivery units within each department are overseen by the County Health Management Team (Nairobi City County, 2013).

11.14 Challenges facing Nairobi County's health sector

Poor health financing and governance, inadequate health care infrastructure, and rapid population growth due to rural-urban migration are among the key problems facing the health sector in Nairobi County (Mutisya & Yarime, 2011; Bakibinga et al., 2014; Kimathi, 2017). Overcrowding and congestion continue to increase in public health facilities, particularly in informal settlements (slum areas). According to Bakibinga et al. (2014), public health facilities in Nairobi's informal settlements are almost non-existent. The low health care coverage is a result of the ever-growing population in the city's slums, where there is little expansion of health services (Ziraba et al., 2009). A survey conducted by the African Population and Health Research Center (APHRC) in 2000 found that health indicators in the Nairobi City slums are worse off compared to other counterparts, including in rural areas of the country. This situation continuously place pressure on the available few resources and, as such, there communicable diseases such as TB spread quickly. In addition, the unstable/lack of power supply affects medical operations in public facilities in terms of operating/running medical equipment, while inadequate security in HCs located in slums remains a challenge due to high crime rates. Inadequate commodity supplies (both medicine/drugs and non-pharmaceuticals) and special equipment as well as the lack of skilled health personnel and ambulatory services to attend to emergencies continues to hinder health care services (Ziraba et al., 2009). In addition, low health literacy levels among urban poor populations have led to an overreliance on traditional medicine as an alternative to primary health care, causing unpreventable hospital admissions and deaths. There is high burden of NCD outbreaks, including cancer, asthma, and diabetes, among other diseases, while malaria continues to affect health care delivery negatively, hence poor population health outcomes (Ziraba et al., 2009; Nairobi City County, 2013).

11.15 Chapter conclusion

In this chapter, the Kenyan health care situation was explored. The case study of Nairobi's informal settlements was discussed as a typically underserved context. In the next chapter, the data analysis and findings of the study are presented.

Chapter 12: Data Analysis and Findings

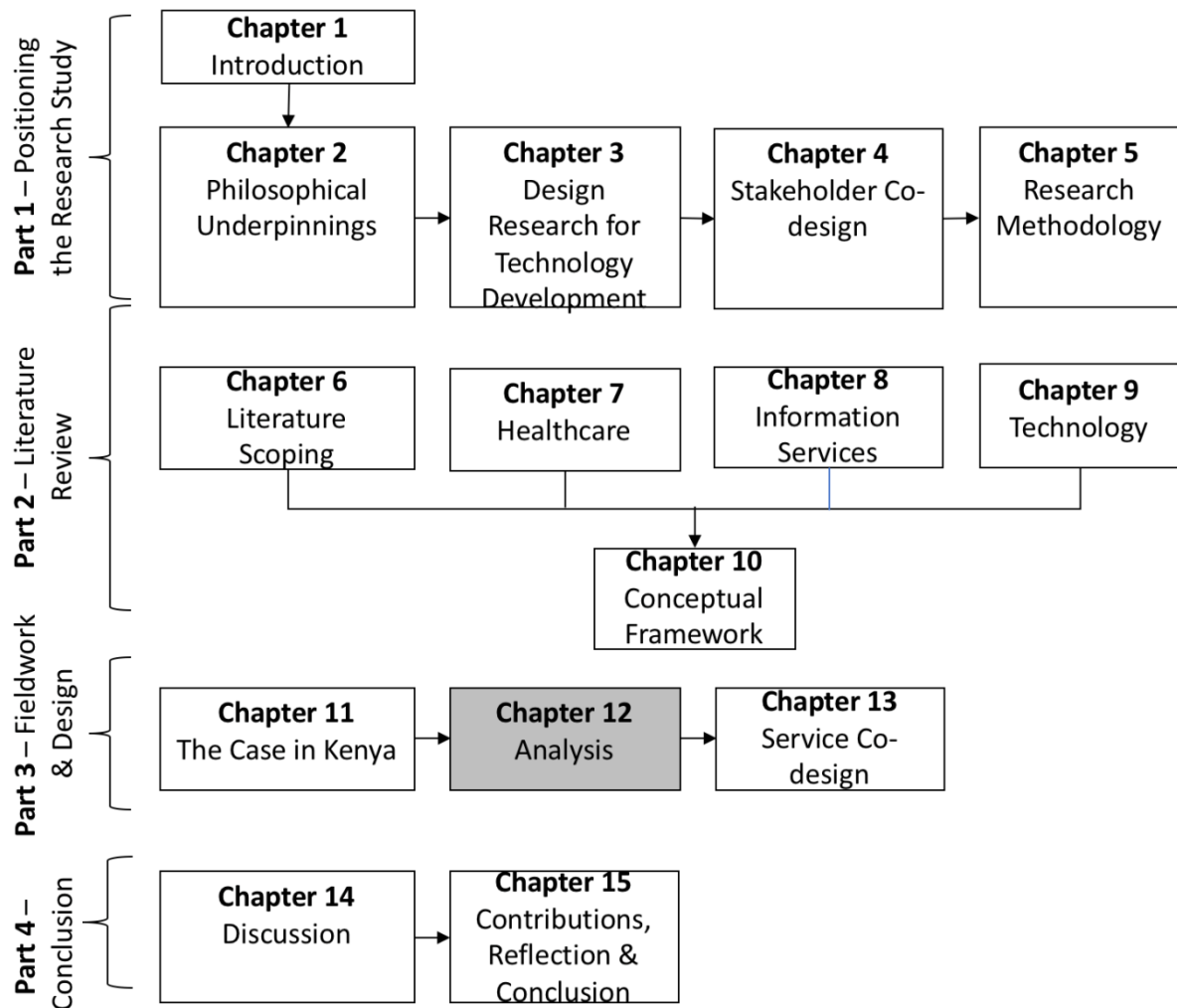


Figure 12.1: Thesis Layout - Chapter 12

12.1 Introduction

This chapter presents the data analysis process and the interpretation of results, which involve various thematic analyses and categories per each unit of analysis. Specifically, the chapter highlights the empirical case of the study, constraints, current maternal health and wellbeing services, information infrastructure, stakeholders, information flows, data collection and the analysis process as well as the study findings.

12.2 Research context

This study was conducted at government health facilities in the informal settlements of NCC. The county has ten administrative units known as sub-counties, with a total population of 4,337,080 residents and 1,506,888 households, according to the 2019 national population census (Kenya National Bureau of Statistics, 2020). The health care sector is organised into ten (10) community units known as health zones that provide primary health services. There

are 115 public facilities with 3,290 workers, of which 2,604 (79%) of the required 5,208 workers are technical staff (Nairobi City County, 2017b). About 60-70% of the city's residents who were among the target population live in slum areas (Nairobi City County, 2013; Ziraba et al., 2009). The health care sector continues to experience the effects of rapid urbanisation and particularly the proliferation of slums in the city, which is characteristic of mass poverty, inadequate social infrastructure and the high burden of infectious diseases, among other challenges (Bakibinga et al., 2014). For instance, the 2020 metro area population of Nairobi increased by 3.93% from 2019 (Macrotrends, 2020). Because of this, the population surpasses the available government capacity, including health care services due to inadequate health care infrastructure, to provide basic services in the underserved areas (Mutisya & Yarime, 2011), hence low health care coverage (Bakibinga et al., 2014). This leads to congestion in public health care facilities operating in the informal settlements, prompting poor service delivery and high health care costs, among other challenges. Also, this situation is attributed to the general perception that health care services are cheaper in government institutions as opposed to the private sector, hence the scramble, which leads to the long queues witnessed in public facilities and eventual poor health outcomes (Bakibinga et al., 2014).

While the hospitals provide secondary care, the remainder of the facilities offer basic and/or primary health care services. Generally, doctors are only available in the hospitals where they treat and manage operations. Health centers, dispensaries and clinics are run by clinical officers (COs) and nurses, while community units are managed by community health workers/volunteers (CHW/Vs). Therefore, care activity begins at community level, and then progresses to the next levels, which are dispensary, health centers, district hospitals (county referral facility), and then finally to the National Referral Hospital for special treatment as need may arise.

In addition, the health care infrastructure in NCC remains inadequate as most of the health facilities are situated in informal settlements where there is a lack of basic social amenities such as food, water, shelter, sanitation, education and health. Communities receiving care from these facilities live in the slums neighbourhood and are of low socioeconomic status (SES) with high levels of poverty. Consequently, there is a lack of essential working equipment and electricity to operate this equipment, as well as commodity supplies such as drugs. Also, staff shortages are acute because the majority of health care professionals prefer to work in upper class places and in private hospitals where remuneration is better. As a result of these, universal health coverage (UHC) has not yet been achieved as the majority of communities still lack access to basic health care.

CHWs are the first point of contact with the community; however, they are not authorised to diagnose illness or subscribe drugs for patients, since they do not have the relevant training.

The majority of them are trained as public health officers (PHOs) and/or social workers. As such, they can only provide preventive care services at community level and refer clients to community facilities for treatment when the need arises. Health education services are mainly rendered at community units and include hygiene, sanitation, the transmission of communicable diseases such as HIV/AIDS and TB, and distributing prescriptive drugs to patients with chronic conditions as advised by caregivers at the facility. However, in some cases and particularly during emergencies, CHW/Vs act accordingly to administer care and/or treatment especially where a baby is delivered before the mother arrives at the facility/hospital. CHW/Vs are also in conjunction with nurses charged with the responsibility of following-up on clients through home visits within their assigned households.

12.3 Study constraints

This study was faced with challenges that negatively affected the data collection process, including bureaucracy, resource scarcity, geographical scope, and time constraints. To begin with, the process to seek clearance from relevant authorities to access selected health facilities was bureaucratic to the extent that it took months before the study could commence as scheduled. This prolonged the period of the study. Also, the project had no sponsor; hence, it was difficult to secure the necessary permits, research material and equipment as well as transport to and from the field. Specifically, geographical coverage of the project was enormous; it involved six facilities/hospitals spread across the county, hence the researcher had to squeeze the budget, mainly funded from personal savings that were not sufficient. Time management was also a challenge for the researcher in terms of achieving project milestones as scheduled due to situations beyond his control, and particularly emergencies that caused participants to fail turning up for the interviews as planned. Therefore, meetings had to be rescheduled – a scenario that led to time wastage.

12.4 Current maternal health and wellbeing services

Maternal mortality ratios in Kenya have remained average, with about 400 deaths per 100,000 live births while neonatal mortality accounted for about 60% of all infant deaths in Kenya. In 2013, maternal health care services started being offered for free in public facilities in efforts to achieve UHC, following an executive order by the President. However, the services have not been sufficiently effective, as user fees are an important source of revenue for health facilities; the waiver of user fees has negatively influenced service delivery. To implement this directive, the government, through the NHIF implemented the Linda Mama programme, which is a publically funded maternity health scheme to ensure that pregnant women and infants have access to quality and affordable health services in public health facilities. Also, the Beyond Zero national campaign programme (a charitable organisation) was launched in 2014 by the First Lady (Margaret Kenyatta) to help improve maternal and child care, and also to

eliminate new HIV infections among children to improve health outcomes. The aim of the project is to enhance policy prioritisation and formulation, increase resource allocation, and improve service delivery with better individual health seeking behaviours among pregnant women and nursing mothers to prevent maternal and children deaths.

As at 2014, NCC witnessed an average of 93% of first to fourth antenatal care (ANC) visits within NCC; however, the fourth ANC visit coverage was the lowest at 48.6%. At the same time, 74% of expectant mothers delivered at the county's health facilities, while 26% delivered elsewhere. Currently, among the leading causes of illness in children younger than five years include respiratory and skin problems, diarrhoea, malaria, and intestinal worms. About 73% of children younger than 5 years were immunised, 3% of children attending CWC were suffering from stunted growth, while 0.32% were underweight. The County Government's target coverage for children younger than 5 years is 80%; however, it currently stands at approximately 34%. The county continues to experience a high burden of disease, including HIV/AIDS, TB, reproductive health, and non-communicable diseases (NCDs) such as cervical cancer, among others.

12.5 Health information infrastructure

At present, a print version of the ANC booklet, which is the officially approved maternal document of the Kenyan Ministry of Health, was used to manage clients' maternal health information. Health care personnel update the client health data in this booklet throughout their maternity period (both ANC and PNC) and up until the child is five years of age. The client (mother) is the custodian of the booklet and produces it during each subsequent visit to the clinic. Administrative health information is recorded in a book known as the "*Maternal Register*", which is kept and maintained by staff in health facilities. In general, Kenya has not yet advanced in terms of HITs due to infrastructure related challenges, which have slowed down the growth and development of ICT in the health sector. The existing national HIS system (DHIS) is only used for reporting to the national office. Individual health facilities therefore do not have direct access to DHIS except for senior health officers at the county health office, who receive aggregated data from various county facilities in print form and then key it into the system for reporting purposes.

Being unexceptional, NCC's health information infrastructure is largely manual, whereby documentation is mainly based on paperwork. ICT has not been leveraged in health care delivery due to the lack of supporting infrastructure, including policies to guide ICT implementation, equipment and machines, skilled IT personnel to install and maintain systems, staff training to develop computer literacy skills, and funding to avail the requires resources, among others. As a result, facilities across the county rely on manual services, which have now become a culture. Of the 6 facilities examined in this study, only a few used computer

systems to manage information, through the support of donors. For example, IQCARE system was used in one of the facilities to manage HIV/AIDs data on clients, including general statistics such as the number of patients put on drugs, drug defaulters, and appointments, for easy tracking and monitoring by the nurses and CHW/Vs. However, all the facilities have computerised financial services and management fully supported by the County Government. In addition, mobile phones are used to a large extent by health care personnel, including CHW/Vs, to carry out follow-up appointments with reminders to clients through message alerts and phone calls. For purposes of communicating health information, each facility has a mobile phone that is used during emergency and referral cases, especially those involving external institutions.

12.6 Maternal health information stakeholders

This sub-section highlights the stakeholders in the case, which included women, CHWs, health care professionals, health care managers and ICT experts. Respondents in this category comprised mainly pregnant women and/or mothers with maternal experience, and who were residents of NCC, Kenya. They were the ultimate receivers of maternity services, namely pre-natal, ANC, and postnatal care services in public community health facilities within the county. In total, 23 women were interviewed as potential clients of maternal care as the study focused on maternal health care services.

CHWs provide basic health and medical care support to clients (pregnant women) at community level, which include preventive, promotional and rehabilitation care services. Besides household mapping and community health reporting to local health authorities within NCC, they provide health education services and refer citizens to community health facilities for care advice. For the study, the researcher interviewed four (4) respondents in this category, whose portfolios were as follows: Sub-County Community Focal Person-1; Community Health Assistant-1; Community Social Worker-1, and CHW/V-1. People with these portfolios generally operate within all branches of health care, including medicine, surgery, midwifery, nursing, public or community health experts whose endeavour is to work for the common good of the society as a whole.

It is mainly the caregivers who interact with pregnant women and nursing mothers during their maternity journey, from their antenatal to their post-natal care. These caregivers include doctors and nurses who work at the selected public health facilities (H/Cs and hospitals) situated around communities within NCC. For this study, the researcher interviewed 11 participants in this category, with the following portfolios: Community Health Nurse-3; Nursing Officer-4; Nutritionist-1; COs-1; and Doctor-2.

In the administrative category, stakeholders mostly occupy managerial portfolios (positions) at their respective stations, which are selected public health facilities within NCC.

They are officers in charge of hospitals and HCs overseeing the smooth running of the day-to-day activities of health institutions, which include managing resources and reporting, for example, budgeting, staffing, commodity and supplies as well as day-to-day running of operations, among others. They also provide direction and enforce/implement government policy in health care delivery and services. In total, five (5) managers were interviewed, with their portfolios as follows: Medical Superintendent-1, Deputy Medical Superintendent-1, Facility-In-Charge-2, and Maternity Unit In-Charge-1.

The final category of respondents comprised mainly people with knowledge and diverse specialisation(s) in the ICT field, particularly those associated with or who worked in the health sector, and, more importantly, who were familiar with the research context. During the study, the researcher observed that ICT services were almost non-existent in public health facilities, and, following in-depth observation, noted that the current maternal health information practices were mainly manual. Being a technical subject, the researcher needed participants with adequate ICT knowledge and skills to readily answer interview questions appropriately, particularly those concerning design considerations for ICT-facilitated health information services in the research context. Four (4) experts were interviewed from academia, ICT and health care domains. The composition of this category of participants was as follows: Lecturer-1, Health Systems Developer-1, Cloud Services Manager-1, and IS Manager-1.

12.6.1 Maternal health information flows

The flow of maternal health care services between institutions (health facilities) and activities are presented according to the health care system hierarchy, from community level, to county level and then to national level. Figure 12.2 was developed to illustrate the interrelationships between the layer of institutions/organisations, stakeholders, care activities and flow of services within Kenya's health care system, NCC included, demonstrating that citizens can receive health care services from the public, private and/or traditional sector.

Three main levels of formal health care services were identified, namely primary, secondary and tertiary (specialist) care. In the public sector, primary (basic) care is provided at dispensaries and health centers are run by nurses and COs (clinicians), which is the same as with licensed private practices. Because the services offered at this level mainly involve out-patient (OPD) care, professional skills in terms of medical personnel, facilities and equipment such as wards, theatre, and X-rays, are limited/not available. Services offered in private practice are mainly run by General Practitioners (GP), unlike in the public sector.

Services offered on the secondary level are more expanded and include both out-patient and in-patient (hospitalisation in wards) care. This level is mainly run by higher skilled personnel such as Medical Officers (MO) and GPs, and they have access to facilities and equipment which are otherwise not available on the primary level.

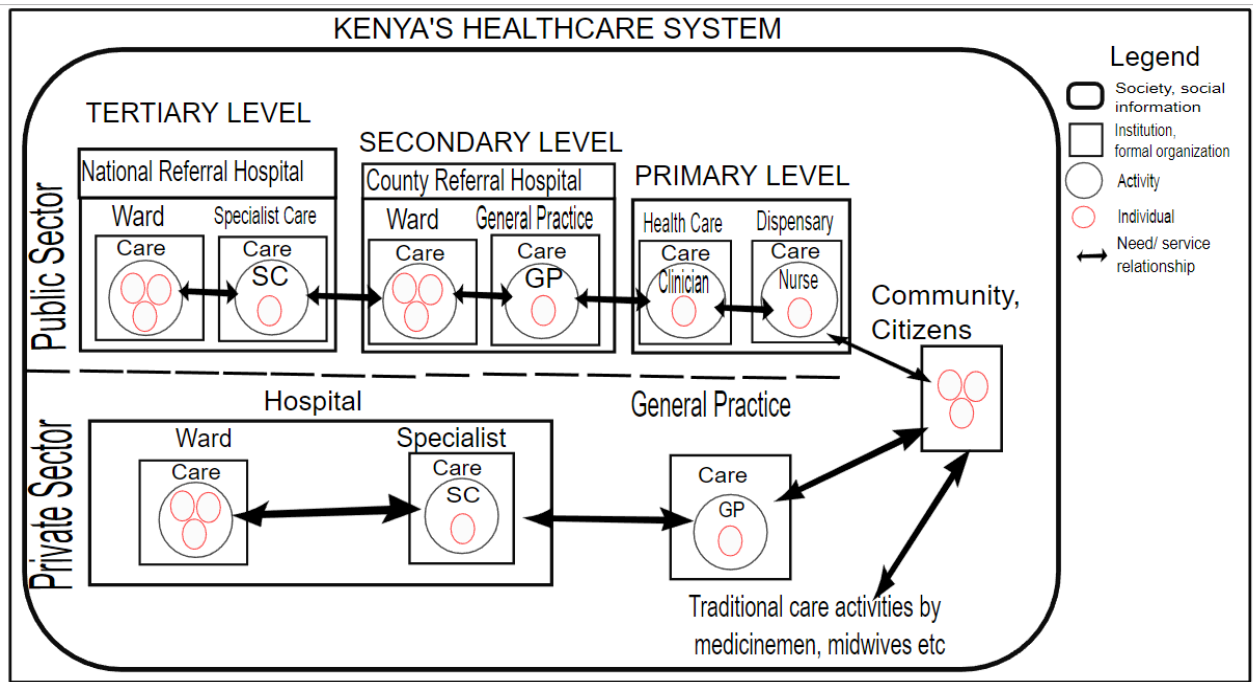


Figure 12.2: Institutions, stakeholders, activities and service relationships in the Kenyan context

Finally, services rendered – both OPD and in-patient (IPD) care – on the tertiary level are more specialised and run by specialist consultants (SCs), with advanced medical equipment which are not available on the lower (primary and secondary) levels. In the event that a client's (patient) condition cannot be addressed on the primary level, they are referred to the County Referral Hospital, and if the situation still cannot be managed, the matter is referred to the National Referral Hospital for specialised treatment. In private practices, SCs are not necessarily employed on a full-time basis; they mainly provide consultancy services on a part-time basis and/or for operating personal businesses within the hospital infrastructure. Thus, in the same way maternal health care services flow, health information also flows from primary level, to secondary level, and then to national level.

12.7 Data gathering process

This sub-section highlights the data collection process, including number of facilities under study, number of research participants, data collection methods used, total number of interviews conducted, and data saturation level.

12.7.1 Study setting

Six government facilities located in Nairobi's informal settlements, offering from comprehensive primary care to holistic services, including maternity IPD care, were selected for this study. Four are health centers (H/Cs) and two are hospitals, named as follows: Mathare North H/C, Embakasi H/C, Eastleigh H/C, Kibera South H/C, Mutuini Sub-District Hospital and Pumwani Maternity Hospital. Table 12.1 provides a summary description of each of the selected facilities in terms of services offered, average number of clients attended per month,

total number of technical/medical staff, and number of participants, including medical staff and community health coordinators (CHCs), who participated in the study.

Table 12.1: Description of health facilities and number of participants selected in each facility

S/N	Facility Name	Type of services offered	Average No. clients attended per month	No. of medical staff	No. of medical staff interviewed	No. of CHCs interviewed
1	Mathare North H/C	OPD, maternity, laboratory, pharmacy, , public health, MCH, prevention of mother-to-child transmission (PMTCT), radiology, HIV test & counselling	4,410	55	2	1
2	Embakasi H/C	OPD, maternity, laboratory, pharmacy, MCH, PMTCT, HIV test & counselling	2,100	22	2	None
3	Eastleigh H/C	OPD, maternity, laboratory, pharmacy, MCH, PMTCT, HIV test & counselling	2,250	22	2	1
4	Kibera South H/C	OPD, maternity, laboratory, pharmacy, MCH, PMTCT, HIV test & counselling	1,400	48	2	1
5	Mutuini Sub-District Hospital	OPD, IPD, maternity, laboratory, pharmacy, MCH, PMTCT, family planning, physiotherapy	3,090	64	3	None
6	Pumwani Maternity Hospital	OPD, IPD, laboratory, pharmacy, MCH, PMTCT, physiotherapy, theatre, paediatrics, radiology, HDU, ICU	2,250	330	5	1
Total			15,500	523	16	4

12.7.2 Participant selection

The key stakeholders identified in maternal health care apart from the development partners were the government, citizens, health care providers, health care managers, and community health workers/CHWs (Kreindler, 2015; Brownstein et al., 2011; Korpela et al., 2008). In the specific context of HIS/eHealth however, the relevant stakeholders include health care providers, the people (clients), and technology providers (Korpela et al., 2013; Gao & Sunyaev, 2019). Generally, these are players who either affect or can be affected by the health system (Javanparast et al., 2009).

Based on this understanding, the study identified five participant groups, namely: Facility-In-Charge (administrators/managers), health care professionals, clients, CHWs, and ICT professionals/experts as the key stakeholders of eHealth in health care organisations. In this case, the Facility-In-Charge group represents the government as the policy maker; medical staff are the health care providers; clients are the consumers of health care services (potential patients); CHCs are the link between health facilities and the surrounding community; and ICT experts are the providers of eHealth services. Health professionals and CHCs were recruited at the health facilities while clients who received care at the facilities were recruited from different households within the neighbourhood through the help of the CHCs. ICT professionals were however recruited from outside the facilities, academia, the ICT sector and health care

institutions. This is because the participating facilities had neither an IT department nor the relevant personnel to provide the relevant information. Various criteria were applied during the selection of professional participants, including level of education, role, profession, job position/rank, work experience and station (Marshall, 1996), as opposed to client participants.

12.7.2.1 Profile of professional participants

The professional category of participants includes health care managers, health professionals, CHW/Vs, and ICT experts; they were profiled according to their profession, job position/rank, and industry as per the key considerations related to their selection (see Table 12.2). The four participant groups were coded as follows:

Legend:

Health Professionals: HP001-HP011
 Facility Administrators: AP001-AP005
 CHW/Vs: CHW001-CHW004
 ICT Experts: ICT001-ICT004

Table 12.2: Profile of professional participants

S/N	Participant code	Profession/Career	Position	Industry
1	HP001	Gynaecologist	Deputy Medical Superintendent (Deputy Facility-In-Charge)	Health care
2	HP002	Registered Nurse	Paediatric Nurse	Health care
3	HP003	Registered Nurse	Nursing Officer	Health care
4	HP004	Clinician	Clinical Officer	Health care
5	HP005	Registered Nurse	Nursing Officer (In-Charge Maternity)	Health care
6	HP006	Registered Nurse	Nursing Officer	Health care
7	HP007	Registered Nurse	Midwife	Health care
8	HP008	Registered Nurse	Nursing Officer	Health care
9	HP009	Registered Nurse	Nursing Officer	Health care
10	HP0010	Registered Nurse	Nursing Officer	Health care
11	HP0011	Enrolled Nurse	Nurse	Health care
12	AP001	Registered Nurse	Nursing Officer (In-Charge Maternity)	Health care
13	AP002	Registered Nurse	Nursing Officer (Deputy Facility-In-Charge)	Health care
14	AP003	Registered Nurse	Nursing Officer (Facility-In-Charge)	Health care
15	AP004	Registered Nurse	Nursing Officer (Facility-In-Charge)	Health care
16	AP005	General Practitioner	Medical Superintendent	Health care
17	CHW001	Social Worker	Community Health Volunteer (CHV)	Health care
18	CHW002	Public Health Officer	Sub-County Community Focal Person	Health care
19	CHW003	Social Worker	Community Health Volunteer (CHV)	Health care
20	CHW004	Public Health Technician	Community Health Assistant	Health care
21	ICT001	IT Professional	Software Developer (Medical Lab Systems)	Academia
22	ICT002	IT Professional	IT Lecturer	Academia

S/N	Participant code	Profession/Career	Position	Industry
23	ICT003	IT Professional	Information Systems Manager	ICT
24	ICT004	IT Professional	General Manager (Client Services)	Health

12.7.2.2 Profile of client participants

Client participants who mainly received health care services in public facilities were selected from within the neighbourhood of the participating facilities, and were over 18 years of age (>18 years), among other criteria.

Legend:

Clients: MP001-MP023

Table 12.3: Profile of client participants

S/N	Participant code	Age bracket (Years)	Marital status	Education level	Nature of health care services received	Medical insurance
1	MP001	18-30	Married	College certificate	Public	Insured
2	MP002	31-40	Unknown	College certificate	Public	Insured
3	MP003	18-30	Married	University degree	Private	Insured
4	MP004	18-30	Married	College certificate	Public	Not insured
5	MP005	31-40	Married	College certificate	Public	Insured
6	MP006	31-40	Married	College certificate	Public	Unknown
7	MP007	31-40	Married	College certificate	Public	Insured
8	MP008	18-30	Married	College certificate	Public	Insured
9	MP009	18-30	Unknown	High school and below	Private	Insured
10	MP0010	18-30	Married	High school and below	Private	Insured
11	MP0011	18-30	Married	High school and below	Public	Unknown
12	MP0012	18-30	Married	High school and below	Public	Not insured
13	MP0013	18-30	Married	High school and below	Public	Unknown
14	MP0014	31-40	Married	College certificate	Public	Insured
15	MP0015	18-30	Married	College certificate	Public	Insured
16	MP0016	18-30	Married	High school and below	Public	Insured
17	MP0017	18-30	Married	College certificate	Public	Insured
18	MP0018	18-30	Married	College certificate	Public	Insured
19	MP0019	18-30	Married	High school and below	Public	Insured
20	MP0020	18-30	Married	College certificate	Public	Not insured
21	MP0021	18 & below	Married	High school and below	Private	Not insured
22	MP0022	31- 40	Married	College certificate	Public	Insured
23	MP0023	31- 40	Married	College certificate	Public	Insured

According to Kerr et al. (2010), the optimum number of required subjects in a qualitative study evolves over time as the study progresses until data saturation is attained. In this study,

six (6) Facility-In-Charge and four (4) CHC participants were purposively selected to represent their respective facilities (Kerr et al., 2010). The snowball sampling technique was then used whereby the Facility-In-Charge and CHC participants nominated other participants (Marshall, 1996), including medical staff (nurses, clinicians and doctors) and clients from different households. However, two of the selected facilities did not have community health teams at the time of the study hence no participants were recruited in the CHWs category in those facilities. A total of (n=47) participants were recruited; (n=24) professionals for personal in-depth interviews and (n=23) clients for focus group interviews. Specifically, Facility-In-Charge (n=6), medical staff (n=10), CHCs (n=4), clients (n=23) and ICT professionals (n=4) were interviewed. Client participants were organised in three groups, (n=8), (n=7), and (n=8). Participant observation was however performed across all participant groups to gain a deeper understanding of the research phenomena (Hirsch, 1985; Moritz, 2005).

12.7.3 Data collection

Data collection was conducted between the period August 2018 and March 2019. The study was performed in two stages: (i) survey research to perform context analysis; and (ii) design research to co-create the desired solution. Data collection involved applying qualitative methods, including in-depth semi-structured interviews, focus groups and participant observation. Interviews and focus group discussions lasted for an average of one (1) hour per session. Interview questions were formulated using predefined theoretical themes as guidelines. Also, separate interview guides were designed for the client and health professional participants. Design research, on the other hand, involved applying the co-design-oriented SDR approach using service prototyping techniques (Salgado et al., 2017), presented in more depth in Chapter 13.

Specifically, interviews with the Facility-In-Charge participants were aimed at understanding the stakeholders in maternal health care, the nature of the health care organisation, the type(s) of services offered, government policy, resource availability, challenges faced in the health care delivery process, and health outcomes. Health personnel participants helped explore the nature of the public health care services provided, relevant stakeholders, their perception regarding patient-centred care, barriers to the delivery of quality health care service, and their perceived role of ICT in improving health care delivery. Community Health Volunteers (CHVs) assisted with exploring the nature of the community health services offered, challenges experienced in accessing public health services, and their perceived role of ICT in improving health care delivery. The ICT expert interviews focused on exploring the potential of ICT to improve health care delivery to the residents in Nairobi's informal settlements, key factors to consider in the design of patient-focused eHealth solutions, and possible challenges.

The focus group discussions with the clients explored their perceptions related to the quality of health care services offered in public health facilities, relevant stakeholders, barriers towards accessing health care services, desired personal health and wellbeing services, and their perceived role of ICT towards providing personal health information needs.

Observation was done to supplement the primary data gathered from the interviews. Observatory field notes were taken at the study site(s) using observation forms/sheets, capturing events as they unfolded during the interview phase. Specifically, the researcher keenly observed participants and their environments during the study, which helped in gaining a deeper insight into the research phenomenon. Non-verbal cues were noted, as well as the operations in the actual work environment, which included the interactions between various stakeholders and the devices used. Observatory notes and pictures were taken by the researcher, which were later analysed. This method enabled the researcher to investigate social systems in terms of the perceptions and behaviour of participants in the research context, i.e. the maternal health information services.

Secondary data were also used to supplement primary data, particularly in determining theoretical themes for the research, which helped the researcher gain prior knowledge about the research context. This was necessary to facilitate the formulation of a set of predefined theoretical themes to guide the collection of primary data.

Data saturation was attained with 35 respondents; however, the researcher continued to interview 12 more respondents, following the assumption that new concepts would emerge from the data. It was however noted that the findings were merely a repetition of what the previous 35 respondents said. According to the researcher's observation, close similarities were identified across responses since the study was conducted in the same research context, i.e. health care operations were run using the same business model, and, as such, having the same governance structure (County Government of Nairobi).

12.7.4 Limitations of data collection

Some of the challenges experienced with data collection include language barrier, insufficient data collection equipment, unavailability and/or non-cooperation by some of the participants, and socio-cultural issues. In addition, data collection was limited to a small number of public facilities.

Firstly, there was the challenge of a language barrier between the researcher and client participants whereby some of the women were unable to express themselves in English due to it not being their home language. However, the researcher interpreted interview questions in Swahili language to obtain conclusive answers to the questions.

Secondly, some of the required data collection equipment were not available, particularly a digital camera to take photos during interviews in the research environment. This is because the gadget was expensive to acquire; however, a smart phone was used to serve the purposes despite it not being as effective as a digital camera.

Thirdly, some of the scheduled appointments did not take place due to the unavailability of respondents to answer questions because of tight work schedules, and some were on leave. In such cases, the researcher had to reschedule appointments, wait for those on leave to resume, and/or recruit other participants. Furthermore, some of the respondents refused to allow a digital recording of their responses and taking photos during visits to the study sites. The researcher resorted to taking field notes from the responses while at the same time recording observations (observatory notes).

Fourthly, the socio-cultural context further limited the collection of data, as some questions were deemed inappropriate by participants. For example, the question relating to the number of pregnancies one has had. The researcher however, clarified the purpose of the research and assured the participants that the data collected were to be used for research purposes only.

Finally, the study was conducted at a few selected public facilities offering maternity services within NCC, thus excluding private institutions despite these constituting a reasonable share of the health care business where part of the city residents received maternal health care services.

12.8 Data analysis

The data analysis process was performed on two levels:

- Analysis of demographic data related to the respondent groups' demographics, comprising quantitative characteristics, hence data were analysed quantitatively
- Analysis of qualitative data (personal interviews, focus groups interviews and observation), comprising respondents' perceptions, attitudes, opinions, myths, beliefs, and/or rumours concerning the phenomenon under study. This was performed using thematic analysis (TA) and according to pre-defined theoretical themes and objectives of the research

Pre-analysis of the research context was done during field interviews through writing memorandums, followed by the actual data analysis, which involved generating initial codes, categories and themes. The six theoretical themes linked to the sub-research questions were used to guide the data collection process. Interview responses were then mapped to these theoretical themes for easy analysis.

12.8.1 Analysis of demographic data

The following sub-sections present and describe the analysis process of the demographic data using percentages.

12.8.1.1 Client/women participants

According to the study findings, all the women respondents were below 40 years of age, with the majority (65%) falling in the *18-30 years* category, while 30.4% of the respondents were within the *31-40 age* bracket and about 4.3% in the category *18 years of age and below*.

Education levels ranged from high school or lower to undergraduate level, whereby 60.8% resorted under the *college level qualifications* category, 34.7% under the *high school qualifications and below*, category, while 4.3% indicated they have an undergraduate degree. In total, 82% of the women reported they could comprehend both English and Swahili languages, which are Kenya's official and national languages. However, 18% did not state whether they are familiar with either of the languages.

In terms of employment status, the study revealed that 43.5% of the respondents were employed, 34.7% were self-employed, and 8.6% were unemployed, while 13% did not indicate their employment status. About 9% of the respondents did not indicate whether they were employed or not. In total, 87% of the women said they were married, 4% were single, while 9% of them did not indicate their marital status.

Regarding medical insurance coverage, 69.5% of the mothers said they had a medical cover, 17.3% of them were not covered, and 13% did not indicate whether they had a medical cover. Overall, 39% of the respondents stated that they were able to comfortably access maternal care services, while 17% said they could not afford to meet most of the care services.

Concerning the respondents' frequency of hospital visits, 57% of the mothers reported to have visited a health facility monthly during their pregnancy period(s). About 17% of them said they had attended hospital more than once per month, while 4% rarely visited a health facility.

Another important observation from the study findings is that 83% of the women received and/or relied on public facilities for their health care needs, while 13% of them received care in private hospitals. This group of participants played a big role in enabling the researcher to understand the information needs of pregnant women.

12.8.1.2 CHW/Vs participants

The age distribution of this category of respondents ranged between 31-60 years, with 50% falling in the 31-40 age bracket, while the 41-50 year and 51-60 year groups constituted 25% each.

All four respondents indicated that they have diploma qualifications; their professions were indicated as: Public Health Officer-1, Social Worker-1; and CHW/Vs-2. Their job ranks included: a Sub-County Community Strategy Focal Person, a Community Health Assistant, and CHW/VS. In total, 75% of respondents had 6-10 years of work experience while 25% had over 10 years' experience.

According to the researcher, the implication of the above findings is that the respondents were well informed of the nature of the community health and wellbeing information services offered, and had participated in this programme. The qualifications and experience of the respondents were sufficient to furnish the researcher with relevant information, particularly regarding community health dynamics and the challenges thereof, towards finding a solution.

12.8.1.3 Health professional participants

The age of the respondents was distributed across different age brackets, with the majority (72.72%) falling in the 31-40 (27.27%) and 41-50 (45.45%) years category, 18.18% were in the 51-60 years category, and 9.09% in the 21-30 years category. There was none in the 60 years and above age bracket.

In terms of qualifications, the majority of respondents stated that they have a diploma (36.6%) and a degree (36.6%); 18.18% said they possess postgraduate qualifications, while certificate qualifications constituted 9.09% of the respondents.

Of the eight (8) respondents, two (2) occupied the positions of Medical Superintendent and Deputy Medical Superintendent respectively, with one (1) Clinician, two (2) Facility-In-Charge respondents, five (5) Registered Community Health Nurses and one (1) Enrolled Community Health Nurse.

According to the findings, the majority of professional respondents were nurses who constituted 72.7% of the respondents, COs 9.09%, and doctors 18.18%. The above scenario is attributed to the fact that most of the selected health facilities are H/Cs offering primary health care services provided by nurses and COs, and falling in the level 2 category of the health care service delivery structure as opposed to doctors who mainly operate on the secondary level (County referral facilities and above) where equipment are available to support the operations.

According to the findings, 72.72% of respondents had work experience of 10 years and more; 9.09% had 6-10 years of experience, while 18.18% had between 3-6 years of experience. Based on these findings, the researcher's assumption was that the majority of the participants provided valid responses as they were well versed in the local health care sector in terms of providing health services and the challenges thereof due to their long experience(s) in the sector, which were vital in the overall validity and reliability of the research. This category

of respondents was important to the study, especially in determining the caregivers' information needs and the challenges involved prior to, during, and after care activities.

12.8.1.4 Facility-In-Charge (Manager) participants

Four (4) out of five (5) respondents were categorised in the 31-40 years age bracket, while one respondent resorted under the 51-60 years category. The majority of respondents indicated they have diploma (40%) or degree (40%) qualifications, while 20% stated they possess postgraduate qualifications. Of these, 80% had over 10 years of experience while 20% had 3-6 years of experience in the health care sector. According to the researcher, these findings confirm the richness of the responses provided during the data collection phase, thus guaranteeing reliable research findings, particularly in terms of challenges and policy-related issues in the health care sector.

12.8.1.5 ICT expert participants

The ICT respondents' age brackets were identified as 18-30 and 31-40 years. Two (2) of the respondents stated they have a degree, and two (2) have postgraduate qualifications. Their work experience ranges from 3-10 years, which the researcher believes was crucial in informing the study accordingly in terms of the various components and features of ICT-facilitated health information services.

12.9 Analysis of qualitative data

The data collected through in-depth personal interviews, focus group discussions and observation were heterogeneous since the responses were obtained from different categories of respondents. This is because the participants' interests varied due to their different roles and tasks in the delivery of maternal health care. Prior to the actual data analysis, field interview notes, information sheets, tape-recordings and observation field notes were transcribed and/or organised according to data properties, similarities and contrasts. The thematic analysis (TA) method was used, whereby the following procedures were performed: (i) writing memorandums during field interviews (pre-data analysis); (ii) mapping interview questions/responses to theoretical themes; and (iii) performing coding (initial coding of data and categorising initial codes) to derive data themes.

12.9.1 Thematic alignment process

The researcher commenced the analysis of qualitative data with categorisation, according to the six theoretical themes, and aligned with the research questions and objectives, which guided the construction of the data collection tools (interview questions, field memorandum, field observation form, and information sheets).

During the TA process, incidents with fundamental relationships to the corresponding central categories were combined, while the researcher expounded memorandums to derive

data themes. The researcher also blended participant observation into the study in addition to interviews, hence the comparative analysis whereby indicators' meaning from the various data sources were carefully compared in a systematic manner to generate conceptual properties. These sources played a part in informing the development of the research model, understanding, distinguishing and grouping of the properties of various concepts, which yielded into data themes.

The subsequent sub-sections demonstrate how the researcher executed the TA process for responses from various participant groups throughout data analysis.

12.9.2 Memorandum writing

Memorandums were written as part of pre-data analysis during fieldwork. Each subsequent interview was then continuously reviewed prior to the actual coding to enable the researcher to make sense of the data collected during the study. This was done to theorise ideas in order to derive propositions towards drawing conclusions (Miles & Huberman, 1994).

Figure 12.3 represents a sample memorandum as a form used by the researcher to capture data during the field interviews.

Memo
Ensure that you link the memo to participants, forms or resources.

What is/was the catalyst for this memo?
Event, idea, observation, data comparison, theory implication etc.

Perceptions of stakeholders regarding use of ICT in healthcare compared to traditional records/paper based records
Benefits of ICT in healthcare services

Adoption of ICT in maternal care is critical for purposes of improving the quality of services.
Care given, for example can easily monitor pregnant women in antenatal clinic and hence easier for follow-up.
ICT increases efficiency and reduces cost in managing health information i.e. data storage, data analytics & reporting, quick access and retrieval of information, retrieval, collaboration and knowledge and sharing.
But in order to deliver desired results e-health innovations should be designed with stakeholder involvement and tailored to meet stakeholder needs.
Adequate and sustainable infrastructure should be built with appropriate technologies i.e. software and tools.
Systems should be integrated using e-health standards to facilitate information sharing and coordination, and also communication.
Proper security measures should be put in place to ensure data availability, confidentiality and integrity.

Key notes(s) From memo

1. ICT improve health
2. Track from birth to
3. Increase efficiency
4. Collaboration/sharing
5. Involve stakeholders
6. A feasible technology
7. Integrations system
8. Data Security

Understand the Possible consequences when designing/using ICT in maternal care

Figure 12.3: Sample memorandum written during field interviews with ICT experts

12.10 Mapping interview questions with theoretical themes

Figure 12.4 is an example of the mapping of the ICT experts' responses to theoretical themes 1.3, 1.4, 1.5 and 1.6.

Mapping ICT Expert Responses		
Theoretical Themes		Interview question No.
1.3: Current maternal health information practices(T3)	←	IQ 1
1.4:Challenges to personal health information management(T4)	←	IQ 2
1.5: Perceptions on potential maternal information services (T5)	←	IQ3
	←	IQ4
	←	IQ5
	←	IQ6
	←	IQ7
1.6: Design considerations for ICT-facilitated maternal health information services (T6).	←	IQ8
	←	IQ9

Figure 12.4: Mapping of ICT experts' responses to theoretical themes

Specifically, interview questions were set to probe design considerations for ICT-facilitated maternal health information services in an underserved context. The researcher used a similar procedure to map responses from the various respondent groups throughout the analysis process (see attached in the appendices).

12.11 Data coding

Data coding was performed in two levels: initial coding and the categorisation of initial codes.

12.11.1 Initial coding

Actual analysis commenced whereby the researcher identified initial codes, that is, emerging ideas from the data (Charmaz, 2006). Individual interview transcripts from each of the five respondent groups were analysed thematically according to the theoretical research themes. This was done word-for-word and line-by-line whereby occurrences (Boore, 2018) were extracted with the aim of generating codes. The codes were created from the sentences and paragraphs of the transcriptions obtained from the audio-taped interviews, field notes and observation notes. For the generated codes to make sense, the researcher attempted reverberating significant events to derive activity verbs (Charmaz, 2006).

For example, one ICT expert said:

“Take patients as stakeholders and involve them to also own the platform, ensure proper change management processes to win their confidence, proper security infrastructure including user access control, encrypt data, mask data, proper physical security, quality Internet connection etc...” (ICT004).

An example of activity verbs in the aforementioned occurrences include: ‘involving’, ‘owning’, ‘ensuring’, ‘managing’, ‘controlling’, ‘encrypting data’, ‘masking data’. Further analysis was then performed whereby related codes were inter-linked with related subjects to produce high order co-occurrences or similarities, i.e. multiple concept frameworks to develop a core category (Lings & Lundell, 2005). Likewise, these concepts were also grouped together to generate high order similarities, that is, categories of which the main aim was to help reduce the number of concepts so as to ease subsequent analysis and to justify the basis of the subjects and/or theories developed (Birks et al., 2013).

At this point, initial categories began to re-emerge from subsequent interviews while comparisons were continuously done to analyse data from various standpoints or categories (Birks et al., 2013). The equation and comparison of initial categories was done iteratively on the various portions of the data to derive their relevance (Charmaz, 2006). Tables 12.4 and 12.5 demonstrate how the researcher turned interview transcripts into initial codes, which provided a basis for generating categories and then themes.

To identify and code occurrences from participants’ comments, interviewees were assigned a combination of an acronym and Arabic numerals, for example, ICT001, ICT002, etc. The acronym ‘ICT’ represents the respondent group (ICT expert), while the numerals represent the ID number assigned to each of the individual respondents. ICT001, for example, implies ICT participant number 1 and their corresponding responses (propositions, perceptions, attitudes or comments), in connection with their perceived considerations on designing ICT-facilitated maternal health information services.

Table 12.4 presents the main points extracted from the responses of the ICT experts, with the initial codes generated alongside the corresponding theoretical themes. The researcher uses the format in Table 12.4 as an example to demonstrate on how responses from other respondent groups were analysed throughout the data analysis process in the study.

Table 12.4: Initial codes from ICT experts’ responses with corresponding theoretical themes

ID	Main points from participant responses	Initial codes	Theoretical themes	IQ
ICT001	The data set in the personal health information service should be based on MoH guidelines for reporting as provided in the ANC booklet which is the minimum requirement as prescribed	Maternal PHR dataset	Design considerations	5
ICT002	Every standard should provide fields that you choose according to what you need	eHealth standards	Design considerations	5

ID	Main points from participant responses	Initial codes	Theoretical themes	IQ
ICT003	It should contain demographics data that is, age, date of birth, nationality, sex, a unique identifier will be very key vital signs and doctor's prescription	Personal health data	Design considerations	5
ICT001	With the use of ICT.... we can see and track the number of clients enrolled for ANC services and follow them up!	Quality health care service	Stakeholder perceptions	1
ICT002	ICT makes retrieval of patient records and information easier and faster	Quality health care service	Stakeholder perceptions	1
ICT003	Adoption of ICT is key in improving the quality and delivery of health care services with reduced costs	Cost effective services	Stakeholder perceptions	1
ICT004	ICT helps in better analysis of data, quick access to information, information sharing and collaboration	Quality health care service	Design considerations	1
ICT001	Localise and customise software to allow development of own skills	Customise software	Stakeholder perceptions	2
ICT001	Consider affordability and quality of the technological infrastructure itself	Affordable and Quality infrastructure	Design considerations	2
ICT002	The use of ICT ensures easy access to information and should be in real time	Easy access to information	Design considerations	2
ICT002	Customise software to suit users' needs that is, open MR software for doctors and nurses	Customise software	Stakeholder perceptions	2
ICT002	Map user requirements with involvement of stakeholders	Map user requirements	Stakeholder perceptions	2
ICT001	Consider stakeholders' requirements and map users' needs... also the quality of existing ICT infrastructure ...as well as affordability of the technological infrastructure	Stakeholders' requirements	Stakeholder perceptions	3
ICT001	Consider government policy and regulatory framework for health information when designing HIS	Policy and Regulatory framework	Information practices	3
ICT002	Health care providers should consider to provide education and literacy levels of the users of the new system	Provide education and literacy	Information practices	3
ICT004	One of the most critical things with design of a system is to ensure security that is, confidentiality, integrity and availability of patient data	Confidentiality, integrity and availability	Design considerations	3
ICT001	Understand primary user needs, e.g. nurses and doctors and through active participation	Active participation	Stakeholder perceptions	3
ICT001	Ensure availability of Technical skills	Availability of Technical skills	Information practices	3
ICT003	Availability of services should be 24/7 with minimum downtime	Availability of services 24/7	Design considerations	2
ICT003	Most important is connectivity between the facility and the national system (DHIS) hence Internet connection	connectivity between the facility and the national system	Design considerations	3
ICT003	The system should be responsive to existing hardware, e.g. smartphone, laptop, iPad...	Responsive to existing hardware	Design considerations	4a
ICT003	The system should be integrated	System should be integrated	Design considerations	4a

ID	Main points from participant responses	Initial codes	Theoretical themes	IQ
ICT003	Use data science tools such as machine learning and develop a database to mine data stored	Use data science tools	Design considerations	4a
ICT003	There is need to have trained IT literate staff in order to be able to key in and use this data	Trained IT literate staff	Information practices	3
ICT001	Use agile methodology to iterate the process with prototyping in order to have a users' guided design	Prototyping in order to have a users' guided design	Design considerations	4d
ICT002	The system should be user-friendly with good click depth, accessible, reliable, maintainable and secure	User-friendly, reliable, accessible, secure and maintainable	Design considerations	4c
ICT003	The system should be well-integrated to enhance information sharing with an API to enable different users to query data from the system	Information sharing with an API	Design considerations	4c
ICT003	Consider configurations for offline systems to enable data collection when Internet fails and ensure unique user identification	Configurations for offline systems	Design considerations	4d
ICT003	Set cloud environment and create a replica of the local server that require a global ID to synchronise data to avoid confusion	Local server that requires a global ID	Design considerations	4d
ICT003	The system should protect data by default through user name and password with different security features and physical access to server and computer room	Protect data by default	Design considerations	4d
ICT004	Consider system ability for scalability, input/output ration processing, resilience on day-to-day processing, disaster recovery with secure endpoints	Ability for scalability	Design considerations	4a
ICT001	Use computers that is, laptops and desktops, servers, IoT to take measurements and mobile phone for patients however, mobile phones are not meant for doctors but patients	Laptops and desktops, servers, IoT	Design considerations	4a
ICT003	Use mobile applications, laptops, pads.... in order for patients to easily and quickly access their data.	Mobile applications, laptops, pads	Design considerations	4a
ICT001	Software should have different modules, e.g. ANC, lab tests, and prescriptions, among others	Software modules	Design considerations	4b
ICT004	Patients need smart phones, while doctors will need smart phones with more processing power and laptop/desktop	Patients /doctor needs	Stakeholder perceptions	4a
ICT004	An integration point that is, API will be needed by different users to query data from the system	Integration point	Design considerations	4a
ICT004	Appropriate and adequate infrastructure should be built using affordable technologies including hardware and software tools	Appropriate and adequate infrastructure	Design considerations	3
ICT003	The system should have a well distributed system hierarchy that is, database and application server	High quality and specifications	Design considerations	4c
ICT003	Among important features include specifications of such components, e.g. CPU speed, RAM capacity, HDD size, a web-based system, open-source software	Important features	Design considerations	4c
ICT002	Integration will require specific eHealth standards such as HL7 and FHIR especially in facilities with systems already installed	eHealth standards	Design considerations	4d

ID	Main points from participant responses	Initial codes	Theoretical themes	IQ
ICT003	Connectivity is key for integration so the quality of Internet connection must be guaranteed	Quality of Internet connection	Design considerations	4d
ICT001	Security concerns will be the privacy of individual records that is, information leakage and social engineering hence patient/doctor confidentiality must be protected at all cost	Patient/doctor confidentiality	Information practices	6
ICT002	Security of personal health information, especially in cases of research, whether patient data are aggregated or in actual form should be protected	Security of personal health information	Design considerations	6
ICT003	Data protection should be system-wide under SSDRL with use of access credentials and data encrypted with ammonisation of patient identifiers	Protection should be system-wide under SSDRL	Design considerations	6
ICT003	Enforce password policies including frequent password change, length of password ...etc., user training and use technology security standards	Enforce password policies	Information practices	6
ICT004	Ensure proper security infrastructure that is, technology, people and quality of Internet connection	Proper security infrastructure	Design considerations	7
ICT004	Take patients as stakeholders and involve them in order for them to also own the platform	Take patients as stakeholders	Stakeholder perception	7
ICT003	Enact laws and regulations to limit access to patient data as per authority regulations including ethical issues that is, personal consent and rights to access data	Data management policy	Information practices	7
ICT004	Ensure proper change management in order to win customer confidence and involve stakeholders in order to also own the platform	Change management	Information practices	7
ICT001	Functionality of a new system should be tested at facility level first and observe the outcome before full implementation.	Test the system at facility level first	Design considerations	8
ICT002	Carry out a pilot survey in a single institution to target feedback from at least 30 people who are actual users of the system	Pilot survey with 30 people	Design considerations	8
ICT003	Develop the system and pilot it in one county and evaluate the impact.	Pilot it in one county	Design considerations	8
ICT004	Pilot test the system using a few facilities	Pilot test the system	Design considerations	8
ICT001	There is lack of technical skills.....and high technology and maintenance costs	Lack of technical skills/ high maintenance costs	Information management challenges	9
ICT001	Donor effect creates a silo for example some partners only cater for HIV reporting and thus creating parallel reporting systems alongside the national health reporting system (DHIS) .	Donor effect and parallel systems	Information management challenges	9
ICT001	There is a problem with policy implementation especially on devolution of health and misappropriation of funds	Problem with policy implementation	Information management challenges	9
ICT004	ICT infrastructure is expensive that is, there is high technology and maintenance costs	ICT infrastructure is expensive	Information management challenges	9

ID	Main points from participant responses	Initial codes	Theoretical themes	IQ
ICT004	The HR element should be looked at that is, there is low developer capacity and technical skills that is, developers do not understand execution of systems	Low developer capacity	Information management challenges	9
ICT004	There is lack of clear objectives characterised by short-term thinking	Lack of clear objectives	Information management challenges	2
ICT004	There is a lot of bureaucracy that policy people are not open with new technologies but they favour paperwork	A lot of bureaucracy	Information management challenges	2

As the researcher progressed with the analysis, he became more familiar with the subject matter and began gathering data more selectively, concentrating on the theme development. The following section explains how the researcher performed the second level of coding to derive data themes.

12.11.2 Categorisation of initial codes

For the second level of coding, the researcher attempted to reduce the number of the initial codes, whereby concepts were regrouped according to categories of related and/or similar codes, as shown in Table 12.5. Further analysis of the categories was carried out, after which themes began to emerge from the data, which eventually became representative of interviewee responses, thus enabling the researcher to make sense of the research phenomena. The researcher used this format to analyse the ICT experts' responses as an example to demonstrate how the thematic analysis process was performed to generate data themes from the initial codes, categories and sub-categories of data. This includes responses from the ICT experts, clients/women, health professionals, CHWs and health care managers/Facility-In-Charge respondents (see the appendices).

Table 12.5: Categories and data themes generated from ICT experts' responses with corresponding theoretical themes

Theoretical Themes	Initial codes	Categories	Data themes	IQ
Design considerations	Information sharing with API	Information sharing	System/service integration	4c
Design considerations	Stakeholders' requirements	- Stakeholder requirements - Stakeholder's needs	Service Contextualisation	3
Design considerations	Customise software	Software requirements	Service Contextualisation	2
Design considerations	Map user requirements	User requirements	Service Contextualisation	2
Design considerations	Configurations for offline systems	Configurations	Service Contextualisation	4d

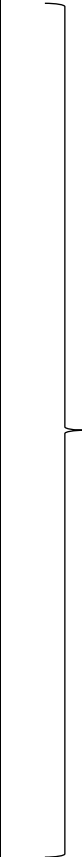
Theoretical Themes	Initial codes	Categories	Data themes	IQ
Design considerations	Quality of Internet connection	Connectivity	System quality	4d
Design considerations	Laptops and desktops, servers, IoT	Devices	Service Contextualisation	4a
Information management challenges	ICT infrastructure is expensive	Infrastructure affordability	Service Contextualisation	9
Design considerations	Appropriate and adequate infrastructure	Infrastructure	Service Contextualisation	3
Design considerations	IoT to take measurements	Interactivity	System quality	4a
Design considerations	Responsive to existing hardware	Responsiveness	System quality	4a
Design considerations	Ability for scalability	Scalability	System quality	4a
Design considerations	Important features	Specifications	System quality	4c
Design considerations	Mobile applications, laptops, iPads	System components	Service Contextualisation	4a
Design considerations	Local server that requires a global ID	Access	Data access	4d
Design considerations	Protect data by default	Data security	Data access	4d
Design considerations	Security of personal health information	Data security	Data access	6
Design considerations	Easy access to information	System access	Data access	2
Information practices	Patient/doctor confidentiality	Privacy	Data access	6
Design considerations	Protection should be system-wide under SSDRL	System security	Data access	6
Design considerations	Maternal PHR data set	Data set	User-centred design	5
Information management challenges	Problem with policy implementation	Management	Health system	7
Information management challenges	Lack of clear objectives	Management	Health system	9
Information management challenges	A lot of bureaucracy	Management	Health system	9
Design considerations	Use data science tools	Analytic tools	HIT utilisation	4a
Design considerations	PHR standards	PHR data integration	System/service integration	5
Design considerations	Personal health data	Personal health data	System/service integration	5

Theoretical Themes	Initial codes	Categories	Data themes	IQ
Stakeholder perceptions	Affordable quality health care service	Cost effective service	Quality health service	2
Stakeholder perceptions	Quality health care service	Quality health care	Quality health service	1
Design considerations	High quality specifications	Quality specifications	System quality	4c
Design considerations	Test the system at facility level first	System evaluation	System implementation	8
Design considerations	Pilot it in one county and evaluate the impact	System piloting	System implementation	8
Design considerations	Connectivity between the facility and the national system	Interconnectivity	System/service integration	3
Design considerations	Global database schema	Database design	System/service integration	4d
Design considerations	System should be integrated	System/service integration	System/service integration	4a
Design considerations	Integration point	System/service integration	System/service integration	4a
Design considerations	eHealth standards	Interoperability	System/service integration	4d
Design considerations	Software modules	Modules	System/service integration	4b
Information management challenges	Donor effect and parallel systems	Parallel systems (Silos)	System/service integration	9
Information practices	Provide education and literacy	IT literacy	Service provider	3
Information practices	Availability of Technical skills	Expertise	Service provider	3
Information management challenges	Low developer capacity	Expertise	Service provider	9
Information management challenges	Low technical skills/high maintenance costs	Expertise/ Costs	Service provider	9
Information practices	Enforce password policies	Information security	Service provider	6
Design considerations	Affordable and quality infrastructure	Infrastructure	System quality	2
Information practices	Change management	Management	Service provider	7
Information practices	Policy and Regulatory framework	Policy guidelines	Service provider	3
Design considerations	Proper security infrastructure	Security	Data access	7
Information practices	Data management policy	Information management guidelines	Service provider	7

Theoretical Themes	Initial codes	Categories	Data themes	IQ
Design considerations	Availability of services 24/7	System availability	Data access	2
Design considerations	Confidentiality, integrity and availability	Security	Data access	3
Stakeholder perception	Take patients as stakeholders	- Stakeholders' role - Stakeholder involvement	Stakeholder engagement	7
Design considerations	User-friendly, accessible, reliable, maintainable and secure	- Usability - Accessibility - Reliable - Maintainability - Securability	System quality	4c
Stakeholder perceptions	Active participation	Active participation	User-centred design service	3
Design considerations	Prototyping in order to have a users' guided design	- Prototyping - Participatory design - UCD	User-centred design service	4d
Stakeholder perceptions	Patients /doctor needs	Users' needs	User-centred design service	4a

The mapping of the data analysis is depicted in Table 12.6 to illustrate how the themes were derived from the data.

Table 12.6: Data analysis coding mapping

Research questions	Theoretical themes (6)	Codes	Categories (265)	Data themes (20)
RQ1: What are the characteristics of an integrated ICT-facilitated health and wellbeing service(s) for maternal care that could enable patients to actively participate in managing health information in an underserved context?			265 categories	Collaborative information service
				Community health information service
SRQ1.1: How do the key stakeholders in maternal health information services influence the information services in maternal care in an underserved setting?	Information stakeholders			Data access
				Health communication
				Health system
SRQ1.2: What are the personal information needs of stakeholders in maternal care?	Information needs			HIT utilisation
				Information needs
SRQ1.3: How do stakeholders in maternal care currently obtain and manage information relevant to their needs?	Information practices			Information services
				Information sources
				Infrastructure
SRQ1.4: What are the challenges faced in accessing and managing maternal personal health information?	Information management challenges			Personalised information service
				Quality health service
RQ2: What are the methods, constructs, propositions and definitions that describe the design process of an integrated secure electronic personal health and wellbeing information service to enable patients to be more involved in their own health information services?				Service contextualisation
				Service provider
				Stakeholder engagement
SRQ2.1: How could stakeholders perceive a potential information service relevant to the needs of pregnant women in maternal care?	Stakeholder perceptions			Stakeholders
				System implementation
SRQ2.2: What are the considerations for the design of a functional ICT-facilitated maternal health information service that is personalised?	Design considerations			System quality
				System/service integration
				User-centred design

12.12 Extracts from respondents describing data themes

The following sub-sections provide extracts from the respondents that were used to describe and explain the identified data themes.

12.12.1 Collaborative information service

The concepts gathered strongly demonstrate the need for a *collaborative information service*, which appears to have a compelling influence on service delivery. The respondents' responses clearly suggested a sense of collaboration among stakeholders across the board in terms of sharing/exchanging information, particularly in terms of administrative and patient health information. Health professionals, i.e. nurses, doctors, clinicians, CHWs and clients, demonstrated the importance of the practice in form of regular updates, including managing and sharing information about future seminars/workshops/trainings, special cases on patients, patient referral details, and even daily/routine activities and reports. To achieve this, different methods were used to enable the sharing and exchanging of information, including print records, electronic systems such as the International Quality Care (IQCARE) system, emails, WhatsApp, memorandums, client health records, and verbally (face-to-face) and/or telephone conversations.

The following are extracts from the respondents in support of this argument:

"We share information through monthly reports which are manual/printed, daily registers, ANC booklet and/or patient file including during referral from this hospital to another. Also, we do verbal consultation one-on-one with colleagues and phone calls" (HP008).

"We share information among colleagues verbally via mobile phone call and face-to-face conversations, WhatsApp, text messages and print material such as MOH 100" (CHW001).

"Information is shared through one-on-one discussions with the nurse 90%, and I share verbally with colleague mothers both on phone and on a face-to-face basis. For example, for example I told a colleague expectant mother to wear flat shoes! I share information verbally with colleague mothers either on phone or face-to-face basis" (CP010).

"I use WhatsApp, Continuous Medical Education (CME), memorandums and the Nursing CARDEX to share information with colleagues" (HP002).

"We share information through use of clinical notes recorded on ANC booklet, call them on phone or text them, we see patients on one-on-one basis where they ask questions and responses are given that is, active participation. Also, we do it through work improvement teams, emails, phone calls, WhatsApp, CME for lectures, consultations amongst colleagues, CME, on job training (OJT), in reaches, outreaches, and seminars/workshops" (HP009).

"I share information with colleagues electronically through an automated computer system that is, International Quality Care system (IQCARE)" (HP004).

"We use the phone calls, WhatsApp group where we can disseminate information in a group of people, emails, we still use paper and also, we have meetings internally" (CHW001).

"We share handover reports, communicate verbally, phone calls, official records such as patient file, ANC booklet, staff trainings and seminars" (HP010).

“We share patient information through written clinical notes on the ANC booklet, also we give information verbally on phone. During emergency a staff/nurse accompany the client to the referral facility with the partograph” (HP011).

Essentially, it was observed that information collaboration was embraced as a culture among stakeholders, hence its significance in promoting the delivery of health care services. There was a need to share information collectively to guarantee informed/evidence-based care decisions. The researcher therefore observed that a collaborative information service was an important aspect to be considered during the design of health information services to guarantee quality health care services.

12.12.2 Community health information service

The theme *community health information service* emerged as an important aspect in the delivery of preventive public health care. As such, it was the first level of interaction between pregnant women and CHWs through one-one-one sessions. Participants' comments, particularly those of the CHW/Vs, suggest a strong awareness of the significance of community health information services. It is at community level where women are informed and enlightened through health education talks on maternal health and wellbeing, mainly focusing on preventive care, for example, PMTCT of HIV, water sanitation and hygiene, and baby immunisations. Specifically, they were advised on where and how to access these services at community health facilities and/or centers. More importantly, community profiling was done to ensure effective service delivery with the involvement of community members, the local administration and community health officials who conduct community profiling to identify the needs of different households for following-up in conjunction with caregivers in health facilities. CHWs were assigned specific households to oversee and execute the services (see appendices). The following extracts support the above argument:

“The care process starts from the community with household visits daily with children under 5 years and pregnant mothers. Dialogue day is held quarterly and community meetings monthly where we meet community members and address their issues” (CHW002).

“Every six months we do a process called mapping and house hold registration, where we map out the area in our community” (CHW002).

“So, we usually have monthly home visits where we share health talks on maternal health and immunisation. Then we advise them to attend [an] ANC clinic to be tested for HIV/AIDS and for further care advise”. We work with a Community Chairman, Assistant Chief, and Facility-In-Charge who are Community Health Committee (CHC) members, with Community Health Assistants (CHAs) and CHWs looking at how to improve community services” (CHW003).

“I worked with my spouse and other family members during my pregnancy. We also consulted with experienced colleague mothers, neighbours and CHW/Vs” (CP004).

“Also, CHW/Vs do assist in getting vital information to assist in providing care to clients at community level” (HP009).

“First, we make sure that women attend ANC clinics at least four visits, then also we cancel them on individual birth plan and once they identify the preferred place of delivery, we do follow up as they attend the clinic. We make sure that the last month before delivery we link them to

the facility, also after delivery we do follow ups in the community and make sure that the mother and the child are going for the clinic until the child is five years” (CHW004).

However, in the same context, one participant reported that she had not heard about community health services in maternal care in her neighbourhood:

“There are no community health programmes in my neighbourhood, I have not even heard about them” (CP009).

According to the responses, the majority of the participants, however, generally agreed that community health services indeed exist. The researcher therefore observed the significance and/or contribution of this element as a success factor in the delivery of public health care services within Nairobi County, as it helped to sensitise citizens and connect them to community health facilities and services.

12.12.3 Service contextualisation

Participants identified concepts related to both *contextual requirements* and the *technology environment* regarding the design of health and wellbeing information services. The requirements aspect mainly focuses on stakeholder requirements, and particularly on software customisation in cases of open-source software (OSS). Concerns were raised by some of ICT experts, who indicated that stakeholder needs should be given priority when designing ICT-enabled health information services. The comments revealed the perceived importance of taking into consideration stakeholder requirements to ensure the successful implementation of services.

“You should ascertain stakeholder requirements and map user needs first” (ICT001).

“Customise software to suit users’ needs for example Open MR software for doctors and nurses” (ICT002).

“Localise and customise the system to allow development of own skills” (ICT001).

The researcher therefore observed that considering stakeholder requirements is a critical indicator towards achieving success in the implementation of ICT-enabled information services in public health care, and should thus be given attention.

In addition, participants revealed the significance of the theme *contextual technology environment* as opposed to existing information infrastructure and designing health and wellbeing information services with the focus on an underserved environment. In particular, the theme was recognised through views gathered from both ICT experts, clients (women) and community worker participants, which demonstrates the need to consider this factor towards successful implementation of information services. The responses mainly revolved around system infrastructural aspects such as hardware and software tools, devices, technologies and the general system components suitable for building an automated system for maternal HIS to warrant meaningful use. Also, it included some of the features such a system should have,

based on its context of use (see appendices). The following extracts from the responses support this argument:

“Use computers that is, laptops and desktops, servers, IoT to take measurements and mobile phone for patients however, mobile phones are not meant for doctors but only patients”. (ICT001).

“One should consider configurations for offline systems to enable data collection when Internet fails and ensure unique user identification” (ICT003).

“Appropriate and adequate infrastructure should be built using affordable technologies including hardware and software tools” (ICT004).

“Consider affordability and quality of the technological infrastructure itself” (ICT004).

“Mobile phone, computers (desktop and laptop), WhatsApp, radio and TV can be used to improve maternal health information services” (CP012).

Women participants in particular said they prefer the use of mobile/smart phones in communicating information among stakeholders:

“Smart phones should be used to improve communication in maternal health care” (CP011).

“Mobile phone is both the easiest and fastest way of communicating information, especially during an emergency” (CP003).

One community worker strongly indicated the preference for a mobile phone as part of ICT requirements to improve the delivery of health care services:

“A mobile phone is preferable: It is not heavy, and it saves time, also geographically unlimiting – but the challenge is that you need airtime... you can’t make a follow up because you do not have airtime, and data bundles- which you need to have a smart phone, not just any phone which is expensive” (CHW002).

Notably, participants unanimously agreed that there is a definite need to consider the elements of context in terms of stakeholder/user requirements and the contextual technology environment when designing the proposed services. The researcher therefore noted the importance of ensuring service contextualisation in accordance with the aforementioned perspectives as a success indicator to guarantee meaningful use and sustainability of the proposed services in health organisations.

12.12.4 Data access

The concepts and categories identified emphasise concern regarding data access, which involves the confidentiality, integrity and availability of health information in relation to handling and managing health data by custodians. Reactions among stakeholders – clients, ICT experts, CHWs and health professionals – reflected a high degree of awareness regarding the significance of ensuring the protection of personal health data as a requirement for the successful implementation of ICT-facilitated health information services. For instance, client participants indicated that caregivers leaked personal health information and thus breached the doctor-patient confidentiality principle. Also, health professionals and CHW/Vs raised

concerns regarding methods used in communicating and managing patient health information, which were not confidential, thus affecting the client's (patient) right to privacy as well as the successful implementation of services. This theme mainly revolves around concepts and/or categories such as data access and rights, confidentiality, integrity and availability, data security, data privacy, and data management policy (see appendices). The following are extracts from ICT experts' responses in support of the argument:

"Enforce password policies including frequent password change, length of password...etc., user training and use technology security standards" (ICT003).

"Security concerns will be the privacy of individual records that is, information leakage and social engineering hence patient/doctor confidentiality must be protected at all cost" (ICT001).

"Set cloud environment and create a replica of the local server that require a global ID to synchronise data to avoid confusion" (ICT003).

"Security of personal health information especially in cases of research whether patient data are aggregated or in actual form should be protected" (ICT002).

"Ensure proper security infrastructure including user access control, encryption of data and masking of data" (ICT004).

"The system should protect data by default through user name and password with different security features and physical access to server and computer room" (ICT003).

"Ensure easy access to information and should be in real time" (ICT002).

"Ensure system security that is, confidentiality, integrity and availability of patient data, data protection should be system-wide under SSDRL with use of access credentials and data encrypted with ammonization of patient identifiers" (ICT003).

"Enact laws and regulations to limit access to patient data as per authority regulations including ethical issues that is, personal consent and rights to access data" (ICT003).

In the same context, some of the health professionals raised concerns over the ways and methods used in communicating and/or sharing health data:

"Implement EMRs to handle medical data electronically for easy access and share data among staff, patients and other stakeholders. Train staff on IT skills and literacy" (HP002).

"Using personal mobile phone is costly and you share your personal contacts with so many people, no privacy of the client" (HP008).

"The Mother and child confidentiality is not guaranteed though It is good to relay information about the patient" (HP003).

One client (woman) participant expressed concern regarding doctor/patient confidentiality as per the following extract:

"Information is not confidential because some nurses and CHW/Vs leak information. Otherwise, nurses do not keep information secret! Nurses should be trained as counsellors" (CP005).

On the same note, one participant from the CHWs participant group raised the following concern:

"I can say there is a challenge of some mothers giving out their ANC booklets to other people - they share their privacy!" (CHW004).

As observed from the responses, the participants unanimously agreed that data access is quite critical in as far as health data are concerned. The researcher noted with great concern that data access is a very critical factor for designing and successfully implementing electronic health information services in public health care.

12.12.5 Health communication

Emerging concepts under the *health communication* theme were linked to the health communication system, specifically focusing on different ways and methods, i.e. media that were used to communicate and share health information, including during referrals to support and improve health care delivery. Participant reactions, particularly clients, CHWs, health professionals and managers, reflected awareness concerning various media that were used to communicate health information among stakeholders as a requirement towards the successful delivery of health care services. These categories include verbal communication through face-to-face meetings and dialogs, print media, and electronic/digital means such as phone calls and mass media, including radio and TV channels (see appendices). The following are extracts of client respondents to support this argument:

"I normally receive information through one-on-one discussions with the nurse at the clinic" (CP010).

"I receive information verbally during health education sessions during monthly ANC clinic visits" (CP021).

"The commonly used media to communicate health information is TV, mobile phone and radio and print" (CP008).

"Also, I sometimes receive information through CDS and clinical notes" (CP008).

"Print material mainly used to communicate health information include[s] books, magazines and posters" (CP006).

"Mostly English and Swahili languages are used in both print and electronic media" (CP005).

The following were responses from some of health professional participants:

"ANC booklet is normally used to share information during patient referral to another facility because It is a government initiative with comprehensive data involving ANC visits, delivery, PNC visits, family planning and immunisation" (HP008).

"A referral report/letter is issued which the patient takes to the referral facility while a phone call is made to the referral facility to give update on the case, and also a partograph is attached in case of complications with delivery" (HP006).

"We share patient information through written clinical notes on the ANC booklet, also we give information verbally on phone... during emergency, a staff/nurse accompany the client to the referral facility with the partograph" (HP011).

"The facility phone is very important for communication especially during follow-ups, emergency, consultation. But clients have no way of communicating back to hospital /clinic hence must come physically" (HP003).

Responses from CHWs elicited the following reactions:

"I use smartphone, printed material, verbally especially with colleagues and patients" (CHW001).

"We prepare a meeting simply because not everyone is having a mobile phone so we prepare a meeting date in dialogues and action days we talk about matters facing our community" (CHW003).

"We do phone call, email, WhatsApp, text messages. Also, we do our hard copies for our reporting and data collection" CHW002).

"We mainly use print materials, electronic is not so much" (CHW004).

In the same context, some of the responses of the facility administrators are:

"During emergency, the client is accompanied by a staff to give information but, transport is only available during the day but not at night....one must fill a referral form or the Mother Child booklet and/or partograph tool during labour to show how client is progressing and whether she has passed the action line from alert line, staff should accompany the client to provide the information at a referral facility" (AP001).

"Adoption of ICT is low but, mainly a referral phone is issued by partners to enhance referral services by different programs using modems" (AP001).

According to participants' reactions, it is clear that they agreed on the significance of communication in health care for the delivery of health care in health care organisations. The researcher observed that the communication of health information among stakeholders is an indicator towards the effective delivery of health care services.

12.12.6 Health system

Concepts related to politics surrounding the health system, which mainly touched on the responsibilities of government, were identified from the participants' responses. Generally, their responses focused on the public health care infrastructure, and especially the challenges facing health care delivery, including infrastructure, health policy/guideline and management issues, funding and resource allocation/provision, and the general management of public health care. Ideas and concerns raised were mirrored in the nature of the health care system and its influence on the quality of health care services. Specifically, emerging issues in this category include inadequate commodity supplies and resources, and the lack of UHC, health care programmes, and health information tools. The majority of respondents generally expressed their concern on the gaps in public health care, including the failure to adequately provide basic services such as commodities and equipment in public health facilities, hence poor services (see appendices). The following are extracts from the various responses:

Comments from the health care manager participants were as follows:

"Funding is needed for ICT infrastructure, and also to hire trained personnel" (AP003).

“Challenges include lack of commodities and supplies, e.g. ANC booklet hence patients lack access to essential information in the booklet, problems of care discontinuity and creating public awareness” (AP005).

“The major challenges include lack of resources/funding, lack of Wi-Fi/Internet, training of staff, accessing electronic communication from headquarters is challenging” (AP003).

“Concerning management of information and records, we mainly emphasise on professional training and the code of conduct...otherwise, no organisational policy is in place to guide management of health information, including during referrals” (AP005).

“Information management policies used in this place are based on WHO Guidelines” (AP002).

“We have policy guidelines on referrals information, and patient records are kept for minimum of 5 years but after that destroyed to create space” (AP003).

“The key factors that influence the nature of our information services include poor funding hence inadequate infrastructure” (AP002).

“We have manual information services for maternity wing as there is no infrastructure for IT except partners for example University of Maryland who transmit some data online” (AP003).

“Major factors include the fact that there is inadequate funding by government, staff are reluctant and feel its extra work to use computers, inadequate personnel, lack of staff training and computer literacy, health workers’ phobia of computers, lack of equipment maintenance” (AP001).

Reactions from the client participants were as follows:

“Maternity services are not 100% free because mothers pay a fee of 550/- during first clinic visit and 50/- for each clinic visit so some mothers do not attend clinic” (CP002).

“I do not have Linda Mama card to access free maternity services...I do not know about it!” (CP003).

“There are no community health programmes in my neighbourhood, I have not heard about them”. (CP011).

The view of one health professional participant regarding the government-approved ANC booklet is as follows:

“The ANC booklet is complicated and the graphs in it bring confusion to patients. Also, the fading of ink makes the notes unreadable. The book should be written in all languages (English, Swahili and vernacular” (HP007).

On the same note, the following is a comment from a community worker participant regarding the ANC booklet:

“The mother child booklet is very instrumental as the mother’s information, when she is pregnant is all entered...but after she delivers its more of the child than the mother because the child continues with the immunisation and the rest which are recorded in the booklet...even when children are starting school minus the birth certificate the ANC booklet is recognised as a legal document” (WHWP002).

The following were views of ICT expert participants touching on various aspects of this subject:

“There is a problem with policy implementation especially on devolution of health and misappropriation of funds” (ICT001).

"The data set in the personal health record (PHR) system should be based on MOH guidelines for reporting as provided in the ANC booklet, which is the minimum requirement, as provided" (ICT001).

"There is lack of clear objectives characterised by short-term thinking.... and a lot of bureaucracy that policy people are not open with new technologies but they only favour paperwork" (ICT004).

"Enact laws and regulations to limit access to patient data as per authority regulations including ethical issues that is, personal consent and rights to access data" (ICT003).

According to the responses, it was observed that the respondents agreed on the significance of the health system, since it has a huge influence/impact on public health care in various dimensions. More importantly, participants expressed concern about various aspects, including the lack of commodities and supplies in health facilities, inadequate funding to provide resources and equipment, the lack of UHC, the ANC booklet content, policy implementation on health issues, and the lack of clear and strategic objectives and laws concerning access to health data, which are primarily the responsibility of government. The researcher observed that proper functioning of the health system is fundamental in as far as delivery of public health care is concerned.

12.12.7 Information needs

Concepts identified with *the information needs* subject are linked to the health information needs of maternal care stakeholders, including clients, health professionals, CHWs and managers. These include the prenatal, ANC and postnatal care needs of clients; the maternal profile, including medical and surgical history, gynaecological/obstetrics history and client bio-data and contacts for caregivers; preventive care and guidelines, disease outbreak and community profile for CHWs; policy guidelines and statistical reports for managers (see appendices). The following are extracts from the client participants:

"I would want to know risks associated with pregnancy... and the best time to conceive, how to get a baby boy or a girl, a mother's health and nutrition, finances" (CP003).

"I want to know pregnancy associated risks, the best time to conceive, mother's health" (CP005).

"I would want to understand nutrition and diet needs that is, what food to eat during pregnancy" (CP002).

"I seek to know where to attend ANC clinic with that is, the best health facility for maternal care" (CP011).

"I seek to understand danger signs of pregnancy, complications and how to manage them" (CP008).

"The sitting position while breast feeding and also baby winning is important and I would want to get information on this" (CP010).

"To understand the expected signs of pregnancy, body changes and weight" (CP006).

"I'll seek to know where to attend ANC clinic with that is, the best health facility for maternal care" (CP011).

"More importantly I would like to know how to monitor the condition of the baby" (CP003).

The following were responses from the health professionals:

"I first ask to know gestation period to know when the mother saw the last menstrual period" (HP008).

"I need to observe presenting symptoms and signs first before deciding what care to give" (HP001).

"First, I would check gynaecological history that is, number of children, number of pregnancies, and number of babies lost before term, try to know her economic status...etc." (HP003).

"At PMTC I would need the patient card number, client history that is, previous admission, illness, weight loss, HIV status of client, where they live, contact details, contacts of partner, and number of children...also the viral load if one is HIV-positive that is, amount of virus in blood" (HP004).

"In the case of PNC services, I need to know client HIV status, history from labour ward that is, looking at the partograph, outcomes of labour, drugs given etc....Outcomes of the mother and baby, lab test results where necessary, observing the baby for vital signs, and physical examination to check if uterus has contracted..." (HP004).

"During the first visit, I would ask the client their last menstrual period, parity, ANC profile including medical and surgical history, HIV status and family history" (HP011).

Reactions on the same from the CHWs were as follows:

"I need information concerning the community and you do not limit yourself to health only. Sometimes you find the information is flowing to personal issues, domestic issues and even administrative. Basically, I am a public health officer and I major in preventive care" (CHW002).

"Mostly, I am interested in information about changes and current issues such as disease outbreaks through seminars, HIV, TB and nutrition" (CHW002).

"I need information on HIV/AIDs and PMTCT, breast feeding, ANC care, maternal health and danger signs in new born and after delivery" (CHW003).

Some of the comments from the manager participants include:

"I need daily updates on the care of patients, maternal auditing for example what happened and why, ANC and PNC monthly reports, average number of baby deliveries per month and staffing" (AP001).

"I would like to know about the number of patients attended to weekly/monthly, ailments mothers are treated for during ANC visits, delivery diagnosis and outcomes for mother and child, pharmaceutical needs and budgetary needs" (AP005).

"My information needs include policy guidelines, health records and the tools to facilitate the same" (AP003).

"Mine is to oversee HR capacity, logistics and resource availability, planning and budgeting, carry out supportive supervision/staff audit" (AP004).

Based on the quoted responses, it was observed that various participant groups were in agreement on the significance of personal information needs, which were related to their specific job and/or tasks in care delivery. Considering the responses, participants across the board demonstrated a strong sense of recognition of the information needs that would support their duties. The researcher was therefore able to identify specific types of information needs

necessary for different stakeholders in maternal health care hence *information needs* as indicator for successful implementation of ICT-facilitated HIS.

12.12.8 Information services

Various ideas related to information services were recognised from the participants' reactions, in particular the nature of maternal health information services rendered. This specifically involves aspects of information management and communication among stakeholders, including various media of communication used, existing information services, type(s) of information, technologies used, ICT tools used, and language of communication and documentation, among others. Generally, the concepts demonstrate the characteristics of the existing information infrastructure in the research context, which was critical in understanding the situation on the ground (see appendices). The following are responses from various participant groups supporting the above argument:

Comments from women participants include:

"About 90% of information is shared through one-on-one discussion with the nurse" (CP010).

"We use the ANC booklet which is very educative, and has a lot of important information for mothers. It is a good book, very educative, has a lot of important information for the mother, father and the unborn baby and it helps us very much for records" (HP008).

"Some of the media used to communicate health information is TV, mobile phone and radio and print materials" (CP008).

"TV and radio programmes are used sometimes to communicate information to masses although not always" (CP001).

"I receive information continuously through radio, TV and reading magazines" (CP008).

"Print material mainly used to communicate health information include[s] books, magazines and posters" (CP008).

"Mostly English and Swahili languages are used in both print and electronic media" (CP005).

"I share information verbally with colleague mothers both on phone or face-to-face basis" (CP018).

"I sometimes use Internet and mainly WhatsApp, YouTube to access or share information with colleague mothers" (CP008).

The following were responses from the health professional participants:

"Our system is mainly manual whereby patient data are captured manually and recorded in patient file while the patient goes home with the same information on The ANC booklet...which is also known as ANC booklet" (HP003).

"Yes, we give clients a chance to express themselves. Also, there is a classroom where we give health education/information and also one-on-one sessions to discuss on mother and baby care during and after delivery" (HP008).

"We use materials like charts, seminars/workshops and verbal that is, discussions with colleagues and even with clients" (HP009).

"Mostly we use print media, e.g. reports, books, referral books, ANC booklet, hand over report book etc... also, verbally such as face-to-face with colleagues and client's phone to communicate information" (HP010).

"Our information services are manual most of the time...and partly electronic (minimal); they photo-shoot and scan records then send to DHIS" (HP008).

"There are computers donated by partners and a mobile phone for every department but.... It is difficult to find it especially during emergencies...also, we have photocopying machines and a TV at reception" (HP003).

"The IQCARE system is used to manage HIV and AIDS related data while a mobile phone is used to call clients for follow-up" (HP004).

"We hold health education talks, one-on-one discussions during clinic visits, making client aware of reasons for kind of care given, mothers are charged with the responsibility of taking care of the ANC booklet" (HP005).

"We have computers for reporting, mobile phones and printers from partners" (HP009).

Some of the participants raised concerns regarding the effectiveness of the current services:

"Photocopy machine and computers are available however; computers are not used at all. A facility mobile phone is used by staff" (HP011).

"Computers are not connected to an EMR, no computers for health care workers; no training on computer literacy, only mobile phone is available" (HP001).

"The computer system is incomplete! Computers are not used here! Ahh...since I came it just looks like a picture here in the office... It is not working but it is like a picture. Using personal mobile phone is costly and you share your personal contacts with so many people no privacy for the client" (HP008).

"The facility phone is very important for communication especially during follow-ups, emergency, consultation...but clients have no way of communicating back to hospital /clinic hence must come physically" (H003).

CHWs comments were:

"Right now, information system is manual because we are just using printed tools to collect information such as MOH tools" (CHW004).

"I use smartphone, printed material, verbally especially with colleagues and patients" (CHW001).

"Our information services are both hard copy and electronic. We use computers, the phones, but we are not facilitated on the phone" (CHW002).

"We get this information from Community Health Extension Workers (CHEW), Community Health Assistant (CHA), colleagues, trainings and seminars, and from Internet" (CHW001).

"We do phone call, email, WhatsApp, text messages. Also, we do our hard copies for our reporting and data collection" (CHW002).

Reactions from the administrative participants were as follows:

"Adoption of ICT is low but, mainly a referral phone is issued by partners to enhance referral services by different programs using modems" (HP001).

“Adoption of ICT in this facility is just medium that is, 50% because out-patient department (OPD), lab and pharmacy are automated while CCC, ANC, Family planning, Child Welfare Clinic (CWC) and maternity are not automated” (AP003).

“Information services are poor – computer system is not adopted by anybody/no practices, the necessary support that is, motivation/training/financial is not available” (AP001).

Based on the responses received, it was evident that the information services concept is quite a complex subject as it touches on various aspects that constitute the current information services. Understanding the nature of information services was critical as it helped the researcher gain insight into the existing infrastructure and how these services may be improved in future, hence coming up with appropriate design strategies, tools and technologies to warrant effective health and wellbeing information services.

12.12.9 Information sources

The concept of *information sources* for various stakeholders in maternal health care emerged from the participants' responses. These include different sources of information that enable stakeholders (i.e. clients/pregnant women, health professionals, CHW/Vs and facility administrators/managers) to perform their duties, according to the findings of the study, which reflected part of the information practices engaged on by users/participants within the research context. To verify this finding, the following are extracts from responses from different categories of stakeholder groups as observed by the researcher.

i) Clients

This group found that sources of information for clients include health professionals, family members, print sources, community health services, the Internet and mass media. Some of the client participants said:

“I receive information verbally during health education sessions during monthly ANC or PNC clinic visits” (CP021).

“I get information from family members, relatives and home visits by CHW/Vs” (CP003).

“Sometimes I get information I need through Internet/social media like WhatsApp, YouTube, Viusasa, Google” (CP017).

“We use the ANC booklet which is very educative..., and has a lot of important information for mothers. It is a good book! Very educative, has a lot of important information for the mother, father and the unborn baby...and It helps us very much for records” (HP008).

ii) Health professionals

This group mainly receives information from clients themselves or their next of kin/partner during ANC/PNC clinic visits, the ANC booklet, and the client profile, i.e. clinical notes, basic formal knowledge, training sessions and workshops, Continuous Medical Education (CME) sessions, laboratory test results, physical examination, referral letters and MOH guidelines. One nurse said:

"We get information from the client herself, ANC booklet, on job trainings, basic professional training (Nursing), Continuous Medical Education (CME...It can be CME or MOH guidelines" (HP008).

iii) CHW/Vs

Participants from the CHW/Vs category reported that they obtain information from training sessions and seminars, colleagues, community health profiles, the client ANC booklet, MOH tools and guidelines and the Internet. Some of the CHW/V participants said:

"We normally do something called house hold mapping where we use a tool called MOH 513 - it captures information like household head, the partner, number of children, ages of the children, visitors, under-fives, NCD, pregnant mothers, their age, etc." (CHW002).

"The ANC booklet is a good innovation because it contains information of the mother from the time of pregnancy until the child is sixty months old hence educative" (CHW004).

A community worker said,

"The ANC booklet is very instrumental/educative... Recognised as a legal document" (CHW002).

iv) Facility administrators

This category of participants reported that they receive information from both internal and external sources. Internal sources include the facility Records department and/or organisational health statistics. External sources include MOH guidelines from the relevant ministry and other government partners, the County Government's head office for health, professional training and workshops, and professional code of conduct. Some of the participants said:

"We rely on our internal Records department, health statistics, and directives from both MOH and County head office" (AP004).

"Regarding management of information and records, we mainly emphasise on professional training and the code of conduct, otherwise no organisational policy is in place to guide management of health information, including client during referrals" (AP005).

From the above extracts of the participants' responses, it is evident that stakeholders obtain information from different sources to support their work-related operations, as they find it convenient. This reveals the types and variety of sources of information used in the research context, thus providing the researcher with insights into the nature of the existing information infrastructure.

12.12.10 HIT utilisation

Concepts related to HIT utilisation were recognised, particularly from ICT experts and health professional participants. These include data analytics tools; and specifically that the analytics tools lack facilitating the generation of important health reports for the effective utilisation of health data. At the same time, there was a suggestion to employ data science

tools to facilitate data mining (see appendices). The following were extracts in support of this argument:

“Existing system for nutrition does not meet needs of the nutritionist...the current system cannot generate reports so I need a tool to analyse and generate reports” (HP006).

“Use data science tools such as machine learning and develop a database to mine data stored” (ICT003).

There was a strong indication that the use of analytics tools is a critical requirement for implementing ICT-facilitated HISs. The participants’ reactions indicate that the availability of such tools is critical as far as health and wellbeing information services are concerned for easy analysis of reports by relevant stakeholders. The researcher therefore noted that ensuring the availability of analytic tools is critical towards the successful implementation of maternal HISs.

12.12.11 Personalised information service

Concepts linked to personalised care services, particularly activities associated with doctor/patient relations, emerged from the responses. Participants focused on personalised care activities such as seeking client consent, question/answer sessions, chance for self-expression, client awareness/being informed of care decisions for them and client responsibility to manage the ANC booklet. These concepts demonstrate the importance of engaging clients (women) in their care process as stakeholders (see appendices). Responses from clients on this subject are follows:

“I normally participate in my care activities with caregivers during ANC/PNC clinic visits where we normally have one-on-one session with the nurse” (CP007).

“I normally ask questions during clinic visits, and the nurse answers my questions and gives me advice” (HP022).

“Reasons are given by doctors in case of a referral to another hospital” (CP006).

One client participant however reported that:

“Nurses are harsh during one-on-one sessions if you fail to follow instructions. They should be friendly” (CP003).

Some of the health professionals’ responses were as follows:

“Yes, we give them a chance to express themselves. Also, there is a classroom where we give general education and also one-on-one sessions to discuss on mother and baby care during and after delivery” (HP008).

“We meet with mothers and talk to them; mothers’ have the personal responsibility to manage their ANC Card (Mother and Child booklet)” (HP007).

“The doctor explains to them the care they need on face-to-face discussions” (HP001).

“We hold health education talks, one-on-one discussions during clinic visits, making client aware of reasons for kind of care given, mothers are charged with the responsibility of taking care of the ANC booklet” (HP005).

"We usually have one-on-one meetings with the mothers and we give mothers time to ask questions. Also, we seek client consent during referral where necessary. The client chooses where to be referred to and It is his/her right to choose" (HP010).

On the same note, some of the community worker participants commented as follows:

"We share information with clients when providing care through meetings that is, community dialogue, sometimes focus group discussions, and also we give them information education and communication (IEC) material" (CHW004).

"I normally have conversations with them and also I organise for question answer/answer sessions with them to clarify issues" (CHW001).

"I normally get the contact of the client and call them and if It is something that needs me to be there in person, I make a point of going to the community and talk to them so I engage them in dialogue" (CHW004).

The aforementioned responses show that the respondents are in agreement agreed that personalised service is of great significance as far care delivery is concerned. In general, stakeholders recognised and confirmed the fact that personalised information service is a critical requirement to deliver quality services to clients. More importantly, the researcher observed that ensuring the provision of personalised information services is key towards satisfactory care service.

12.12.12 Quality of health care service

Concepts related to the quality of health services offered to the public in general were recognised from the participants' responses. Specifically, client participants expressed concern and/or dissatisfaction regarding various aspects direct impact on the quality of health care services offered in the selected facilities, particularly the exchange of health information between caregivers and clients. On the other hand, ICT experts provided revelations regarding various considerations that would help improve health care delivery using ICT. Issues mentioned include language of communication, legibility of clinical notes, empathy, credibility of information, service delivery, trustworthiness of information, cost-effective HIT infrastructure, and system quality (see appendices).

The following extracts were obtained from client participants' responses:

"The ANC booklet should include all languages... English and Swahili languages are not easy for some mothers to understand" (CP017).

"Written information on The ANC booklet should be clear. The doctor's notes are not readable! In most cases only the nurse and doctor understand what is written in the ANC booklet. The book is ok but the doctor's notes is what is not readable or satisfactory" (CP001).

"Nurses are sometimes harsh because of for example dirty dress, failure to follow instructions, others is due to attitude to their work and emotions naturally ...they should be friendly. Trainees are used sometimes and they hurry up!" (CP003).

"Information received is relevant although it is negative sometimes" (CP016).

"Nurses are always in a rush and they do not bother in public hospital ...they say that is normal" (CP015).

"The nurses contribute 90% of the complications in public hospitals... This is common in public hospitals" (CP010).

"I do not trust information received from both friends and doctors 100%! For example, when I went to hospital to deliver one time the doctors told me, 'no head of the baby', and others said 'they are twins'...but I finally delivered one child" (CP006).

Reactions from ICT expert participants were as follows:

"ICT helps in better analysis of data, quick access to information, sharing and collaboration" (ICT004).

"IT makes retrieval of patient records and information easier and faster" (ICT002).

"With the use of ICT...we can see and track the number of clients enrolled for ANC services and follow them up" (ICT001).

"Adoption of ICT is key in improving the quality of health care delivery with reduced costs" (ICT003).

"Connectivity is key for integration...so the quality of Internet connection must be guaranteed" (ICT003).

"An appropriate and adequate infrastructure should be built using affordable technologies including hardware and software tools" (ICT004).

"Consider affordability and quality of the technological infrastructure itself" (ICT001).

"The system should have a well distributed system hierarchy that is, database and application server of high quality and specifications" (ICT003).

"Ensure proper security infrastructure that is, technology, people and quality of Internet connection" (ICT004).

Generally, according to the responses, there was consensus that the element of quality in health care delivery is key towards guaranteeing improved health care delivery. The majority of responses and particularly those from both clients and ICT experts emphasise aspects indicative of the need to embrace quality in health care delivery. Therefore, the researcher observed that ensuring the element of quality in health care service is a significant indicator for effective care delivery.

12.12.13 System/service implementation

Ideas linked to the element of system implementation emerged from the responses, which in particular revolved around issues concerning the need to implement ICT to ensure transparency in health care delivery; the lack of goodwill to implement ICT for cost-effective operations; improved management and maintenance of health records; implementing EMRs to handle medical data electronically; and the approach towards implementing and testing new information services. In addition, concern was expressed over the lack of good will to implement ICT in some public health organisations in general (see appendices).

Comments from some of the facility administrators were:

"Implement ICT fully to bring transparency to improve health care delivery" (AP001).

"ICT would be better than manual services but there is lack of good will to implement it. ICT is cost effective in terms of information sharing, retrieval and space" (AP001).

Reactions from health professionals regarding the implementation of information services were as follows:

"Provide feedback and training in a timely manner whenever reviews are done on documentation...Implement ICT to improve management and maintenance of client records" (HP011).

"Implement electronic services for easy capturing of data and tracking information and also emphasise periodic training of staff and continuous job training of new staff" (HP008).

"Implement EMRs to handle medical data electronically for easy access and share data among staff, patients and other stakeholders. Train staff on IT skills and literacy" (HP002).

The following were responses from the ICT experts regarding the approach towards implementing new, ICT-based information services:

"Test functionality of the new system at facility level first and observe the outcomes before full implementation" (ICT001).

"Carry out a pilot survey in a single institution to target feedback from at least 30 people who are actual users of the system" (ICT002).

"Develop the system and pilot it in one county and evaluate the impact" (ICT003).

"Pilot test the system using a few facilities" (ICT004).

Accordingly, it was observed that there is a clear indication, from the participants' responses, that the aspect of implementing ICT-based information services is of high significance towards improving health care services. In particular, the approach and/or method of implementation of the services was emphasised by experts to ensure effective service delivery. The researcher noticed that besides implementing ICT services in health care, it is important to use suitable approaches in order to guarantee desirable results, hence a significant factor to be taken into consideration.

12.12.14 System/service integration

Several concepts emerged from the responses associated with the integration of health information services, including system/service integration, APIs to enhance information sharing and collaboration, Internet connectivity, database design, eHealth standards, software modules, parallel systems and data integration. In particular, most of the aforementioned ideas and suggestions emerged from the ICT experts' responses (see Table 12.3).

Reactions from the ICT experts were as follows:

"The system should be well-integrated to enhance information sharing with an API to enable different users to query data from the system" (ICT003).

“Integration will require specific eHealth standards such as HL7 and FHIR especially in facilities with systems already installed” (ICT002).

“An integration point that is, API will be needed by different users to query data from the system” (ICT004).

“Connectivity is key for integration so the quality of Internet connection must be guaranteed” (ICT003).

“Most important is connectivity between the facility and the national system (DHIS) hence Internet connection” (ICT003).

“Use a global database schema and break down into different user groups or modules to apply role-based access” (ICT003).

“Integration will require specific eHealth standards such as HL7 and FHIR especially in facilities with systems already installed” (ICT002).

“Software should have different modules, e.g. ANC, lab tests, prescription...etc.” (ICT001).

In the same context, however, there were concerns that some donor interests encourage building of data silos, derailing efforts towards developing a national health reporting system:

“The donor effect creates a silo, for example, some partners only cater for HIV reporting and thus creating parallel reporting systems alongside the national health reporting system (DHIS)” (ICT001).

On the same note, one health professional participant commented as follows:

“Use IT to integrate information systems, and recruit adequate personnel” (HP009).

It is clear that there was agreement, particularly among ICT participants, that the integration of information services is critical towards the successful implementation of eHealth. The respondents' reactions demonstrate that integrating information services is key towards improving health care delivery. The researcher observed that the availability of an integration point is a significant indicator for successful implementation of eHealth in maternal health care.

12.12.15 Service provider

Concepts associated with the element of service provider were recognised from participants' reactions. Most of the responses mainly focused on challenges facing the delivery of maternal health services, and were contrary to stakeholders' expectations as opposed to the responsibility of health care providers (health organisations) to provide the necessary support. These include inadequate information infrastructure, understaffing, lack of staff training, inadequate commodity supplies, low adoption of ICT in facilities, lack of resources and facilitation, thus poor service delivery (see appendices). The following were comments from facility administrators who were interviewed:

“Records are mainly processed manually and then digitised at the county headquarters on monthly basis...computers are available at the facility but they are not being used!” (AP001).

“Adoption of ICT in our facility is still low because ...and also no ICT infrastructure is in place including IT personnel!” (AP002).

"The key challenges we face here include loss/damaged/misplacement of records, lack of ICT equipment, e.g. photocopying machine. Government is not providing support, shortage of staff, and lack of training on ICT for staff" (AP002).

"Our challenges include lack of supplies, e.g. The ANC booklet hence clients lack access to essential information in the booklet ...and also problems of care discontinuity as well as creating public awareness" (AP005).

"There is lack of space to store records, lack of ICT infrastructure, lack of staff training on IT, shortages of staff, retrieval of print information/records for maternal services, e.g. birth notification is difficult and may be destroyed" (AP003).

"Services in this place are poor because the necessary support is not available" (AP001).

In the same context, participants' reactions suggested the following regarding the future improvement of health care services:

"Information services can be improved by automation and training staff in IT literacy" (AP002).

"Improve ICT infrastructure, create awareness/training of staff in ICT and ensure global automation of departments' information services" (AP005).

"More personnel should be hired, funding for training of ICT skills be provided, and creation of more space for training and keeping records" (AP003).

"Implement ICT fully to bring transparency towards improving health care delivery" (AP001).

CHWs' reactions concerning the same subject were as follows:

"I started by saying we do not Have airtime to use mobile phone, and also there is no Internet...even computers are provided by partners" (CHW002).

"The services should be digitised to make referencing easier to improve referencing of information easily" (CHW004).

"The manual information system is bulky...and sometimes It is almost impossible to access information at the given time you need it, can be easily lost to fire outbreaks in the slums. Electronic will be better but it still has its own challenges" (CHW002).

"Sometimes facilities lack the ANC booklet... mothers are asked to buy an exercise book!" (CHW004).

"A mobile phone is preferable. It is not heavy, good and saves time...and also It is geographically un-limiting... But the challenge is – you need airtime – you can't make a follow up on a client because you do not have airtime, and data bundles- which you need to have for a smart phone, not just any phone and which is expensive!" (CHW002).

"We need Internet connectivity, and one computer for each officer to be facilitated with airtime and data bundles, maintenance of machines and IT training for officers" (CHW004).

Also, the following extracts were obtained from women participants:

"There is lack of Internet connectivity which limit access to information" (CP019).

"There are always long queues during clinic visits and this discourages...especially for mothers at 7-9 months of pregnancy from attending clinic" (CP009).

"There is a small waiting area at ANC and PNC clinic and so mothers miss clinic due to the long queues and lack of sitting space... not enough chairs to sit" (CP002).

"Not all mothers are provided with booklets hence... insufficient information to clients!" (CP001).

"Smart phones should be used to improve communication in maternal health care" (CP011).

Responses from the health professionals were as follows:

"Computers are not connected to an EMR, no computers for health care workers; no training on computer literacy, only mobile phone is available" (HP001).

"The computer system is incomplete. Computers are not used here! Ahh...since I came it just looks like a picture here in the office ...It is not working! Still...using a personal mobile phone is costly and you share your personal contacts with so many people, no privacy of the client" (HP008).

"There is a problem of inadequate supply of the booklet where clients are asked to use exercise books sometimes" (H005).

"Current information services are tedious, clients do not read the ANC booklet, the booklet get lost and/or damaged, information go[es] missing from the records...etc." (HP010).

"We need computers in order to reduce paperwork, employ more people /clerks to do data entry" (HP006).

"Documentation is too much with the few staff, sometimes one can forget to record information. Also space is a big problem due to too much paperwork, security of patient records is not guaranteed" (HP007).

"There is poor retrieval of files, scarcity of storage space, and confidentiality of patient data especially Mother/Child booklet, misplacing of patient files...etc." (HP003).

"The system is complex...and no trainings are done on reviews done by the ministry on documentation to familiarise staff on data elements added or removed from the booklet... there is no personnel to manage access to data" (HP011).

"Train staff on computer skills...recruit IT personnel...establish IT department and install fixed telephone extension for effective communication" (HP003).

"Implement electronic services for easy capturing of data and tracking information and also emphasise periodic training of staff and continuous job training of new staff" (HP008).

"Provide feedback and training in a timely manner whenever reviews are done on documentation. Implement ICT to improve management and maintenance of client records" (HP011).

"The use of ICT is minimal currently to cause substantial impact!" (HP008).

However, some of the professional respondents seemed comfortable with the current ICT services, and particularly argued that the use of mobile phones improved communication of health information among stakeholders. The following were some of the mixed reactions concerning existing ICT services:

"Phone calls have really improved communication of new knowledge among staff (caregivers), link with patients and also CHW/Vs" (HP009).

"There is positive impact though not sufficient since only phone is used. Other ICT tools including computers and electronic medical records are needed in order to create reasonable positive impact" (HP001).

One participant said there was positive impact since her facility used the IQCARE system to track HIV patients:

“There is positive impact since the IQCARE system prompts and alert staff regarding clients’ due for appointment, collecting drugs, HIV viral load..., etc.” (HP004).

Reactions from the ICT experts were mainly focused on issues related to the nature of desired ICT services:

“Health care providers should consider to provide education and literacy levels of the users of the new system” (ICT002).

“The HR element should be looked at that is, there is low developer capacity and technical skills that is, developers do not understand execution of systems” (ICT004).

“There is lack of technical skills... and high technology and maintenance costs” (ICT001).

“Enforce password policies including frequent password change, length of password...etc., user training and use of technology security standards” (ICT003).

“Consider affordability and quality of the technological infrastructure itself” (ICT001).

“There is need to have trained IT literate staff in order to be able to key in and use this data” (ICT003).

“Ensure proper change management in order to win customer confidence and involve stakeholders in order to also own the platform” (ICT004).

As observed from the participants’ responses, there was agreement that the service provider has an important role to play in providing support to address the challenges facing health care delivery in health facilities. Specifically, reactions concentrated on ICT infrastructural issues, resources provision and the general management and administration of health care. From the reactions, the researcher observed that the role of the service provider is a significant indicator in terms of implementing appropriate health information services to guarantee the delivery of quality health care services.

12.12.16 Stakeholder engagement

A number of concepts associated with stakeholders in maternal health care were identified from the participants’ responses. These include clients themselves (women), family members, caregivers/health professionals, facility administrators, hospital departments and units, CHWs, health institutions/hospitals, government, partners, local administrators and the community as a whole. The following are extracts from the various participant groups in support of the above argument.

Reactions from the administrator participants in support of the above argument were as follows:

“The key stakeholders are patients, caregivers, CHW/Vs, Community health committee (CHC), other facilities including, and referral hospitals” (AP001).

"The main stakeholders of maternal health and wellbeing services are the County Government, National Government, Maryland university, USAID, PEPFAR, Patients, staff, The community" (AP002).

"Internal units working closely with maternity services department are Family planning, CWC, ANC, OPD, Lab, Records and Pharmacy" (AP005).

"Among department stakeholders include Lab, Pharmacy, OPD, CWC, Comprehensive care clinic (CCC)" (AP003).

"Internal units working with maternity department are Nutrition, Physiotherapy, medical equipment, OPD, lab, public health, pharmacy" (AP004).

From the above responses, it was observed that administrators mainly interact and consult with other stakeholders on administrative matters in health care. They include staff at community facilities, local health committees, the County Government, partners and hospital departments. Reactions from client participants revealed the following in support of this argument:

"During my pregnancy...I worked with my spouse and other family members during my pregnancy" (CP001).

"We always consulted with experienced colleague mothers, neighbours and CHWs on how to manage my pregnancy" (CP004).

"I worked with nurses, the midwife, doctors and matron throughout my pregnancy period" (CP004).

According to the responses, clients mainly interact and consult within their neighbourhood, and mainly the spouse, relatives/family, colleague mothers and caregivers/health professionals at the community health facility. The following were the responses from health professionals on the same note:

"We work with nurses, doctors, counsellors, subordinate staff, student nurses and various departments such as Lab, Pharmacy, X-Ray, theatre, ANC for immunisations" (HP002).

"In the course of duty...I normally work with the Lab, Pharmacy, PNC and other facilities" (HP006).

"We work with Children Welfare Clinic, Nutrition, Clinician, VCT, Pharmacy, Laboratory, OPD" (HP007).

"I work with Medical Engineers, medical Officers, Clinical Officers, Student nurses, Nutritionist, Lab, Pharmacy, Medical schools/KMTC, Referral hospitals" (HP008).

"Normally, we work with clinicians, Community Health Assistant (CHA), CWC, Community Care Coalition (CCC), CHWs (CHWs), Management, Lab, PMCTC, Gender-Based Violence (GBV)...etc." (HP009).

"I normally work with fellow nurses, domestic workers, Assistant clinicians, Counsellors, Clinicians, Lab, Pharmacy, OPD, MCH and referral facilities" (HP011).

"Mostly I work with Record Officers, Clinicians and Doctors. Departments include Lab, Pharmacy, ANC, Casualty, OPD, Stores" (HP005).

"I work together with fellow doctors, nurses, midwives, Mothers/Patients and departments including pharmacy, theatre and radiology" (HP001)

“Departments I work with include Lab, Pharmacy, Theatre, Labour and delivery, Radiology and physiotherapy” (HP002).

From the above responses, health professionals mainly work and interact within their respective health facilities, whereby the main stakeholders are fellow staff, CHWs, facility administrators, internal hospital departments and referral hospitals.

The following responses were elicited from community worker participants in support of the same:

“We work with Community Health Assistant (CHAs), clients, nurses, third parties including relatives and volunteers” (CHW001).

“In most cases...I consult and work with the family that is, husband and wife and the Sub-county Medical Officer (MOH), clinical staff and clerks” (CHW002).

“In our community work we normally involve the Community Chairman, Assistant Chief, and Facility-In-Charge who are Community Health Committee (CHC) members, with CHAs and CHWs (CHWs) looking at how to improve community services” (CHW003).

“We mainly work with nurses, colleague CHW/Vs, CHAs, Nutritionist, public health officer (PHO), health records information officer (HRIO)” (CHW003).

As observed from the responses, CHWs mainly work with stakeholders at community level, together with colleagues, clients, relatives and health care professional based at community health facilities.

ICT experts emphasised the need to engage all the relevant stakeholders in designing and developing the proposed ICT-facilitated health and wellbeing services, including patients. One ICT expert said:

“Take patients as stakeholders and involve them to also own the platform, ensure proper change management processes to win their confidence” (ICT004).

Subsequently, participants agreed on the significance of stakeholders in maternal care, playing an important role as far as delivery of health care services is concerned. According to the majority of participants from the various groups, the clients, health care personnel/staff, CHWs, facility administrators, health institutions and government are the main stakeholders in maternal health care.

12.12.17 System quality

Concepts associated with the theme *system quality* were identified from the participants' responses, and particularly from ICT experts. Specifically, observable concepts featured as essential system quality attributes mainly form part of the non-functional system requirements. These include system responsiveness, accessibility, reliability, maintainability, securability, interactivity, scalability, specifications and affordability, among other attributes. The following are extractions from the responses in support of the above argument:

"The system should be responsive to existing hardware e.g. smartphone, laptop, and iPad... use mobile app... in order for patients to easily and quickly access their data" (ICT003).

"The system should be user-friendly...with good click depth, accessible, reliable, maintainable and secure" (ICT002).

"Connectivity is key for integration of services so the quality of Internet connection must be guaranteed" (ICT003).

"Consider the system's ability for scalability, input/output ration processing, resilience on day-to-day processing, disaster recovery with secure endpoints" (ICT004).

"Among important features to consider include specifications of such components for example CPU speed, RAM capacity, HDD size, a web-based system, open-source software" (ICT003).

"Consider affordability and quality of the technological infrastructure itself" (ICT001).

"Appropriate and adequate infrastructure should be built using affordable technologies including hardware and software tools" (ICT004).

The above statements demonstrate the degree of the awareness of the participants regarding the features a good HIS should possess to warrant delivery of quality services to users. This is crucial, as the identified features will provide insight for system designers and developers into delivering innovations that meet the needs of users within the context of use, thus ensuring quality services.

12.12.18 User-centred design

The concepts identified in this category relate to user-centred design service, which in this case may also refer to UCD and the co-design method. This include taking into consideration users' (individuals) latent needs, mapping stakeholder requirements, client/user involvement and active participation prior to the design, development and implementation of the proposed personal health and wellbeing services. Specifically, reactions on this subject emanating from the ICT expert participants include:

"Take patients as stakeholders and involve them in order for them to also own the platform" (ICT004).

"Map user requirements with involvement of stakeholders" (ICT002).

"Consider stakeholders' requirements and map users' needs... also the quality of existing ICT infrastructure ...and affordability of the technological infrastructure" (ICT001).

"Health care providers should consider to provide education and literacy levels of the users of the new system" (ICT002).

"Understand the primary user needs for example for clients, nurses and doctors... and through active participation" (ICT004).

"Customise software to suit users' needs that is, open MR software for doctors and nurses" (ICT002).

"Use agile methodology to iterate the process with prototyping in order to have a users' guided design" (ICT001).

"The system should be user-friendly with good click depth, accessible, reliable, maintainable and secure" (ICT002).

“Use mobile applications, laptops, pads... in order for patients to easily and quickly access their data” (ICT003).

“Health care providers should consider to provide education and literacy levels of the users of the new system” (ICT002).

As observed, participants agreed that user-centred design is a significant requirement towards successful implementation of the proposed service. More importantly, information services should generally be user-friendly through the mapping of stakeholder requirements, and the customisation of user needs is a critical requirement in this process. The researcher therefore observed that user-centred design service is among the significant indicators to the successful implementation of ICT-enabled health information services.

Based on the use of the ANC booklet as a point of reference, the researcher used the co-design process to enable participants to select information elements which they consider relevant to their information needs that should be included as part of the clients' mobile application design. Data were generated from discussions using an unstructured interview questionnaire and observations that lasted two (2) hours.

12.13 Observation data analysis

The researcher used the observation technique to gather data on the phenomena under investigation during fieldwork. Specifically, the researcher observed the nature of the maternal health information services offered by noting participant behaviour during interviews, taking videos and photos, and making observatory notes on an observation form (see Figure 12.5).

Generally, one of the most important observations made is that health information services at the selected public health care facilities were mainly managed manually, according to the researcher's observation. Only a few units and/or departments in some of the facilities under investigation used electronic information services, specifically the IQCARE system, which was provided by partners to document and track HIV patients.

12.13.1 Participant observation

During observations made during field interviews with health professionals, most of the participants were co-operative in providing responses to the interview questions; however, a few were suspicious and therefore did not open up with their answers. Also, there was the challenge of distraction by clients during interviews since the caregivers, and particularly nurses, had to stop the interview to attend to client, hence low concentration by the participants. This led to the postponement and/or premature ending of interview sessions. Furthermore, the understaffing of health professionals was observed in most of the selected facilities, whereby one individual worked in a unit from 8 AM until 5 PM, without a break, thus paying little attention to the study. In addition, a negative attitude was observed among staff respondents towards the research as they felt that the study was a waste of their time. Some

of the participants were uncomfortable and/or could not speak the English language due to illiteracy and the nature of a multi-cultural environment, hence there was a bit of a challenge to understand each other. The research context focused on low socio-economic status (low SES), since most of the facilities were situated in slum places where the majority of the people could not afford basic care.

Cape Peninsula University of Technology

Observation Form

To be used in conjunction with other recording methods. Note down key aspects that you observe before or during the research activity, or upon reflection. Indicate if you have asked the participant(s) about something you have noted.

Participant Code: AP 007

Research Activity: Research interview session

Date: 20/8/2018

The Person Level of engagement, emotions, reactions to questions, body language etc. - Participant fully cooperative throughout the interview process - ~~Some~~ Participants (Patients) had serious language barrier challenges hence could not fully participate	The Place Context, environment etc. Eastleigh H/C - Records handled manually - no ICT services - Low SES - Language barrier due to multi-cultural environment ~~and~~ ^{and} ~~many~~ ^{many} ~~people~~ ^{people} ~~do not~~ ^{do not} ~~understand~~ ^{understand} English - so much paperwork in documentation - Charts on the walls on MCH, Immunisation, Growth & monitoring and nutrition, Antenatal and family Planning.
The Research Tool Facilitating interaction, understandable, etc. - Staff are free to interact via interview questions - Interview guide allow the researcher to make clarifications on unclear questions - Interview guide allow the researcher to translate questions in ~~another~~ ^{Swahili} Swahili language for participant who do not understand English	The Researcher Behaviour, learning, reflective practice, etc. - Characteristics of an under-served context are explicit ie understaffing, low SES of community members, some level of illiteracy among patients and mostly small women, poor infrastructure

Figure 12.5: Observatory notes recorded on an observation form

12.13.2 Health care environment

The research environment was mainly characterised by a lower SES as the health facilities were located in slum areas that were specifically meant to serve members of immediate communities. Therefore, the health care infrastructure was poor in general due to

evident resource constraints because of poor government funding and low SES of the people (Figure 12.6).



Figure 12.6: A Community Health Facility in one of the slum areas

12.13.3 A section of community health facility providing ANC services

Because of a low SES, some of the participants, and particularly CHWs, asked for compensation to participate in the study. It was observed that paper documentation of health information was too much and therefore tedious for staff to manage information effectively (Figure 12.7).

Charts were placed on the walls at the reception area of the community facilities where health education sessions. These charts included ANC, growth and nutrition, Mother and Child Health (MCH), family planning and child immunisation. This was used as a way of communicating maternal health information to the mothers who visited the clinic. Some of the facilities, especially referral hospitals, were quite complex, with many departments such as the theatre, X-rays, and surgical wards were not available at the smaller facilities (i.e. the health centers). Long queues were observed in these facilities as they mainly handled referral case from smaller facilities.



Figure 12.7: Pregnant women attending ANC health education session at a community health facility

12.13.4 Research tools

The research tools used include an interview guide, information sheets and observation forms. The interview guide, in particular, was 'comfortable' as it facilitated interaction between the researcher and interviewees, especially the nurses and doctors who were busy with work. In such as case, the researcher would ask one question at a time and then record responses, without the respondent having writing their response down. Also, the researcher was able clarify questions that were not clear to the participant. For those respondents, particularly clients, who could not speak English, the researcher translated the interview questions in Swahili to enable them to respond to the questions.

12.13.5 The researcher

Through observation, the researcher gained more insight into the study phenomena as he observed and learnt from the activities at the various selected health facilities, after which he was able to reflect on the learnt experiences. As the researcher engaged in reflective practice, he was able to relate scenarios and learn many things, particularly understanding the characteristics of and *underserved context*, such as poor infrastructure, low SES and illiteracy among members of the community including clients, which were out right evident in the research context. At times, the nurses and doctors in some of the facilities found it difficult to communicate with some of the clients who sought maternal care services and treatment at the selected facilities. This is because some clients could not express themselves in English or Swahili, even though these are the official national languages in Kenya. In such cases

however, the CHWs were asked to help interpret the communication between the health professionals and the clients.

12.13.6 Emerging themes from observation data

Six (6) themes emerged from the observation data: community health information service, health communication, health system, information services, service provider, and maternal care stakeholders.

- **Community health information service:** Aspects linked to community health care were observed, which mainly comprise health education talks including one-on-one sessions facilitated by the nurses to clients (pregnant women) alongside CHWs. Major services rendered at the community facilities include ANC, child growth and nutrition, Mother and Child Health (MCH), family planning and child immunisation, among others. This revealed to the researcher the critical role and importance of community health services in improving the delivery of maternal health care to the women, particularly in an underserved context
- **Health communication:** Aspects of health communication emerged from the participant responses and observation notes, whereby caregivers and CHWs indicated that they use various modes of communication to communicate health information, for example, verbal communication that includes face-to-face/one-on-one sessions with clients during ANC clinic visits. Print media is also used largely to communicate information to clients and among stakeholders, and specifically the ANC booklet as well as charts posted on the walls at the exceptions area of the clinic hall. Mobile communication is the most popular form of electronic communication used among stakeholders to communicate health information, particularly by the midwives (nurses) to both colleagues and clients. These various ways of maternal health communication services offered at community facilities are meant to create awareness to the clients whenever they visit the facility. From these observations, the researcher was able to identify existing health communication weaknesses and challenges for future improvement
- **Health system:** It was observed that issues related to the health system mainly concern inadequate general public health care infrastructure due to poor policy decision-making and governance structures, resulting in poor funding and resource provision and allocation, which is the sole responsibility of both the National and the County Governments. The lack of proper governance has led to global infrastructural challenges that have a negative impact on health facilities and thus poor delivery of health care services. The researcher therefore noted the significance of an effective health system as an indicator towards effective public health care delivery
- **Information services:** Some characteristics of existing information services were observed during the field study, which were mainly manual, given the nature of infrastructure. It was noted that print materials are mainly used to relay health information, particularly books and charts. Also, information exchange is mostly verbal using face-to-face conversations especially between the caregivers and clients. The phone is the main ICT tool used to pass and/or share information among stakeholders, including CHWs, nurses and clients. There are, however,

challenges of language barriers especially in multi-cultural environments, and also due to illiteracy among clients who cannot freely express themselves during care activity. Based on this understanding, the researcher was able to identify gaps that this research could address to improve information services in future

- **Service provider:** Issues linked to service provision were observed, including facility infrastructure. In particular, it was observed that information services in most of the facilities are mainly manual, a scenario that has led to challenges such as storage space, delayed retrieval hence tedious loss and damage of patient records. The researcher also noticed staff shortages whereby staff were overworked and the work environment non-conducive in terms of equipment and facilities, maintenance and environmental hygiene. For instance, during the fieldwork it was observed that pregnant women were forced to stand while attending health education talks since there was neither seating space nor seats to sit on. These revelations enabled the researcher to gain a deeper insight into the research phenomena, which was vital in terms of informing the study accordingly towards improving existing health information services
- **Stakeholder engagement:** The study revealed the various stakeholders performing different roles in providing maternal health care services. Specifically, clients, CHW/Vs, health professionals and hospital departments were identified as the key stakeholders at facility level. While the clients are the service recipients, CHWs are the first point of contact, guiding and directed clients to the community facility. Caregivers on the other hand are the health professionals who administer primary care to the clients at the community facilities. Various departments, including OPD, laboratories, pharmacy, and maternity, offer specific health care services to the clients. By understanding the roles of various stakeholders, the researcher was able to comprehend the nature of the relevant design for health and wellbeing information services in maternal care

12.14 Study findings

This section presents a detailed account of the eighteen (18) data themes that emerged from the study. The section is organised systematically according to the pre-defined set of theoretical themes that guided the research. These include identifying stakeholders, information needs, current information practices, challenges experienced, stakeholder perceptions, and design considerations for ICT-facilitated health and wellbeing information services in maternal health care.

12.14.1 Emerging data themes from different participant groups

This section provides a detailed account of the data themes revolving around maternal health information services that were derived from the data collected from various participant groups. Specifically, twenty (20) data themes were generated across the five participant groups: ICT Experts (10), clients (10), health professionals (13), CHW/Vs (10) and health care managers/administrators (7). Most of the themes re-emerged across various respondent groups hence overlapping despite the study population being heterogeneous, i.e. the

characteristics, roles and responsibilities in maternal care varied. Figure 12.8 represents the 20 data themes that emerged from the analysis of the responses of the different participant groups in the research context.

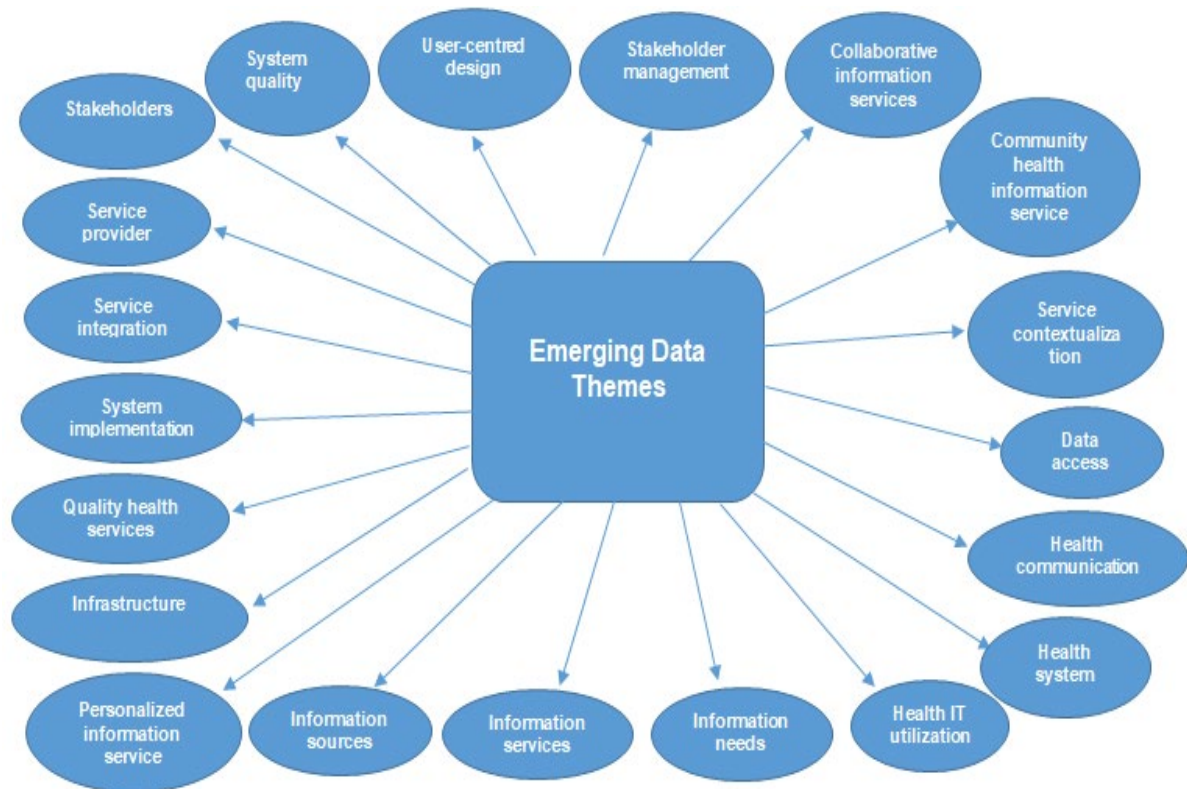


Figure 12.8: Emerging contextual data themes

12.14.1.1 Themes emerging from ICT experts

Themes identified in the 'ICT experts' category include: data access, health system, HIT utilisation, service/system implementation, service contextualisation, system/service integration, service provider, stakeholder engagement, system quality, and user-centred design.

12.14.1.2 Themes emerging from clients

Themes identified in the 'clients' category include: service contextualisation, data access, health communication, health system, information needs, information services, information sources, personalised information service, quality health service, service provider, and stakeholders.

12.14.1.3 Themes emerging from health professionals

Themes identified in the 'health professionals' category include: Collaborative information service, data access, health communication, health system, information needs,

information services, information sources, infrastructure, HIT utilisation, personalised information service, service provider, stakeholders, and system/service integration.

12.14.1.4 Themes emerging from facility administrators

Themes identified in the 'facility administrators' category include: health communication, health system, information needs, information services, information sources, service provider, and stakeholders.

12.14.1.5 Themes emerging from CHW/Vs

Themes identified in the 'facility administrators' category include: information services, community health information service, data access, health communication, information needs, information services, information sources, personalised information service, service provider, and stakeholders.

12.15 Combined data themes and their relative importance to various participant groups

Table 12.7 presents a combined list of the identified data themes and their relative importance in maternal health information services as they emerged through analysing the data collected from various respondent groups. This helped the researcher gain more insight into, and understanding the research context better from the stakeholders' views, opinions, perceptions and propositions concerning the nature of maternal health information services. Specifically, the researcher attempted to understand the significance of the various identified data themes to the different participant groups according to pre-defined theoretical themes (stakeholders, practices, challenges, perceptions and design considerations) regarding maternal health and wellbeing services. The significance was rated as either 'important', 'very important' and/or 'extremely important' as shown in Table 12.7.

Table 12.7: Combined data themes and their relative importance to different participants concerning maternal health care services

S/N	Theme	Clients	Health Professionals	CHW/Vs	Administrators	ICT Experts
1	Collaborative information service		Very important	Important		
2	Community information services			Important		
3	Data access	Important	Very important			Extremely Important
4	Health communication	Extremely important	Very important	Very important	Important	
5	Health System	Important	Important		Very important	Very important
6	HIT utilisation		Very important			Important

S/N	Theme	Clients	Health Professionals	CHW/Vs	Administrators	ICT Experts
7	Information needs	Very important	Important	Important	Extremely important	
8	Information services	Very Important	Extremely Important	Very important		
9	Information sources	Very important	Very important	Important		
10	Infrastructure	Important				
11	Personalised information service	Important	Very important	Important		
12	Quality health service	Extremely important				Important
13	Service Contextualisation	Important				Extremely important
14	Service provider	Important	Extremely important	Very important	Extremely important	Very important
15	Stakeholder engagement					Very important
16	Stakeholders	Important	Very important	Important	Very important	
17	System implementation					Very important
18	System quality					Extremely important
19	System/service integration		Important			Extremely important
20	User-centred design service	Important				Very important

Table 12.8 represents a summary of the study's findings in terms of the frequency of the various themes as they emerged under the corresponding theoretical themes.

Table 12.8: Frequency of data themes against theoretical themes

Frequency of Data Themes	Theoretical Themes						Theme Count
	Design Considerations	Information management challenges	Information needs	Information practices	Information stakeholders	Stakeholder perceptions	
Collaborative information service	Nil	Nil	Nil	5	Nil	Nil	5
Community health information service	Nil	Nil	Nil	1	Nil	Nil	1
Data access	8	1	Nil	1	Nil	3	13
Health communication	Nil	1	Nil	24	Nil	1	26
Health system		8	Nil	Nil	Nil	1	9
HIT utilisation	1	Nil	Nil	Nil	1	1	3

Frequency of Data Themes	Theoretical Themes						Theme Count
	Design Considerations	Information management challenges	Information needs	Information practices	Information stakeholders	Stakeholder perceptions	
Information needs	Nil	Nil	27	Nil	Nil	Nil	27
Information services	Nil	Nil	1	26	Nil	3	30
Information sources	Nil	Nil	Nil	12	Nil	Nil	12
Infrastructure	Nil	Nil	Nil	Nil	Nil	1	1
Personalised information service	Nil	Nil	Nil	9	Nil	Nil	9
Quality health service	Nil	Nil	Nil	2	Nil	9	11
Service Contextualisation	11	1	Nil	Nil	Nil	Nil	12
Service provider	Nil	12	Nil	11	Nil	23	46
Stakeholder engagement	Nil	Nil	Nil	Nil	Nil	2	2
Stakeholders	Nil	Nil	Nil	Nil	26	Nil	26
System/service implementation	2	Nil	Nil	Nil	Nil	Nil	2
System/service quality	12	Nil	Nil	Nil	Nil	Nil	12
System/service integration	9	1	Nil	Nil	Nil	1	11
User-centred design service	4	Nil	Nil	1	Nil	2	7
Cumulative Theme Count	47	24	28	92	27	47	265

12.15.1 Stakeholders in maternal health and wellbeing services

Two data themes emerged under this category of theoretical themes (stakeholders). The snowballing technique was used to identify potential stakeholders who had various working relationships in the delivery of maternal health care services to the communities around Nairobi County. Each of these stakeholders performed various roles and has had either direct or indirect impact on maternal health information services offered in public health facilities. Stakeholders identified during the study include government, partners, health institutions/hospitals, health professionals/caregivers, facility administrators, CHWs, clients/women, local administration, and community members, among others.

12.15.1.1 Government as a stakeholder

Government was identified as a key player in the provision of maternal health care services, being charged with the responsibility of providing health care policy direction, needed resources, facilities and health care infrastructure to support service delivery to citizens (Korpela et al., 2013). Specifically, all five health care administrator participants mentioned

government as one of the main stakeholders with whom they have a close collaboration and working relationship, among other stakeholders, by virtue of their duty and responsibility within the health care system.

One administrator said,

“Important stakeholders in maternal care include clients, relatives, caregivers, hospital facility, referral hospitals, County Government partners, National Government and management” (AP005).

Two levels of government are involved, namely the National Government and the County Government. The main role of the National Government is to formulate national health policies through the Ministry of Health, funding County Governments, and managing level 6 facilities, that is, national referral hospitals Kenya Health Care Federation, 2016). County Governments, on the other hand, are charged with the responsibility of managing health care services at lower-level facilities (1-5), including budgeting and the provision of needed resources and organisational health care infrastructure at county level Kenya Health Care Federation, 2016). These include building and equipping health facilities, the provision of medical supplies and commodities to the facilities, staff recruitment, formulating and implementing health care policies, including management of health information.

12.15.1.2 Development of partners/donors as a stakeholder

Partner activity was observed in most of the selected facilities during the study, which involved partnerships with government on the sponsorship of various health care projects in Nairobi County. Specifically, partners were identified by the facility administrators as important, working closely with government health facilities to implement various health projects targeting maternal care services. Also, CHW/Vs and health professionals mentioned partners who made some contributions towards building health care infrastructure. One administrator said,

“The main stakeholders of maternal health and wellbeing services include County Government, National Government and partners such as Maryland university, USAID, PEPFER, Patients, staff and the community” (AP002).

Some of the partner projects include erecting new or renovating existing facilities, launching health intervention programmes such as campaigns and awareness about HIV/AIDS, providing medical supplies and commodities, providing HIT infrastructure to manage programmes, and recruiting staff to run programmes, among others, to enable government to fulfill its mandate of delivering health care services to the citizens.

One nurse said,

“There are computers and mobile phones donated by partners for every department but sometimes It is difficult to find it especially during emergencies” (HP003).

12.15.1.3 Health institutions/health care providers as a stakeholder

Public health institutions/hospitals (health care providers), i.e. dispensary, health centers, district/county hospitals and national referral hospitals, were identified as important stakeholders of maternal health information services. Hospitals were mainly identified as a key stakeholder by clients, CHW/Vs, administrators and health professionals having a close working relationship with health facilities. Clients stated that: (i) they receive care services from health care providers; (ii) CHW/Vs refer clients to health facilities and they work in collaboration with caregivers; (iii) health professionals work/provide care services to clients at facilities and refer patients to another facility for further treatment; and (iv) administrators coordinate and manage service delivery at the facilities. In general, hospitals provide maternal health care services to the public, which include ANC, baby delivery and PNC, among other services. Health institutions/health care providers thus generate, store, share and communicate health information, including patient referrals, hence they are custodians of information.

12.15.1.4 Health professionals as a stakeholder

Health professionals/providers were identified as key stakeholders of maternal health information services as they were recognised as active participants during care activity (Korpela et al., 2013). Specifically, this category of stakeholders was identified by administrators, CHWs and clients, which reveal the close collaboration among the four stakeholder groups, i.e. clients, CHW/Vs, administrators and health care providers, in the health care delivery chain. As caregivers, health professionals play a central role since they are the first point of contact and/or interaction with the client(s) at the facility/hospital, which commences with ANC visits, admission, delivery, postpartum and discharge from the hospital. One client said,

"I worked closely with the nurses, the midwife, doctors and matron throughout my pregnancy period" (CP016).

Also, the health professionals record and document the activities as they administer care. These activities include the client's physical examination, maternal profile, medical history, diagnosis, and drug prescription, among other details. They give advice to the client according to their condition, including the next visit or appointment at the clinic, all of which are documented in the ANC booklet.

12.15.1.5 Facility administrators as a stakeholder

Facility administrators (managers) were also identified as part of the key stakeholders of maternal health care services, since they have the responsibility of overseeing the smooth running of operations in the health facilities. This category was identified as stakeholder by both CHWs and health professionals who work in collaboration to deliver services to clients. Administrators mainly perform a supervisory role and coordinate activities that involve

caregivers and CHWs. This is done either within or outside of the facility, for example, mobile clinic health services taken to the community. One caregiver said,

“Normally, we work with the hospital administration who facilitate and provide the necessary support. Also, clinicians, the community health assistant, CHWs and the Gender-Based Violence (GBV) team” (HP009).

Also, internal departments/units within a hospital work in collaboration to deliver care services to clients, for example, OPD, laboratory, pharmacy, and maternity, among others, to ensure client satisfaction under the coordination of administrators. They make organisational policies and implement them (including government policies) through ensuring strict adherence to these policies by staff and clients, demanding accountability from staff, reporting to health authorities, provisioning of resources, and organisational infrastructure through budget allocation to support health care activities and service delivery.

12.15.1.6 CHW/Vs as a stakeholder

CHWs were mentioned as well to be among the potential key stakeholders of maternal health information services as frontline public health workers who serve as a bridge between community members and health care providers at the health facilities (Brownstein et al., 2011). They play a critical role in preventive care to support the delivery of maternal health care services to women at community level. This stakeholder category was primarily identified by the administrators, health professionals and clients with whom they have a close working relationship in terms of organising community health events. They work closely with clients (pregnant women and nursing mothers), community health facilities and caregivers at community level. One nurse said,

“I work with CHWs/Volunteers and the Community Health Assistant, who reach out and educate pregnant women in various households, and to advise them to attend ANC clinic” (HP001).

In the case of this study, their main role was identified as educating and supporting women on how to manage pregnancy risks factors and diseases, as well as linking them to needed care and resources (Brownstein et al., 2011). This is meant to ensure that each pregnant woman in each household attend an ANC clinic and deliver in a health facility, which is achieved through following up on pregnant women and referring them to the nearest facility to receive medical attention, including ANC, postnatal and immunisation, among other care services, as deemed necessary.

12.15.1.7 Clients/pregnant women as a stakeholder

The clients are regarded as the central subject since they are recipients of maternity services offered at health facilities. They therefore qualify to be among the key stakeholders of maternal health information services. Specifically, the women work closely with the caregivers (nurses) and CHWs during the maternity journey, right from conception through to

the postnatal period. While CHWs interact with the clients at community (household level), health professionals, including nurses, meet them at the health facility where care services are administered.

12.15.1.8 Local administration and other stakeholders

Other potential stakeholders include the local administration comprising the area Chiefs or Assistant Chiefs, village elders, and household heads, among others, who work with community members and workers through various community health and intervention programmes to promote public health care and awareness.

A community worker said,

“In our community work we normally involve the Community Chairman, Assistant Chief, and Facility-In-Charge who are Community Health Committee (CHC) members, with CHAs and CHWs (CHWs) looking at how to improve community services” (CHW003).

Specifically, activities being carried out include sensitising members of the public about preventive health programmes and strategies such as disease outbreaks, water, sanitation and hygiene, through chief barazas. In this case, the local administration represents the government in terms of facilitating public forums by authorising or licensing such events and also providing security during these events. Members of the community/people who are mainly health care consumers are also recognised as potential stakeholders of maternal health care information services, because they are the recipients and/or beneficiaries of the services in which they participate. Generally, the argument follows the understanding that clients of maternal health care services, including women and their immediate families, are members of community whose cooperation is needed in this process.

12.15.2 Information needs of stakeholders

Study findings in this category revolve around the data theme ‘information needs’ of stakeholders in maternal health care services. This research investigated the information needs of the various stakeholders, including clients, health care professionals, CHWs and facility administrators. According to the study findings, it was observed that the information needs of various stakeholder groups are mainly influenced by their specific roles and responsibilities within the health care service ecosystem as described in subsequent sub-sections.

12.15.2.1 Information needs of clients

According to the study findings, the maternal health information needs of women were identified and classified into three main categories, namely prenatal, ANC, and postnatal needs. Women participants in particular want to know more about preventive care measures that will enable successful pregnancy as well as eventual safe delivery.

i) Prenatal needs

Prenatal needs are mainly concerned with preparations by women whenever one plans to conceive, especially those who are anticipating their first pregnancy/child. Specifically, participants expressed a desire to know the appropriate time to conceive and how one could influence the gender of the unborn baby. One woman said,

“For me I would want to know the best time to conceive...and how to get a baby boy or a girl... mother’s health and nutrition... the needed finances and associated risks” (CP003).

ii) ANC needs

The major ANC information needs identified among the majority of the women during the focus group discussions mainly revolve around the mother’s health and nutrition, danger signs of pregnancy complications and causes such as miscarriages, and how to monitor the baby’s condition. About 12 of the 23 women said they would like to understand nutrition and dietary needs during pregnancy, such as the kind of food one should eat as this is crucial for foetal growth and development as well as the mother’s own health in terms of body changes. This was observed to be more of a lifestyle matter hence the need for nutritional education sessions and advice on appropriate type of food to eat. Expectant mothers in particular expressed concern to be enlightened more on common complications of pregnancy that they were likely to experience, danger signs and associated risk factors as well as appropriate preventive measures. One participant said,

“I seek to understand the danger signs of pregnancy, complications and how to manage them” (CP008).

According to their responses, the women wanted more information on how to monitor the baby’s condition. This is necessary to ensure timely attention to any issues that may arise before the next clinic appointment date. Other information needs observed include the desire to know where to find better and affordable maternity services with the assurance of safe delivery and security for both the mother and the baby. More so, the participants wanted to find out more about appropriate dressing and shoes to wear during pregnancy, among other information.

iii) Postnatal needs

Regarding postnatal needs, nursing mothers in particular expressed that they want more information on breast-feeding, while the mother’s sitting position were identified as an area of concern on which the women wanted more information. This was observed especially among young and/or inexperienced mothers. One woman said,

“I want to know the correct sitting position while breast feeding and baby wining” (CP010).

Essentially, postnatal needs were identified as an important requirement for lactating mothers to maintain good health for both the baby and mother. Also, the participants reported

that they want information on important child immunisations and vaccines against diseases, possible baby complications such as jaundice, and, above all, how to observe and/or maintain general hygiene for the baby, among other needs.

Another participant said,

“I want to know how to avoid pregnancy risks including miscarriage, possible infections, danger signs for the baby, e.g. jaundice and how to prevent it... also, whom to consult in case they occur. Also, I need to know about important immunisations for the baby” (CP009).

Based on the above observations, it was noted that participants are aware of their relevant information needs, which are mainly focused on preventive care. However, to improve services, there is a need for stakeholders to engage in close collaboration with the women, caregivers and CHWs. This will enhance information sharing, and thus awareness among women to eradicate preventable risks and complications both during and after pregnancy.

12.15.2.2 Information needs of CHW/Vs

According to the study findings, the information needs of CHWs mainly focus on preventive care services, including prescriptive guidelines and community profiling. As observed, the main role of CHWs is to prevent and/or minimise communicable diseases to improve public health care. Preventive care information needs identified include updates through refresher training on various ways to control communicable diseases and outbreaks to avoid further spread. Among common diseases mentioned, include HIV/AIDS and TB, of which participants need to have the knowhow on relevant prevention strategies. Mother to child transmission (PMCTC) and breast-feeding were the main focus of participants in the case of HIV/AIDS. One participant said,

“Mostly, I am interested in information about changes and current issues such as disease outbreaks through seminars, HIV, TB and nutrition” (CHW002).

At the same time, the need for information on water sanitation and hygiene for the control of the spread of waterborne diseases was identified. Another preventive information need observed is that of nutrition and diet, which is critical in controlling diseases associated with malnutrition. A participant said,

“I need to know about MCH guidelines, nutrition, water sanitation and hygiene, record keeping. I also need to know the population and number of households around my working area” (CHW004).

Also identified is the need for updates on guidelines concerning preventive strategies in maternal health care. Specifically, MCH and HIV/aids management guidelines were mentioned as providing policy direction on how various health programmes and activities are supposed to be conducted.

A CHV said,

“We need refresher trainings because sometimes we were taught about HIV long time ago like five years back and now, we have the new guidelines on HIV and Aids. They keep on bringing the new guidelines. Like the mother to child booklet, they renewed it on 2016” (CHW003).

To ensure improved service delivery to the public, participants need to understand the community population(s) and their demographics to create a profile(s) towards ensuring effective preventive care measures. This includes establishing the number of households within a community and the total population for better planning. An official said,

“Every six months we do a process called mapping and house hold registration, where we map out the area in our community then, every community health volunteer is given households to visit and do registration, so once the information is collected it is submitted to the community health assistant who now creates a data base for that community” (CHW004).

As observed from the study findings, CHWs mainly require information that is relevant to enable the development of strategic preventive care measures, and specifically to minimise the spread of communicable diseases. Therefore, statistical and administrative information is needed to facilitate both planning and policy decisions. In order to achieve this, CHWs need to work in collaboration with clients, caregivers and health authorities/ government to acquire the needed information.

12.15.2.3 Information needs of health professionals

According to the findings, the information needs of caregivers are mainly influenced by their professional duty and responsibilities as well as for administrative purposes. Specifically, information needs that were identified during the study include client bio-data and contacts, maternal health profile (HIV status, vital signs, blood pressure allergies and parity, among others), professional knowledge and administrative information. Health professionals need client bio-data and contact details to open a file, especially during the first visit to an ANC clinic. This information is essential for purposes of referencing, communication and follow-up on clients currently in the maternal journey pipeline.

One nurse said,

“I would check client bio-data, surgical history, allergies, blood group 2, blood pressure, HIV status.....etc. from the ANC booklet. Also, bio-data and contact details of the next of kin especially in case of referrals” (HP006).

First of all, it was reported that the caregiver has to investigate the general health condition of pregnant women at the point of care through a physical examination, observation and/or prescribed laboratory test results to determine the relevant care decisions and nature of treatment to be given.

Further investigations are then conducted, specifically based on the maternal profile, and particularly the profile of experienced mothers. The further investigations include clients'

obstetric and gynaecological history such as previous pregnancies and deliveries, type of delivery (normal or caesarian), as well as labour and surgical history as this information is necessary to assist caregivers to understand the gynaecological condition of the client in order to avoid medical mistakes. One participant said,

“I would check gynaecological history that is, the number of children, number of pregnancies, and number of babies lost before term, type of delivery....etc.” (HP003).

Another information need identified from the responses is the ANC profile/history, i.e. the progress of the current pregnancy including the last menstrual period, HIV status, chronic illnesses, vital signs, drug allergies, and blood group and pressure, among others. Therefore, the aforementioned information needs are necessary to administer professional maternal care services to different clients, according to their profile and condition. One participant said,

“During the first visit, I would ask the client about their last menstrual period, parity, ANC profile that is, HIV status and family history” (HP011).

Another participant said,

“I ask for surgical history of the client, family history that is, chronic illnesses, drug allergy, obstetric history and ANC profile, e.g. HB, blood group, rhesus factor and infections if any” (HP010).

To provide quality health care services, caregivers need professional knowledge and skills through basic formal training and refresher courses to update the knowledge already acquired. One health professional said,

“As a professional, I first ask to know gestation period to know when the mother had their last menstrual period. Also, as a nurse...I need professional knowledge and skills to be acquired through formal training to determine what kind of care to give at what particular point” (HP008).

Lastly, it was noted that caregivers need relevant administrative information, specifically routine information such as daily patient registers, commodity supplies, work shifts and scheduling in the form of handover reports. One nurse said,

“I take care of mothers in maternity ward, admit new clients, teach nursing students, give treatment to mothers in PNC, document activities of the day and submit hand the over report...” (HP007).

As observed by the researcher, the information needs identified above are solely of a professional nature and therefore meant to enable health professionals to deliver quality care delivery to clients. Specifically, caregivers deal with medical diagnostic information, which should therefore be handled and maintained with care and in a correct and accurate manner to avoid medical errors. Such information needs to be available in a timely manner to warrant decision-based care.

12.15.2.4 Information needs of health care managers/administrators

Facility administrators are officers concerned with the administrative affairs of health care facilities, including overseeing and managing day-to-day activities. According to the study

findings, the information needs of administrators (hospital managers) are mainly influenced by the nature of their role and responsibilities, including routine management and the coordination of hospital operations, as well as planning, formulating and implementing policy decisions. As observed during the study, administrators need administrative information, specifically statistics on hospital routine operations and activities to facilitate supervision, coordination and planning. The statistics include recording daily activities, monthly reports, number of clients treated, number of baby deliveries per month, daily supplies and consumption of commodities, among others. This information is meant to facilitate planning, i.e. budgeting and the allocation of resources, including provisioning finances, meeting staffing requirements and general hospital infrastructure which includes facilities and medical equipment to support operations. Another participant said,

“Generally we see 54,000 patients/clients annually in this facility, and about 100 baby deliveries per month... this information helps us to plan for the next financial year because we are able to project expenditures” (AP004).

Another critical information need identified is policy guidelines and decision-making. One of the key roles of administrators is to formulate policies in order to create structures that guide delivery and/or the provision of health care services. Policies assist with developing guidelines to ensure consistency and order in following stipulated procedures and protocols, which have to be adhered to by the involved parties to achieve harmony within the hospital establishment and beyond. A facility manager said,

“My information needs include policy guidelines, health records and the tools to facilitate the same” (AP003).

Another participant said,

“My main roles are to provide facilities and equipment such as ambulance. Also, I make policy decisions, maintain good standards of care for patients, and attend to needs of health workers” (AP005)

Generally, facility administrators need information that supports the administrative affairs of the hospital, specifically supporting planning and policy decisions that influence the nature of health care delivery. This information is therefore a critical ingredient for proper planning to avail the necessary resources to ensure quality service delivery. It was thus noted that for this to happen, complete and accurate timely information is necessary.

12.15.3 Current information practices

The study observed the nature of existing health information practices associated with maternal care across the selected health facilities. Specifically, eight (8) themes emerged in this category: information services, community health information service, health communication, health system, collaborative information service, information sources, personalised information service, and service provider. Generally, the content in this section

mainly revolves around the nature of information services (electronic and manual), media and tools used to communicate information and the sources of information for various stakeholders.

12.15.3.1 Information services

According to the study findings, the nature of current health information services is primarily manual across all selected facilities, while only a small portion of the services is handled electronically. This is influenced by the existing information infrastructure, which basically relies on manual procedures as opposed to electronic services. As observed during the study, information processing from community level to facility level mainly involves paperwork in form of books, magazines, posters, charts, reports, and referrals letters. The ANC booklet is at the center stage as far as communication, sharing and the management of personal maternal health information are concerned. The document contains a full maternal profile and can be used until the child is 5 years old. One community worker said,

“The mother child booklet is very instrumental and educative- it captures like all areas that is, the birth of the child, age, name, and all the health services we give to the child” (CHW002).

One nurse said,

“Our information system is mainly manual...whereby client data are captured manually and recorded in patient file while the mother goes home with the same information on The ANC booklet” (HP003).

The client was identified as the custodian of the booklet, but unfortunately, the document has been exposed to wear and tear, loss, and fading of ink due to aging, thereby losing client health information. In addition, the manual practices triggered challenges such as a scarcity of storage space for records; the organisation and retrieval of information; and an unfriendly work environment due to bulky records. Also noticeable was that the level of adoption of HITs is very low since ICT is almost non-existent in health facilities under investigation. A facility administrator said,

“We have manual information services for maternity as there is no infrastructure for IT except partners for example university of Maryland transmit HIV related some data online” (AP003).

It was observed that electronic information services are used on a smaller scale, such as the utilisation of automated systems, which occurs when ICT (software) is used to report on donor-funded projects, for example HIV/AIDS, in a few of the facilities. Components of electronic information systems include computing devices, equipment, software and IT personnel, among others. Other identified electronic tools used to share and communicate information include compact disks (CDs), TV and radio. The following are abstracts to confirm these findings. A clinical officer said,

“I share information with colleagues electronically through an automated computer system that is, International Quality Care system commonly known as IQCARE” (HP004).

The researcher however, noted that the existing HIT infrastructure is unreliable as it is unevenly distributed – only a few of the facilities use ICT for reporting on donor-funded programmes. Despite some of the facilities having desk top computers donated by donors, these computers are not utilised as the IT infrastructure is incomplete in terms of staff training on computer skills; there is also a lack of Internet connectivity, IT personnel and goodwill among stakeholders. As observed during the study, the various electronic media and tools used by stakeholders are more personal and not organisation-based, except for the facility mobile phone that is used during emergency cases and follow-ups.

12.15.3.2 Community health information service

Concepts related to the data theme 'community health information service' were identified during the study, whereby various stakeholder groups including CHWs and health personnel work in collaboration to provide health information services at community level. The aim of this is to sensitise communities through health education talks on preventive health care strategies, including those for maternal health care, HIV/AIDS and immunisation. According to the study findings, CHWs do this through home visits whereby each household is then engaged in one-on-one session(s). A woman participant said,

“So, we usually have monthly home visits where we share health talks on maternal health and immunisation. Then we advise them to attend ANC clinic to be tested for HIV/AIDS and for further care advise” (CHW003).

Also, chief barazas and mobile clinics are used, whereby health care personnel give health education talks to the public around communities. Health care professionals and specifically nurse participants at selected community facilities reported that they are working together with CHWs to reach out and educate women. One nurse said,

“I work with CHW/Vs and the Community Health Assistant who reach out and educate pregnant women in various households, and advise them to attend ANC clinic” (HP001).

This is aimed at reaching out to women who neither attended an ANC clinic nor received the services of skilled birth attendants hence the need to create awareness on the importance of seeking services from qualified personnel in a health facility. This was to promote better health seeking behaviour among pregnant women to reduce both maternal and infant mortality, thereby improving maternal health care. However, some of the women interviewed in some of the facilities reported to the contrary.

One of the women said,

“There are no community health programmes in my neighbourhood...I have not heard about them” (CP011).

According to the researcher, the above statement revealed an uneven distribution of community health information service to women, which is a hindrance towards the achievement of the aforementioned goal. It was therefore observed that the need exists to improve ways of sharing information to create awareness among all women in various communities within the County.

12.15.3.3 Health communication

According to the study findings, a variety of media for communicating health information among stakeholders was observed during the study. These include print media, verbal and/or oral communication and electronic media.

i) Print media

It was observed that the largest part of the health information, generated and/or created in various health facilities is managed manually. Daily/weekly/monthly reports, handover reports, patient files/records, registers, and statistics, among others, are kept in paper/print form. One health professional said,

“Mostly we use print media, e.g. reports, books, referral books, e.g. the ANC booklet, hand over report book...etc. Also verbally such as face-to-face with colleagues and client’s phone to communicate information” (HP010).

For example, the client maternal profile, including clinical notes, has been updated in the ‘Mother and Child’ booklet, and is used as a point of reference by stakeholders, particularly caregivers, during clinic visits, in times of emergency, and for cases of referral to another facility. Also, administrative records, i.e. handover reports, registers and statistics are managed and shared in the same manner. Another professional said,

“We share information through monthly reports which are mainly manual, daily registers, The ANC booklet and patient file... including during referral from this hospital to another” (HP008).

It was noticed that the largest part of the documentation in health facilities is manual (i.e. in print form), which is cumbersome and difficult to work with, thereby leading to slow productivity among staff and generally poor quality of services to clients.

ii) Verbal and oral communication

Verbal and oral communication is done on a large-scale to share maternal health information among stakeholders, particularly women, CHW/Vs and caregivers who interact regularly during care activities. This involves face-to-face conversations which, for example, take place during health education talks, ANC and PNC clinic visits, and through telephone calls by caregivers when following up on clients. Both client participants and caregivers reported that they hold one-on-one session(s) to discuss individual issues for purposes of confidentiality and privacy. From her own experience, one woman said,

“About 90% of the information on health education is shared verbally through one-on-one discussion sessions with the nurse during ANC clinic visits” (CP010).

One health professional said,

“Yes, we give the women a chance to express themselves. Also, there is a classroom where we give general health education talks and also one-on-one sessions...to discuss on mother and baby care during and after delivery” (HP008).

The above responses of the participants demonstrate the use and role of verbal communication of maternal health information among stakeholders. The researcher, however, also observed some of the limitations associated with this method of communication, such as a lack of documentation hence clients easily forget instructions given during clinic visits. Furthermore, the client has to visit the clinic physically to receive the relevant health education.

iii) Electronic media

According to the study findings, some of the electronic media methods used by stakeholders to communicate information include social media, i.e. WhatsApp, YouTube, Viusasa, and Google, among others, and mass media. One woman said,

“Sometimes I get information I need through Internet/social media like WhatsApp, YouTube, Viusasa and Google” (CP017).

For instance, clients, CHWs and health professionals reported that they use WhatsApp groups to share information on upcoming events such as workshops and training. Also, a few of the women reported that they use YouTube, Viusasa and CDs to share information. They furthermore watch and listen to important talks on TV and radio programmes, including breast-feeding, baby and mother hygiene, baby weaning, and immunisations. It was however observed that the mobile phone was the most popular mode of communication and sharing information of all methods of communication identified by the various stakeholder groups. A professional participant said,

“The facility phone is very important for communication especially during follow-ups, emergency, consultation. But clients have no way of communicating back to hospital /clinic hence must come physically” (HP003).

Smart phones are just as popular among staff as it enables stakeholders to multi-task during work activities. One community worker said,

“There is positive impact in terms of multitasking with use of phone. With community work every other place is a service point even by the road side” (CHW002).

Gaps identified in mobile communication include clients lacking a mechanism to communicate (report) back to the care providers; therefore individuals need to physically visit the health facility to receive services, which include feedback. According to the researcher's observation, this situation could easily lead to care discontinuity, particularly in circumstances where a client is not able to personally visit the facility for whatever reason. The extract above by one of the participants confirms this finding.

12.15.3.4 Collaborative information service

The theme ‘collaborative information service’ emerged from concepts identified in participant responses revolving around sharing information among health professionals and CHWs. During the study, the researcher noted the presence of a strong culture of information sharing among staff, colleagues, and departments, and between different facilities, particularly during referrals. According to observations made during the study, medical and administrative information are exchanged manually or electronically. A nurse in one of the facilities said,

“We share information through monthly reports which are printed, daily registers, The ANC booklet and/or patient file...including during referral of a client from this hospital to another. Also verbal consultations using one-on-one with colleagues and through phone calls” (HP008).

In particular, the medical information being shared included primarily client health record(s) and the ANC booklet, which is critical at the point of care. Administrative information, on the other hand, comprises routine records, for example, daily handover reports, registers and general statistical data for decision-making. A community worker said,

“We normally share information among ourselves through phone calls, WhatsApp groups... where we disseminate information in a group of people, emails, and we still use paper and also, we have meetings internally” (CHW002).

In general, the researcher observed that the sharing of health information by stakeholders forms part of a routine activity and is meant to support the delivery of health care services and operations within facilities/hospital establishments. However, it was observed that some of the methods of information, including manual/print and verbal media sharing, are ineffective, as this information has geographical limitations hence making it difficult to maximise information collaboration. There exists thus a need to improve the services in order to realise maximum impact.

12.15.3.5 Information sources

Various stakeholders, i.e. clients, health professionals, facility administrators and CHWs, reported that they receive the information they need from different sources to perform their duties.

i) Clients’ information sources

To begin with, the researcher identified several sources of information for clients, as these clients need information for their health and wellbeing. Specific sources include health professionals, print sources, community health services, the Internet and mass media. Most of the clients reported that they receive information from health professionals, including the nurses and doctors, during ANC clinic visits, particularly the nurses who are the first point of contact for clients at the health facility. Information is mainly provided through health education talks during one-on-one session(s) between the client and the nurse. A client said,

"I receive information verbally during health education sessions during monthly ANC or PNC clinic visits" (CP021).

Also, clients stated that they receive information through community health services, which mainly involve interaction with CHW/Vs at the community. CHW/Vs, family members and colleague mothers offer inexperienced mothers advice on appropriate care during pregnancy. These include referring pregnant women and nursing mothers to the nearest health facility to receive the needed maternal care. A participant said,

"I get information from family members, relatives and home visits by CHW/Vs" (CP003).

The Internet was also identified by a few of the women during the study as their source of information, which include social media, i.e. YouTube, Viusasa and Google. Also, clients obtain information through print sources such as the ANC booklet, magazines and posters issued at the clinic. Another source of information for women is mass media, distributed mainly through TV and radio programmes organised during health campaigns for maternal care. One woman said,

"Sometimes I get information I need through Internet/social media like WhatsApp, YouTube, Viusasa, Google" (CP017).

As observed during the study, the ANC booklet is an important document that is very educative for pregnant women, serving as a point of reference as it contains the maternal history of the client, including clinical notes. One health professional said,

"We use the ANC booklet which is very educative..., and has a lot of important information for mothers. It is a good book! Very educative, has a lot of important information for the mother, father and the unborn baby...and it helps us very much for records" (HP008).

ii) Professionals' information sources

According to the study findings, health professionals mainly receive information from clients (pregnant women and nursing mothers), next of kin/partner(s), the ANC booklet and patient files (clinical notes), basic formal knowledge, training and workshops, CME sessions, laboratory test results, physical examination, referral letter and MOH guidelines. One nurse said,

"We find information from the patient herself, The ANC booklet, on job trainings, basic professional training (Nursing), continuous medical Education (CME)... It can be CME or MOH guidelines" (HP008).

The researcher observed that caregivers have to rely on a variety of sources for information to provide care services. Most of the information is obtained from the stakeholders themselves, that is, clients, colleague and professionals through clinical notes on the ANC booklet and other health institutions, especially during referrals. This revealed to the researcher the need for a strong collaboration among stakeholders to ensure the availability of sufficient information to support care activities.

iii) CHW/Vs' Information sources

On the same note, CHWs receive information to support their work activities from various sources, including training sessions and seminars, colleagues, community profiles, the ANC booklet, MOH tools, guidelines and the Internet. In particular, community profiles are a key tool whereby households within a community are mapped and registered to facilitate the creation of a household database to improve service delivery. A community worker said,

"We normally do something called house hold mapping where we use a tool called MOH 513- it captures information like household head, the partner, number of children, ages of the children, visitors, under-fives, NCD, pregnant mothers, their age, etc." (CHW002).

Also, CHWs at times obtain information from the ANC booklet for the client, which enables them to give appropriate advice in maternity-related cases, also during emergencies. One participant said,

"[The] ANC booklet is a good innovation because it contains information of the mother from the time of pregnancy until the child is sixty months old hence educative" (CHW004).

A community worker said,

"[The] ANC booklet is very instrumental/educative ...recognised as a legal document" (CHW002).

Based on the above statement, the researcher noted the value and significance of the ANC booklet for maternal health care, hence the need to ensure its proper management and safe custody.

iv) Administrators' information sources

Health care administrator participants reported that they receive their information from both internal and external sources. Internal sources of information include the Records department and organisational health statistics. External sources include MOH guidelines, County Head Office, professional training and workshops, and professional code of conduct. One Facility-In-Charge respondent said,

"We rely on the Records department, health statistics, and directives from both MOH and County head office" (AP004).

Both medical and administrative health records are stored and maintained at the Records office in health facilities, which is the main source of information for planning and decision-making. Administrators therefore consult organisational records for reference, and especially statistical data, for example, the number of out-patients, admissions, baby deliveries, staff and medical supplies, among others, to facilitate budgeting and resource allocation. Other identified sources of information include formal training and the professional code of conduct. An administrator said,

"Regarding management of information and records, we mainly emphasise on professional training and code of conduct otherwise no organisational policy is in place to guide management health information including during referrals" (AP005).

External information sources, on the other hand, mainly address policy needs, including guidelines and directives from higher authorities (i.e. County Government and MOH) on how to formulate and implement various policies to guide health care delivery in public facilities.

12.15.3.6 Personalised information service

Personalised service to clients by health care personnel, including health professionals and CHWs, was noted during the study, which is practiced culturally across health facilities. Accordingly, this is indeed aligned to modern health care delivery models, which advocate for personalised health care service. Health care personnel address client information needs through one-on-one discussion(s) and allowing clients to express themselves while also respect individual basic rights of confidentiality and privacy. Specifically, caregivers involve their clients and seek consent from them on care decisions taken while they also entrust the women with the responsibility of managing their own ANC booklet. The following quotes from health care professional participants are in support of the above findings: One nurse said,

“Yes, we give our clients a chance to express themselves. Also, there is a classroom where we give general education and also one-on-one sessions to discuss on mother and baby care during pregnancy and after delivery” (HP008).

Another participant said,

“We usually have one-on-one meetings with the mothers and we give them time to ask questions. Also, we seek client consent during referral where necessary. The client chooses where to be referred to and it is his/her right to choose” (HP010).

On the same note, a woman participant reported as follows:

“I normally ask questions during clinic visits, and the nurse answers my questions and gives personalised advice” (CP022).

Also, a community worker reported the following:

“I normally have conversations with them and also, I organise for question /answer sessions with them to clarify issues” (CHW001).

From the above responses, the researcher concluded that health information services, although mainly verbal, are person-centred hence attach clients to seek services in health facilities as their confidentiality and privacy are protected. However, there is a need to improve the way of capturing and/or recording advice given as one could easily forget to observe verbal instructions.

12.15.3.7 Service provider

Concepts that emerged related to the data theme ‘service provider’ are directly associated with information practices across public health facilities. Specifically, ICT experts and health care administrator participants pointed out issues regarding the responsibility of service provider(s) as opposed to expectations on information practices. According to the study findings, two major policy issues were identified concerning the management of public health

information. These focus on areas of compliance with government policy/regulations and the adoption of ICT in health facilities. Also, this extends to internal organisational policy guidelines, for example, data security concerns including both logical and physical security. For instance, it was observed that health facilities do not have a standard procedure to guide the creation, storage, access, sharing and disposal of health records despite operating under the County Government. A facility administrator said,

“Regarding management of information and records, we mainly emphasise on professional training and code of conduct otherwise there is no organisational policy in place to guide management of health information including during referrals” (AP005).

The above response revealed weaknesses among service providers in streamlining policy matters on the management of health information, which greatly affects information practices. As a result, the situation has led to the following scenarios whereby organisations never adopt any procedures, or formulate their own procedures, or follow prescribed government guidelines on health information management, bringing about the confusion witnessed across the public health system, and eventually poor information practices.

Concerning the adoption of ICT-facilitated health information services, it is the responsibility of service providers to ensure compliance through the enforcement of government policies and regulations to guarantee appropriate health information practices. Therefore, all processes of determining, acquiring and implementing ICT technologies have to be done within the prescribed regulatory framework. One ICT expert said,

“Consider government policy and regulatory framework for public health information when designing HIS” (ICT001).

On the same note, it was observed that the actual adoption of ICT in health organisations is the responsibility of the service provider in terms of resource provision, particularly infrastructure, which includes equipment and relevant personnel. However, according to the study findings, ICT services are not available in most facilities and inadequate in some. One facility administrator said,

“Records are mainly processed manually and then digitised at the county headquarters on monthly basis. Computers are available at the facility but they are not being used” (AP001).

Another participant said,

“The level of ICT adoption in our facility is low!” (AP001).

According to the researcher, the above responses from health care administrators reveal failure by the service provider, i.e. the government, to implement ICT services. For instance, the non-use of available computers implies a lack of the necessary facilitation hence an overreliance on manual information procedures leading to poor information practices.

12.15.4 Challenges facing maternal health and wellbeing information services

This section presents the findings on challenges affecting the management of health information services in the research context, hence poor quality of services. Specifically, six (6) data themes were derived, namely: service contextualisation, data access, health communication, health system, system/service integration and service provider. Service contextualisation issues concern information infrastructure in health facilities. Data access involves issues on the security of health data as well as the privacy and confidentiality of clients. Health communication points to issues on communication among stakeholders. Health system involves issues on with government decisions and the implementation of health projects for the public. System/service integration involves issues regarding the integration of HIS. Service provider involves the role and responsibilities of health institutions/facilities in providing the necessary support, i.e. general health care infrastructure and facilitation to provide basic health care services to the public.

Generally, the findings highlighted in this section are mainly focused on issues that negatively affected maternal health and wellbeing services in the research context. These include weaknesses of both government and service provider(s) in the public health care system, hence the issues emerging from the data mirror characteristics of the health care system and its influence on current information practices.

12.15.4.1 Service contextualisation

Service contextualisation emerged as theme from the participants' responses in the context of technology environment. The era of ICTs is becoming increasingly dynamic while user demands for the utilisation of ICTs in health care are increasing. According to observations made during the study, there is a need for health organisations to adopt HIT innovations which are context specific and affordable to ensure meaningful use in order to increase operational efficiency. One health professional said,

"The existing system for nutrition does not meet needs of the nutritionist. The system cannot generate reports so I need a tool to analyse and generate reports" (HP006).

The above extract from a participant's response confirms this finding in terms of demand for meaningful modern ICTs in the work place to promote operational efficiency.

Modern technology environments today require the convergence of various technologies, for example, mobile technology, social media, big data and analytics, and sensors and location-based services. Unfortunately, acquisition, implementation and maintenance processes are costly for the service providers, hence the need to contextualise the technological environment. One ICT expert said,

"ICT infrastructure is expensive...there is high technology and maintenance costs" (ICT004).

This was observed to be among the possible causes of the slow adoption of ICT across health facilities. One facility administrator said,

“Adoption of ICT in our facility is still low because no ICT infrastructure is in place including IT personnel” (AP002).

The researcher noted the importance of having a thorough understanding of the context, including the user environment and availability of resources to implement the relevant technologies. This will enable one to determine the required infrastructural and maintenance costs prior to investment in order to guarantee sustainability, hence service contextualisation.

12.15.4.2 Data access

Challenges related to data access were reported during the study, whereby the major concerns are related to the security of health information, such as client privacy and confidentiality due to the nature of the information practices. This is indicative of a violation of the individual's right to privacy and confidentiality, which is a critical requirement considering sensitivity of personal health information. One community worker said,

“I can say there is the challenge of some mothers giving out their ANC booklet to other people...and so they share their privacy! Some facilities lack the mother child booklet whereby mothers are issued with exercise books where the doctor writes clinical notes!” (CHW004).

Also, there were concerns among women who reported that some of the staff have a tendency to leaking client information. This is indicative of the possibility to cause stigma among clients, particularly when an individual is HIV-positive. The leaking of information makes clients' to outright shy away from seeking medical advice at maternal clinics, thus causing care discontinuity. One client participant said,

“Information is not confidential because some nurses and CHW/Vs leak client information. Otherwise, nurses do not keep information secret! Nurses should be trained as counsellors” (CP005).

The same issue of data access was also reported whereby use of mobile phones by the health personnel to follow up, compromised the clients' confidentiality.

“Using personal mobile phone is costly and you share your personal contacts with so many people ... there is also no privacy of the client” (HP008).

This happened despite the agreement that the mobile phone is the most preferable mode of communication among stakeholders in maternal care. One client said,

“Mobile phone is the both easiest and fastest way of communicating information, especially during an emergency” (CP003).

A facility administrator said,

“The impact of ICT is still low since only mobile phone is used to communicate especially during emergency” (AP002).

12.15.4.3 Health communication

Challenges related to health communication were noticed during the study, whereby some of health care personnel expressed concern regarding the use of mobile phones to communicate to clients during follow-up actions. It was reported that clients have no means of

communicating with the hospital since they are not provided with the facility's contact details to reach caregivers, even during cases of emergency. Clients are therefore forced to visit to the facility in person to make inquiries, which is unnecessary. One nurse said,

"The facility phone is very important for communication especially during follow-ups, emergency, consultation... But clients have no way of communicating back to hospital/clinic hence must come physically" (HP008).

This was identified as a communication breakdown as the communication process is complete. According to observations made during the study, the researcher attributed the situation to the lack of adequate communication infrastructure for facilitating effective communication between health care stakeholders, particularly clients and health care personnel. Furthermore, health care personnel reported a lack of facilitation by the service providers in performing their tasks effectively, including following up on clients. For example, client follow-up actions are mainly done through phone calls; however, individuals are forced to use their personal phones and airtime to make calls due to the lack of a maintenance budget. A community worker said,

"There is no facilitation in terms of airtime... we use our money to make calls...but only the necessary ones. The client may not have the technology so we have to use print! Also, we have computers provided by partners but there is no Internet – no proper infrastructure" (CHW004).

One nurse said,

"Still... using a personal mobile phone is costly and you share your personal contacts with so many people, no privacy of the client" (HP008).

This greatly hinders communication, because despite there being a facility phone provided by partners, there is still no resource provision, including airtime, to facilitate communication between caregivers and clients through follow-up actions.

12.15.4.4 Health system

The theme comprises issues related to policy and governance, decisions and the implementation of health projects meant to focus on the interest of the public. It is the responsibility of the government to determine health policy objectives and guidelines for public health care services to provide a standard approach towards guiding the delivery of these services. However, according to observations made during the study, the situation is the opposite as far as public health care management, including administration of funding and information management policies in public facilities, is concerned. One participant said,

"There is a problem with policy implementation especially on devolution of health and misappropriation of funds" (ICT001).

According to the researcher, there are major concerns on the provision of funds and allocation of resources by National and County Governments, whereby facilities receive inadequate funding, and with prolonged delays that compromise the quality of health care

services. Furthermore, there is no consistence in the application of information and records management policies across the facilities that were investigated. The following extracts from participant responses confirm this finding. A facility administrator said,

“Regarding management of information and records, we mainly emphasise on professional training and code of conduct otherwise no organisational policy is in place to guide management health information including during referral” (AP005).

One ICT expert said,

“There is lack of clear objectives characterised by short-term thinking...with and a lot of bureaucracy that policy people are not open with new technologies but they only favour paperwork” (ICT004).

In another facility, an administrator said,

“Information management policies used in this place are based on WHO guidelines” (AP002).

The researcher observed that the health care system is not keen on standardising policy guidelines in public health care. As a result, this negatively impacts on information practices, which are managed by the service provider as the custodian(s) of the information, including patient records. No standard approach was observed; each facility uses their own procedures, a scenario that compromises the processes of creation, storage, retrieval and sharing of records among stakeholders, including referral facilities. More important to note is that procedures are not harmonised towards facilitating the exchange of client health information, even during patient referrals. This has led to poor health care collaboration among health care stakeholders, as patient records sometimes go missing sometimes at the point of care. This then compromises the continuity of care. Also, caregivers complain of difficulties experienced at times when retrieving records; some records ‘go missing’ while are disposed of prematurely.

One nurse said,

“There is poor retrieval of files, scarcity of storage space, and confidentiality of patient data especially Mother/Child booklet, misplacing of patient files...etc.” (HP003).

In the absence of a standard information management framework, it is not possible to have effective information practices, and this directly affect the overall quality of health care services. A working standard information policy is therefore critical for manual and electronic information practices/services.

12.15.4.5 System/service integration

During this study, issues associated with system/service integration, including the integration of health systems across the board, which is critical for enhancing national health care collaboration, were reported. The researcher, however, noted challenges associated with health data silos occasioned by partner (donor) projects, which dominated the research context, and were mainly focused on the interests of the donor rather than the government. The following extract confirms this observation: One ICT expert said,

“Donor effect creates a silo...for example some partners only cater for HIV reporting and thus creating parallel reporting systems alongside the national health reporting system (DHIS)” (ICT0010).

It was observed that partners established their own information infrastructure in public health facilities to support reporting on their project activities/programmes, without necessarily aligning it to government strategic plan/objectives. Partners established their own infrastructure, including facilities, equipment, personnel, and commodities, among others, to support operations without necessarily involving government employees. For instance, one facility administrator said,

“We have manual information services for maternity as there is no infrastructure for IT except partners for example university of Maryland transmit some data online” (AP003). This created loopholes in the health care system] such that parallel reporting systems emerged, compromising efforts towards health care collaboration to improve service delivery.

12.15.4.6 Service provider

Funding public health care is the core-responsibility of the government. The Kenyan public health care system is managed on two levels of government, i.e. a devolved system. While the National Government is responsible for providing County Governments’ needed funds, the County Government is responsible for budgeting and allocating resources to service providers to run public health facilities. According to the study’s findings, funding to facilitate the planning and allocation of resources to service providers is poor; these include prolonged delays to release funds, thereby compromising the quality of services. Implications of this scenario include inadequate resource allocation, HIT infrastructure, and commodity supplies, among other challenges.

i) Inadequate resources and infrastructure

In this sub-section, challenges associated with the inadequacy of resources and infrastructure, and specifically on facilities and equipment, and UHC, are reported on.

• Facilities and equipment

A lack of basic facilities and equipment to support health care operations was noticeable during the study. According to observations made, some of the health facilities lacked basic equipment in their workstations and inadequate sitting space in the triage (waiting) area, while there were long queues of clients in these facilities. This situation caused some of the women not to attend the clinic, particular those who were over seven (7) months pregnant as they could not cope with this strenuous experience.

One woman said,

“There are always long queues during clinic visits and this discourages...especially for mothers with 7-9 months of pregnancy from attending clinic” (CP009).

Another woman said,

“There is a small waiting area at ANC and PNC clinics... and so, mothers miss clinic due to the long queues and lack of sitting space...not enough chairs to sit on” (CP002).

A number of the women were discouraged from attending clinic appointments and as a result missed health education talks, including one-on-one sessions with caregivers. These types of situations deny individuals the opportunity to receive advice on their personal health and wellbeing, hence care discontinuity, which leads to poor health outcomes.

- **Universal health coverage (UHC)**

Despite the government’s promise to provide UHC for all pregnant women receiving care in public facilities, it is difficult for the service providers to do so without charging clients a fee for services offered due to inadequate facilitation by government. Unfortunately, this service charge prevents women who are unable to pay to attend ANC clinics where health education is provided. One client said,

“Maternity services are not 100% free because mothers pay a fee of 550/- during first clinic visit and 50/- for each clinic visit so some mothers do not attend clinic” (CP002).

Furthermore, some of the women are not aware of the ‘Linda Mama’ programme, a national project launched through the NHIF to spearhead the UHC initiative for pregnant women, which does give them access to the service. One woman said,

“I do not have [a] Linda Mama card to access free maternity services...I do not know about it!” (CP003).

This confirms that not enough is done by the relevant authorities to create awareness of available health care opportunities for women.

- ii) **Health information infrastructure**

This sub-section focuses on limitations associated with current information services provided by public health facilities, particularly on the ANC booklet and ICT services.

- **ANC booklet**

According to the study findings, it was observed that the ANC booklet is quite instrumental in educating women in maternal health care. The booklet is also used to manage personal maternal health information, and serves as a reference book for women, health professionals and referral facilities. A community worker said,

“The mother child booklet is very instrumental and educative – it captures like all areas that is, the birth of the child, age, name, and all the health services we give to the child” (CHW002).

One nurse said,

“ANC booklet is normally used to share information during patient referral to another facility because It is a government initiative with comprehensive information involving ANC visits, delivery, PNC visits, family planning and immunisation” (HP008).

However, according to the researcher's observations, the booklet is characterised by limitations including that it is a printed (physical) document in the custody of the client and therefore vulnerable to damage and loss, which compromises the quality of information services. To begin with, it was observed that the booklet is mainly manual and always in custody of the client; being a physical document, mothers may from time to time lose the booklet, or the booklet may be damaged by fire or water. A community worker said,

"Information services are bulky and sometimes... it's almost impossible to access information at a given time you may need it. For example, ANC booklets can be easily lost to fire outbreaks in the slums! Electronic will be better but it still has its own challenges" (CHW002).

It was noted that in the event of the above occurrences, all the information are lost, hence the client needs to begin afresh, making it difficult for caregivers to update the records. Inconveniences are caused for both the client and health care personnel whenever the maternal profile is lost, especially in case of a referral. More so, clients and health personnel indicated that some of the content in the booklet is complicated for laypersons (clients) to understand and therefore confusing. It is sometimes difficult to read the notes in the book due to faded the ink. In addition, only the English language is used, which is not flexible enough for many to read and understand due to illiteracy. These observations are an indicator that some of the clients may not be able to comprehend the content. A woman participant said,

"Information written on ANC booklet should be clear-the doctor's notes are not readable! In most cases only the nurse and doctor understand what is written in the ANC booklet. The book is ok but the doctor's notes is what is not readable or satisfactory" (CP001).

A medical doctor said,

"The ANC booklet is complicated and the graphs in it bring confusion to clients. Also, the fading of ink makes the notes unreadable. The book should be written in all languages, that is, English, Swahili and vernacular" (HP007).

- **ICT services**

Another challenge observed is the inadequate use of ICT services across various health facilities that were under investigation. According to observations made at various sites as well as responses from the participants, existing ICT services are wanting. Only a few facilities have computers and relevant software, provided by partners to manage their projects, and particularly HIV/AIDS, which focuses on PMTCT. There is no established HIT infrastructure in most of the facilities due to the lack of lack of necessary equipment and skilled manpower. One administrator participant said,

"Key factors contributing to the nature of current information services are understaffing, lack of ICT infrastructure, lack of staff training, resistance to use of computers, lack of knowledge or benefit of IT" (AP005).

Under these circumstances, it is difficult to establish a working ICT system to support operations, hence poor services. The reason for the above is that stakeholders, including users, do not understand the value of ICT in their work activities, causing resistance against using computers despite the fact that partners donated computers to some of the facilities. One nurse said,

“Photocopy machine and computers are available; however, computers are not used at all. Only the facility mobile phone is used by staff” (HP011).

Also noticeable was that the service provider does not put effort into implementing ICT since basic equipment and tools are missing, including computers, Internet connection, and EMRs, among others. An administrator said,

“Staff are reluctant! And they feel its extra work to use computers since we do not have adequate personnel, lack of training and computer literacy! Health workers have a phobia with computers...and lack of equipment maintenance” (AP001).

As a result, most of the staff are not confident enough to use computers due to inadequate exposure, which has become a culture, hence creating an avenue for staff resistance against the intent to adopt ICT. As a result, information services are mainly managed manually, resulting in challenges of bulky records with increasing volumes over time hence a scarcity of physical storage space and the retrieval of records.

iii) Commodity supplies

Essential commodities and facilitation, including the ANC booklet, which is the government approved minimum standard document for providing maternal health education, are unavailable in most of the facilities. As a result, the clients are sometimes asked to buy/use a plain exercise book. Arguably, such a situation denies individuals the opportunity to access relevant information for their health and wellbeing. The following extractions from participant responses confirm this finding: A client participant said,

“The ANC booklet sometimes is not available; mothers are asked to buy exercise books” (CP007).

One facility administrator said,

“Challenges include lack of supplies e.g. ANC booklet hence clients lack access to essential information in the booklet, problems of care discontinuity and creating public” (AP005).

Also, the researcher observed that the service provider failed to provide facilitation and other basic items to support and maintain operations, including computers, telephone extensions, and airtime to enable client follow-up actions by the caregivers to complete medication. A community worker said,

“There is no facilitation in terms of airtime – we use our money to make calls... but only the necessary ones” (CHW004).

In general, the above responses confirm the challenges associated with commodity supplies in the delivery of health care services. The researcher observed that despite inadequate funding by government, the service provider does not prioritise the provision of important commodities to ensure smooth running of operations in the facilities.

12.16 Stakeholder perceptions regarding maternal health information services

This section focuses on findings concerning the perceptions of various stakeholders in both current and desired maternal health information services. Their experiences enabled the researcher to explore and better understand the delivery of information services. In total, eight (8) data themes emerged under this theoretical theme: data access, comprising issues related to the privacy and confidentiality of health data; health communication, particularly the impact of ICT, including mobile communication, on health care; HIT utilisation, specifically generating health reports; health system, mainly concerning contents of the ANC booklet, information on maternal health information, and training and education; information services, which is the core information document of reference in personal maternal health information services for clients; quality health service, including the language used in the ANC booklet, legibility of doctors' notes, and credibility of doctors' information; system/service integration, which involves the need to integrate IS; and service provider, which focuses on resource provision, commodity supplies and infrastructure issues.

12.16.1 Data access

Observations related to issues on data access were made during the study. In particular, these issues are attributed to the general privacy and confidentiality of personal health information, including the clinical notes in the ANC booklet. Specifically, a section of health professionals, clients and CHWs indicated their discomfort with the manner in which the information is managed. One nurse said,

"The Mother and child confidentiality is not guaranteed though It is good to relay information about the patient" (HP003).

While government recommends the use of the booklet, it was observed that by virtue of its physical nature, the security of information in the ANC booklet is somehow compromised and may thus infer the violation of patient privacy and confidentiality. One women participant said,

"Information is not confidential because some nurses and CHW/Vs leak client information. Otherwise, nurses do not keep information secret! Nurses should be trained as counsellors" (CP005).

There is thus the need for health care professionals to embrace the professional code of ethics and respect client privacy and confidentiality, as violating this will make clients shy away

from seeking care at the facilities. Also, concerns were expressed by CHWs that women share their ANC booklet carelessly, thereby compromising their privacy. One community worker said,

“I can say there is the challenge of some mothers giving out their ANC booklet to other people...and so they share their privacy!” (CHW004).

The above incidences point to a potential problem in terms of the privacy and confidentiality of current maternal health information services hence the need to improve the situation.

12.16.2 Health communication

The health communication theme also emerged under this category of findings whereby reactions from participants were focused on the communication of health information. Generally, these include the impact of ICT on maternal health information services in public health care delivery in Nairobi County. The study attempted to investigate the influence of ICT in health care. Respondents gave mixed reactions that enabled the researcher to gain deeper insight into the extent of ICT adoption in the research context. One administrator said,

“The impact of ICT is still low since only the mobile phone is used to communicate especially during emergency” (AP002).

A community worker said,

“There is positive impact in terms of multitasking with use of phone. With community work every other place is a service point even by the road side” (CHW002).

One participant said,

“Mobile phone is the both easiest and fastest way of communicating information, especially during an emergency” (CP003).

Considering the above responses, it was observed that the health communication system is mainly characterised by mobile technology. According to the study findings, this is attributed to the nature and advantages of mobile technologies, including mobility, productivity, and user-friendly, higher rate of penetration and affordable by the majority of citizens, among other advantages. Therefore, it was noted that mobile communication is more readily compatible with the users' needs. Despite its impact being positive, it was observed that extensive use of mobile communication greatly lowered the overall impact of ICT as far as health care delivery is concerned. This is attributed to obvious technological limitations of the technology, including less processing power, small screens and keyboards, low battery life, insufficient bandwidth and security standards, among others.

As a result, applications that require heavy energy consumption for data processing, strong Internet connectivity, and large data display screens and presentations, among others, especially in hospitals, cannot utilise mobile technologies. Therefore, more powerful computing

technologies are needed, including desktop applications, which unfortunately are expensive to acquire, thus keeping the impact of ICT low.

12.16.3 HIT utilisation

Opinions related to the use and application of HIT innovations was observed from the responses of participants, particularly from ICT and health professionals. This involved concerns by stakeholders to have a platform that incorporates technologies that enable users to generate health care reports from the system. One ICT expert said,

“Data science tools and machine learning should be used in order to develop a database to mine health data stored in the system” (ICT003).

This observation demonstrates ICT stakeholders’ understanding of how innovative ways may be applied to improve productivity and enhancing the decision-making process by health care personnel and relevant authorities. For instance, one nutritionist in a CWC section of a hospital said,

“The existing system for nutrition does not meet needs of the nutritionist. The system cannot generate reports...so, I need a tool to analyse and generate reports” (HP006).

The above statement reveals the frustrations of health care personnel in analysing health records that are largely processed manually. The researcher observed a need for introducing more innovative solutions to support the reporting and statistical functions of staff. This will surely improve productivity and save on time and costs as information will be readily available in the system to make timely managerial decisions. Specifically, this includes planning, budgeting, and resource allocation, i.e. logistics, and for commodity supplies, which is the core duty of managerial health care staff. This can be a solution to staff shortages in public facilities, as information-processing operations do not have to be labour intensive.

12.16.4 Health system

Some of the opinions raised by stakeholders touched on matters related to the health care system, including the role of government in terms of policy decisions that have a direct impact on maternal health information services. Specifically, these are issues concerning the content of the ANC booklet. Despite the fact that both government and most of the health care personnel commended the book as being educative to women, some of the participants indicated that the book content was not ideal for clients. It was stated that the content is complicated and confusing, particularly for illiterates. One consultant gynaecologist said,

“The ANC booklet is complicated and the graphs in it bring confusion to clients. Also, the fading of ink makes the notes unreadable. The book should be written in all languages including English, Swahili and vernacular” (HP007).

The participant’s observation reveals the difficulties some of the women experienced in interpreting the graphs in the booklet that the clients probably neither understand nor

comprehend. In particular, some of the women have low education and literacy levels as observed in the study. Furthermore, some of the women participants indicated that they experience difficulties in reading the doctor's notes in the booklet while others said only the nurses and doctors understood the contents – a fact confirming the above observation. One woman said,

“Information written on ANC booklet should be clear-the doctor's notes are not readable! In most cases only the nurse and doctor understand what is written in the ANC booklet. The book is ok but the doctor's notes is what is not readable or satisfactory” (CP001).

There is thus a need for the relevant government authorities to reconsider simplifying the content in the booklet, which remains the responsibility of the Ministry of Health, in order to accommodate the information needs of all women.

12.16.5 Information services

According to the study findings, the ANC booklet plays a critical role in terms of educating, documenting, sharing and managing personal maternal health information for women. Also, the booklet was noted to serve as a core reference document, and recognised as a legal document among stakeholders in maternal health care, specifically for clients, caregivers, CHWs and the referral facilities.

One nurse said,

“We use the ANC booklet which is very educative, and has a lot of important information for mothers. It is a good book, very educative, has a lot of important information for the mother, father and the unborn baby and it helps us very much for purposes of records” (HP008).

At the same time, a community worker said,

“The mother child booklet is very instrumental and educative- it captures like all areas that is, the birth of the child, age, name, and all the health services we give to the child. Even when children are starting school minus the birth certificate the ANC booklet is recognised as a legal document” (CHW002).

From the above statements, it was observed that the ANC booklet is indeed an essential document in managing personal health information in maternal health care. However, the booklet is not without limitations, which negatively impacts on information management, including damage and loss of information. For instance, one caregiver said,

“Current manual information services are tedious...clients do not read ANC booklet...and the booklet can easily get lost and/or get damaged. Information goes missing from the records...etc.” (HP010).

Despite being highly commended as instrumental in educating both pregnant women and nursing mothers, the booklet is characterised by the aforementioned limitations, and thus not ideal in terms of managing information. Being a physical document, it is prone to damage

and loss due to exposure to natural agents of destruction, including fire, fading of ink, wear, theft and tear, among other limitations.

12.16.6 Quality health service

The findings under this theme specifically highlight the perceptions of participants associated with the quality of service. Participants, particularly the women being the service consumer(s) for maternal care expressed various concerns over issues that are directly related to the quality of maternal health care, including information services. In addition, ICT experts pointed out on issues regarding the quality of service in terms of ICT-facilitated health information services. Specifically, concerns raised by women are mainly associated with the ANC booklet – including the language barrier, the illegibility of clinical notes and negative information – and the mistreatment of clients by caregivers, affecting credibility and trustworthiness, thus compromising the quality of service to clients. A woman participant said,

“ANC booklet should include all languages... English and Swahili languages are not easy for some mothers to understand” (CP017).

The ANC booklet is mainly written in the English language; however, women with a low literacy level cannot read and comprehend the information in the booklet due to a language barrier, hence the need to have the book translated to the local languages. Furthermore, the illegibility of clinical notes in the booklet was raised, whereby clients reported that sometimes the doctor’s handwriting is not readable. One nurse said,

“The current manual information services are tedious, clients do not read the ANC booklet, and the booklet can easily get lost and/or damaged, information go[es] missing from the records...etc.” (HP010).

As a result, most of the women do not read the book. This is of concern as it is one of the key educational materials for women recommended by the government, et clients do not benefit from it. Issues related to negative information and mistreatment by nurses in the course of seeking care in health facilities were reported. It was observed that a number of women had negative experiences related to maternal health care services, particularly in public health facilities. One woman said,

“Sometimes I do not trust information received from both friends and even doctors 100%! For example, when I went to hospital to deliver one time the doctors told me ‘no head of the baby’ and others said ‘they are twins’ ... but I finally delivered only one...and a normal baby!” (CP006).

Another client said,

“Nurses are sometimes harsh because of for example wearing a dirty dress..., failure to follow instructions, others is [sic] due to attitude to their work and emotions naturally ...they should be friendly! Trainees are used sometimes and they hurry up” (CP003).

ICT experts, on the other hand, pointed out issues related to the role of ICT and its benefits in improving the quality of health services. These include better organisation and

retrieval of health records, easy access, and the analysis and sharing health information among the stakeholders. One participant said,

“ICT makes retrieval of patient records and information easier and faster” (ICT002).

It was observed during the study that the availability of medical information is crucial, particularly at the point of care, otherwise care activities cannot take place. Caregivers need timely and accurate information to make evidence-based care decisions while providing care. Therefore, quick and/or faster retrieval of patient records is necessary at this point to warrant efficient service delivery, a role that ICT plays very well.

Another participant said,

“ICT helps in better analysis of data, quick access to information, information sharing and collaboration” (ICT004).

According to the participants, ICT aids in managerial decision-making as data can be analysed better using analytic tools as opposed to the manual processes, which are prone to errors and time consuming, hence low productivity. In general, it was observed that ICT does play a key role in improving health care services, particularly the ability to manage health information services.

12.16.7 System/service integration

According to the study findings, issues that emerged under this theme mainly focus on system/service integration to enhance information sharing. Specifically, it involves the need to use ICT to integrate health information services in order to promote health care coordination and collaboration using HIT standards.

One ICT expert said,

“Integration will require specific eHealth standards such as HL7 and FHIR especially in facilities with systems already installed” (ICT002).

According to participant responses, it was observed that by so doing, health care services would be equally integrated across the health care system both internally and externally, thus improving health care collaboration.

One health professional said,

“Use IT to integrate information systems, and recruit adequate personnel” (HP009).

During the study, it was observed that the complexity of health facilities varies depending on the cadre an institution is classified into. Some of the facilities are larger and more complex in terms of the number of internal units/departments, and particularly referral hospitals, of which the departments are required to work collaboratively. Hospital departments working with maternity services units were identified to be the OPD, casualty, MCH, laboratory, pharmacy, theatre, radiology, physiotherapy, stores and above all, referral facilities, among others. Clients

need services from across various departments, not only from maternity, hence the need for collaboration. However, due to the complex nature of the services being rendered by hospitals, proper integration mechanisms are needed to improve collaborative efforts to deliver health care services across various departments internally. One health professional said,

“The system is complex....and no trainings are done on reviews done by the ministry on documentation to familiarise staff on data elements added or removed from the booklet... there are no personnel to manage access to data” (HP011).

However, it was observed that most of the facilities under investigation rely on manual information services hence information sharing among staff is not effective as patient records need to be delivered physically from one department to another. Furthermore, there are challenges associated with referrals whereby a staff member has to accompany a patient to a referral facility, especially during emergency, to present the case/information. A nurse said,

“We share patient information through written clinical notes on the ANC booklet, and also, we give information verbally on phone. But...during emergency a staff/nurse should accompany the client to the referral facility with the partograph” (HP011).

Given an understanding of the circumstances under which the facilities are operating, including acute staff shortages, the situation is even worse. To address this problem, it was observed that the adoption of integrated ICT systems by service providers is necessary to enhance information sharing and collaboration among hospital departments and beyond. This will ensure the availability of information in a timely manner, thus improving service collaboration and delivery.

12.16.8 Service provider

According to the study findings, a number of issues related to service providers were pointed out by various participant groups, particularly by health professionals, CHWs and administrators. These issues involve resource provision, information management and the overall health care infrastructure, including the need for ICT and automation of health care services. According to observations made, these concerns are among the core-responsibilities of the service provider. For instance, one health professional said,

“There is a problem of inadequate supply of the ANC booklet... and now clients are asked to buy exercise books sometimes” (HP005).

The implication of the above statement is that the service provider (facility management) failed to ensure the availability of the booklets, which is their core-responsibility in terms of resource provision. As such, it was observed that the management was not keen on the prioritisation of their managerial decisions regarding commodity supplies such as the ANC booklet, which is an essential item as far as maternal health information and education is concerned.

Another observation made is that there is too much manual documentation, which is inefficient, according to responses received from stakeholders. This sometimes frustrates staff as the records are insecure and difficult to trace given the lack of adequate storage space. One participant said,

“Paper documentation is too much with the few staff, sometimes one can forget to record information. Also, space is a big problem due to too much paperwork, security of patient records is not guaranteed” (HP007).

It is the responsibility of the service provider to ensure proper information management, including formulating and implementing strategies and mechanisms that will guarantee quality protection of health records/information services in the facilities. In response to these challenges, participants suggested the adoption of ICT and the recruitment of relevant personnel. One nurse said,

“We need computers in order to reduce paperwork, and employ more clerks to do data entry” (HP006).

Another participant said,

“The services should be made electronic, to make it easy to track patient records unlike the manual booklet. Also emphasise periodic training especially for new staff” (HP008).

The above statements indicate inadequate application of ICT for improving the management of health information services. It was therefore observed that the service provider(s) are slow in adopting ICT in the public health care domain in general, a scenario which continues to hinder information management in health institutions. Consequently, this negatively impacts on health care operations across various facilities in the county.

12.17 Design considerations for ICT-facilitated health and wellbeing services

This sub-section focuses on those aspects of system design associated with ICT-enabled health information services gathered from participants' responses. According to the study findings, eight (8) data themes were identified, namely: data access, HIT utilisation, service contextualisation, system implementation, system/service integration, stakeholder engagement, system quality, and user-centred design. According to observations made, among the design considerations identified are both functional and non-functional system requirements and/or characteristics associated with aspects of system quality, namely the usability, reliability, interactivity and affordability of ICT services. The following is a highlight on the findings in each of the aforementioned data themes:

12.17.1 Data access

Concepts related to the data access theme featured across the responses from nearly all the participant groups, specifically ICT experts, health professionals, clients and CHWs.

The, participants raised concerns about the confidentiality, integrity and availability of health data in the context of ICT-facilitated HISs. For instance, one expert said,

“One of the most critical things with design of a system is to ensure security that is, confidentiality, integrity and availability of patients’ data” (ICT004).

The above statement demonstrates the level of awareness among the participants about the sensitivity associated with health data, which the design of the system should protect and safeguard against abuse and/or violation of an individual’s basic human right to privacy. Another participant said,

“The system should protect data by default through user name and password with different security features and physical access to server and computer room” (ICT003).

Concerns regarding the need for data security precautions, including a user name and password as well accessing the computer room, were noted from participants’ responses. In particular, the researcher observed that in order to ensure sufficient data security measures, there is a need to put in place and balance precautionary measures for both logical and physical security. In particular, the secure software development lifecycle (SSDRL) approach was identified as the most preferable to ensure a holistic and practical approach to use during system design and development to check against security vulnerabilities. An expert participant said,

“Data protection should be system-wide under SSDRL with use of access credentials and data encrypted with ammonisation of patient identifiers” (ICT004).

The above responses demonstrate the importance of ensuring proper data security mechanisms and features to guarantee the security of electronic health data. Specifically, it was noted that system-wide data protection and development technique(s) through the use of SSDRL is needed to guarantee maximum data security.

12.17.2 HIT utilisation

On the same note, concepts related to the HIT utilisation theme were identified from the responses of the respondents. According to the study findings, participants demonstrated an understanding of the role of ICT towards ensuring the efficient management of public health care services. One expert said,

“With the use of ICT... we can see and track the number of clients enrolled for ANC services and follow them up!” (ICT001)

This largely involves considering designing HIT innovations with analytic capability, particularly using data science tools and machine learning techniques. Another participant said,

“Use data science tools such as machine learning and develop a database to mine data stored to enhance reporting” (ICT003).

This will enable the mining of health data to generate statistical reports and therefore ensuring the availability of timely and accurate information to support operations of health care stakeholders. According to the study findings, the adoption of these tools is critical for enhancing activities such as disease surveillance and evidence-based decisions by service providers and relevant government authorities for the effective management of public health services. Unfortunately, this was not the case on the ground according to the study findings, where ICT services are almost non-existent in most of the facilities visited. The researcher observed frustrations among some of the participants, particularly one health professional who wished to use such tools to support her work activities, but they were not available. One health care professional said,

“[The] existing system for nutrition does not meet my needs! The system cannot generate reports...so I need a tool to analyse and generate reports to make work easier” (HP006).

The aforementioned findings gave the researcher deeper insight into some of the major gaps in re-designing existing health information infrastructure to improve efficiency and productivity.

12.17.3 Service contextualisation

From the participants' responses, the study identified concepts related to the need to contextualise proposed ICT-facilitated health and wellbeing services. Important concepts identified include stakeholder/user requirements, technology requirements, system configuration, computing devices and infrastructure, and system components. The researcher observed a need to understand both the requirements of stakeholders/users and technological requirements in order to guarantee their meaningful use as opposed to the research context of users prior to designing new services. Participants emphasised the need to carefully consider the contextual requirements of new information services. Specifically, there is a need to map stakeholders' requirements for electronic health information services in the context of use, and particularly hardware and software requirements. One expert said,

“Consider stakeholders' requirements and map users' needs. Localise and customise software to allow development of own skills” (ICT001).

Another expert said,

“Customise software to suit users' needs that is, open MR software for doctors and nurses” (ICT002).

According to the participant responses, it was observed that prioritising the mapping of user requirements is crucial for system designers to ensure compatibility of the intended solution(s) to user needs to guarantee their meaningful use towards meeting the change objective. Also, it involves aspects of understanding existing health information architecture to

inform the re-design and configuration of new services, which are largely influenced by socio-economic factors. Participants said the following:

One ICT expert said,

“Consider stakeholders’ requirements and map users’ needs...also the quality of existing ICT infrastructure...as well as affordability of the technological infrastructure” (ICT001).

One client participant said,

“Mobile phone, computers (desktop and laptop), WhatsApp, radio and TV should be used to improve communication of maternal health services” (CP012).

From the above statement, it was observed that ICT technologies and components, including computing devices to be used in a particular environment, are influenced by their context of use, based on prevailing circumstances. According to the response above, the researcher gained more insight into the research context and was able to understand characteristics of the nature of the current technology environment according to technologies identified by the participants. From observations made, important technologies and devices identified in the research context include smart technologies, particularly use of the smart phone, which has the highest preference among the majority of the participants. This represents part of the user needs and requirements towards designing new services for users, i.e. health professionals, CHWs and clients, in terms of sharing information.

12.17.4 System/service implementation

In the context of the system/service implementation theme, concepts related to design were identified from participants’ responses, and particularly from a perspective of validating a new service (system). According to the study findings, it was important to subject the new system to a pre-evaluation process to provide preliminary outcomes and/or findings, which will then facilitate its re-designing/engineering before full implementation. The following are extracts from participants in support of the above findings: One participant said,

“Functionality of the new system should be tested at facility level first and observe the outcome before full implementation” (ICT001).

Another expert said,

“A pilot survey should be carried out in a single institution to target feedback from at least 30 people who are actual users of the system” (ICT002).

The researcher observed that design plays an important role during the testing phase, whereby various aspects of a service are scrutinised for re-designing prior to full implementation. In this case, it was noted that a pilot survey(s) is the most ideal approach for checking and verifying the overall system design and functionality, including input (data captured), output (generated report formats), and interlinking various system processes before

the actual installation. Errors and gaps identified during this process are then addressed, whereby the system undergoes re-engineering before it is finalised.

12.17.5 System/service integration

Concepts associated with design were identified from the responses of participants under system/service integration theme. These include APIs/integration point, eHealth standards, Internet connectivity and system modules, among others, which focus on the need to integrate health care services across the health care system, both within and beyond health institutions. One health professional said,

“Use IT to integrate information systems, and recruit adequate personnel” (HP0090).

This observation demonstrates the awareness among users and developers regarding the role of ICT in system/service integration in health care delivery. According to the study findings, this is to be achieved through designing an appropriate HIS to facilitate information sharing and collaboration among stakeholders. One ICT expert said,

“The system should be well-integrated to enhance information sharing with an API to enable different users to query data from the system” (ICT003).

Specifically, it was observed that an API is a critical requirement to facilitate the querying of data by different users according to their needs. Also, the application of eHealth standards is needed to facilitate interoperability between different software modules and applications, including those in other facilities. Another expert said,

“Integration will require specific eHealth standards such as HL7 and FHIR especially in facilities with systems already installed” (ICT002).

In this case, eHealth standards were identified as a key component of system design in facilitating the distribution, access and sharing of information across the health care system. With a quality Internet connection, health information will be readily available to stakeholders to support care decisions by caregivers and for planning by health authorities at different levels of governance. However, one major challenge was observed regarding efforts to integrate health care services nationally, which is the issue of parallel reporting systems. A participant said,

“The donor effect creates a silo, for example, some partners only cater for HIV reporting and thus creating parallel reporting systems alongside the national health reporting system (DHIS)” (ICT001).

This situation was witnessed across the facilities under investigation, whereby some donor projects have been implemented. According to the study findings, the projects focus on reporting specific epidemics of interest such as HIV/AIDS. At the same time, other cases presented to the same facilities were not reported on hence parallel systems of the national

reporting system (DHIS) creating silos of health data, which confirms the need to re-design public health information services.

12.17.6 Stakeholder engagement

According to the study findings, concepts were identified that are directly related to the role of stakeholders in maternal health care, including service provider, clients, health professionals, and facility administrators, all having an influence over the design of health care services. For example, the provision of relevant resources such as infrastructure and the interpretation of organisational business requirements is the responsibility of the 'service provider', including the general health care infrastructure in health facilities. It was observed that the service provider(s) has influence on the design (nature of health care services), being among the key stakeholders in terms of determining policy decisions, planning and budgeting, and provisioning resources and information needs on behalf of the organisation, among other factors. One expert said,

"Enforce password policies including frequent password change, length of password...etc., user training and use technology security standards" (ICT003).

It was observed that management represents interests of the service provider (County Government), which has a direct impact on organisational operations, including the design of health care services. For instance, policy decisions are determined at management level to guide the processes of acquisition as well as the design, development and implementation of ICT systems. Also, planning and resource provision is the sole responsibility of the service provider, including the provision of health information infrastructure. One facility administrator said,

"The key challenges we face here are loss/damaged/misplacement of records, lack of ICT equipment, e.g. photocopying machine Government is not providing support, shortage of staff, lack of training on ICT for staff" (AP002).

The above statement is an indication that it is the mandate of the service provider to avail needed resources to facilitate operations in the facilities, hence having influencing power. Lastly, the overall information needs of the organisation are to be determined by management, e.g. for reporting and decision-making purposes. On this basis it was noted that stakeholders play an important role in the design of IS and services. As a result, the researcher noted the significance of taking into consideration propositions of the service provider while designing ICT systems to support the delivery of health care services.

12.17.7 Service/system quality

The service/system quality theme was equally identified as a consideration in designing a system, particularly in terms of both the functional and non-functional features of a system. Quality refers to 'standard' or 'degree of excellence'. It therefore points to those attributes

and/or characteristics a system should possess for meaningful use. According to the study findings, several concepts associated with system quality were revealed, including usability, accessibility, reliability, interactivity, responsiveness, affordability, maintainability and specifications of a system. The following are some of the responses of ICT expert participants in support of the above argument:

“The system should be user-friendly with good click depth, accessible, reliable, maintainable and secure” (ICT002).

“The system should be responsive to existing hardware, e.g. smartphone, laptop, iPad...” (ICT003).

“Consider system ability for scalability, input/output ration processing, resilience on day-to-day processing, disaster recovery with secure endpoints” (ICT004).

The researcher observed that the aforementioned attributes are among the essential features that cut across designing a system. In other words, the quality of a system is a product of its design. In general, design addresses both software and hardware aspects of a system, and because of this, the researcher noted the fact that the better the design of a system the better the quality, and vice versa.

12.17.8 User-centred design

The user-centred design theme emerged from responses of ICT experts as one of the design considerations for proposed ICT-facilitated health and wellbeing services. Important concepts identified during the study that relate to user-centred design include users’ needs, prototyping, participatory design and co-design. According to the study findings, designing the proposed services needs active participation by stakeholders through UCD, which involves the co-design method to understand users’ needs – a critical requirement towards the successful implementation of new services. This involves applying an iterative design process whereby designers mainly focus on users’ needs throughout the design process. In this case, designers constantly engage users throughout the design process using various design tools and techniques in order to create user-friendly service innovations. The following extracts from participant responses confirm this finding: One participant said,

“Understand primary user needs, e.g. nurses and doctors and through active participation” (ICT003).

One expert said,

“Take patients as stakeholders and involve them in order for them to also own the platform” (ICT004).

“Use agile methodology to iterate the process with prototyping in order to have a user guided design” (ICT001).

Therefore, co-design involves a good understanding of the research context, user requirements, identification of alternative design solutions, and evaluating those solutions

against the specified requirements. Through this process, users become part of the design process and hence develop a sense of ownership. This approach helps avoid resistance from users and other stakeholders later on in the implementation stage of the new services, thus avoiding failure of a project.

12.18 Surprises

These refer observations made by the researcher during the study that were not anticipated. The greatest surprise was the observation that ICT services in the public health facilities under investigation are almost non-existent, given that we are in the 21st century, the Computer Age. Health records are solely managed traditionally (paper-based and verbal methods), which has numerous limitations, hence compromising the quality of health care services. It was observed that most facilities have automated their financial management services (revenue collection) while other services did not. There was generally a negative attitude among health care personnel regarding use of ICT in health care delivery as there were no ICT personnel at the facilities under investigation. The researcher therefore had to recruit ICT expert participants from outside the target facilities. Despite this situation, partner/donor projects (PEPFAR), such a working towards sustained HIV/AIDS responses, running in some of these facilities are fully automated. Donors recruited their own personnel (for ICT and health care) to run the project; facility personnel are neither involved nor concerned, hence parallel operations. The researcher learned that despite partners donating computers to these facilities, the machines are not used due to the lack of capacity, including ICT personnel, relevant user training, and Internet connectivity, among other requirements, which is not justifiable.

12.19 Chapter conclusion

In this chapter, the data analysis process and findings were discussed in the Kenyan health care context. The empirical case was presented whereby the research context was discussed in detail in terms of the nature of current maternal health information services. Data themes were generated, hence forming the basis of the study findings to inform the design solution (research model). In the next chapter, the service co-design process is discussed based on the study findings to co-create new maternal health and wellbeing information services.

Chapter 13: Service Co-Design

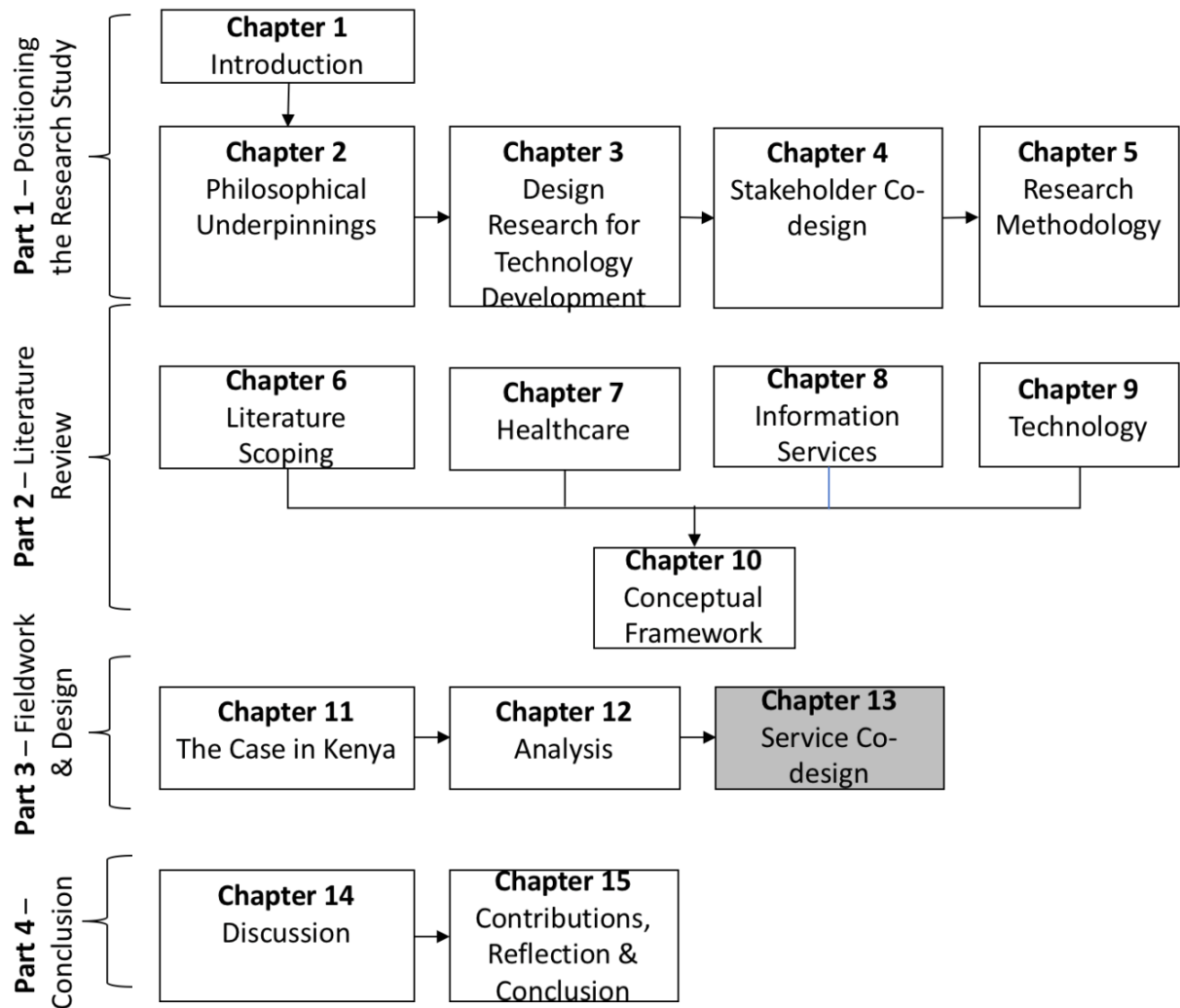


Figure 13.1: Thesis Layout - Chapter 13

13.1 Introduction

This chapter discusses the service co-design process based on the study findings and the emerging data themes from the research context that informs the co-creation process of new services (solution) to the research problem. The key concepts of the proposed service are discussed, which are the service layer, information layer, and user layer to create a prototype service (system) as a proof of concept.

13.2 Exploring emerging data themes through literature

In this section, the various data themes presented in Chapter 12 are explored and compared to the literature according to predetermined theoretical themes.

13.2.1 Stakeholders in maternal health care

The study identified various stakeholder groups performing different roles in the maternal health care delivery chain. The stakeholder groups included the government/ Ministry of Health, research institutions, donors, health care providers (hospitals and health care personnel), CHWs, clients/pregnant women, local administration, and the larger community as a whole (Pakenham-Walsh & Bukachi, 2009). During their study on community-based maternal care interventions to increase access to health facility care in order to promote ideal family care practices, Namazzi et al. (2013) noted the necessity to assess and map different stakeholders' potential impact on a project in terms of their power and influence. This assessment involves the understanding of resource distribution, i.e. who owns what resources or privileges, and who can directly or indirectly act either in favour or against the project (Namazzi et al., 2013). The authors found stakeholder analysis to be crucial as it assists with organising the stakeholders that are likely to influence a project according to their influence on decisions to be taken. Namazzi et al. (2013) furthermore identified five stakeholder categories, namely: drivers, blockers, supporters, bystanders and abstainers. While drivers have a high influence in terms of championing the project, blockers have high levels of power but they oppose the project. Supporters, on the other hand, support the project but they have a limited influence, while bystanders have both a low influence and low support. Last, but not least, abstainers' support for the project is neutral and they may or may not have influence.

For this study, the researcher involved influential stakeholders who work and collaborate closely in the delivery of maternal care services to the community. Women health care providers (hospitals and health care personnel), technology providers (ICT experts), and government departments were specifically identified as the key stakeholders. More importantly, both the clients and the caregivers are actively involved in core-care activity as opposed to other stakeholders. Government, on the other hand, plays a key role in terms of providing policy guidelines and resources needed to support public health care services. Research institutions provide support services through research on better treatment and preventive interventions on various diseases. Therefore, the study recognised these as the main users of the proposed new prototype service in the delivery of maternal health care.

13.3 Information needs

This sub-section highlights the health information needs of various stakeholders, including women, caregivers, management and CHWs.

13.3.1 Pregnant women's information needs

This study sought to identify the various information needs of pregnant women from the participant responses, which enabled the researcher to gain insight into the research phenomenon under investigation. Specifically, three categories of information needs were

identified during the study, namely prenatal, ANC, and postnatal needs. Almost all information needs identified by Grimes et al. (2014) were observed, except mothers' postnatal recovery, infant settling and sleeping, psychosocial changes, and home routine and expectations.

Pre-natal needs require preparation time, especially for women conceiving for the first time. Preparation time is defined as the time during which an individual seeks information that will help them with the process of transitioning to motherhood (Grimes et al., 2014). The learning needs identified by Grimes et al., include knowing the right time to conceive; how to influence the sex of the baby; health care financing; and possible risks associated with conception. Antenatal care (ANC) learning needs identified include the mother's health and nutrition; danger signs; pregnancy complications; and monitoring the baby's condition. According to Grimes et al. (2014), various important information needs may arise while parents work towards adjusting to their new responsibility, hence the need to have access to relevant information. More so, the authors argue that women should benefit from accessing midwifery advice during pregnancy to have their learning needs addressed. In the case of postnatal needs, participants demonstrated concern to learn more about breast-feeding and the mother's sitting position. The researcher furthermore observed concerns in the area of general hygiene of both the baby and the mother's environment, including feeding and cleaning the baby. The need for information on child immunisations at different developmental stages is another concern that the researcher identified. Pregnant women should be encouraged to become active participants in the decision-making process during their pregnancy period as well as the early parenting phase (Grimes et al., 2013). Women should be able to meet their personal information needs, hence the necessity to access quality health information that reflects current evidence of their needs at that specific point in time. Consequently, this ability of women meeting their personal information needs will enable them to perform their role as service consumers of maternal health care services. Grimes et al. (2014) identified various maternal learning/ information needs, including: community resources; planning of care; pregnancy care and complications; labour and birth; infant care; breast feeding; and neo-natal complications/ danger signs.

Mulauzi and Daka (2018) identified and grouped women's needs into three stages, namely pregnancy, childbirth and postpartum needs. Specific needs identified include: check-ups; nutrition; sex; expected child; TB, HIV and malaria in pregnancy; medicines in pregnancy; family planning; exercise; child immunisation; maternal recovery; hygiene; premature birth; low birth weight; infections; umbilical cord care; diarrhoea; self-care (weight loss); house and family; emotional support; physical rest and sleep. As can be observed, the needs overlap to a high degree across different literature sources. Also noticeable is that Mulauzi and Daka (2018) grouped the information needs they identified in their study into the aforementioned

three categories (pregnancy, childbirth and postpartum needs), while this research grouped the identified needs into prenatal, ANC, and postnatal needs as discussed in sub-section 12.15.2.1. Both researchers observed that the ability of a woman to have her learning or information needs fulfilled is influenced by the level of access she has to multiple sources of information, as well as her ability to understand that information (Grimes et al., 2014). However, important information needs identified in this study, and which did not feature in Grimes et al.'s study, include prenatal needs, mother health and nutrition, hygiene and immunisation.

13.3.2 Health professionals' information needs

The study sought to identify specific information needs of health care workers, particularly maternal caregivers, i.e. nurses, clinicians and doctors, who administer care services to clients in public health facilities in Nairobi County. Various information needs were identified during this study, determined by the role of the participants, work cadre/level, and individual work station(s); for example, ANC, labour, delivery, and postnatal maternity services. Therefore, participants provided responses according to the tasks they were assigned to perform during the study. Specific information needs identified include client bio-data and contacts; maternal profile; ANC profile; professional knowledge; and administrative needs. Furthermore, according to literature, health workers' needs vary depending on the availability of diagnostic treatment and referral facilities (D'Adamo et al., 2012; Pakenham-Walsh & Bukachi, 2009), a scenario that was also witnessed in this study, as different levels of health facilities were involved.

The study observed that caregivers mainly obtained bio-data, maternal and ANC information needs directly from the client through various ways, including: physical examination; laboratory test results; documented information such as clinical notes in the ANC booklet; and personal responses to the doctor's queries via face-to-face communication. According to Pakenham-Walsh and Bukachi (2009), these core-information needs of caregivers, also referred to as *practice knowledge*, enable caregivers to make patient diagnoses and determine the nature of treatments to be administered. Professional knowledge, according to the participants, refers to knowledge acquired by a caregiver through formal education and training in a medical or health related field/career (Pakenham-Walsh & Bukachi, 2009). Administrative information needs refer to information that was created and/or generated within a selected institution for reference and administrative purposes by facility administrators in the work place. These include documentation of daily activities and operations (such as hand over reports and works schedules) in the work place for accountability. Pakenham-Walsh and Bukachi (2009) found the information needs of health workers in developing contexts to be varied and continuously evolving due to a variety of variables, which include professional, institutional, cultural and infrastructural factors.

However, the researcher identified similarities between the two studies regarding the information needs of caregivers; for instance: client bio-data, maternal and ANC profile needs were found to be similar in terms of practice knowledge; administrative information was found to be similar to institutional knowledge; and professional knowledge needs were similarly identified in both studies.

13.3.3 Facility administrators' information needs

Participants from the *management stakeholder category* were primarily individuals, including heads of maternity units, in the hospital in charge of the health facilities that were investigated. They were treated as the representative(s) of the service provider at their respective workstations. Specifically, two main categories of information were identified in this group, namely administrative and policy-related information. Administrative information, in particular, comprises statistical data on routine operations necessary to facilitate planning and budgeting processes. Policy information, on the other hand, is needed for regulatory compliance and decision-making. Based on Pakenham-Walsh and Bukachi's (2009) study, the information needs of health care workers vary depending on career, roles, and/or tasks performed by individuals. In this case, according to the researcher, both administrative and policy-related information needs would be classified as institutional knowledge since it is information created and used within an organisational setup.

13.3.4 CHW/Vs information needs

The needs of CHWs mainly revolved around preventive health care services since the main role of this stakeholder group was preventive health care. Specifically, needs identified include information on the prevention of communicable diseases such as HIV/AIDS and TB to avoid further spread. Another information need identified is information on water sanitation and hygiene to facilitate prevention of waterborne diseases. The need for general guidelines on preventive strategies in health care, e.g. for MCH and HIV/AIDS, was also observed, as these guidelines provide policy direction on various preventive strategies. A further information need identified focuses on community demographics and profiles to facilitate planning for preventive health care activities for the respective communities.

13.4 Current information practices

This study explored information services offered in public health facilities to understand the nature of information practices that characterised the research context. Eight (8) data themes and/or perspectives were used to describe the situation, namely information services, community health information service, health communication, health system, collaborative information service, information sources, personalised information service, and service provider. It was noted that both the government, which controls health care system(s), and the

service providers (hospitals) have a major influence on the nature of existing health information practices. This is by virtue of their role of controlling the relevant policies and funding as well as planning and resource allocation.

To begin with, the *information services* theme focuses on the nature of current health information services, which are primarily manual across all selected facilities, with only a small portion being handled electronically. This is influenced by the existing information infrastructure, hence a culture whereby the health care system widely relies on manual documentation procedures as opposed to electronic services. According to the findings of a study carried out by Korpela et al. (2008), processing of health information in the facilities mainly involved paperwork such as books, magazines, posters, charts, reports, and referral letters, among others. In particular, the ANC booklet, which is a government-approved document, plays a key role as far as the management of maternal health information is concerned. The ANC booklet contains notes on maternal health education and the full maternal profile of the client, with space for recording pregnancy and child development, and it can still be used until a child has reached five years of age (Turner & Fuller, 2011).

Noticeable is that the level of ICT adoption in general is very low since ICT services are almost non-existent. Electronic information services are available in a few facilities to support reporting on donor activity, but this is on a smaller scale and involves the use of automated HISs such as IQCARE to manage HIV/AIDS programmes. Relevant computing equipment is available in the facilities, including hardware, software, Internet and IT personnel, among other components. In addition, mass media, and particularly TV and radio, is used to relay information to the public/community. Grimes et al. (2014) found that electronic information services, and particularly the Internet, did not play a significant role in enabling access to information of interest, as only 154/350 (44%) of the women used the Internet. According to the findings from the study by Grimes et al. (2014) conducted in Australia, the nature of the maternal care delivery model has a major influence on the source of information that women rated as most useful. The authors found that the majority of women preferred traditional media, and particularly books, as the most popular method of managing maternal health information. In particular, Turner and Fuller (2011) identified Kenya's "Maternal and Child Health booklet" as one of the best examples of paper-based records used among developing countries. Although Turner and Fuller's study and the current study have been conducted in different settings, the researcher noted a similar trend in both studies.

13.4.1 Community health information service

Community health information services play a key role in educating communities about various preventive health care interventions and strategies such as disease outbreak, water,

sanitation and hygiene, health and nutrition, and child immunisation and vaccinations, among others. This involves both CHWs and medical personnel who work in collaboration with other stakeholders to provide health education and information at community level. The aim is to educate pregnant women in various households on the importance of attending an ANC clinic and also engaging skilled birth attendants. The educating process includes CHWs holding health education talks with women on how to avoid health risks and prevent the spread of diseases such as PMTCT of HIV/AIDS. The services are provided through home visits whereby each household, and particularly those with a pregnant woman, is assigned a community worker who engages each family through one-on-one discussions according to their needs. In this case, the clients receive advice on preventive care methods and strategies needed according to their situation, and they are referred to a health facility whenever the need arises. The overall aim is to promote better health-seeking behaviour among pregnant women to reduce both maternal and infant mortality, thus improving health outcomes. However, some of the women interviewed in some of the facilities reported to the contrary – they were not aware of such programmes, which is a hindrance towards achieving the aforementioned goal.

13.4.2 Health communication

Health communication is defined as “the study and use of communication strategies to inform and influence decisions and actions to improve health” (Centers for Disease Control and Prevention, 2020:1). According to the study findings, communication of health information among stakeholders, including across health facilities, is done through verbal, print and electronic means. However, most of the information is communicated through traditional methods, that is, verbal and print. Most of the information is communicated face-to-face as well as through telephone conversations. Data, including both patient and administrative health records such as reports in paper/print form, are mainly created and documented manually.

According to literature, health communication is among the opportunities that can be maximised by health care designers to promote health care delivery through communication and behaviour design (Tsekleves & Cooper, 2017). It is only when care providers have a holistic understanding of an individual patient’s condition, that they are able to develop realistic treatment plans (Naughton, 2018). According to the author, patients’ experiences of their illnesses and related medication can be used as measure to assess their adherence to medication in terms of appropriateness, safety, and efficacy.

In the case of verbal communication, the researcher observed that health education talks are mainly done through face-to-face meetings, especially between midwives (nurses) and clients. In addition, telephone conversations are conducted specifically during caregivers’ follow-up activities on clients with reminders regarding their medication to ensure continuity of care. It was noted that mobile communication is one of the most popular methods of electronic

communication among stakeholders. According to literature, the use of communication channels that match with health workers' needs is critical in improving access to information and the sharing of knowledge. It was found that meetings are the most preferable way of communication for health workers. Midwives in particular communicate health information through one-on-one discussions and is hence one of important sources of information for women, which is in agreement with this study (D'Adamo et al., 2012; Grimes et al., 2014).

In terms of print media, the study observed that the ANC booklet, patient-held material, is the main document used to manage and share of maternal health information between caregivers and clients. It was observed that the book contains the full client maternal profile/history, which is updated with clinical notes at each ANC and/or postnatal clinic visit; hence it guides health care personnel who provide care (Turner & Fuller, 2011). As a result, the document is used as the main point of reference by health care stakeholders, and particularly caregivers, whenever a client attends the clinic and during a client referral to another facility for further treatment. Generally, the book is noted to be popular among stakeholders, particularly caregivers and CHWs who highly regard the booklet as being very instrumental and/or educative to clients. On the same note, according to the researcher's observation, administrative records/information such as handover reports, maternity registers, and statistical records, among others, is shared among staff in print form. According to Grimes et al.'s (2014) study, it was found that nearly 50% of the 350 women that participated in the survey rated books as the most useful media and/or source of information. In the same way, the researcher observed that the two studies agree on this fact.

The study noted the non-use of computers as tool to facilitate better health communication in the facilities under investigation. For instance, there is no Internet connectivity to facilitate electronic communication, except for mobile phones. A few of the women said they use their smart phones to access the Internet, particularly social media such as YouTube and Viusasa. The majority of caregivers indicated that they mainly use WhatsApp communicate and share information among themselves. Also, the majority of staff appeared to be comfortable with the manual information procedures. Regarding the use of modern technologies, Grimes et al. (2014) found that despite using modern technologies, including mobile applications, these technologies are not likely to supersede more traditional information sources, especially books. According to the researcher, the findings from the two studies are similar despite variations in terms of context.

13.4.3 Collaborative information service

The researcher noted a culture on information sharing among health care stakeholders, including caregivers, CHWs and departments as well as between different facilities, thus encouraging health care coordination. Client information, for example, is transferred from one

staff member to another in a different department whenever such information is needed in the course of a care activity. The medical information shared is mainly client health records, including the ANC booklet/client file, which is a critical requirement at the point of care during both clinic visits and referrals to another facility. Administrative information, on the other hand, involves routine records, e.g. daily handover reports, maternity registers and general statistical information for decision-making by supervisors. In general, the researcher observed that the sharing of information among stakeholders is part of routine health care activities, meant to support health care delivery. Korpela et al. (2013) argue that the emergence of people-centred health care models has increased the demand for health care collaboration, and information is a critical component for health care personnel in their daily tasks. HISs, therefore, should be designed to support work flow and information flow in health care.

Sneha and Straub (2017) affirm that eHealth has the potential to enhance the collaboration of health care service as it presents a range of technologies that support the health care sector. In their study to analyse collaboration between hospitals and community health services, Van Eyk and Baum (2002) found that collaboration among health care stakeholders is necessary to improve the co-ordination of care for clients who require multiple services, including referrals. A key benefit of health care collaborative information services include cost cutting as it helps to avoid the overlapping of service providers and better planning by relevant authorities (Van Eyk & Baum, 2002). According to the researcher, findings from both studies are in agreement regarding the significance of collaboration among health care providers.

13.5 Information sources

According to the study findings, various stakeholders, including clients, health professionals, CHWs and facility administrators, receive the information they need from different sources.

13.5.1 Client information sources

To begin with, identified sources of information for clients include health professionals (midwives), print sources, CHWs, the Internet and mass media. The majority of women, however, reported that they receive information from the midwives (nurses) during ANC clinic visits, which are the first point of contact at the health facility. Information is mainly provided through health education meetings/talks, including one-on-one sessions between the midwives and client. In addition, the ANC booklet plays a major role in providing maternal health education and information to pregnant women, whereby their full maternal profile, including clinical notes, is updated in the booklet right from ANC and throughout postnatal care. Also, clients receive information from CHWs and the Internet although not all women have access to these services, particularly Internet sources. Grimes et al. (2014) in his study found that the

majority of women preferred meetings with the midwives as well as print media, and particularly the use of books as their most prevalent sources of maternal health information, hence the similarity in both studies.

13.5.2 Health professional's information sources

Important sources of information for health professionals include clients/next of kin, client health record (ANC booklet and files), basic formal knowledge (training and workshops, CME sessions, referral notes) and Ministry of Health (MOH) guidelines. Most of the information was obtained from the clients and colleague professionals, whereby clients provided information during clinic visits. The ANC booklet contains clinical notes for the client, which was updated during ANC clinic visits. This booklet is used as a referral document among different facilities. On the other hand, professionals rely on basic knowledge they acquired during their formal training and CME, which includes training sessions and workshops. Pakenham-Walsh and Bukachi (2009) in their study found that both professional/formal knowledge and practice knowledge are among other important sources of information for health care workers, which was a similar observation in this study.

13.5.3 CHW/Vs information sources

Sources of information identified for CHWs include training and seminars, colleagues, community profiles, MOH tools and guidelines, the ANC booklet and the Internet. It was observed that the majority of CHWs has a background in public health, which is in line with their core-duty, i.e. preventive health care, while a few others belong to social services. Furthermore, community profiles are used to identify and assign various individuals' specific households while MOH guidelines are provided by health authorities to guide operations and service delivery. Specifically, professional knowledge plays an important role as a source of information for CHWs in general.

13.5.4 Health care managers' information sources

Facility administrators, on the other hand, receive information from both internal and external sources. These include the Records department, organisational statistics, MOH guidelines and professional training (workshops and professional code of conduct). It was observed that all information created within a facility, particularly medical and administrative records, is kept and maintained at the Records department/office, which is mainly used for reference purposes and hence regarded as an important internal source of information. MOH guidelines are issued by health authorities to guide the formulation and implementation of various policies to guide health care delivery, and are thus an external source of information. Generally, the researcher noted similarities between this study and that of Grimes et al. (2014), who identified both institutional (internal) as well as professional sources of information for health care workers.

13.5.5 Personalised information service

The study observed the provision of personalised services to clients by health care personnel, a practice that is in line with modern health care delivery models, specifically IPCHS, according to the researcher. Personalised information service is defined as “services which deliver the right information at the right time on a media preferred by the consumer” (Ritz, 2002:20). During the study, the researcher observed that health care workers, and particularly midwives and CHW/Vs workers, engaged clients in one-on-one discussions during ANC/PNC clinic appointment/visits, whereby information related to individual maternal health and wellbeing was shared. This was based on the client’s profile and clinical notes recorded in the ANC booklet while individuals’ rights including privacy and confidentiality were observed. More so, the caregivers used a language familiar to the client, that is, either English or Swahili, to ensure that the clients understand instruction provided at the clinic to take care of themselves while at home. This practise allows individuals to express themselves freely while caregivers have to seek consent from a client first before care decisions are taken, including referral decisions. The women are charged with the responsibility to take care of the ANC booklet to track (monitor) their own health information generated during clinic visit. The booklet is used by caregiver(s) to reference or update clinical notes during each clinic visit. According to the researcher, this greatly improves the quality of health services for the women as they feel part of the care process, hence hence empowering individuals and families.

According to World Health Organisation (2015), the people centred-approach to care is critical because it empowers individuals and communities as a service consumer. More importantly, it requires that people access health education, literacy and the support they need to make decisions and participate in their own health and wellbeing. Ogden et al. (2017) argue that shared responsibility for personalised health literacy is vital in the delivery of patient-centred care. However, the researcher observed that the services offered are mainly based on traditional media, including verbal (face-to-face meetings) and paper records (ANC booklet), which are characterised by limitations of geographical barriers and distance as well as vulnerability to loss and damage. According to literature, however, eHealth can help keep patients at the epicentre, and the barriers associated with geographic, socio-cultural/behavioural, organisational, financial, political, and technical are addressed with the objective to empower patients (Sneha & Straub, 2017; Shuvo et al., 2015).

13.6 Challenges experienced

The study findings generally focus on issues that negatively affect the management of health information services, thus compromising the quality of services. Six (6) data themes emerged from exploring the research context in comparison with literature, namely: service

contextualisation, data access, health communication, health system, system/service integration, and service provider.

13.6.1 Service contextualisation

Based on observations made during the study, it was found that there is a need for health organisations to adopt HIT innovations that are context specific to ensure meaningful use to increase operational efficiency. It was noted that context plays a critical role in determining relevant ICTs, particularly stakeholder requirements, user needs and technological infrastructure, among others. According to the researcher, the aforementioned factors influence the choice of technology that people and/or organisations adopt within their context.

Specifically, mobile technology is the most preferred mode of communicating health information. This is attributed to existing mobile infrastructure's affordability, ease of use, portability, and ubiquitous access and ability to multi-task; it is therefore more established than other technologies. It was found that desktop applications, which have greater data processing and storage capacity, are not used in most of the health facilities as the relevant infrastructure is lacking in terms of equipment, software, Internet, IT personnel, and computer literacy skills, among others, hence the use of manual procedures. The study observed that some of the users' requirements were not met, hence frustrations among staff.

One nutritionist said,

"[The] existing system for nutrition does not meet my needs! The system cannot generate reports...so I need a tool to analyse and generate reports to make work easier" (HP006).

According to literature, contextualisation of technology environment refers to the development, implementation and assimilation of information technologies into organisational practices (Davidson & Chiasson, 2005). The researcher therefore noted the need for understanding context and the user environment to ensure the implementation of the relevant technologies as well as maintenance costs prior to investment to guarantee sustainability.

13.6.2 Data access

Issues related to the security of health data were reported during the study, including the privacy and confidentiality of clients due to the nature of information practices and/or services offered. According to the researcher, the responses received are indicative of the violation of an individual's right to privacy and confidentiality, which is a critical requirement in health care delivery, particularly concerning the handling of individual health information.

Women participants raised concern that some of the health care personnel do not keep client information confidential, they leak it out, a situation that could cause stigma among women. This leaking of information makes some women, particularly HIV-positive mothers, shy away from seeking care advice at health facilities, thus leading to care discontinuity. On

the other hand, CHWs reported that some of the clients were ignorant and they gave out their ANC booklet, which contained sensitive personal information to other people! On the same note, a nurse reported that using a personal mobile phone to call/follow-up on clients was not safe as one shared their contact with many people, and thus compromising individual privacy. At the same time, client privacy was compromised too because information sometimes leaked to a third party who received calls other than the client herself.

Despite the services offered being manual, the observations made above indicate the inappropriate nature of information and communication practices in the health facilities that were under investigation in terms of individual data access. It was observed that there are loopholes in the system, whereby personal health information leaks and ends up in the wrong hands, thus compromising client confidentiality. According to FAIR (2016), there are four main standards (find-ability, accessibility, interoperability, and reusability) known as the 'FAIR Guiding Principles for Scientific Data Management and Stewardship', which should be applied to guarantee the security and confidentiality of digital data. According to the author, the concept of *access* as used here refers to the universal design of products, devices, services, and/or environments in order to be usable by people, including those with disabilities (FAIR, 2016). This is to be done through assistive technology to ensure both direct and indirect access. According to the researcher, there is a need to re-design health information and communication services to control health data access to health using the FAIR principles, particularly using appropriate technologies.

13.6.3 Weak health communication services

This sub-section discusses issues related to communication of health information among stakeholders that were reported during the study. Some of health care personnel raised concern that they are forced to use their personal mobile phone to do follow-ups on clients, hence using personal resources. The study therefore noted a lack of facilitation in terms of communication equipment and airtime by administration, thus making it challenging for staff to perform their assigned tasks appropriately. Also, staff expressed their concern that clients do not have a way of communicating to the health facility since there is no dedicated line through which to contact facilities, including during emergencies. In this case, clients are forced to visit the facility physically to make inquiries, even when it is not necessary to do so. This makes it difficult to access care at the facilities, as some of the women cannot reach the ANC clinic for various reasons such as distance and lack of transport, among others.

According to observations made during the study, there is lack of adequate communication infrastructure to facilitate effective communication between health care clients and health care personnel. The communication system is not able to adequately support health care services, hence a communication breakdown, which compromises the quality of health

services. Furthermore, health care personnel reported a dearth of facilitation by the service providers, which is needed for them to perform their tasks effectively. For example, client follow-up actions are mainly done using phone calls; however, individuals have to use their personal phone and airtime to make calls (Watkins et al., 2018) due to a lack of maintaining the budget. The researcher therefore observed the need to develop appropriate health care design intervention(s) to facilitate better communication between health care providers and their patients.

Madula et al. (2018) argue that effective health care communication between caregivers and their patients is a key element in optimal service delivery in maternal care, thus the need for a good relationship between health care providers and patients in order to communicate effectively. Positive communication between the two parties encourages women to utilise maternal services at a health facility (Madula et al., 2018). Despite evident patient-centred improvements in health care services, optimal health has not been fully realised yet because of poor communication between patients and health care providers (Naughton, 2018). In their study to find the way forward regarding on public health care, Tseklevs and Cooper (2017) identified *health communication* as one the opportunities to leverage in order to promote health and wellbeing. The authors argue that communication and behaviour design can bring about an immense contribution towards health promotion and preventive care. Specifically, communication can facilitate this through the contribution of typography and information design to health communication and also through designing care for both acute and chronic health.

13.6.4 Weak health system

A weak health system involves issues concerning government decisions on health projects, such as their funding and implementation in the interest of the public. According to the study, it is the responsibility of the government to determine public health policies, objectives and guidelines to provide a standard approach for guiding the delivery of health services. However, a number of observations were made which are contrary to the expectations. According to the researcher's observation, there are major concerns regarding the provision of funds and resource allocation by the government. Specifically, health facilities receive inadequate funding, characterised by prolonged delays that compromise the quality of health care services. This has led to the lack of commodity supplies and equipment necessary to support care delivery. Han (2012) found that health outcomes are related to the way policies are designed. The performance of a health system depends on its design, which includes intervention policies regulating both the demand the supply sides, and the implementation and monitoring of the policy (Han, 2012).

A further observation made is a lack of consistency in the application of information management policies across the health care system. Various health facilities that were

investigated apply their own procedures, while some do not have any policy guidelines to guide the creation, storage, access, retrieval, sharing and disposal of records. This is indicative of the non-commitment of relevant authorities, as custodians of health records, to standardise and enforce policy guidelines on public health information practices in health facilities. Furthermore, this situation negatively affects health care collaboration in terms of information sharing both within and between facilities, and especially during referrals, hence the need for a working policy intervention mechanism for effective information practices. According to literature, a health information policy is an important tool to ensure cost-effectiveness in designing health care services and promoting collaboration among stakeholders to eliminate data silos, thus improving health care experiences for people (Treglia et al., 2019; Yue et al., 2019).

13.6.5 Lack of system/service integration

Issues related to the integration of health care services, for example loopholes associated with the integration of the health care system, and specifically concerning HIS, were identified during the study. The researcher noted the existence of data silos occasioned by partner (donor) projects which have been implemented in various health facilities beside DHIS, which is the national HIS. This observation is an indication that the projects are mainly focused on the interest of the sponsor(s) rather than the interest of government. In particular, the researcher observed that the partners have established their own ICT services in specific facilities of interest to support the reporting of their project activities, which include HIV/AIDS. Furthermore, these activities are not necessarily aligned to government strategic objectives. The partners put in place the full infrastructure needed to support their programmes, including equipment, personnel and commodities, among others. According to the researcher's observation during the study, operations run independently, i.e. without the involvement of government staff at the same facilities, hence no health care collaboration. This has resulted in parallel reporting systems, which creates silos of data and compromises efforts towards integration of the health care system.

The challenge of donor influence in developing countries has been discussed in literature. Donor influence causes conflict of interest among health care stakeholders, hence data silos, a situation that leads to parallel reporting, which causes the fragmentation of health care systems (Miah, 2017; World Health Organisation, 2016b; Many et al., 2016; Many et al., 2012). This confirms the need of adopting an overall approach towards integrating the health care system through leveraging eHealth to support collaboration and coordination among health care stakeholders and support systems, hence patient-centric care (Koumaditis et al., 2015).

13.6.6 Poor service provision

During this study, issues relating to resource provision, which is the responsibility of facility administrators to plan and allocate resources to facilitate health care delivery, were reported. Issues include the provision of equipment, basic health care services, and information infrastructure and commodity supplies, among others. According to the study findings, health facilities face the challenge of resource constraints, such as the lack of basic equipment to support operations in the workstations, including sitting space and furniture at the waiting area, causing clients to stand in long queues for many hours. This situation has led to some women failing to attend the clinic due to the strenuous experience of waiting in long queues. Furthermore, essential commodities such as the ANC booklet and drugs are sometimes not available. As a result, clients are asked to buy/use a plain exercise book. This denies women the opportunity to access relevant education and information for their health and wellbeing contained in the ANC booklet. There is also a lack of basic items to support maintenance operations, including computers, telephone extensions and airtime needed by the caregivers to facilitate follow-up actions with clients to complete their medication.

Facilities are unable to provide basic health care services, particularly universal health coverage (UHC), and as such, women rely on their families for financial support, which is sometimes not possible, thus they fail to seek care at the facilities. This is due to inadequate funding and/or the untimely release of funds by government as well as poor planning, budgeting and prioritisation. Consequently, facilities offer maternity services at a fee that some of the women cannot afford; they therefore stay at home, not visiting the ANC clinic to receive care. Several limitations were noted of the ANC booklet, which is a core document to educate women and document their maternal health profile; the booklet is also a point of reference for caregivers, including referrals, but with these limitations, the quality of services is compromised. According to the researcher, the booklet is paper-based and in custody of the client, which makes it vulnerable to damage, loss, ageing and fading of ink, such that it cannot retain information for long. In the event of loss or damage, the client has to begin afresh, thereby making it difficult for caregivers, as they have to update the full record all over again.

Both clients and health personnel indicated that some of the content in the booklet is complicated for a layperson to understand and the graphs, particularly those showing child growth and development stages, are confusing. The doctor's handwriting is sometimes illegible to the women. Ageing of the booklet, fading of ink, and the language barrier among illiterate and/or semi-illiterate women is a scenario also witnessed in literature (Salgado et al., 2017). ICT services are almost non-existent across all the facilities that were investigated due to a lack of the necessary support and facilitation in terms of computing equipment, software and skilled manpower. The researcher noted a lack of understanding of the value of ICT among facility administrators and staff in their work activities; manual procedures are the culture in

these organisations. This causes phobia among staff against the use of computers and hence resistance against the adoption of ICT due to computer illiteracy.

In their study to demonstrate the value of how a human-centred approach (SDR) can improve the quality of childbirth care in low-resource settings, Salgado et al. (2017) explored barriers to accessing maternal health care. Their study identified some of the barriers and bottlenecks similar to those identified in this study. Among the major barriers identified is the lack of a source for health care financing/UHC, as the majority of women cannot afford the services at the facility. Also, due to poverty, many families lack the financial resources for necessary expenses such as transport and service charges hence women fail to attend the ANC clinic (Salgado et al., 2017). Furthermore, the information needs of women, including packaging, content, language, and format errors, are not met by service providers, leading to women not having adequate access to information, hence low health literacy levels. Among the bottlenecks identified are the long queues and congestion in health facilities, a situation that discourages women from attending the clinic (Salgado et al., 2017). This is because of resource constraints experienced by service providers, which include staff shortages, and the inability to comprehend the contents of the ANC booklet due to language barriers, leading to a lack of understanding the basics of maternal health education (Salgado et al., 2017). The study Salgado et al. was conducted in Nigeria and Uganda, both of which are situated within low-resource settings. The researcher confirmed the similarity and validity of the findings of both studies.

13.6.7 Stakeholders' perception

Perceptions of various participant groups were observed in relation to both existing and desired maternal health information services to provide the researcher with deeper insight into the research phenomena. The responses given touch on various themes as highlighted in the subsequent paragraphs.

13.6.7.1 Data access

Comments on this subject were mainly made by health professionals, clients and CHWs. Specifically, health professionals and CHWs expressed dissatisfaction with the manner in which client information is managed and relayed in the ANC booklet, as, in their opinion, this violates client privacy and confidentiality despite it being the standard document recommended for maternal use by government. Clients reported leakage of personal health information to a third party by the nurses, leading to stigmatisation, which makes women stay away from the ANC clinic. These observations indicate weaknesses of the current HIS, hence the need to improve the situation.

13.6.7.2 Health communication

Feedback from participants on this subject was generally focused on the communication of health information, and particularly the impact of ICT on health care communication in the research context. Three participant groups, namely administrators, CHWs and clients, reported that the impact of ICT is low as far as communication of health information is concerned since only mobile phones are used. It was noted that the health communication system is mainly characterised by mobile technologies (Watkins et al., 2018); this is attributed to the nature and advantages of the technology, such as high penetration, affordability, mobility, productivity, and user-friendliness, indicating the popularity among the majority of citizens.

Despite extensive use of mobile phones and the accompanying benefits, the overall impact of ICT in health communication is low due to obvious technological limitations such as less processing power, small screens/keyboards, low battery life, insufficient bandwidth and security standards, among other disadvantages. Therefore, more powerful computing technologies and applications with high data processing capacity, strong Internet connectivity, and large data display screens are needed in health facilities.

13.6.7.3 HIT utilisation

Opinions related to adoption of HIT innovations to improve the quality of health care were realised, particularly from ICT and health professionals, involving concerns by stakeholders for not having a platform to incorporate technologies that will enable users to generate health care reports electronically. Suggestions provided include developing a database and use data science tools and machine learning techniques to mine data for reporting and decision-making purposes. According to the researcher, some of the staff, particularly health personnel, understand the benefits of using ICT Innovations, for example, productivity and efficiency, in their work. There were frustrations noted among some of the staff in their attempts to analyse health data manually due to the lack of appropriate infrastructure, which compromises the quality of information services.

13.6.7.4 Health system

Comments that emerged for this theme relate to the general role of government in terms of policy decisions that have an impact on the delivery of maternal health services. Specifically, comments touched on issues revolving around the content of the ANC booklet, which is a government-designed and approved document for managing maternal profiles. A senior health staff member reported that the graphs in the booklet are too complicated for clients to comprehend, and this creates confusion. Furthermore, the physical nature and/or medium of the booklet makes it more susceptible to destruction/damage, such as fading ink, which may lead to the illegibility of clinical notes. There is also a language barrier, since the booklet is presented in the English language as opposed to vernacular. Women participants particularly

said that only the health professionals understand the doctor's notes in the booklet. The researcher noted that it is the core responsibility of government to address the aforementioned issues, as they need policy interventions to address the alteration of content/ graphs and the inclusion of vernacular languages.

13.6.7.5 Information services

Responses from participants under this theme were focused on the ANC booklet as a focal point of maternal health education and information services to women. Extremely positive remarks were noted from the participants, specifically the midwives and CHWs who praised the booklet. According to the study findings, the booklet plays a critical role in educating, referencing, sharing and documenting the maternal profile of clients. Furthermore, it was indicated that the document could also be used a legal document, in place of a birth certificate when a child join school before attaining the certificate. However, the researcher noted that the ANC booklet also has limitations in terms of information management – it is a paper-based document that somehow affects information services negatively, including loss, damage and ageing, among other limitations.

13.6.7.6 Quality health service

The findings mainly highlight both positive and negative aspects of the participant responses on the quality of maternal health services, including information services rendered to clients. Specifically, the various comments touched on the ANC booklet, mistreatment, and ICT services. It was reported that some of the women are not familiar with English as the only language used in the booklet, thus causing a language barrier, while the notes of doctors are illegible. As a result, some of the women cannot read the booklet; they therefore miss important information. Nurses also complained of difficulties they experience in managing manual/paper-based documentation. Clients reported that some of the information they receive from face-to-face meetings during ANC clinic visits is misleading and confusing; therefore, they do not trust the credible of the information. The women indicated that they are mistreated by midwives, who are harsh with them whenever they omit following instructions; this causes them to have negative experiences. From an ICT perspective, participants suggested the adoption of ICT in health facilities towards improved efficiency as well as better organisation and retrieval, access, analysis, reporting, collaboration and sharing of health data among stakeholders. According to the researcher, the aforementioned issues affect the quality of services in one way or another, whereby clients' negative experiences indicate poor quality services and vice versa.

13.6.7.7 System/service integration

This theme highlights the participants' perceptions on matters related to the integration of health care service, particularly using IS. It was noted that the adoption of ICT is a critical

requirement for integrating HISs towards promoting health care coordination and collaboration. According to the study findings, various facilities under investigation display varied levels of complexity based on their hierarchical classifications according to cadres. Some of the facilities are smaller while others are larger and more complex in terms of the number of internal units/departments, for example, referral facilities. The integration of services is therefore required to enable departments and staff to work collaboratively in order to improve efficiency. More importantly, it was noted that facilities mainly rely on manual information procedures, which makes information sharing among stakeholders difficult both internally and externally. Furthermore, referral cases, including emergencies, require a nurse to accompany the patient in order to present the case/information. Therefore, appropriate interoperability standards in health care, such as Health Level 7 (L7) standard Fast Health care Interoperability Resources (FHIR), Digital Imaging and Communications in Medicine (DICOM) and Health care in the Enterprise (IHE) (Bender, 2013), should be leveraged to enhance the integration of health systems, information exchange, and the sharing and communication of health information to improve health care delivery.

13.6.7.8 Service provider

Participants focused on aspects related to the provision and allocation of resources, commodity supplies and infrastructure in health facilities, all of which are the responsibility of the service provider. The researcher noted concern over information management, particularly the automation of health care services, which is negatively affected by the lack of supplying essential commodities such as the ANC booklet; hence, the clients are requested to buy an exercise book instead. This observation is an indicator of failure by the service provider to prioritise managerial decisions, i.e. supplying the ANC booklet, which is regarded as an essential commodity for maternal health education (Grimes et al., 2014). Also, there are too much manual documentation, which sometimes frustrates staff activities as records are insecure and difficult to retrieve, while storage space is inadequate; this leads to poor quality of service. Service providers are furthermore slow with adopting ICT in health facilities, and this continues to hinder the management of information in health institutions. Consequently, is negatively affects health care operations across various facilities in the County.

13.7 Design considerations

ICT-facilitated design considerations identified during the study will be highlighted in this sub-section. These considerations were mainly gathered from ICT experts, whose responses, according to the researcher, are better placed to provide deeper insight into understanding the research context better. The concepts are discussed in subsequent paragraphs alongside corresponding findings from literature.

13.7.1 Data access

Participants' concerns mainly revolved around aspects of confidentiality, integrity and the availability of health data in the context of ICT-facilitated HISs, and hence data access. The study observed that the management of health data is a sensitive matter and therefore needs attention from designers in all three aforementioned perspectives of data security to guarantee the security and privacy of client information. One participant said:

"One of the most critical things with design of a system is to ensure security that is, confidentiality, integrity and availability of patient data" (ICT004).

More importantly, it was noted that for the above to be achieved, holistic system security design needs to be ensued to safeguard against abuse and/or the violation of individuals' right to privacy. Also, both logical and physical data security mechanisms should be put in place, including user name and password as well as role-based access control measures.

In particular, the SSDRL approach has been identified as the most preferable approach to use during the design and development stages of a system check against security vulnerabilities. This approach will enhance universal design of the service components including products, devices, services, and entire information security environment to make them usable by users. An expert participant said,

"Data protection should be system-wide under SSDRL with use of access credentials and data encrypted with ammonisation of patient identifiers" (ICT003).

These findings demonstrate the importance of ensuring proper data security mechanisms and features, particularly in an automated environment. In her study to explore user perceptions regarding the use of online services for the ageing population, Du Preez (2018) identified privacy and security among other emerging themes as important considerations for eHealth, which mainly focus on threats and privacy issues. According to findings from a study by Wilkowska and Ziefle (2012), security and privacy play a critical role in facilitating the adoption of ICTs in health care management. The authors noted that individuals prefer a high degree of confidentiality, anonymity and understanding (Wilkowska & Ziefle, 2012). Specifically, the researcher noted the relevance of the FAIR principles for scientific data management, i.e. find-ability, accessibility, interoperability, and reusability (FAIR, 2016), in this case, to regulate health data access.

13.7.2 HIT utilisation

This theme involves considering the design of HIT innovations with analytic capability, and particularly using data science tools and machine learning techniques. The participants demonstrated an understanding of the role of ICT to ensuring the efficient management of health care services. Two participants said the following:

“With the use of ICT... we can see and track the number of clients enrolled for ANC services and follow them up!” (ICT001).

“Use data science tools such as machine learning and develop a database to mine data stored to enhance health reporting” (ICT003).

Based on above statements, it was observed that IT has the potential to enable the generation of reports in real time hence the availability of timely information to users. Also, it was noted that the use of analytics tools will enhance disease surveillance, hence facilitating evidence-based decisions by administrators for the effective management of public health care.

Unfortunately, it was observed that ICT services are almost non-existent in most of the facilities under investigation whereby only paper-based records were used. The researcher noted frustrations among staff as they have to generate reports manually, which is tedious and time consuming. For instance, one health professional said:

“[The] existing system for nutrition does not meet my needs! The system cannot generate reports...so I need a tool to analyse and generate reports to make work easier” (HP006).

These observations provided the researcher with deeper insight into the gaps in the current health care situation and associated information infrastructure. This is necessary to inform the re-design of health care services to provide the desired solution in terms of health information infrastructure in order to improve efficiency and productivity.

Gibbons (2011) argues that advances in IT have huge potential to transform various functions of health care, including consumer health, clinical care, administrative and financial transactions, professional education, biomedical and health services research, among other areas. The role of IT has been identified as central in the re-design of the health care system to address disparities towards improving quality health service for all populations. There is also a growing demand to understand the potential role of HIT in addressing health care disparities among racial and ethnic minority populations (Gibbons, 2011). According to the researcher, these observations are in agreement with the findings of this research, particularly in terms of health care activities, which include care giving/treatment, administration, education and medical research, among other activities, therefore the need to leverage on IT to transform health care services.

13.7.3 Service contextualisation

The study identified concepts related to the context of stakeholder/user requirements and contextual technology environment, mainly influenced by factors such as social, economic, cultural and technical aspects hence the need to contextualise the design of proposed services. A participant said:

“Consider stakeholders’ requirements and map users’ needs. Localise and customise software to allow development of own skills” (ICT001).

It was observed that an understanding of the contextual requirements, including the social and technological needs (hardware and software) of stakeholder/users, guarantees the design and creation of interventions with meaningful use. Based on these observations, the researcher noted that prioritisation of service requirements in the context of use is critical in enabling designers to deliver solutions that are compatible with user needs towards meaningful use in order to meet the change objective. Participants identified various technologies (both hardware and software) used to support the delivery of health care services in the research context. Based on responses received, it was observed that mobile phones/applications are the most popular technology used to communicate information within and across public health facilities (Watkins et al., 2018). According to the researcher, this is mainly influenced by the nature of the technological environment, hence contextual implementation of relevant technologies to enable the meaningful use of new services.

According to Blickstein and Holtzblatt (1999), the contextualisation of requirements promotes state-of-the-art approaches towards designing products that are based on the designer's knowledge and/or understanding of how the users perform their work activities. It is therefore a combination of the designer's understanding of both users' needs and the possibilities introduced by technology. Steps to be taken during the mapping of requirements include contextual inquiry, work modelling, work re-design, user environment design, UI design, and mock-ups and test with customers (Blickstein & Holtzblatt, 1999). In this case, the technical aspects to be explored include functional specifications, development of customisable features and automatic adaptation by the system. However, contextual influences may vary across cultural and social system environments in terms of specific locations (Sutcliffe et al., 2005).

Boore (2018) argues that the application of ICT in health care (eHealth) requires contextual considerations to guarantee successful implementation as well as sustainability. The author argues that contextualisation of ICTs in developed countries in particular is organisational-based as far as the utilisation of ICTs is concerned, involving the automation of health records, electronic appointments, telemedicine and use of Internet to communicate health information, among others. The researcher therefore, noted the significance of contextualising the technology environment, particularly when implementing ICT-facilitated services organisations. On the same note, Korpela et al. (2013) assert that existing eHealth systems lack holistic contextualisation to address issues affecting systems, and are therefore deficient to support health care delivery effectively.

13.7.4 System/service implementation

This theme involves aspects related to the validation of new services before launching it for use. According to the study findings, it is important to subject the new service (prototype

system) to a pre-evaluation process to assess preliminary outcomes, which will facilitate re-designing and/or re-engineering services before full installation, according to business requirements. Participants said:

“Functionality of the new system should be tested at facility level first to observe the outcome before full implementation” (ICT001).

“A pilot survey should be carried out in a single institution to target feedback from at least 30 people who are actual users of the system” (ICT002).

The researcher noted that design plays an important role in the testing phase, whereby various aspects of a system – unit test, system test, integration test, and user acceptance test, among others – are scrutinised and then modified prior to full implementation after a number of repetitive system tests. In particular, pilot survey(s) have been identified as the most ideal approach to check and verify overall system design and functionality before finalising a system. This involves checking input (data captured), output (e.g. generated report formats), and the interlinking of various system processes to fix errors/re-design before actual installation.

According to Hudgons et al. (2011), the quality of a software application mainly relies on extensive testing to validate each functionality used to execute the intended transaction(s) and ensure that each transaction is consistent with predefined business requirements. The authors identified six (6) phases of system testing, namely unit test, system test, integration, user acceptance testing, customer installation, and support test. Of these phases, the system test phase is designed to validate the functionality and performance of a software application, which involves the highest number of repetitive tests to ensure effective functionality (Hudgons et al., 2011).

13.7.5 System/service integration

Concepts addressed under this theme are mainly related to the integration and design of health care services. Specifically, the concepts recognised from participant responses include API/integration point, eHealth standards, Internet connectivity and system modules. According to the researcher, the concept is suggestive of the need to integrate health care services both within and beyond health institutions. Some of the participant responses include the following:

“The system should be well-integrated to enhance information sharing with an API to enable different users to query data from the system” (ICT003).

“Integration will require specific eHealth standards such as HL7 and FHIR especially in facilities with systems already installed” (ICT002).

According to the study findings, the integration of services is to be achieved through designing appropriate HISs, while observing the relevant standards to facilitate information sharing and collaboration among health care stakeholders. The researcher noted that an API is a critical component of desired services to facilitate querying health data by different users

and according to individual needs. In addition, eHealth standards are needed to facilitate interoperability between different software modules and applications both within and beyond a health facility.

According to observations from the study, eHealth standards are a key component in the design of HISs to facilitate the distribution, access and sharing of information across the health care system. More so, it was observed that the quality of Internet connectivity is also crucial to ensure quick transmission of information and to be readily available to users at the point of need. More importantly, caregivers need access to patient record(s) in real time to support care decisions while health authorities need statistical data for planning purposes. However, it was observed that efforts to integrate health care services is faced with the presence of parallel reporting systems emanating from donor influence, who look after their own interests rather than collaborative health care hence fragmented health systems. A participant said:

“The donor effect creates a silo, for example, some partners only cater for HIV reporting and thus creating parallel reporting systems alongside the national health reporting system/ DHIS” (ICT001).

According to the researcher, this observation is suggestive of the need to rethink health care design to enhance system/service integration and collaboration to improve the quality of health care. During her study on factors for successful implementation of eHealth in Kenya, Boore (2018) identified *systems integration* as one of the key requirements. Systems integration is to be achieved from the perspectives of interoperability and interaction where two or more systems work jointly both within and between organisational boundaries through using eHealth standards to enhance health care delivery within society as a whole. Specifically, the author noted that *interoperability*, which is an element of integration, is fundamental in ensuring cross-institutional points of access to accurate data at the point of care in a cost-effective manner. Integration is necessary because it has the capability of address complexity of both socio-technical systems (Du Preez, 2018). Based on these observations, the researcher noted similarities between findings from the two studies hence the need to improve the integration of health care systems.

13.7.6 Stakeholder engagement

Concepts identified under this theme are related to the role and/or responsibility of various stakeholders in maternal health care, i.e. clients, health professionals, facility administrators (representing service provider), CHWs and ICT experts; it is their right to participate and provide their opinion on existing health care services. For example, it was observed that most of the responses were directed towards issues concerning obligations of the service provider as a stakeholder, who is central in matters associated with health care management. These include policy administration, planning and budgeting, provision of resources, and determining organisational business requirements, among others. According

to the researcher, this observation demonstrates the significance of stakeholder influence, and particularly the service provider, over the general health care design of health care services. Participants said:

“Enforce password policies including frequent password change, length of password and...etc., user training and use technology security standards” (ICT001).

“The key challenges we face here are loss/damaged/misplacement of records, lack of ICT equipment for example a photocopying machine! Government is not providing support, shortage of staff, lack of training on ICT for staff” (AP002).

As observed, the service provider, as a health care stakeholder, has influence over decisions on the design of health care services, including information services, through the implementation of various policies and providing needed resources to address challenges identified through facility administrators.

According to the researcher, it is the responsibility of managers to determine and/or interpret organisational information requirements, which will definitely have an impact on design considerations for ICT-facilitated health information services. On that basis, it was noted that stakeholders play a significant role in the design of HISs, and hence the importance of taking into consideration propositions of each relevant stakeholder while designing health care services. Freeman (1984) argues that an organisation should be seen as a set of relationships among groups having a stake in the activities that make up the organisation and how these activities relate in terms of interactions and value-creation. Johnson et al. (2008) proposed two key dimensions in stake holding, namely power and interest, which may hold low, medium or high influencing power.

In the context of Health Informatics, which is the main subject of this research, Korpela et al. (2013) identified three key stakeholders and relations, i.e. technology providers (ICT experts), health care providers (hospitals, administrators, health care personnel, among others) and the people (health care consumers) who have different levels of power, interests and influence in eHealth. According to the researcher, literature agrees with the findings from this study concerning the role and significance of stakeholders in the design of health care.

13.7.7 System quality

A number of concepts related to the *system quality* theme were identified during the study, related to both functional and non-functional system requirements, namely system reliability, usability, accessibility, responsiveness, interactivity, scalability, maintainability, specifications and the affordability of ICT services. From participant responses, the researcher observed that *quality* involves processes that affect customer experience and satisfaction. Participants said:

“The system should be user-friendly with good click depth, accessible, reliable, maintainable and secure” (ICT003).

“Connectivity is key for integration hence quality Internet connection must be guaranteed” (ICT003).

“Consider system ability for scalability, input/output ration processing, resilience on day-to-day processing, disaster recovery with secure endpoints” (ICT004).

It was observed that the quality requirements of the proposed cloud PHR service are important for consideration during the design process to deliver efficient health care services (desired situation).

Service quality is an important strategy for business success or survival, particularly in a competitive business environment (Zeithaml et al., 1996). The three-pillar approach, namely Excellent Health care Service Model (EHSM), proposes three quality dimensions for health care industry concerning the delivery of quality health care services, which include cost (Lee et al., 2006). According to the authors, excellence in health care delivery should be anchored in clinical engineering for high quality care delivery, economic engineering for cost effectiveness, and hospital engineering for operational efficiency. In this research, similar quality factors identified in literature were also observed during the study. According to the participants' responses, there is a need to adopt affordable quality ICT infrastructure and system features. These two key findings imply the aspects of economic efficiency and quality system features as identified in literature, hence both findings are in agreement.

13.7.8 User-centred design

The study identified concepts related to active participation by stakeholders/users in the design process of new services, namely user needs, prototyping, participatory design and co-design. According to the study, the service designer(s) is required to continuously engage users through active participation to understand their needs in each phase of the design process, while using various tools and techniques to create user-friendly interventions.

The person-centred approach may be described as a practice whereby the focus of interest is on individuals' position on latent needs or dimensions influenced by certain attributes (Laursen & Hoff, 2006) concerning the issue in question. The UCD approach, which employs the co-design method, enables a good understanding of the research context, user requirements, identification of alternative design solutions and the evaluation of these solutions against the specified requirements (Interaction Design Foundation, 2016). Du Preez (2018) describes UCD as a process through which products and services are created from the perspective of the end-user.

On the other hand, Salgado et al. (2017) describe co-design as the creative activity of both the designer(s) and people not trained in design working together in the design development process. Through the application of UCD, users become part of the design process, and through this, develop a sense of ownership. This approach helps to avoid

resistance from users and other stakeholders later on during the implementation stage of the new services, thus avoiding the failure of a project. Part of the design considerations for the proposed system is primarily based on non-functional requirements, i.e. characteristics associated with system quality such as usability, reliability, interactivity and affordability of the ICT services.

In their study to demonstrate the value of UCD in improving maternity care experiences in low-resource settings, Salgado et al. (2017) observed that the approach creates innovative and human-centred service solutions with the potential to immensely improve maternity care experiences and outcomes in low-resource settings. Specifically, UCD challenges designers to tailor the user interface around their capabilities and needs, thereby integrating information in ways that fit goals, tasks, and the needs of users (Endsley, 2016), hence user-centred design.

The researcher noted that engaging stakeholders in a design process facilitates clarity of the stakeholders' requirements to deliver desired solutions that are meaningful in the context of use. The co-design process contributes actively towards empowering potential users, which is a human-centred approach for re-designing health care services to fulfill needs and recognise the value of health care for the people (Salgado et al., 2017). This process is therefore crucial to the service concept as it facilitates inclusion of user feedback and ideas during the design process, which may result in approaches such as participatory design and co-operative design (Du Preez, 2018; Thobias & Kiwanuka, 2018), hence UCD.

13.8 Problematisation

The researcher identified various categories of stakeholders in maternal health care, including clients, health care providers (hospitals, health care personnel), CHWs, administrators and government. It was noted that the information needs of stakeholders vary due to the diverse roles and responsibilities of individuals, thereby making the situation complex. Thus, in order to deliver quality services to clients, stakeholders need to work collaboratively, internally (within the organisation) and externally (beyond the organisation); this includes the sharing of client information and referrals.

However, current information services provided in public health facilities are mainly traditional and characterised by paper-based records (the ANC booklet and other print material) and verbal communications (face-to-face and/or telephone conversations). Therefore, information has to be delivered physically in person, from one department or organisation to another due to geographical distance, which makes it impossible for stakeholders to engage in any meaningful collaborative practices given the nature and limitations of manual information services. As a result, this situation continues to compromise

the quality of health care services due to poor information processing and ineffective management procedures. This leads to limited data storage space as well as limited data, access, retrieval and sharing, with increased cases of data loss, damage and insecurity.

More importantly, it was noted that health care services are fragmented, causing data silos (World Health Organisation, 2016b) within individual institutions and the lack of patient-centric care as system/service integration is not possible. Ultimately, poor funding by government is the main reason for the aforementioned situation, which results in acute shortage of resources to run operations in public health facilities. Specifically, the entire health care system is compromised by staff shortages, inadequate commodity supplies and health information infrastructure, among other issues, which, in turn, compromises the quality of health care.

To address this and improve current information services, it was observed that a re-design of current services, including the incorporation of ICTs into maternal health care, is needed. For this re-designing of services, the researcher used a combination of theories, methods and techniques to address this complex situation. To begin with, the *stakeholder theory* and *SDR theory* were adopted. The relevant stakeholders were identified, who were then engaged throughout the design process to help the researcher understand and interpret the information service requirements.

The *SDR strategy* assisted with contextualising the services to enable the development of a solution(s) with meaningful use (Caligtan & Dykes, 2011; Moritz, 2005). The two theories were applied to facilitate active stakeholder participation in order to create user-centred design service(s) acceptable to all. In terms of methods, the researcher used the SDR strategy, co-design, qualitative and agile methods to design effective and personalised services.

The *SDR approach* was used to facilitate contextual inquiry into the research problem through listening to the views of stakeholders and then involving them with designing the new improved service (solutions) with meaningful use in their context of use (Moritz, 2005). The co-design process involved ideation, conceptualisation and prototyping activities, whereby the designer (researcher) partnered with users to take account of their perspective in knowledge development towards product development in its context of use (De Figueiredo & Da Cunha, 2007; Tsekleves & Cooper, 2017).

The activities helped include user feedback and ideas during the design process to deliver user-centred design service hence participatory and co-operative design (Thobias & Kiwanuka, 2018). Qualitative methods used include interviews and observation to elicit stakeholder opinions, ideas, perceptions, attitude and beliefs, among others, to inform the design process towards the desired solution. The agile method was used, specifically RAD, to

enable continuous feedback and faster application development to save time and costs (Khan et al., 2012).

Stakeholder mapping was done using the snowball sampling technique to identify key stakeholders engaged with maternal care in order to obtain the correct interpretation of new service requirements (Johnson et al., 2008). Context analysis was done through organising site visits that enabled the researcher to observe and analyse the research environment to gain more insight into the research problem, alongside interviews to elicit user requirements/needs.

A service blueprint for maternity services was used, enabling the researcher to understand the various service touch points, pain points and barriers women face while searching for information to meet their needs in order to design better services (Tsekleves & Cooper, 2017). This enabled the researcher to understand the various technologies, tools and devices to be used in creating new services, that is, mobile technologies and Web technologies, including affordable large-scale innovations such as cloud technologies to facilitate system/service integration (Miah, 2017), and eHealth standards, among others.

The service prototyping technique was used because the researcher observed user interaction in new services, which facilitated the necessary modifications to tailor the service towards the desired situation.

13.9 Information service concepts

This sub-section highlights information service concepts revolving around development of the proposed new services (solution) to the research problem. A co-design process (i.e. design, develop and test) was applied to deliver the new services using a variety of design methods, tools and techniques. These included focus group discussions, observations, case scenario, user journey/service blueprint, Inkscape software (graphics editor tool), prototyping (Salgado et al., 2017; Moritz, 2005) and the ANC booklet (Mother and Child Health Handbook).

The design process incorporated various design principles, including: principles of IS design theory (Gregor & Jones, 2007); principles of IS design theory: materiality-oriented and action-oriented principles (Chandra et al., 2015); principles of interpretive field research in IS (Klein & Myers, 1999); and principles of the IPCHS framework (World Health Organisation, 2016b). The process involved engaging participants/ participatory design, defining the purpose and scope of the study, defining various constructs, defining the form and function of the IS artefact architecture, expository instantiation as well as the contextualisation of the new service and interaction between the researchers and subjects (World Health Organisation, 2016b; Gregor & Jones, 2007; Klein & Myers, 1999; Thobias & Kiwanuka, 2018).

The subsequent sections provide a detailed description of the various components of the proposed new services, which include relevant IT infrastructure, service layer, information layer (information architecture relevant to the interface), and user layer (user interfaces at the various touch points). This is illustrated through use of various models, namely the research model, data model, business models, case scenario and information flows, architectural design and interfaces.

13.9.1 The service layer

The aim of this research was the integration of health information services to promote access to maternal health information and health care collaboration among relevant stakeholders (pregnant women, CHWs, health care providers, facility administrators and government) in Nairobi County, Kenya. Specifically, the design of the service prototype is based on service touch points in the user journey/maternal pathway as presented by (Salgado et al., 2017).

Figure 13.2 is a typical example of a service blueprint illustrating the touch points on the user's journey, that is, the maternity pathway adopted from the BOLD project by Salgado et al. and used by the researcher during co-design sessions to help clarify issues and elicit reactions from participants to inform the prototype design.

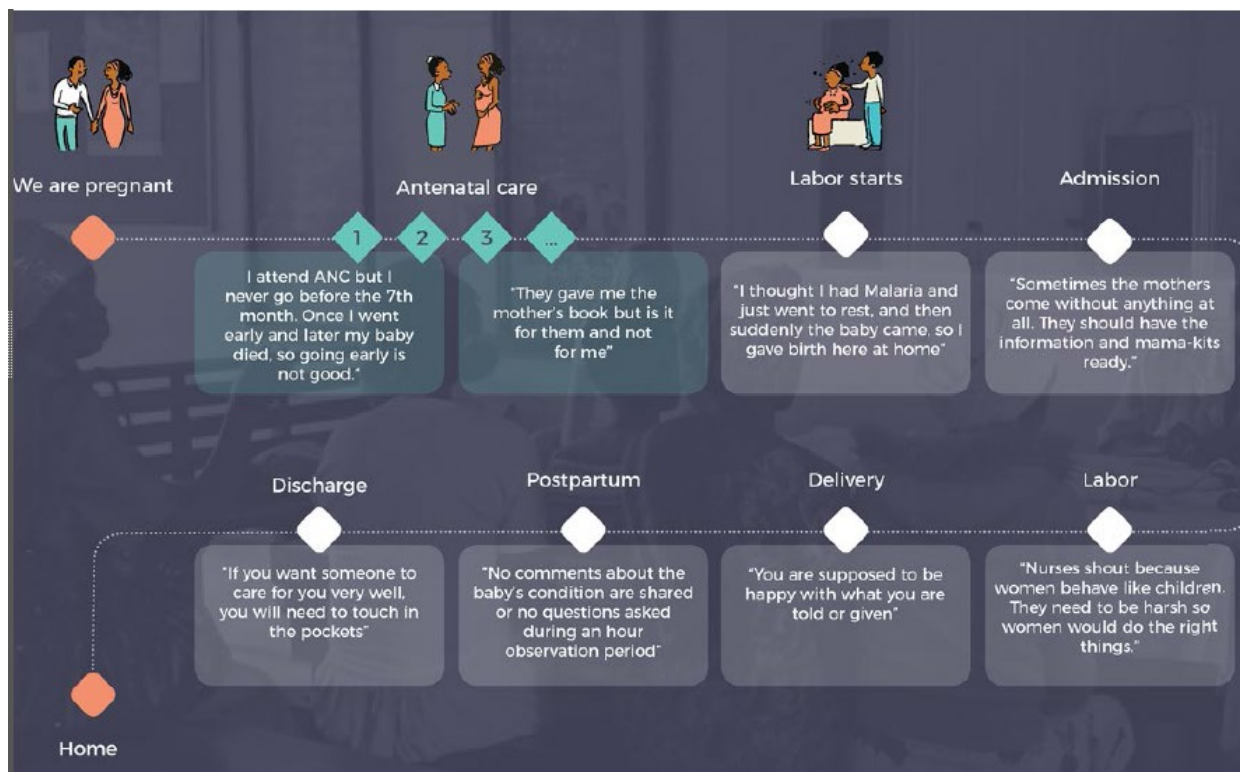


Figure 13.2: Touch points in the maternity pathway/user journey
(Source: Salgado et al., 2017:62)

Figure 13.3 is a case scenario to illustrate the nature of desired community health services (as the solution) towards improving the quality of maternal care. It captures various stakeholders of maternal health care, interactions involving service providers and information flows between different stakeholders, i.e. clients, CHWs, health institutions (community and referral facilities), caregivers (midwives and doctors), government and medical research institutions. It also shows the key technologies to be used, namely CC, mobile and Web technologies.

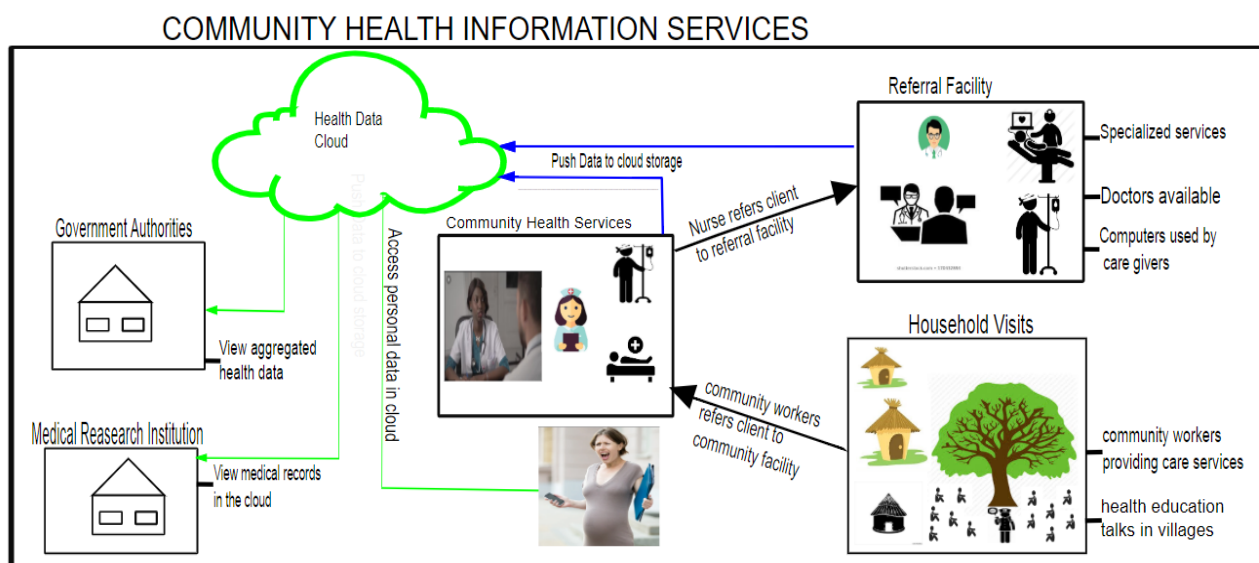


Figure 13.3: Case scenario for community health information service in Nairobi County

13.9.1.1 Scenarios and data flows

Table 13.1 explains the five (5) major scenarios captured in the context data flow diagram (DFD) on information flows:

Table 13.1: Information flows and scenarios for the proposed application

Case scenario	Description
1	The client will have direct access and control with full view of their PHR data in the cloud from multiple sources via personal mobile application for monitoring, tracking and self-management. The doctor must seek client consent to view the patient's full PHR history at the point of care/hospital.
2	CHWs shall refer clients to community health facility and also for follow-up, counselling and ensuring compliance with preventive care guidelines using the mobile application.
3	The service provider (government) will be super admin to add details of health care providers and research institutions in the system while the hospital administrator will add individual facility staff and patient details in the system using the Web application. Hospitals can only have direct access to patient data that are generated locally within the facility.
4	Government/MoH will only have access to aggregated health data in the cloud to generate reports for decision-making and disease surveillance through the Web application.

5	Medical research institutions will only have access to anonymous medical records in cloud storage for clinical/medical research purposes through the Web application.

13.9.1.2 *Service prototyping*

Based on the research context and the findings, the researcher opted to use the SDR approach, which has the capability to apply design principles to engage users in co-creating practical tools to enhance the quality of maternal care in underserved environments (Salgado et al., 2017). The authors refer to service as “a series of interactions between providers and users of a service” (Salgado et al., 2017:57). The SDR strategy therefore involves engaging stakeholders throughout the SDR and development process, thus enabling the researcher to gain deeper insight into the research context and then generate co-design solutions with users through the interpretation of the needs and behaviour of stakeholders.

Various methods and tools (mainly co-design sessions) are used to identify touch points (key moments) for users while accessing services, including the experiences resulting from using those services during interactions between clients and service providers. Being both a holistic and a multidisciplinary-based approach, SDR enables the researcher (who is also the designer) to produce services that can address client needs, including the functional, emotional, tangible and intangible perspectives of a service, thus promoting innovation (Teixeira et al., 2019). It takes into consideration the interests of the client, the service provider (health care provider in this case) and the health system itself, thus promoting the integration of the service ecosystem, according to Salgado et al. (2017).

Besides group interviews and brainstorming session with participants, more data were obtained using various tools, including maternity service blueprinting and the ANC booklet, which informed the researcher of possible barriers women encounter when seeking services. Also, design features were established, including menu screen items for the service prototype (mobile application). These include maternal profile, medical and surgical history, clinical notes, physical examination and ANC profile elements, as shown in the ANC booklet (Figure 13.4).

Participants contributed ideas by writing on sticky notes, which were then displayed on the board for comparison, as illustrated in Figure 13.5. This helped to identify common ideas on design features for the intended solution (cloud-based PHR service) to help track and monitor personal health data. This was done with reference to the typical example of the user journey/maternity path in the study by Salgado et al. (2017), which illustrates various touch points (key moments) from the time a woman realises she pregnant through ANC, labour, admission to hospital, baby delivery, the postpartum period, and the eventual discharge from hospital. This helped both the designer and participants to gauge the applicability of the desired

change in their context as opposed to the current situation. This was done alongside the mapping of user practices, user needs and behaviour as input for the design.

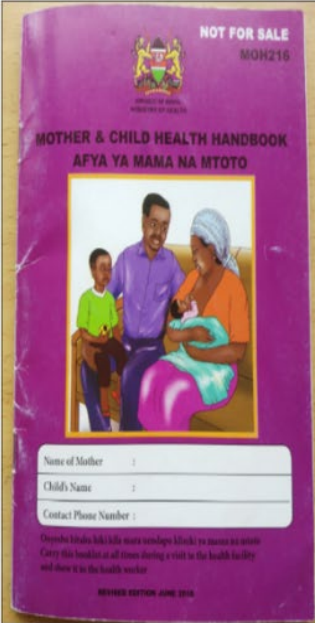
		Table of Contents	
Father's Support 2		SECTION 2 (CHILD HEALTH MONITORING)	
SECTION 1 (ANC, DELIVERY AND POSTNATAL CARE)		Particulars of child and family 23	
Maternal Profile 4		Broad clinical review at first contact below 6 months 24	
Medical and Surgical History 5		Developmental Milestones 25	
Physical Examination (First Visit) 5		Identification of early eye problems in an infant 25	
Clinical Notes 6		Reasons for Special Care 26	
Antenatal Profile 7		Weight for Age boys 27	
Infant Feeding 7		Length/Height for age boys 28	
Weight for Date Chart 8		Weight for age girls 29	
Preventive Services 9		Length/Height for age girls 30	
TT Instruction Notes 10		Growth Monitoring Return Date 31	
Dental Health for you and your baby 11		Immunizations 32	
Clinical Notes 14		Other Vaccines 33	
Care during pregnancy 15		Vitamin A capsules from 6 months 34	
Danger signs during pregnancy 15		Deworming from 1 year 34	
Delivery 16		Identification of exposed children at 6 weeks or soon thereafter 35	
Breastfeeding: Positioning and Attachment 16		Health worker consultations 36	
Early Identification of Impairments and Disabilities 17		Hospital Admissions 38	
Care of Mother and Baby after birth 18		Special Clinic Attendance 39	
Guideline for healthy eating 18		Feeding Recommendations during sickness and health and care for development 41	
Go to health facility immediately if 19		Recommendations for Care for Child Development 42	
Post Natal Examination 20		When to return immediately 43	
Reproductive organs cancer screening 21		Fluids for any sick child 44	
Family Planning 21			
Clinical Notes 22			

Figure 13.4: ANC booklet and contents



Figure 13.5: Joint analysis by designer and participants to map ideas to a menu screen

Focus group discussions, which involve discussions and co-design activities to generate paper-based prototypes as well as role-playing situations, are conducted to facilitate the designer's understanding of health and emotional needs of the users through the maternity pathway. In the case of this study, service prototypes were used during discussion sessions whereby potential users, including women, CHW/Vs and caregivers, had the opportunity to express their different views/opinions and criticisms to generate the initial concepts (Figure 13.6). This facilitated the identification and clarification of important themes as input for design (requirements), and the subsequent development of tools to aid health care providers with providing user-centric maternal care services.



Figure 13.6: Women discussing design requirements for desired PHR service

Service prototypes were created, which enabled the researcher to improve and refine ideas towards creating the desired design solution in the context of use. Therefore, concepts were generated, prototyped and tested iteratively until the desired solution was delivered (Salgado et al., 2017). The researcher constantly checked on the functionality, usability and service desirability by monitoring participants' reactions. Feedback from users was integrated into the prototype during co-design sessions until the final design was attained, with close inspection of mobile screen layouts, menu items, font size and functionality by both the researcher and participants.

According to literature, the human-centred SDR approach was successfully used in the past to address issues in health care, including maternal care, and has yielded impressive results in terms of improved innovative services, project management and the recognition of organisational culture, among other merits. This approach has been used in various projects, including: the Cardboard Hospital Project to prototype patient-centric environments and services for hospitals in Finland; The Nurse Knowledge Exchange Systems Initiative to improve the nursing culture in USA; describing benefits of using Experience Based Co-Design (EBCD) to engage caregivers of malnourished/HIV-positive children to enhance hospital-based quality improvement interventions in South Africa; and the WHO's "Better Outcomes in Labour Difficulty (BOLD)" project to develop the "Passport to Safer Birth" in Nigeria and Uganda (Bate & Robert, 2006; Kronqvist et al., 2013; Lin et al., 2011; Van Deventer et al., 2016).

This research therefore used the co-design-oriented SDR approach in the Kenyan context to develop the CPHIA model, which was validated through the creation of a prototype

service (AfyaTab) to improve the management of maternal health and wellbeing information services. Specifically, the CPHIA framework guides the designing of patient-centred eHealth interventions in terms of creation, storage, access, viewing and generating reports by various stakeholders in maternal health care according to their needs, which include health care providers (hospitals and health care personnel), clients/patients, and government authorities (MoH).

The proposed services will be accessed via a mobile device for clients and via a desktop computer for health care providers/professionals. The following are the Mobile screens and the application flow of the service prototype for the client:

Figure 13.7 represents the mobile login screen and the application flow screen.

Figure 13.8 represents the Menu, Maternal profile and Physical examination screens,

Figure 13.9 represents Medical and Surgical history, Family planning and ANC profile.

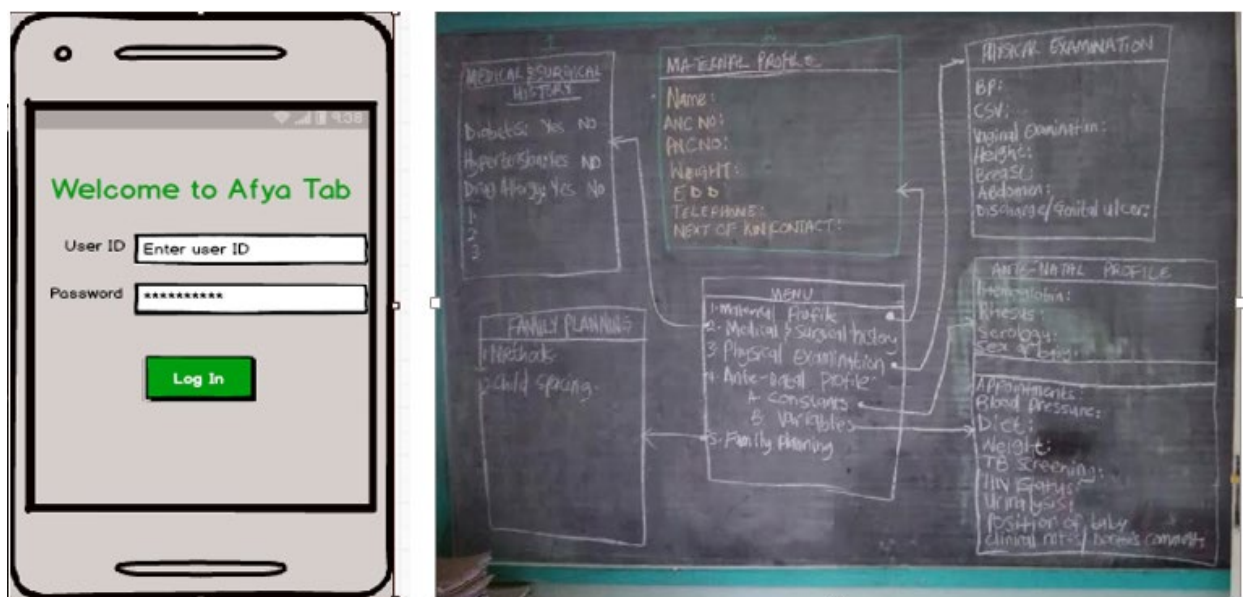


Figure 13.7: Mobile login screen and application flow

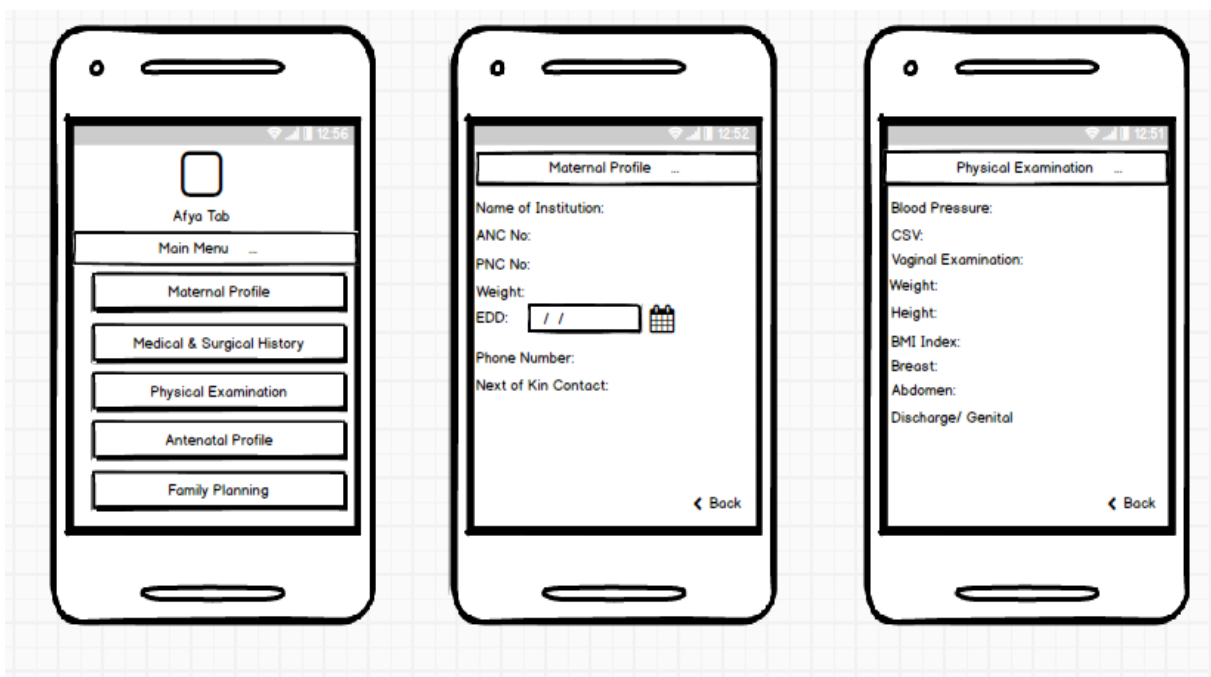


Figure 13.8: Mobile Application screens for Menu, Maternal profile and Physical examination



Figure 13.9: Mobile Application screens for Medical history, Family planning and ANC profile

13.9.2 Information layer

This phase involves the systems analysis and design process to establish information flows and the distribution of the information, which was be used to design the business process model in relation to the business functions. This helped discover *how*, *when* and *what* factors would favour successful information flows within the intended system.

Figure 13.10 is the business use case model that was developed for the project, showing the various actors, their roles and actions as well as interactions with the system.

13.9.2.1 Business Model

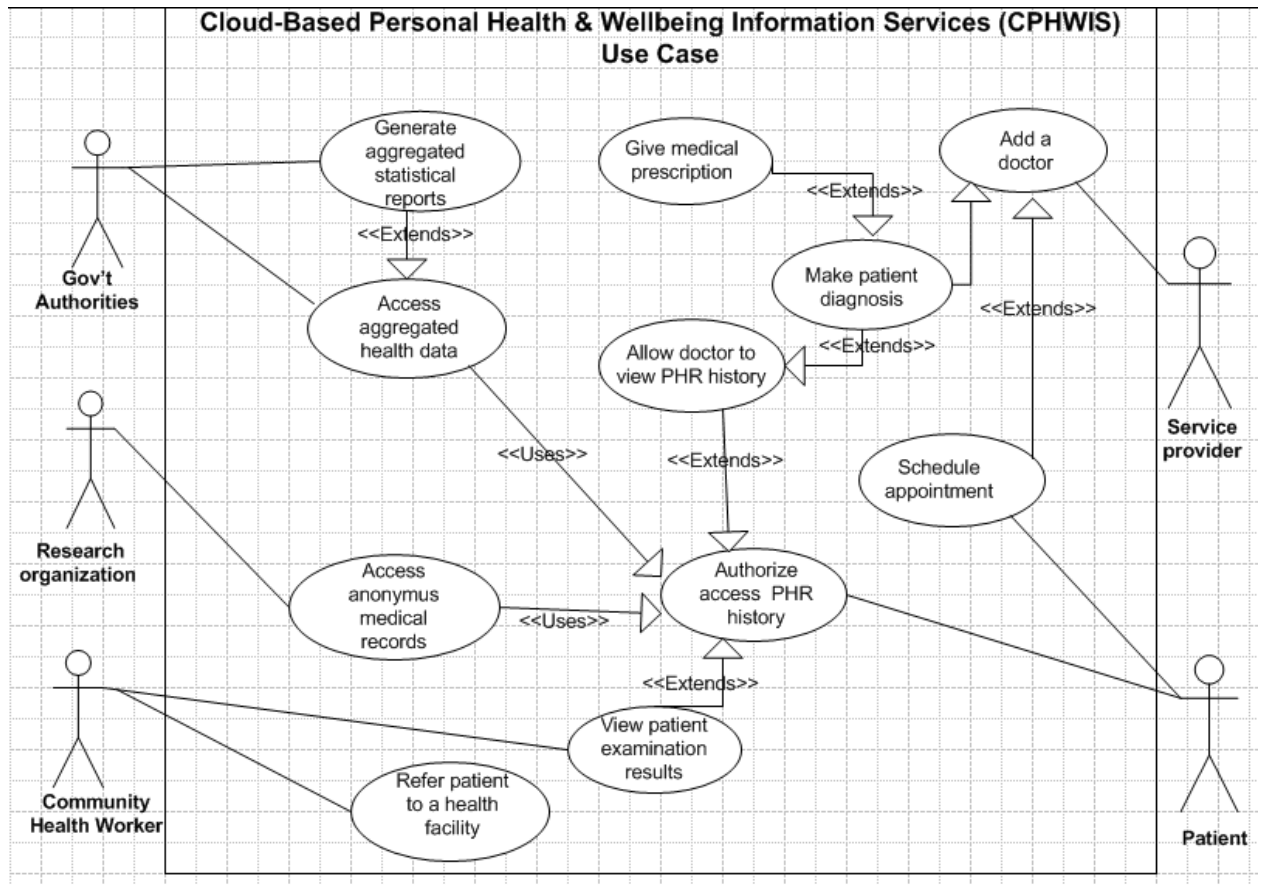


Figure 13.10: Use Case Diagram for proposed cloud PHR services

13.9.3 Flow diagrams

This phase provides illustrations on how information will flow among various users including the data model using context level diagram (context DFD) and architectural design for new information services.

13.9.3.1 Data modeling

Data modeling is the formation of data objects based on the information gathered during the business-modeling phase. The attributes of data objects are identified while the relationships between them are established. These relationships are further defined using a DFD and architectural design diagram for the proposed project. Figure 13.11 illustrates the data flow diagram for proposed the PHR services.

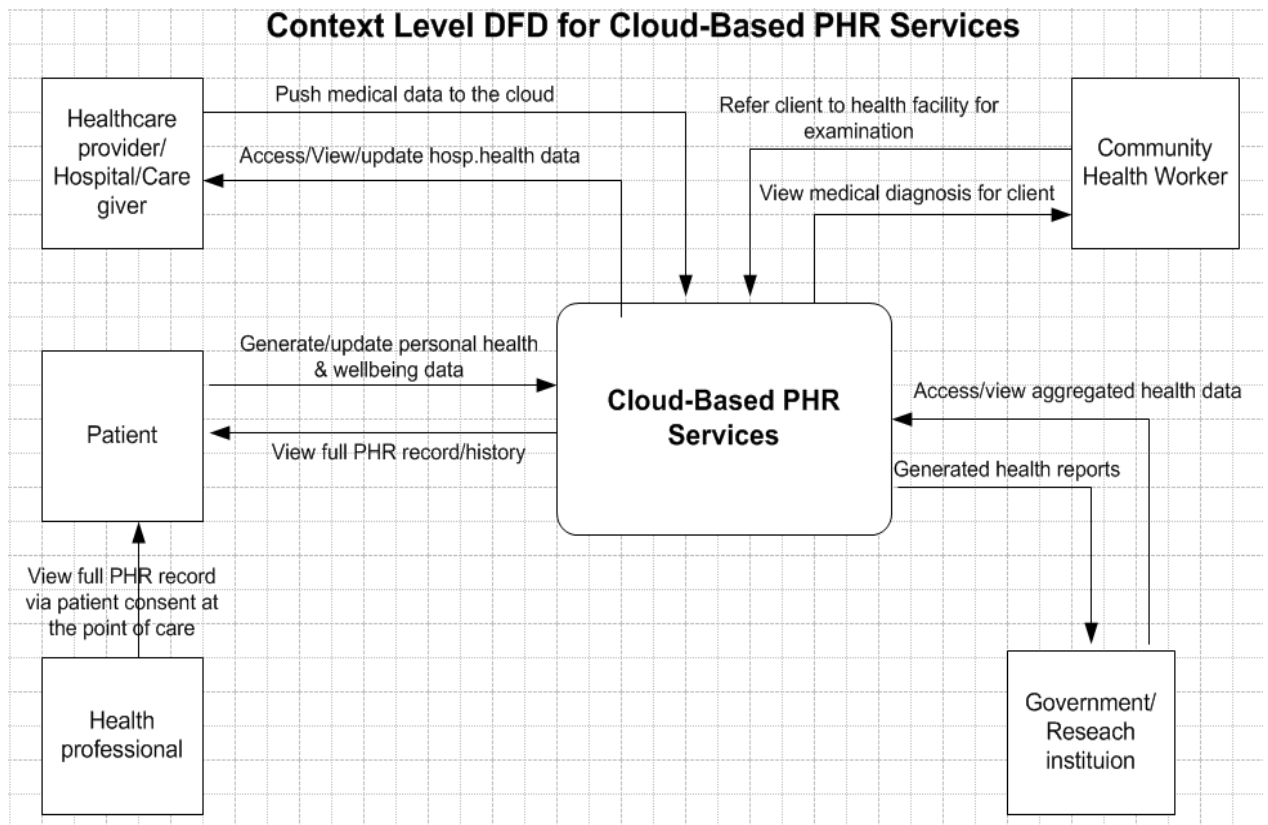


Figure 13.11: Data Flow Diagram for proposed PHR services

13.9.3.2 Architectural design

The business architectural design model shown in Figure 13.12 depicts the various components of the prototype system, including data storage in the cloud, an API interface, the various entities, query engine (data analytics), and care activity and service interactions.

i) Data Storage

Health data are patient data generated on the patient's record and include the patient's demographics, allergies, vital signs, prescriptions, medications, immunisations, laboratory tests, radiology reports, blood sugar level, blood pressure, and heart activity, among others (Heart et al., 2017).

This data may be collected from different sources (hospitals), including home monitoring devices as well as EMRs, including EHRs and PHRs from health various institutions, which will be transmitted and stored in the cloud. Examples of home monitoring devices to be implanted in the human body may include glucometers, electrocardiogram (ECG) sensors, thermometers, and smart phones, among others (Alyami et al., 2017).

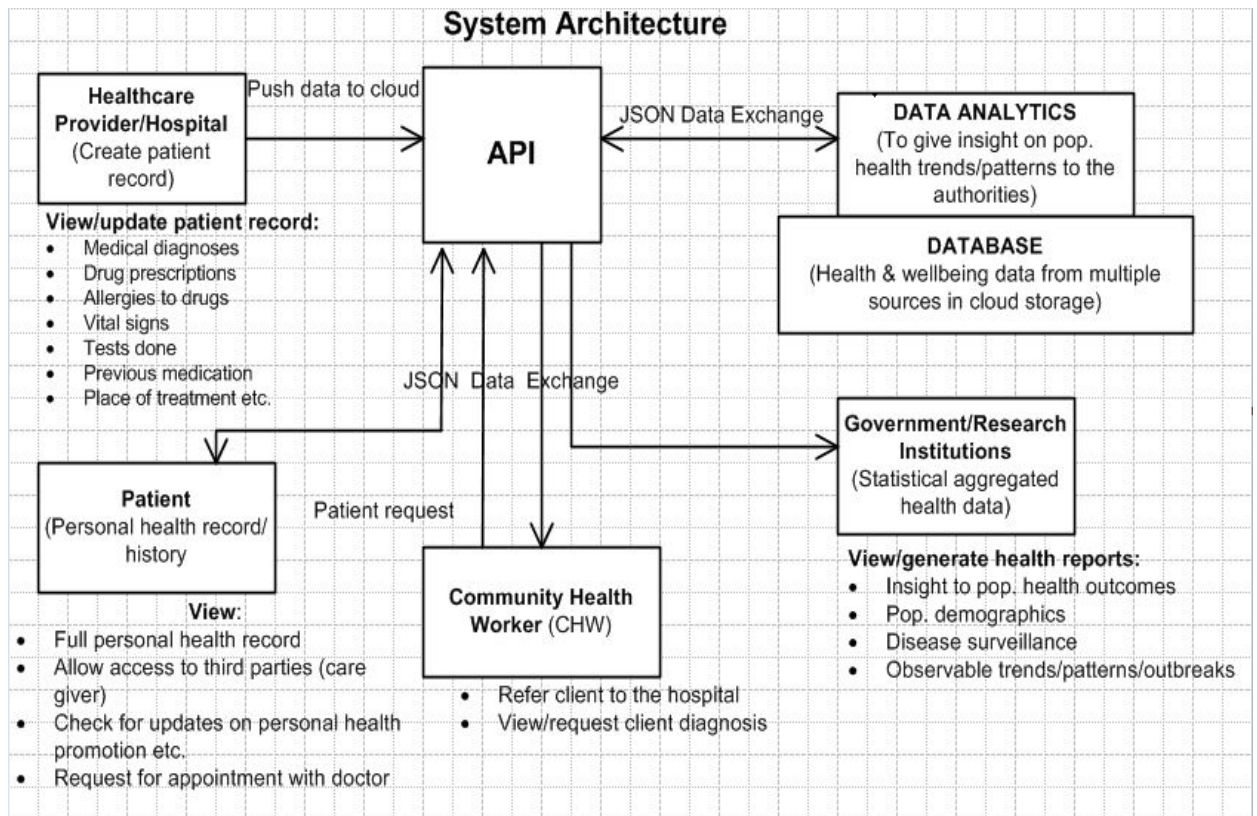


Figure 13.12: Design architecture for proposed PHR services

ii) Data security

Health care data are sensitive and therefore requires protection for high-level security and privacy to guarantee data confidentiality, availability and integrity (Ali et al., 2018; Hu & Bai, 2014). Cloud computing (CC) has the capability to provide data security as a service (SaaS), which is to be built and provided inside the cloud infrastructure to fight security threats (Nkosi & Mekuria, 2010).

Potential data security risks of the proposed PHR system will be addressed through three perspectives: the cloud service provider's side; the client's side (patient and health care provider); and the channel's (transmission) side. The cloud provider will employ key management techniques based on adequate cryptographic mechanisms on data in cloud storage. Access control will be achieved through role-based access, with server authentication services on devices (Nkosi & Mekuria, 2010).

On the client side, the health consumers will be empowered to allow the caregiver access to specific data at the point of care and updating records with new diagnosis, prescriptions, and other information. On the channel (transmission) side, SSL (Secure Sockets Layer virtual private network) will be used to ensure data are not open through the transmission process to storage in the cloud. Also, this will ensure that users are not forced to install the relevant software on their devices.

iii) Query engine

Figure 13.12 is a representation of the proposed PHR service architecture, including a query engine as well as its components, and the various users to query cloud-based health data from different sources, as shown in the illustration. The proposed query engine will be based on SQL Database to enable users to generate reports from data in cloud storage. The engine will have an application programming interface (API) key and a data exchange format, namely JSON. Advantages of JSON include faster execution of data; easily adopting available data, thus flexible; fast parsing on the server side; and the best for sharing data of different sizes, including text, audio, and video, among others, since it stores data in arrays for easier transfer as opposed to XML (Sharma, 2016).

iv) Care activity and service interactions/touch points

This refers to the various electronic service touch points, that is, human-to-computer interaction involving various health information stakeholders. Different actors will interact via the system during care activity, for example, patient vs. CHW/V; patient vs. doctor; doctor vs. nurse; department vs. department; hospital vs. hospital; and vice versa during a health care activity throughout the maternity partway/process (Lee, 2017). Such activities may include care during appointments/clinic visits, labour, admission, delivery, postpartum and discharge. In terms of distribution and access to electronic information, it will involve activities such as consultations; patient access and viewing their own records; doctors viewing and updating patient records; renewal of patient prescriptions; and email communication, among others (Caligtan & Dykes, 2011). Also, in this case, government and research institutions would want to view health data and generate reports.

13.9.4 The user layer

This phase describes user requirements (functional/non-functional), delivery of the potential prototype system and user interfaces for various entities, and how they will interact with the new services at various touch points. Specifically, the application will comprise two main parts, that is: Web application for service providers (community and referral facilities) and government/MOH; and mobile application for clients.

13.9.4.1 Requirements

This involve the co-existence of an interrelationship(s) between humans and machines for required assembling to deliver quality and quantitative programming items, including user requirements, system requirements and software specifications (ELkafrawy & Khalaf, 2016). Specifically, this sub-section highlights both functional and non-functional requirements/characteristics that must be fulfilled to make the new services meet the users' expectations. These characteristics are a set of concerns related to system quality in order to serve its purpose well (Chung & Do Prado Leite, 2009).

13.9.4.1.1 Functional requirements

These are requirements that describe functionality (*what* a software system should do), i.e. specific activities the system must perform for users to accomplish their tasks. This type of requirements provides statements on how the system should react to certain inputs and the expected system behaviour in particular circumstances and/or situations (ELkafrawy & Khalaf, 2016). Based on various users' roles, the proposed prototype system will enable users to perform the following tasks:

- Clients should be allowed to have control over access to personal data in the cloud, and to authorise health professionals to view their full PHR history in the cloud
- Health care providers (health facilities and health professionals) should create, store, and update client records in local storage without seeking client consent
- Health care providers (health facilities and health professionals) should freely send client data in the local server to the central server in the cloud
- Government/MOH is the super admin for controlling service delivery; they can access and view anonymous medical records, view aggregated health data, and generate statistics in cloud storage for disease surveillance, decision-making and research purposes

13.9.4.1.2 Non-functional requirements

These refer to conditions on services offered by the system that are not specifically related to system functionality and/or its execution, such as timing requirements, and limitations on the development process and standards, among others (ELkafrawy & Khalaf, 2016). They place restrictions while the product is being developed, whereby they specify external constraints that the product should satisfy. The proposed system includes, but is not limited to the following requirements:

i) Interface requirements

The landing page will enable the users of the system to navigate through the menu. It is mainly a description of how the system will interface with its environment, users and other systems, for example, user interfaces and their qualities, such as user-friendliness, among others (Chung & Crawford, 2016).

ii) Usability requirements

Usability refers to a variety of concepts, including system execution time, performance, user satisfaction and learnability, among others. According to Abran et al. (2003), a good system should enable users and potential customers (health care consumers, hospitals, health professionals, government, and medical research institutions) to perform their tasks via the system. For example, in this case, potential users should be able to sign in, create an account

and user profile, log into the system and access health data and other services by means of role-based access control.

iii) Security requirements

Each system user must have a valid account and log in credentials to access the services by means of role-based access control, hence the need to put in place logical security measures and precautions to ensure security in terms of permissible information flows (Chung & Do Prado Leite, 2009). This is to guarantee privacy, confidentiality and the safety of personal health data/information in the system database.

iv) Reliability requirements

The system should allow users to enter their inputs correctly and process the desired output without failure. It must also be robust in that it will not fail fully in case of any unanticipated failure. The system should be flexible and adequately reliable, i.e. accessible through various client devices, including mobile phones, which are widely used in Kenya. Important attributes considered include frequency or severity of failure, if any, recoverability, predictability, accuracy, and mean time to failure (Chung & Do Prado Leite, 2009).

v) Performance requirements

The system should be adequately scalable to handle the workload comfortably, while bearing in mind that there will be huge traffic since the system will have many users. Performance requirements therefore provide a description of performance constraints involving time/space bounds, including workloads, survivability, such as system endurance under fire, natural disasters, response time, through-put as well as available storage space, for example the number of transactions the system must process per second (Chung & Do Prado Leite, 2009:368).

vi) Interoperability requirements

The system should have the capability to share and/or exchange data/information and services. Interoperability refers to the degree to which the information and services are to be shared, especially in a complex organisation. In computing, there are two types of interoperability, namely syntactic interoperability associated with specific data communication protocols and formats to ensure communication and data exchange, and semantic interoperability, which enables two systems or more to exchange information (Ide & Pustejovsky, 2010).

vii) Supportability requirements

The system should be adaptive to technological changes and easy to maintain and/or upgrade in case of any changes. Important attributes include system testability, extensibility, adaptability, maintainability, compatibility, configurability, serviceability, installability, localisability, and portability, among others (Chung & Do Prado Leite, 2009).

13.10 Delivery of potential prototype service/system

Based on the analysis performed on the project variables, namely time, cost and project scope, the researcher adopted both the *Rapid Application Development (RAD) model* and the *Structured System Analysis and Design (SSAD) approach*. RAD involves prototyping and repetitive development hence an incremental software development process model which emphasise a short development life cycle and encourages constant feedback from the clientele/users during the software development life cycle (Khan et al., 2012). Advantages of this approach include: faster development as it avoids extensive pre-planning; user involvement, thus create a sense of belonging for all; quick results delivery, and saving costs, easier change of requirements; the realisation of productivity with less people in a shorter period; and easy measuring of progress (Khan et al., 2012). A major disadvantage of RAD, however, is that it is only suitable where requirements are well known while it requires user involvement throughout the development process.

13.10.1 System development tools

The following are the specific development tools used to create the prototype system:

i) User interface tools

Since the prototype system is expected to be a combination of mobile and Web applications, the mobile user interface will be implemented using the Java language. The Web application will be implemented using HTML5, JAVASCRIPT, JQUERY and AJAX languages together with a style sheet, CSS. The project intends to use Java as it is well-known and easy to use. By using of these tools, the project should come up with the front-end designs. The researcher intends to use Visual Studio code as the integrated development environment.

ii) Database tools

To offer fast and reliable services from a server side, the project will use the Golang programming language, which will facilitate the front-end data. By using micro services, incorporated with modular programming, the project intends to ease the implementation phase, which, in turn reduces the time taken in this phase. In addition, queries are to be written using Gin-gonic, which is a Golang framework. Deployment will be done on a cloud-based system, specifically Digital Ocean, which offers scalable clusters, pooled bandwidth, an easy to use CC platform of virtual servers and easy deployment. All aforementioned tools sum up the back-end prerequisites for the project.

iii) Client interface

The clients will mainly use a mobile device to access and track personal health data. Below are the screens shots illustrating the various client user interfaces on a mobile device as shown in Figures 13.13 and 13.14.

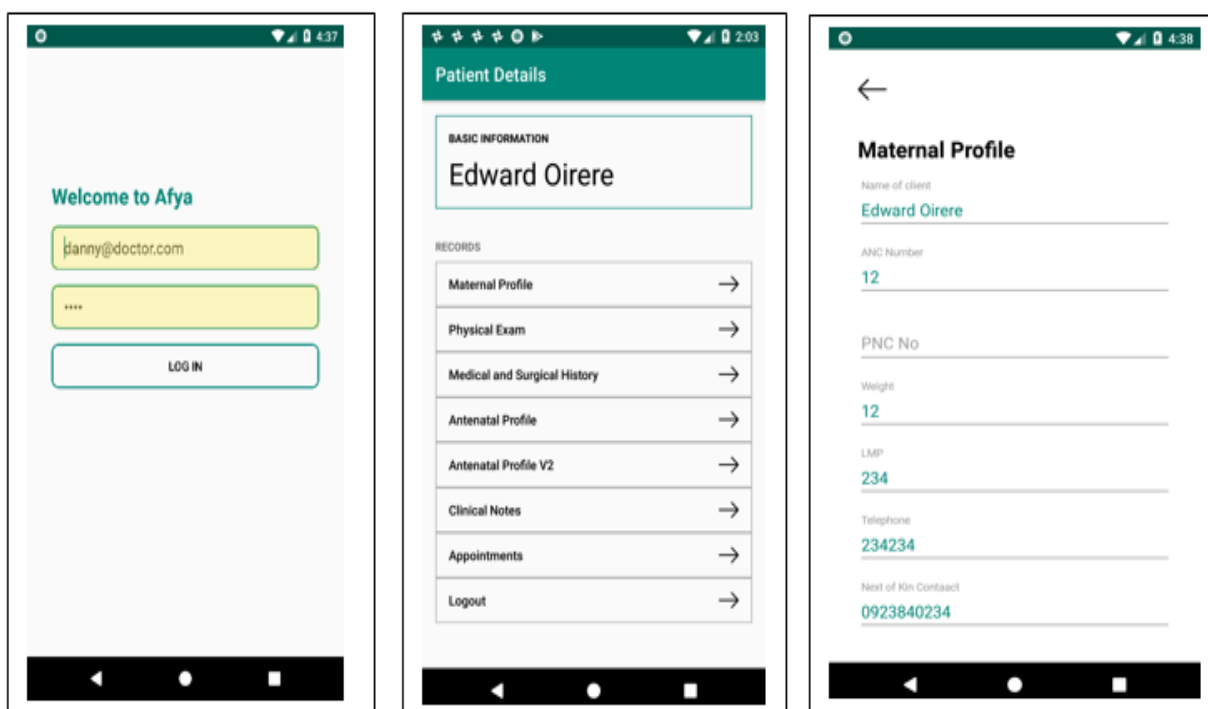


Figure 13.13: Client user's interfaces for log in to Client and Maternal profile

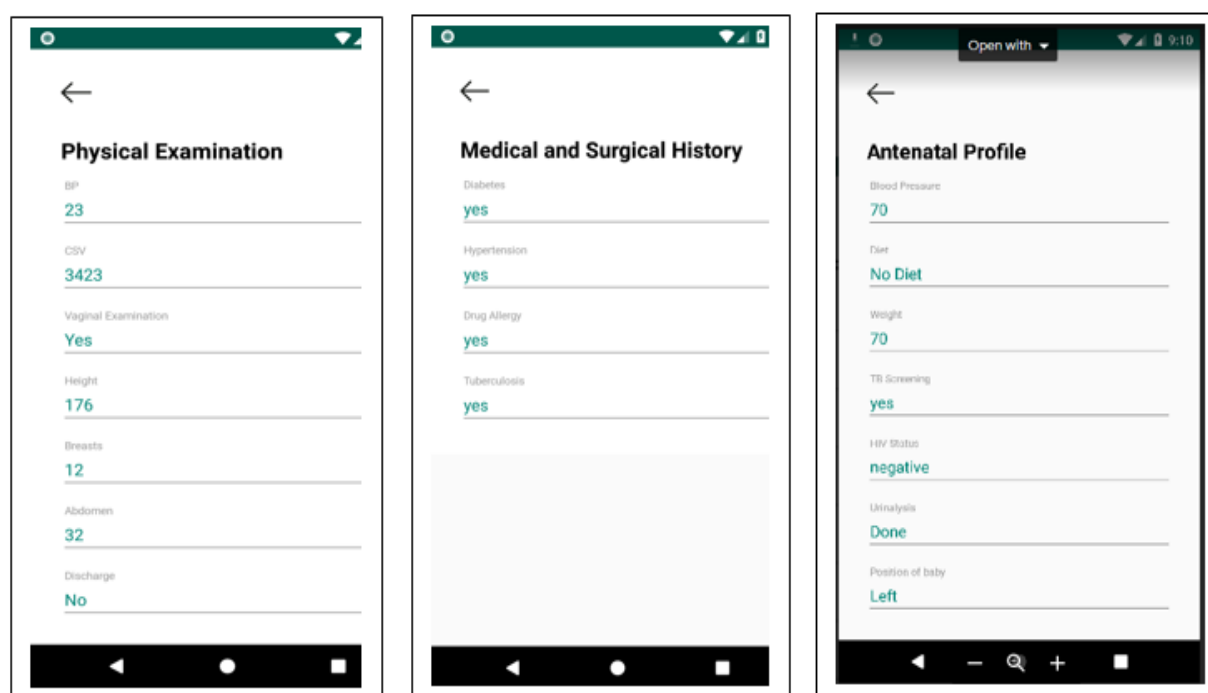


Figure 13.14: User interfaces for physical examination, medical history and ANC profile

iv) Health care provider's interface

The service provider, which includes health professionals and government/MOH, will use the desktop computer to access, view, and update records and generate reports in the system.

Below are screen images representing various interfaces for the health care providers, as shown in Figures 13.15, 13.16 and 13.17.

- **Log in window for health professionals**



Figure 13.15: Health professional's log in window

- **Health care provider's landing page for health care provider**

PATIENTS				
ID	First Name	Last Name	Email	Date Created
300008	Damaris	Kemunto		Thu Aug 29 2019 23:22:41 GMT+0300 (East Africa Time)
300009	Beth	Musotu		Thu Aug 29 2019 23:29:09 GMT+0300 (East Africa Time)

DOCTORS					
ID	First Name	Last Name	User Type	Email	Date Created
18	Edward	Oirere	Doctor	eoirere8@gmail.com	Mon Aug 26 2019 16:50:15 GMT+0300 (East Africa Time)

Figure 13.16: Health care provider's landing page

- **Doctor's view of client PHR history**

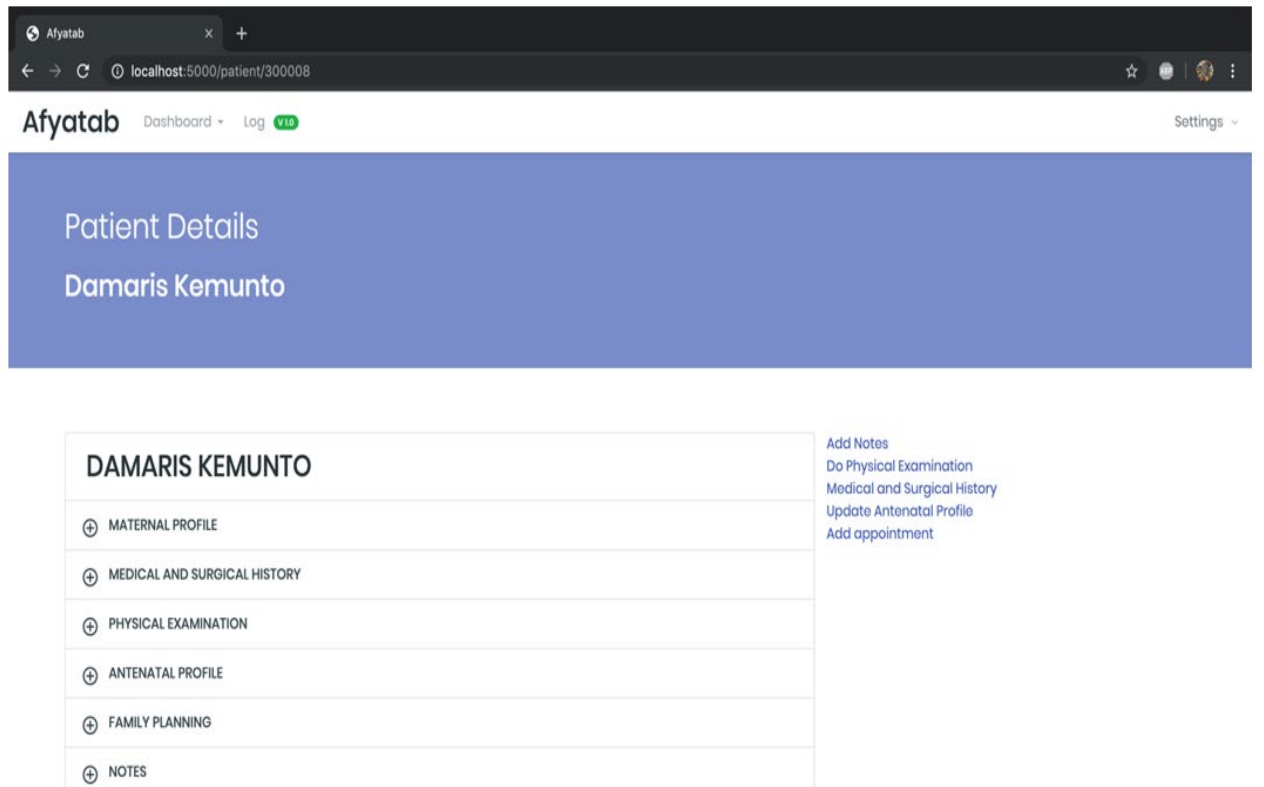


Figure 13.17: Doctor's view of client PHR history

13.11 System/service evaluation: Proof of concept

The prototype system was developed to help validate functionality of the new service (cloud-based PHR service) in practice as proof of concept of the design (Nunamaker Jr et al., 2015). The following is a detailed description of activities involved in the process of evaluating the newly created service, which includes process modelling, application generation, testing and cutover tasks. The system prototype was mainly used to ascertain the degree of meaningful use of the service in its context of use.

13.11.1 Process modelling

More concentration on the business was given during this phase and involved the conversion of the data objects to establish business information flows needed for achieving the project objectives. Future changes on the data objects were defined while manipulation of the data objects, including CRUD (create, read, update, delete) processes, were defined.

13.11.2 Application generation

This phase involved the implementation of the desired PHR service (system), whereby the data models and processes were converted into the real prototype system. This was achieved by generating the system code, whereby information gathered throughout the

previous phases, including co-design sessions and prototyping, aided in the implementation process.

13.11.3 Testing and cutover

Testing in this phase was minimal since independent tests were performed with all prototypes. Specifically, most of the testing was done on the interfaces created in the application generation phase, as shown in Tables 13.2 to 13.5.

13.12 Actual system implementation and testing

Table 13.2: Test case

Test ID	Related requirement	Inspect check	Pre-condition	Test data	Priority test
T1	Allow sign-up	Authentication	Bio-data	- National ID/ Birth Certificate No. - Password	Very important
T2	Allow log-in	Authentication	User name and password	- Phone No. - Password	Very important
T3	Update entries	Data format	Validation of data	Client health records	Very Important
T4	Allow viewing of records	- Data retrieval - Data format, structure and appearance	Authentication	Client credentials	Very Important
T5	Allow client to authorise doctor to view full PHR record	- Prompt client for authorisation - Notify doctor of access to records	- Authentication - Parties should both be in the system - Doctor has no access prior to granting access	Doctor request for data access	Very Important
T6	Allow health professionals to book appointment with clients	- Booking details validation - Client notification of a proposed appointment - Reminder to an accepted appointment	- Authentication - Approved health worker	- Health personnel to book an appointment - Client to accept and decline appointments	Very Important
T7	Allow generation of reports	Report generation	- Data availability - Report structure present and in the right standard and format	Generate a variety of reports	Very Important
T8	Allow a service provider/hospital to make referrals	- Ability to make referrals - Ability of service provider to access the referrals module	- Availability of client details - Availability of referral facility details	Make referrals	Very Important

Test ID	Related requirement	Inspect check	Pre-condition	Test data	Priority test
T9	Allow a service provider to update personnel records	Access to personnel data	• Permission to access personal data • Verified service provider	Staff records that need to be updated or created	Very Important
T10	Allow Government to update health facilities details	Government access of the data through an endpoint or portal	• Approved government health personnel • Permission to enter or modify data in the database	Access to facility records	Very Important
T11	Allow Government to view aggregated health data	• The aggregated data structure • Government access to the data	• Approved government health personnel • Permission to access data in aggregated form	Retrieve aggregated data	Very Important
T12	Allow research institutions to view anonymous medical records	• Access to medical records • Client anonymity in the medical records	• Approved medical research institution • System credentials	Retrieval of medical records from the data warehouse	Very Important

13.12.1 Test environment

Table 13.3: Hardware specifications

Manufacturer	Device Name	Purpose
Huawei	Phone	Testing client/patient application
Lenovo	Desktop	Testing website

Table 13.4: Software specifications

Software	Version	Purpose
Chrome Browser	76.0.3809.132	Open website for testing purposes
Terminal (Server Test)	2.9.1	Run deployed server
Postman (API Test)	7.6.0	Test API calls
Android Emulator	25.3.0	Compile and run android application

Table 13.5: Test results

Test ID	Expected result	Actual result	Status	Remarks
T1	The system should sign up an entity	The system signed up successfully	OK	Successful signed-up
T2	The system should allow an entity to log in	Successfully logged-in	OK	Successful log-in

Test ID	Expected result	Actual result	Status	Remarks
T3	The system should update entries made in the database	Successfully updated entries	OK	Successful update
T4	The system should allow entities to view records	Successfully viewed records	OK	Successful view
T5	The client should be able to authorise the doctor to update personal records from multiple sources	Successfully updated records	OK	Successful up- date
T6	Health personnel should be able to book appointment with clients in the system	Successfully booked appointments	OK	Successful booking
T7	The system should generate reports	Successfully generated reports	OK	Successful generation
T8	The service provider should be able to make referrals	Successfully made referrals	OK	Successful referral
T9	The service provider should be able to update health personnel records	Successfully updated records	OK	Successful update
T10	Government should be able to update health facilities record	Successfully added facilities	OK	Successful addition
T11	Government should only view aggregated health data	Successfully viewed reports	OK	Successful view
T12	Research institutions should only view anonymous medical records	Successfully viewed records	OK	Successful view

13.13 User Manual for the Web application

The following is a brief user manual to guide the user(s) on how to manoeuvre through the system and troubleshoot errors.

13.12.1 Troubleshooting errors

i) Input errors

These are the input-related errors made; in such a case, the system will prompt the user to enter the correct information.

ii) Log in errors

When a user enters a user name that does not match his/her password, a log in error occurs in the form of a text display, for example, “user name does not match password, please input the correct user name or password”. The password entered should be at least six characters; otherwise, a weak password error will be displayed, for example, password too weak”.

iii) Wrong data entry format errors

When a user enters a wrong data format in a field not defined in the system database, a wrong data entry format error will be displayed on the user interface, for example, “invalid ID, please input correct ID format”.

13.14 Chapter conclusion

This chapter presented the service co-design process to create new services based on the research findings, including emerging data themes in the research context. Various service concepts were discussed, including the service layer, information layer and user layer, towards creating a prototype service (system) as a proof of concept of the design. In the next chapter, discussions will be based on a summary of key findings, whereby answers to research questions and objectives will be provided in relation to the proposed solution.

PART IV: CONCLUSION

Chapter 14: Discussion

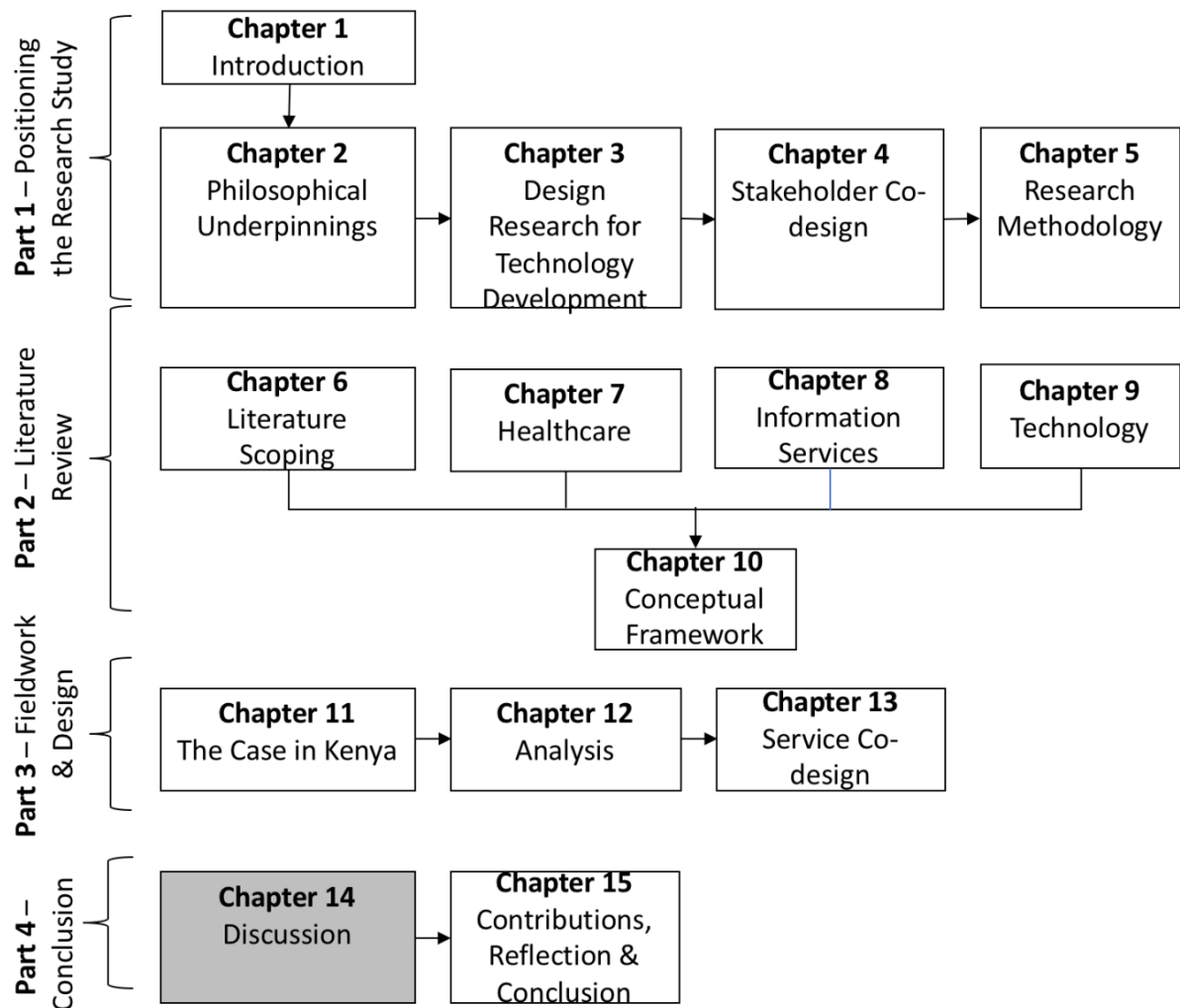


Table 14.1: Thesis Layout - Chapter 14

14.1 Introduction

The chapter presents the discussions based on the research questions and objectives in relation to the proposed solution. Key findings derived from the theoretical findings, data findings, design findings and combined findings are summarised, followed by a detailed discussion of the findings and how the research questions were answered.

14.2 Summary of study findings

The subsequent paragraphs summarise the findings of the study, including the theoretical, data and design findings.

14.2.1 Theoretical findings

From to literature, the researcher identified three categories of stakeholders in the context of Health Informatics, namely: technology developers, i.e. ICT experts/consultants and companies; health care providers, i.e. facilities/hospitals and health care personnel; and the people who are the citizens/members of the public (Groves et al., 2016; Korpela et al., 2013). This finding was noted by the researcher to also be applicable to maternal health information services.

In the case of information needs, literature reveals different types of needs of health care workers, including professional, practical, institutional, cultural and infrastructural knowledge (Pakenham-Walsh & Bukachi, 2009). The researcher noted that the identified information needs in literature are generic as they cut across different categories of health care workers, including CHWs, health professionals, and facility administrators, among others.

According to literature, information practices are mainly characterised by the type of media in which information is packaged/presented or communicated. Traditional methods are more prevalent across health care systems, specifically for maternal health information services (Grimes et al., 2014). These mainly include the use of paper-based/print material and verbal methods such as face-to-face meetings, particularly between clients/women and midwives during care activity. The Internet is also indicated as a source and/or media of communicating health information although not as common as print and verbal media. Furthermore, different sources of information identified for various stakeholders include clients, midwives, print sources, Internet sources, formal training, Ministry of Health (MOH) guidelines and institutional records (Grimes et al., 2014; Turner & Fuller, 2011; Pakenham-Walsh & Bukachi, 2009).

The main challenges identified in literature are poor governance and lack of funding. Poor policy administration affects public health care negatively when service environments are conducive enough (Treglia et al., 2019; Van Deventer et al., 2016; Yue et al., 2019). Poor funding leads to resource constraints in health facilities, which then compromises the quality health care services to the public (Salgado et al., 2017). More importantly, lack of universal health coverage (UHC) in developing contexts makes women stay away from health facilities as cannot afford to pay for health care services.

According to literature, there are three dimensions for the design of health care services, namely: (i) system quality; (ii) affordability and maintainability; and (iii) operational efficiency (Lee et al., 2006). Essentially, system quality represents both the functional and non-functional system requirements, implicating system features and characteristics that determine the quality of service and are related to both the hardware and software aspects of a system. These include system specifications, responsiveness, scalability, reliability, interoperability

and usability, among others. The cost dimension includes affordability and maintainability of services, and the efficiency dimension represents operational factors such as user training and maintenance operations.

14.2.2 Data findings

The study identified various key stakeholder groups, including clients, CHWs, health professionals, facility administrators (service providers) and government, based on their contribution to maternal health care services. Information needs are based on the roles and responsibilities of individuals. Specifically, client needs were identified as prenatal, ANC and postnatal needs, since maternal care comprises these three phases. Health care professional worker needs include professional knowledge, maternal profile and MoH guidelines, and facility administrator needs include administrative and policy information.

Information practices were identified as being the most prevalent and characterised as traditional practices, i.e. paper-based records and verbal communication, which includes both face-to-face conversations and telephone conversations during client follow-up activities. It was also observed that community health information services are offered on preventive health education. More importantly, the ANC booklet plays a critical role as clients used this booklet to manage their maternal profile and for reference purposes. Information communication among stakeholders is mainly done through print, verbal, mass media and telephone communication. Information sources identified include the clients themselves, health care workers, print sources, mass media, formal training, organisational records, MoH guidelines, community profiles and Internet sources. The key challenges experienced are poor health care governance, inadequate funding, over-reliance on manual information procedures, a weak health communication system, and lack of privacy and confidentiality. Specifically, the weak general health care infrastructure is attributed to resource constraints, resulting in the lack of adequate support for operations, a scenario that compromises the quality of health care services.

Considerations for the design of ICT-facilitated health information services were identified during the study. These include contextualisation, data access, HIT utilisation, system/service integration, stakeholder engagement, system quality, and user-centred design service. It was observed that the contextualisation of user requirements and the technological environment are critical to producing solutions with meaningful use. Furthermore, proper data access is needed to guarantee data security, including availability, integrity and confidentiality, whereby only authorised individuals will be allowed to gain this access (Mell & Grance, 2011). Proper HIT utilisation was identified as being critical to maximising operational efficiency and cost savings, generating accurate reports, and managing complex situations (Kaplan, & Harris-Salamone, 2009). System/service integration is key in enhancing the quality of health care

services to promote collaboration among various stakeholders in order to deliver people-centred services (Rodolfo et al., 2014; World Health Organisation, 2016b).

Stakeholders have the responsibility to determine and correctly interpret organisational requirements, because this is crucial to the design considerations for new services, particularly from the two perspectives of stake holding, namely power and interest (Johnson et al., 2008). Thus, for this study, various stakeholders were involved in the service prototype design process to identify value and opportunities, namely, clients/patients, health professionals, CHWs, managers/service providers and technology providers (Groves et al., 2016; Korpela et al., 2013). The researcher noted that the quality requirements of the proposed services (cloud-based PHR) are an important factor for the design process towards delivering efficient health care services (desired situation). In the context of the HIS, the researcher noted that system quality includes *functional* and *non-functional* system requirements, which includes reliability, usability, accessibility, responsiveness, interactivity, scalability, maintainability, specifications and affordability of ICT services, among others, as identified during the study. For the UCD approach, the designer constantly engaged users through active participation to understand their needs in each phase of the design process in order to create user-friendly interventions. Du Preez (2018) describes UCD as a process through which products and services are created from the perspective of the end-user.

14.2.3 Design findings

Relevant stakeholders identified during co-design process include clients (women), health care providers (hospitals and caregivers) and designers. However, for purposes of this study, the researcher considered women, caregivers and designers as the key stakeholders in the design of care services. The information needs identified are mainly from the women and caregivers who were selected from the ANC booklet (prenatal, ANC, postnatal and maternal) and ANC profile (see Figure 13.4). Information services were identified to be mainly traditional, involving the use of print and verbal communication with face-to-face meetings. The main sources of information identified for women included health care professionals, colleagues, mass media and the Internet. The main challenges noted with the current information services are limitations of the ANC booklet, including wear and tear, loss of information, illegibility of clinical notes, and lack of data privacy. Also, it was reported that a lot of initials are indicated in the booklet, which cannot be understood by lay persons. Furthermore, illiterate women cannot read the contents of the booklet, hence limiting service delivery to clients. This calls for re-considering the context of the use of services. Generally, participants' perception on the adoption of ICT to deliver maternal health and wellbeing services may help to overcome some of the aforementioned challenges. Essential design considerations identified for ICT-facilitated health care services include service

contextualisation, i.e. requirements and contextual technology environment, among other considerations.

14.2.4 Combined findings

The following table contains a summary of the research findings:

Table 14.2: Combined summary of key findings on the design of ICT-facilitated maternal health information services

Research question/ themes	Key theoretical findings	Key data findings	Key design findings
Relevant stakeholders	• Women • Community workers • Health care providers • Government	• Technology providers • Health care providers • People • Government	• Clients • Health care professionals • Service designers
Information needs of stakeholders	• Professional knowledge • Practice knowledge • Cultural knowledge • Infrastructural knowledge	• Maternal information • Practice knowledge • Professional knowledge • Administrative/ policy information	• Prenatal • ANC • Postnatal • Maternal profile • ANC profile
Information practices	The nature of information services		
	• Traditional-oriented services • Community health information service • ANC booklet a key document	• Traditional and electronic • ANC booklet a key document	• Traditional services
	Health communication		
	• Mobile communication • Print media/NC booklet • Mass media	• Print media /ANC booklet • Internet	• Traditional media
	Information sources		
	• Clients • Colleagues • CHW/Vs • Health care professionals • Print sources • Mass media • Internet • Professional/formal training • MoH tools and guidelines • Community profile, • Organisational records	• Clients, • Health care Professionals • Print sources • Internet • Formal trainings • MoH tools and guidelines • Institutional knowledge	• Health care professionals • Colleagues • Mass media • Internet

Research question/ themes	Key theoretical findings	Key data findings	Key design findings
Challenges experienced	• Poor health care governance • Inadequate funding • Over-reliance on traditional media • Poor health information infrastructure • Poor health communication services • Inadequate client privacy and confidentiality	• Poor governance • Resource constraints • Poor health care infrastructure • Inadequate privacy for the client	• ANC booklet prone to: -Tear, wear and loss -Illegible clinical notes -Initials used not clear -Lack of privacy -Illiterates can't read English
Stakeholder perceptions	• Low ICT adoption levels • Lack of client privacy and confidentiality • Lack of basic health care services • ANC booklet very instrumental • Mobile technologies have potential to improve personal health information services	• Traditional methods most prevalent • ANC booklet instrumental	• Services should be electronic • Loss of the ANC booklet is total loss of information • Difficult to keep information via ANC booklet • Doctor's notes not readable/ understandable
Design considerations	• Data access • Contextualisation • HIT utilisation • Service integration • Stakeholder engagement • Service implementation • System quality • User-centred design	• Functional system requirements • Non-functional system requirements	• User requirements • Menu items • Usability • Data access and privacy

14.3 Discussion

This section focuses on maternal health and wellbeing services according to the six (6) theoretical themes stated in Table 12.2 in comparison with the study findings. The themes are: relevant stakeholders, information needs, information practices, challenges experienced, stakeholder perception, and important design considerations for ICT-facilitated services.

14.3.1 Relevant stakeholders

According to observations from both literature and the data analysis findings, the researcher identified various categories of stakeholders in maternal health and wellbeing services. These include people (clients), health care providers (health organisations, CHWs, health professionals, facility administrators), technology providers (ICT experts/consultants), and government (Groves et al., 2016; Korpela et al., 2013). The stakeholder's role in maternal health care is strongly emphasised throughout the study. It was therefore observed that the

health care system is a complex ecosystem whereby various stakeholder groups are required to work together, hence collaborative health care. As observed, individuals, organisations and government, among other stakeholders, should be involved to deliver satisfactory services to the public. The need for stakeholder engagement, rated as *very important*, featured prominently during the study, whereby all the five participant groups reported to be working with other stakeholders in the course of their work activities. The relevant stakeholder groups identified in maternal health and wellbeing information services during the study and who participated in the study, include clients, CHWs, health professionals, facility administrators and ICT experts. These groups are considered as key stakeholders based on their roles and contribution in the maternal health and wellbeing information services ecosystem, and each group is affected directly or indirectly by the services in question (Freeman, 1984). The clients/women perform the role of service consumer; CHWs provide preventive care services; health professionals provide care/ treatment; managers plan and allocate resources to support health care activities on behalf of the service provider; ICT experts provide technical advice on the design of proposed services while government provides the necessary funding. In this case, facility administrators represent both the service provider (County Government) and the National Government.

14.3.2 Information needs

The Information needs of various stakeholders vary, based on their role/responsibility and activities. The *information needs* theme in maternal care was rated in this study as being *extremely important* by both the clients (pregnant women) and health professionals. It was found that information needs are crucial for building capacity in health education and literacy for women to self-manage themselves, and for health professionals to make accurate diagnoses and avoid medical mistakes. CHW/Vs and health care administrators said the theme is *very important* in relation to their work activities. According to the researcher, clients' needs are categorised as prenatal, ANC and postnatal, as maternal care is provided according to these stages, and of which information needs are specific to each stage of care. Health care professionals needs on the other hand include professional knowledge and skills acquired through formal/basic training and practice knowledge through the maternal and ANC profile, which mainly comprises clinical notes recorded in the client's ANC booklet (Pakenham-Walsh & Bukachi, 2009). The needs of CHWs are based on preventive care, such as water sanitation and hygiene, PMTCT services, and child immunisations. Facility administrators' needs are mainly administrative and policy related, otherwise known as institutional knowledge, according to Groves et al. (2016). As observed, both administrative and policy related information are primarily generated within an organisation (hospital). This information includes departmental reports and general statistics, which is important for planning and decision-making. The researcher therefore noted that information needs are diverse and based on the

role and/or responsibilities of individuals within the health care ecosystem, and that this information ought to be available at the point of need to enable decision making.

14.3.3 Information practices

According to the researcher, the nature of the information practices identified is primarily characterised by the type of media in which information is packaged/presented or communicated. This data theme is critical as it enabled the researcher to gain insight into the nature of existing health information infrastructure. Specifically, it was observed that traditional methods are most prevalent with the management of maternal health information services across the public health care system; a similar observation had been made in literature (Grimes et al., 2014). The information practices observed in the study include paper-based material (the ANC booklet) as well as verbal communication, particularly face-to-face conversations/meetings between clients and midwives during clinic visits or telephone conversations during client follow-up activities.

Different information sources were identified for different stakeholders; clients said they obtain information from colleague mothers, midwives, print sources, CHWs, mass media and Internet sources. Health professionals identified their information sources as clients, the ANC booklet, formal training/CME and MoH guidelines, whereas CHWs indicated clients, trainings/seminars, community profile(s), the ANC booklet, MoH guidelines and Internet sources as their sources. Facility administrators said they obtain information from institutional sources such as registry departments/organisational records, MoH guidelines and professional training (Grimes et al., 2014; Turner & Fuller, 2011; Pakenham-Walsh & Bukachi, 2009).

According to the researcher, the ANC booklet is highly regarded among stakeholders because it plays a critical role as a government-approved and legal document to manage the client maternal profile in their custody. This concurs with similar observations in literature (Salgado et al., 2017; Grimes et al., 2013; Korpela et al., 2008). The booklet is used as a key reference document by the client and caregivers, also for referring a client to another facility, and it is used until the child has completed all the immunisations at the age of 5 (years).

It was further observed that mandatory community health information services are provided by CHWs at community level, particularly in individual households where a pregnant woman lives. This service involves health education talks that focus especially on communicable diseases such as TB and HIV, and preventive care strategies such as PMTC, immunisations, and water sanitation and hygiene, among other strategies.

Health communication is primarily done through print, verbal and telephone communication. Print media involves the use of books, particularly the ANC booklet and sometimes wall charts at the clinic. Face-to-face meetings and telephone communication

(mobile conversations) are conducted, with the mobile phone being regarded as the most convenient form of electronic communication. Mass media is used to communicate information to the public, primarily through radio and TV programmes that focus on announcements of disease outbreaks, child immunisations, and free medical camps. The Internet is used to share and communicate health information among women, CHWs and health professionals albeit on a smaller scale, of which a similar observation was made in literature (Grimes et al., 2014).

14.3.4 Key challenges experienced

According to the researcher, the major challenges facing maternal health information services are poor governance, inadequate funding, over-reliance on traditional media/manual information procedures, poor health communication, and inadequate privacy and confidentiality for the client.

14.3.4.1 Poor health care governance

Poor governance of public health care is noted as a major concern in literature, with the result clearly visible in the devolution of health care services (Treglia et al., 2019; Van Deventer et al., 2016; Yue et al., 2019). Poor governance is mainly attributed to the implementation of wrong policy objectives and priorities, hence an unstable health care environment occasioned by the devolution of health services following the promulgation of Kenya's new constitution in 2010. This led to poor planning, which resulted in issues such as capacity gaps, staff shortages, lack of proper regulatory framework and institutional infrastructure, corruption and a conflictual relationship between County and National Government, among other challenges (Kimathi, 2017; Treglia et al., 2019; Van Deventer et al., 2016; Yue et al., 2019). In particular, there a serious problem has been detected with revenue allocation by the National Government to County Governments hence resource constraints which greatly compromise health care services.

14.3.4.2 Inadequate funding

Inadequate government funding, particularly in developing countries, was identified as a major issue leading to the failure of health facilities to deliver satisfactory health care services, because the support is both inadequate and untimely hence resource constraints, an observation also made from literature (Salgado et al., 2017). This situation was found to be responsible for the insufficient health care infrastructure characterised by the lack of basic health care, staff shortages, and lack of basic commodity supplies, among other relevant resources. More importantly, it was noted that the lack of UHC in public health facilities deter women from seeking health care services at the health facilities as some of them simply cannot afford the services due to poverty.

14.3.4.3 *Traditional/manual information services*

Resulting from inadequate funding, information services continue to remain traditional and mainly manual, that is, paper-dominated, and as such has become a situation difficult to manage as opposed to electronic services. Health facilities are overwhelmed with enormous volumes of records that grow by the day, hence tedious to work with. Under these circumstances, problems such as lack of storage space for records, retrieval, security/safety, and privacy and confidentiality are witnessed. This makes the work environment non-conducive and unfriendly to work in, and this affects staff productivity negatively. It was reported during the study that health records, and particularly patient files, sometimes become missing or cannot be traced within appropriate timelines due to congestion at the registry. The physical records are prone to destruction by agents of deterioration, including light, fire, water, theft, and pests, among others, which shortens the lifespan of records.

14.3.4.4 *Poor health information infrastructure*

It was observed that ICT services are almost non-existent, despite the fact that ICT solutions have the potential to improve access to health care, save on health care costs, and minimise medical errors, among other benefits (Bantom et al., 2016; Kreps & Neuhauser, 2010). The basic IT infrastructure is not available in most of the facilities, while staff are IT illiterate as they do not have the relevant computer literacy skills to use computers because no training is offered, hence a deep-rooted culture. As reported during the study, previous attempts to automate services attracted resistance, which led to the failure of adoption and utilisation of ICT in delivering health and wellbeing services. Given this situation, it is impossible to achieve system/service integration and collaborative health care, which is a crucial requirement for person-centred health and wellbeing services (World Health Organisation, 2007; Tsekleves & Cooper, 2017).

It was furthermore observed that existing information services compromise the quality of health care services, as information is not always readily available or accessible to support decision-making. This is due to delays in retrieving information and inaccuracy of data because of manually processing and storing the information. Furthermore, it is difficult to share information/records that need to be transferred physically across departments within a hospital or between different institutions in case of patient referral. These manual processes are time consuming, resulting in delays in care delivery, sometimes leading to care discontinuity as some of the information/records go missing hence poor quality of services to clients. Due to lack of ICT services, data silos develop within individual institutions, resulting in the lack of health care collaboration, which is need to promote system/service integration.

14.3.4.5 Poor health communication

Health care communication was noted to be weak due to the prevalence of the aforementioned traditional methods of handling information, which has a number of limitations as opposed to eHealth and desktop applications having more capacity to enhance health care communication, and as a result, improving the quality of care (Kreps & Neuhauser, 2010). Traditional methods are reported to be limited geographically, especially in the case of print and verbal media as information has to be availed physically, for example, the ANC booklet. Also, information is communicated through face-to-face meetings, particularly during ANC clinic visits by the women, which some do not attend for various reasons, including lack of a means of transport particularly where long distances need to be covered. Health personnel must accompany a patient to a referral facility in person during an emergency to provide information, which is even more expensive and time consuming. This makes the situation even more difficult, given the staff shortages experienced in the facilities; and even more so, when individuals have to leave their workstation to accompany patients to the referral facility. Furthermore, telephone/mobile conversations are instant and in real time, hence, if a receiver misses a call, the message cannot be relayed, especially during an emergency.

14.3.4.6 Inadequate client privacy and confidentiality

The privacy and confidentiality of a client remains a challenge because as traditional methods cannot guarantee adequate data security, and this leads to the violation of individuals' right to privacy. For instance, print records such as the ANC booklet can easily be accessed by a third party while in transit during referrals. At the same time, verbal communication and messages, including telephone conversations, can easily be overheard. Sensitive information can thus be leaked, for example, HIV-positive clients whose information leaked are faced with challenges of stigma unlike with computerised systems where logical security mechanisms are applied to safeguard data. This leakage of information make women lose confidence and/or trust in current information and communication services and they shy away from attending the ANC clinic.

14.3.5 Stakeholder perceptions

Perceptions from the participants included varied reactions, both negative and positive, to current health information practices. Negative reactions include the lack of doctor/patient confidentiality and poor-quality services provided in health facilities in general. To begin with, the women said they do not trust the doctor/patient confidentiality, and the clients claimed that the nurses and midwives leak confidential information, hence compromising individuals' privacy. This is a serious challenge, particularly for women who tested HIV-positive, a situation which causes stigma among the victims. As a result, the victims shy away from attending their clinic appointments, and this leads to care discontinuity.

Health care workers expressed the perception that client privacy is not properly safeguarded due to the physical nature of the ANC booklet. This booklet contains the client maternal profile, which the women carelessly share with people as the document is in the client's custody, thus compromising personal privacy. Some of the midwives felt that the extensive use of telephone/mobile communication to do follow-up activities expose the client's confidential information to a third party, who may intentionally or unintentionally receive unintended calls. The nurses reported that some of mothers who are HIV victims do not want their partner to know of their status, as this is known to break up marriages.

Also, participants, and particularly women, felt that the quality of services provided at facilities is generally low, an observation also made in previous studies by other researchers. This perception is mainly based on the women's previous birth experiences, and also in the course of seeking subsequent health care services, including post-natal services, in health facilities, where they continue to interact with the midwives whom they described as being harsh (Salgado et al., 2017). Furthermore, some of the women said that they do not trust the doctor's information fully as they have been misled previously. The researcher observed that due to previous instances of inaccurate information, the women do not always trust the advice from nurses and doctors, which, their view, is regarded as poor quality of service.

In terms of the ANC booklet, despite the document being instrumental in maternity education, its potential exposure to damage compromises the quality of information services. Exposure includes fire, ageing, fading of ink, illegibility, wear and tear, and theft/loss, among others. In this study, the majority of women expressed the perception that reading doctors' notes is difficult, and that only health professionals are able to read clinical notes in the booklet. Also, some of the staff complained that the content includes complicated graphs that are difficult for clients to interpret. Furthermore, the booklet is only written in the English language while some of the women are illiterate and can therefore not read and comprehend the content.

A further issue is the lack of basic health care services, as facilities cannot provide commodities such as the ANC booklet, whereby women are then asked to buy a plain exercise book for recording clinical notes. Also, during the study, congestion caused by long queues was witnessed in the maternity wing, with no sitting space. A similar observation was made in previous studies where such a situation discouraged some of the women from attend their clinic appointments (Salgado et al., 2017).

Positive reactions, on the other hand, were also observed, including commendations by health care workers regarding the ANC booklet, which, besides being used as a health and patient referral document, is also used as a legal document in place of a child's birth certificate to enrol at school. It was generally perceived by various stakeholders that the ANC booklet is a very educative document for mothers, because the book is in the custody of the client, which

improves delivery of health education since clients are able to read the book at their convenience at home apart from advice given at the clinic.

It was furthermore perceived that the mobile phone has made a positive impact in health care delivery since it is regarded as the easiest and fastest means of communicating health information. This is despite its limitations of processing power, small screens and keyboards, low battery life, and inadequate infrastructure such as insufficient bandwidth issues, among others (Watkins et al., 2018). This therefore justifies the need to re-design the health information infrastructure to support large-scale innovations in developing countries to support health care delivery to individuals, organisations and communities as a whole (Miah, 2017). In this study, it was found that the mobile phone is used because there are no Web/desktop applications and Internet connectivity to enable effective communication of information on a larger scale. As a result, there is no system/service integration or collaboration among stakeholders. At the same time, there are no HIT tools to enhance the processing of data to generate reports for decision-making hence leading to low productivity among staff as information management is dominated by manual procedures.

14.3.6 Design considerations for proposed services

Various considerations for the design of ICT-facilitated health information services were identified during the study. These include service contextualisation, data access, HIT utilisation, service implementation, service/system integration, stakeholder engagement, service quality, and user-centred design.

14.3.6.1 Data access

Participants' concerns about data access focused on the aspects of confidentiality, integrity, and availability, among other factors, related to data security (FAIR, 2016; Mell & Grance, 2011). According to observations made from the study, traditional methods of health communication and management, including print and verbal messages such as telephone conversations, were mainly used in the research context. Unfortunately, these approaches lack adequate data security, thus encouraging the violation of individuals' right to privacy (Bantom et al., 2016). For instance, antenatal care booklets (ANC booklets) are used to record maternal/child nursing and clinical notes, and are in the custody of the clients. The maternity clients are required to produce the booklet during each subsequent clinic visit for clinical update by health care personnel. Participants, and particularly health care workers, however expressed concern that confidential information recorded in the booklet could easily be accessed by a third party while in transit including during a referral. Also, there was a general perception among the client participants that some of the health workers leak sensitive personal health information and can therefore not be trusted. A client participant said:

“Information is not confidential because some nurses and CHW/Vs leak it out. Otherwise, nurses do not keep information secret...nurses should be trained as counsellors” (CP005).

It was reported that the situation is causing social stigma among the victims, making the clients shy away from seeking medical advice in health facilities, which then results in the discontinuity of care. Some of the health care personnel felt that the extensive use of telephone/mobile conversations for follow-up activities expose the confidential information of clients' to a third party whereby one could either intentionally or unintentionally receive unintended phone call(s). For instance, it was reported that some of the women attending the ANC clinic are victims of the human immunodeficiency virus (HIV) and they do not want their partner(s) to know their HIV status for fear of breaking up their marriages. A community worker expressed the need to adopt electronic records because the existing traditional methods of information handling sometimes makes it difficult to access clients' information when needed, both at community and facility level. The situation is mainly attributed to the nature of the living environment in the slums whereby pregnant women often lose their ANC records due to frequent fire outbreaks and agents, hence wear and tear, among other causes. One community worker said:

“Information services are bulky and sometimes... it's almost impossible to access information at a given time you may need it...for example, ANC booklets can be easily lost to fire outbreaks in the slums! Electronic will be better but it still has its own challenges” (CHW002).

However, despite the immense opportunities prevalent in HIT tools to address some of the aforementioned challenges, there is a need to empower patients to manage their personal health data online (Lupse et al., 2012). Particularly, security and privacy issues should be given the utmost attention since the users lack physical control over their data (Li et al., 2010). Unfortunately, access to patient data through HITs remains a major challenge due to poor adoption of ICTs in health care management (Wilkowska & Ziefle, 2012; Peleg et al., 2008). According to literature, the reason for the above situation is that users prefer a high degree of confidentiality, anonymity, and intimacy in relation to the use of such tools. eHealth designers and developers should therefore incorporate essential system security and usability features to facilitate adequate data access control. According to du Preez and de la Harpe (2019), this will ensure that threats and risks associated with the privacy and confidentiality of personal data as well as the overall security of the system is contained. More importantly, it should be noted that holistic system security design is paramount to guarantee the users' right to privacy (Lupse et al., 2012).

14.3.6.2 HIT utilisation

The study noted issues revolving around the need for the adoption and utilisation of HIT tools in public health care facilities. A critical examination of large-scale eHealth interventions in particular contributes to the discovering of important features that may facilitate their

effective utilisation (Shuvo et al., 2015). The use of HIT tools such as PHRs and EHRs is perceived to have huge potential in addressing challenges associated with traditional methods of health information management and reporting (Gibbons, 2011), which is a common phenomenon in resource-restricted environments, given the scarcity of ICT resources. The study noted the absence of relevant ICT infrastructure in the majority of the facilities that were investigated. The existing health record systems are mainly paper-based; staff therefore do not have the opportunity to leverage ICT in their work. One Facility-In-Charge respondent said:

“Here we only have manual information services as there is no infrastructure for IT except the one for partners’ programmes! For example, University of Maryland does transmit some of HIV related data online” (AP003).

Despite some of the facilities having desktop computers donated by partners, the machines are not being used due to a lack of relevant ICT personnel, staff training on computer literacy and relevant skills, Internet connectivity, and goodwill from the stakeholders. Furthermore, most of the various digital media equipment and tools used by staff to perform their job tasks are personal, for example mobile phones, rather than organisation-owned. However, staff in some of the facilities reported that they sometimes use a facility mobile phone during emergencies. One Facility-In-Charge respondent said:

“Some of the key factors contributing to the nature of current information services include understaffing, lack of the relevant infrastructure, lack of staff training, resistance to use of computers, lack of knowledge or benefit of IT” (AP005).

Given the situation, some of the health workers expressed their concerns and frustration with the manual work environment, hence the need for government authorities to provide the necessary facilitation and infrastructure. Health care personnel, particularly those in the administrative docket, for example, departmental and section heads, reported to have been experiencing challenges in health reporting. The lack of data analytics tools involving artificial intelligence and machine learning makes it difficult to generate detailed health reports for accurate/better decision-making.

According to Kreps and Neuhauser (2010), HIT tools can promote information sharing, healthy behaviour among health care consumers, and cost cutting towards the delivery of efficient and effective health care services. The use of analytics can improve health care delivery through providing seamless access with unlimited availability of health data in an accurate manner for timely reporting, decision-making and collaboration (World Health Organisation, 2016a; Rodolfo et al., 2014; Braa & Sahay, 2012). Generally, there is growing demand for ICT innovations among individuals, organisations, and communities to promote healthy lifestyle choices, personal wellness and monitoring as well as the provision of, and access to personal health data (Miah, 2017). Subsequently, this effort can foster service integration across health systems, thus promoting collaborative health care, which is critical

for the delivery of patient-centred care (Rodolfo et al., 2014; Ogden et al., 2017). The adoption and utilisation of HIT tools in underserved contexts is therefore paramount in the re-design of health care service. This is vital in addressing some of the prevalent challenges experienced in these environments to facilitate improved population health outcomes (Gibbons, 2011).

14.3.6.3 Service contextualisation

In terms of contextualisation, participants' responses revealed various aspects related to contextual requirements that are critical to designing meaningful eHealth services. Waweru et al. (2019) argues that a good understanding of the overall health care context is critical towards designing effective health services. According to the study findings, understanding the user requirements, technical specifications and the general technology context are of paramount importance. This is essential for informing the technology providers of the relevant design features to warrant the creation of meaningful eHealth interventions. Therefore, while designing eHealth interventions, the technical, social, and organisational factors, among others, should be considered particularly in resource-restricted environments including ethical, financial, and legal aspects (Achieng & Tambovceva, 2017). ICT expert participants in particular emphasised the need to consider both the technological and infrastructural requirements as dictated by both the user and technology contexts to deliver effective eHealth service(s). Some of the participants said:

"Localise and customise software to allow development of own skills" (ICT001).

"Appropriate and adequate infrastructure should be built using affordable technologies including hardware and software tools" (ICT004).

In terms of the overall health care context, the study noted mixed reactions from participants, which include the preferred choice of technology devices and experience, whereby the mobile/smartphone is the most popular computing device. This reveals the nature of the health care technology context, which then determines the mode of health communication and interaction particularly between health care personnel and the clients. Also, cost implications and challenges associated with the use of mobile technologies in delivering services to clients were noted. Affordability of the technological infrastructure should be taken into consideration, particularly the initial investment and maintenance costs to guarantee sustainability (Du Preez & De La Harpe, 2019).

For instance, some CHW participants said:

"Mobile phone is both the easiest and fastest way of communicating information, especially during an emergency" (CP003).

"A mobile phone is preferable! It is not heavy...it saves time and also geographically unlimiting....but you need to have a smart phone! Not just any phone however, the challenge

is that you need airtime. Otherwise, you can't make a follow up because you do not have airtime and data bundles – which is expensive” (CHW002).

Based on the above revelations, eHealth designers and developers should therefore analyse, evaluate and understand the overall health care context, according to Waweru et al (2019), in which health care services are to be provided to create meaningful solutions. Boore (2018) affirms that eHealth applications in health care management, including the automation of health records, electronic appointments, telemedicine, and the use of the Internet to communicate health information, should be contextualised to guarantee effective service delivery. Blickstein and Holtzblatt (1999) argue that the contextualisation of service requirements promotes state-of-the-art approaches towards designing products that are based on the designer's knowledge and an understanding of how users perform their work activities. According to the author, this may be achieved through contextual inquiry, work modeling, work re-design, user environment design, UI design, mock-ups and tests with customers. The point of departure here is that service requirements may be organisational-based, hence the variations across the cultural and social system environments (Sutcliffe et al., 2005). This therefore calls for the need to consider the overall context of the usage of health care services in order to deliver services that meet the needs of the service consumers. Thus, in the context of eHealth, fulfilment of this requirement will go a long way in supporting the delivery of patient-centred eHealth interventions.

14.3.6.4 System implementation

Revelations from the study confirm the need to subject new HIT system(s) to pre-evaluation tests during the implementation process to assess preliminary outcomes. Shuvo et al. (2015) argue that meeting system-wide implementation requirements for eHealth innovations is an important milestone towards achieving adoption, scalability and sustainability, hence successful implementation. According to the participants' responses, the type of system development methodology and the system conversion approach adopted by health care organisations play a critical role in the overall design and implementation of such interventions(s). Also, these approaches have economic implications on health organisations, of which the consequences may be either positive or negative, given the complexity associated with the process. Generally, the implementation of HIS, particularly in public health care, is a complex matter, which is compounded by a myriad of challenges (Achieng & Tambovceva, 2017). Major challenges experienced in underserved contexts include high fragmentation of health care services and non-compliance with eHealth standards, causing a lack of interoperability between different hospital systems. This phenomenon is common in the low-to-medium income countries (LMICs) whereby the majority of the countries experience serious technical and technological challenges as well as limited resources. However, according to the authors, ICT remains the only option to overcome these challenges, hence the need to engage

appropriate eHealth implementation approaches to guarantee success. For instance, one participant said:

“Use agile methodology to iterate the process with prototyping in order to have a user guided design” (ICT001).

In essence, the choice of system development methodology has implications on the overall design and development of a system in terms of both the users and the business requirements. Based on the above findings, agile methodologies are preferred, particularly software prototyping, as it allows active participation during system design and development (Reich-Stiebert et al., 2019). Prototyping methodology grants users the opportunity to repetitively scrutinise the system’s design features and functionality, thus producing a user-centred design (UCD) service (Du Preez, 2018). At the same time, it prompts early detection of errors hence corrective action before system installation, thereby saving on resources. According to Hudgons et al. (2011), the process involves activities such as checking input (data captured) and output (reports generated in specific formats). Also, it involves interlinking various system processes to fix errors, meaning re-designing the system before actual installation. An agile approach, therefore, has the capacity to deliver user-oriented design service, hence customer satisfaction, thereby countering user resistance towards successful system implementation.

More so, it was observed that the choice of a system’s conversion approach is crucial as it helps with weighing the available options before full installation, thereby minimising the risk of failure as well as saving time and resources in general. A participant noted:

“You should carry out a pilot survey in a single institution to target feedback from at least 30 people who are actual users of the system” (ICT002).

One important observation made from the above response is that a good implementation approach should allow room for feedback from the user community to validate system functionality before full implementation (Hudgons et al., 2011). According to the participants’, this can be achieved through project piloting whereby design features and the functionality of a system are tested and analysed to first assess the preliminary results. This includes unit test, system test, integration test, user acceptance test, customer installation and support test phases (Hudgons et al., 2011), which facilitate modifications after repetitive system tests. The authors argue that the quality of software relies on extensive testing to validate each functionality to execute the intended transaction(s) effectively. Also, each transaction should be consistent with predefined business requirements. Specifically, the system test phase is designed to validate the functionality and performance of an application and involves the highest number of repetitive tests to ensure effective functionality (Hudgons et al., 2011). Both pre- and post-system implementation stages play a significant role in developing an effective system whereby design features and other specifications are verified before its full

implementation. Unfortunately, the design and implementation of eHealth services in underserved contexts is still far from meeting the expectations (Achieng & Tambovceva, 2017), hence the need to pay attention to the eHealth implementation process. Gregor et al. (2020) identify *implementation* as one of important design principles to be considered in terms of boundary conditions, implementation setting, and further user characteristics. The system implementation process therefore equally plays a significant role as potential users are given the opportunity to evaluate and assess the system, thus supporting the delivery of patient-centred eHealth interventions.

14.3.6.5 System integration

Integration-related concepts emerged from the participants' responses during the study, particularly from ICT expert participants. Key concepts pointed out by the respondents concerning system integration include the use of APIs, eHealth standards, quality Internet connection, and the integration of different system modules as presented in the data analysis chapter. According to Shuvo et al. (2015), systems integration is a significant feature particularly for large-scale eHealth innovations, involving the application of OpenMRS tools to support the daily workflow of users, including in clinical practice. These aspects of system integration are perceived to have a major influence on the delivery of effective patient-centred eHealth services. According to Boore (2018), the aforementioned concepts emphasise the need to integrate eHealth services to address the challenges associated with the fragmentation of health systems in developing contexts such as Kenya. For instance, a participant noted:

"The donor effect creates data silos...for example some of the partners only cater for HIV reporting which encourages parallel reporting systems alongside the national health system (DHIS)" (ICT0010).

According to the study findings, concerns were raised over rampant fragmentation of health systems, which limits the delivery of patient-centred health care (Korpela et al., 2013). Health care services are mainly delivered within the confines of individual health care organisations, hence a lack of collaborative health care. The study identified this practice as one of the barriers towards the sharing and exchanging of health information among different stakeholders, particularly between patients and health professionals. Furthermore, the majority of the selected facilities manage health data mainly through manual procedures, thus making service integration almost impossible.

A health care administrator in one of the facilities noted:

"We use manual information services as there is no infrastructure for IT services except that of partners...for example, university of Maryland transmit HIV data online" (AP003).

This observation demonstrates the deficiency of existing information infrastructures and can therefore not support the delivery of patient-centred health care. According to Manyá et al. (2012) and the World Health Organisation (2016b), integration of health care is a critical requirement to addressing the fragmentation of health systems in developing countries which experience resource constraints. The magnitude of the new challenges concerning health care infrastructure is beyond the capability of any single health care institution, hence the need for collaboration (Noran, 2015). The author argues that collaboration between health care stakeholders is a mandatory requirement in the modern health care environment as it replaces the legacy siloed health care models, which are no longer useful. New challenges include rapid population growth, ageing, social security, and increasing complexity of pandemics, among others. This prompts the need to build collaborative information systems (CISs) to promote both inter-professional and inter-organisational collaboration through eHealth integration (Smaradottir et al., 2016). CIS therefore plays a pivotal role in engaging patients as they can easily and freely access/track personal health data (Mishra et al., 2018) towards self-management, thus promoting patient centred-care. Also, health care integration improves information flow, leading to the optimisation of the scarce resources in terms of cost-effectiveness.

Generally, designing strong and well-designed APIs will greatly enhance the integration of health care systems and enable users to query health data from different sources according to individual and organisational needs. In addition, the study observed that the adoption of eHealth standards, particularly HL7 and FHIR, is critical to support interoperability and interaction between different hospital systems as well as the internal software modules. According to Boore (2018), eHealth standards enable health systems to work jointly within and between organisational boundaries, thus improving health care delivery. Specifically, interoperability provides an interpersonal and cross-institutional point of access to data in a cost-effective manner.

Above all, the availability of quality Internet connection is critical to facilitating the speedy distribution, access, and sharing of information across health care systems (Boore, 2018). Herrmann (2011, cited by du Preez, 2018) argues that health care integration can address the complexities associated with socio-technical systems. Therefore, in order to overcome health care fragmentation, health systems should be re-designed through the adoption of ICT to support the integration of health services, hence collaborative health care, which is an important requirement for the delivery of patient-centred health care.

14.3.6.6 Stakeholder engagement

Stakeholder engagement in the design of eHealth services emerged as theme from the participants' responses in the data analysis chapter. Shuvo et al. (2015) argue that the

involvement of relevant stakeholders in the implementation of eHealth should be prioritised since it is a key factor that influences the success of an intervention. Particularly, effective partnership between stakeholders makes eHealth innovations a shared investment(s) such that the innovations are embedded in organisations and processes – a practice that facilitates the scalability and sustainability of the interventions (Shuvo et al., 2015). Some of the health care administrator participants noted:

“Some of the important stakeholders in our health care context include clients, relatives, health care providers, hospital facility, referral hospitals, the County Government, National Government and management partners” (AP005).

“The key stakeholders are patients, health care providers, CHW/Vs, Community health committee (CHC), other facilities including, and referral hospitals” (AP001).

In the context of this study, the clients, health care administrators, health professionals, community workers (CHCs), and ICT experts were identified and engaged as potential stakeholders of eHealth services. The participants emphasised the need to involve stakeholders in the design and development of eHealth interventions, and particularly health care consumers and health professionals as potential users of eHealth services. This gives the users an opportunity to contribute their input into the design process, thus promoting patient-centred health care.

The above statements reveal the need to recognise the significant role stakeholders can play in health care design. According to Johnson et al. (2008), there are two dimensions that determine stake holding, namely power and interest, which can be rated as low, medium, or high in terms of influence. In this case, an organisation should be seen as a set of relationships among groups having a stake in the activities that make up the organisation, and how these activities relate in terms of interactions and value-creation (Chung & Crawford, 2016). For instance, insurance companies provide health coverage to patients, while pharmaceutical companies manufacture and market drugs that are prescribed by physicians to treat patients at hospitals. The government, on the other hand, provides health policy direction, funding, and subsidies on health care cost as its core responsibility towards its citizens (Korpela et al., 2008). It is, therefore the responsibility of stakeholders to determine the service requirements that will have a positive impact, hence the provision of meaningful health services and innovations. One ICT participant commented as follows:

“Understand primary user needs...for example those for nurses and doctors through active participation” (ICT003).

This demonstrates the need to seek and consider opinions and predispositions of relevant stakeholders through active participation to guarantee the delivery of desired eHealth solutions (Groves et al., 2016; Korpela et al., 2013). According to the authors, active participation enables stakeholders to identify values and opportunities such as data analytics

tools to deliver context-specific applications. For instance, the research recommends the use of a design approach in the re-design of health care services, including the service design (SD) strategy, which embraces value-creation (Malmberg et al., 2019; Pamedytyte & Akoglu, 2019). According to literature, SD engages patients as key stakeholders and is therefore recognised as a catalyst for initiating cultural change towards organisational transformation. Also, the design approach promotes active participation during the design process, which may induce change in people's health behaviour (Wetter-Edman et al., 2018). Therefore, to counter the challenges and barriers towards successful implementation of eHealth interventions, a collaborative approach is necessary, with openness and transparency among stakeholders (Achieng & Tambovceva, 2017; Ogden et al., 2017). There is thus a need to share power and responsibility as well as coordinating resources to promote patient-centred care.

14.3.6.7 System quality

Participants' emphasised concepts revolving around service quality. The quality requirements for the identified eHealth interventions include scalability, reliability, resilience, security, and affordability, among other components. According to Narang et al. (2010), service quality is defined as "the global overarching judgment or attitude relating to the overall excellence or superiority of the service," and which reflects the consumers' perceptions on service performance. According to Santana et al. (2017), patient-centred care is recognised as a fundamental requirement for health care quality and patient safety. Therefore, in order to deliver quality eHealth service(s), patients' needs and requirements should be assigned a high priority in the design process and in relation to the context of use. Quality health care service is therefore regarded as a key variable or consideration for making the decision(s) to adopt eHealth interventions in health care organisations (Santana et al., 2017). In support of the above arguments, some of the participants made the following observations:

"Adoption of ICT is key in improving the quality and delivery of health care services with reduced costs" (ICT003).

"Affordability and quality of technological infrastructure itself also matters" (ICT001).

Radojicic et al. (2020) argue that a good health system should deliver quality services to all people whenever and wherever they need them despite variations in the nature of the services provided across different health care settings. According to the authors, a good health system requires adequate health care infrastructure, that is, a strong financing mechanism, a skilled and well-remunerated workforce, reliable information to support evidence-based policy decisions, and logistics for commodity supplies. Subsequently, to guarantee the delivery of quality health care to the public, there must be equitable and efficient distribution of resources (Radojicic et al., 2020), including the implementation of eHealth interventions. In the context of typical IS, the aspects of quality, cost, and efficiency should be prioritised towards the

delivery of holistic quality health care; thus, they must be addressed simultaneously (Lee et al., 2006). Narang (2010) identified technical quality and functional quality as critical to the quality of health care service. The author argues that both technical and functional qualities require effective monitoring and managing to ensure successful service delivery. In this case, however, the technical dimension refers to issues related to medical diagnosis and procedures while the functional dimension relates to how these services are delivered to patients, and who the clients of those services are. A quality mobile-based PHR (mPHR) application must have features that are adapted to clients' needs (Bachiri et al., 2016). Specifically, the functionality quality characteristic is regarded as fundamental in the e-Health field as it motivates a wide use of the tools.

In the context of this study, quality implies the aspects related to both the technical and non-technical dimensions. Concerning the technical requirements/specifications of effective eHealth services in the research context, some of the participants noted:

“Among important system features include specifications of such components like CPU speed, RAM capacity, HDD size, a web-based system, open-source software” (ICT003).

“The system should be user-friendly with good click depth, accessible, reliable, maintainable and secure” (ICT003).

The above revelations from participants imply that both the hardware and software features/characteristics of an eHealth system have an impact on the quality of health care services delivered to clients. Lee et al. (2006) argue that quality is an important strategy as it performs an important role in organisational success and survival through the delivery of better service to customers, and particularly in a competitive business environment. According to the author, excellence in health care delivery should be anchored on clinical engineering for high-quality care delivery, economic engineering for cost-effectiveness, and hospital engineering for operational efficiency. Besides the technical dimension, the aspects of affordability, maintainability, and operational efficiency should be incorporated into the design of eHealth interventions (Lee et al., 2006). This is important as it helps to boost the delivery of quality services, whereby quality is a function of trust and satisfaction for users/ clients according to Vance et al. (2008), hence patient-centred care. Trust plays an important role in encouraging users to adopt online and/or automated transactions. More so, this trust is based on the effectiveness of the IT artefact, which, in this case, is the eHealth intervention to consumers' tasks (Vance et al., 2008). Accordingly, it was observed that similar quality aspects identified during the study also feature in the literature. Aspects include affordable, quality ICT services for economic efficiency and quality system features to facilitate operational efficiency hence both findings are in agreement. Therefore, eHealth providers should consider quality from the

perspective of patient-tailored interventions to increase confidence and trust of clients in the interventions to increase their adoption.

14.3.6.8 User-centred design service

Concepts related to the application of the UCD approach were noted by the participants' during the study, which is considered vital in the design of user-centred health services. According to Du Preez (2018), UCD may be described as a process through which products and services are created from the perspective of the end-user, who is the patient in this case. Shuvo et al. (2015) argue that eHealth providers should seek to pre-empt and address issues concerning end users' ability to access, trust, accept, and utilise an eHealth product. In particular, health care stakeholders should work together to give patients a voice towards creating a healing environment (Waters, 2008). Therefore, UCD plays a critical role in the design and development of eHealth interventions since design tools embrace the emotional needs of patients (Runaas et al., 2017), which can promote patient-centeredness. This requires constant engagement of users, including patients, through active participation to understand their needs in each phase of the design process while using various tools and techniques to create user-friendly interventions (Du Preez, 2018). One ICT participant noted:

"Use agile methodology to iterate the process with prototyping in order to have a user-guided design" (ICT001).

According to Du Preez (2018), the merits of UCD include the ability to facilitate a good understanding of the research context, user requirements, the identification of alternative design solutions, and the evaluation of solutions against specified requirements, thus creating meaningful services. According to Tseklevs and Cooper (2017), UCD promotes participatory design, co-design, and co-creation of services and products whereby a closer relationship is developed among health care stakeholders. Particularly, this involves the designer(s), individuals, and communities who contribute towards the outcome of the design activity. Designers are therefore challenged to tailor the user interface around their capabilities and needs, which leads to the integration of health services in ways that fit the goals, tasks, and needs of users (Endsley, 2016). User-centred application development methods can deliver better eHealth innovations since the target users are actively involved in the requirement analysis, system design and implementation, development, and evaluation process (Zhou et al., 2019). This is important for improving the health care experience and outcomes, particularly in low-resource settings.

Based on the findings from both the study and literature, the significance of understanding the relevant design requirements for eHealth interventions in an underserved context becomes clearer. The researchers and designers should know how stakeholders and users perform their work activities in their context (Blickstein & Holtzblatt, 1999). Contextual

inquiry is critical in this case as it helps to produce the facts as part of the social interaction between the designer and participants. More importantly, this helps to understand people's lived meaning and experiences in their context or situation (Klein & Myers, 1999; Gicheru, 2013). It enhances the customisation of eHealth services, the people-centric service especially during conceptualisation, and the actual design process. According to Fischer and Herrmann (2011, cited by du Preez & de la Harpe, 2019), UCD facilitates a systematic review of the technical and social systems at play. This enables designers to understand the relevant technologies needed to create meaningful eHealth interventions in the context of use. Maguire (2014, cited by Du Preez & De la Harpe, 2019) argues that the technical and social systems are inter-dependent and that they keep evolving hence the need for designers to gain a deeper understanding to navigate new socio-technical trends as they emerge. Thus, to enhance patient-centred health care, individuals' values, taste, and preferences must be considered to produce appropriate designs for eHealth interventions.

The aforementioned eight dimensions can therefore be adopted as a blueprint to guide the design of patient-centred eHealth interventions in the Kenyan context. The researcher believes that by doing so, this study promotes personal health and wellbeing towards improving health outcomes among underserved populations.

14.4 Research questions answered

The following sub-sections comprise the answers to the various research questions:

14.4.1 Research Question 1

What are the characteristics of an integrated ICT-facilitated health and wellbeing service(s) for maternal care that could enable patients to actively participate in managing health information in an underserved context?

14.4.1.1 Research sub-question 1.1

How do the key stakeholders in maternal health information services influence the information services in maternal care in an underserved setting? (T1, T5)

According to the findings from the study, five stakeholders who were either directly or indirectly involved in the delivery of maternal health care services were identified as being key in maternal health information services. These include clients (women), CHW/Vs, health professionals (caregivers), facility administrators (service provider) and technology providers (ICT experts). Stakeholders' influence on maternal health information service is mainly based on the role/responsibilities of each stakeholder in the maternal health care ecosystem as well as the general context, which includes organisational requirements and a technology environment.

Clients are mainly women and their next of kin, whose role is to consume maternity services provided at public health facilities. They influence information services that are provided in terms of their health and wellbeing information needs.

CHWs are the first point of contact for pregnant women at community level before they visited a health facility, where they mainly provide preventive health education and information services to the community. They influence information services in terms of their information needs to provide services to the women.

Health professionals are the caregivers themselves, providing treatment and advice to the women in maternal care at the health facilities. They influence information services in terms of their information needs to provide care to clients.

Facility administrators are individuals charged with the responsibility to manage health facilities, namely, overseeing day-to-day activities, including implementing policies and decisions on behalf of the service provider (County Government). Despite their information needs that enable to manage the institutions, they also influence information services in terms of organisational requirements such as policy, decisions, planning and resource allocation to support the delivery of health care services to clients.

Technology providers are ICT experts who provide ICT solutions to support health care delivery. This category of stakeholders does not have information needs directly related to health care; however, they influence information services in terms of the design and development of solutions to support health care delivery. Also, information services are influenced either positively or negatively by the general contextual environment within which health facilities operate. For example, the availability of resources is an important factor that determines the type of facilities/information infrastructure available and the literacy levels of clients and staff to use various tools or technology.

14.4.1.2 Research sub-question 1.2

What are the personal information needs of stakeholders in maternal care? (T2, T3)

Various stakeholder groups reported different kinds of information needs, influenced by individual duties/tasks. In general, the needs of women include pre-natal, antenatal and post-natal information needs. CHWs' needs are mainly focused on the prevention of diseases to avoid further spread and include MoH policy/guidelines on preventive health care, community demographics/profiles, and water sanitation and hygiene, among others. For health professionals, needs include client bio-data, maternal profile (medical and surgical history), ANC profile (details on current pregnancy) and professional knowledge. Facility administrators' needs were mainly indicated as administrative, for example, statistical data for planning and budgeting, and policy information for regulatory compliance and decision-making purposes.

14.4.1.3 Research sub-question 1.3

How do stakeholders in maternal care currently obtain and manage information relevant to their needs?

Stakeholders indicated that they obtain information from different sources and used different types of media to manage information. Common sources of information include colleagues, CHWs, health professionals, print sources, community profiles, MoH tools and guidelines, professional (basic)/training, organisational records, mass media and the Internet. Information is mainly managed through traditional methods such as print-paper-based media, for example the ANC booklet to manage maternal profile, and verbally through face-to-face meetings as well as telephone conversations. However, the use of mass media is minimal while Internet sources are used by very few people across the board.

14.4.1.4 Research sub-question 1.4

What are the challenges faced in accessing and managing maternal personal health information?

The general challenges faced include poor governance of health care services; inadequate funding; traditional information services; and poor ICT infrastructure, health communication and client privacy and confidentiality. The aforementioned challenges hinder accessing and managing maternal health information. Poor governance involves the lack of a standard framework to regulate the management of information, which includes the creation, storage, access, sharing, and disposal of information across health facilities for uniformity. Inadequate funding hinders the provision of relevant facilities and information processing equipment to ensure effective handling of information. Predominant traditional information services, that is, paper-based and verbal methods, have several limitations comprising the quality of information services provided. The health communication system and infrastructure are weak as traditional media (the ANC booklet, telephone calls/conversations) is mainly, which compromises the confidentiality of information. Client privacy and confidentiality are reported to be highly compromised due to the traditional nature of information services; health information is exposed to third parties, causing the information to be leaked.

14.4.2 Summarised answer to Research Question 1

The relevant stakeholders of maternal health information services were identified as clients, CHWs, caregivers, facility administrators and ICT experts by virtue of the roles they perform in the maternal health care ecosystem. Information needs of individuals are determined by the tasks they perform within the health care ecosystem. Also, information services are influenced by the general context of facilities, including organisational requirements, resource availability and infrastructure, among others. The services are mainly traditional as they are managed verbally and in paper-based format. Key challenges

experienced include: (i) lack of policy guidelines to govern the management of health information; (ii) inadequate funding to facilitate operations at facilities; (iii) traditional information services, which have weaknesses such as geographical limitations as opposed to electronic services; (iv) poor information infrastructure, preventing the improvement of information access and collaboration; (v) poor communication services due to poor infrastructure; and (vi) poor client privacy and confidentiality due to the nature of traditional information practices.

Therefore, the information environment is complex and resource-constrained, as there are several stakeholders, but the infrastructure is not appropriate, hence the need to integrate the services using large-scale innovative ICTs. This will help address the issues of information access, collaboration, communication and client data privacy and security to enhance the efficiency of services.

14.4.3 Research Question 2

What are the methods, constructs, propositions and definitions describing the design process of an integrated secure electronic personal health and wellbeing information service needed to enable patients to be more involved in their own health information services?

14.4.3.1 Research sub-question 2.1

How could stakeholders perceive a potential information service relevant to the needs of pregnant women in maternal care?

According to the study, current maternal health information services do not adequately meet the needs of stakeholders, hence poor-quality service. In particular, there is lack of client privacy and confidentiality due to over-reliance on traditional methods (paper-based and verbal) in managing and communicating health information. The services are complex and tedious for the health care personnel, while at the same time records get lost and destroyed prematurely, hence loss of information. At same time, storage space is lacking in most facilities due to the fast accumulation of paper-based records. Generally, the participants perceived that potential information services relevant in maternal care should be both educative and ICT-driven. The researcher therefore used a combination of theories, methods and techniques throughout the design process to deliver personalised information service in maternal health care.

- **Theories:** Both stakeholder theory and SDR strategy were employed whereby the relevant stakeholders were identified and engaged in the design process. This approach was followed to contextualise the services towards building a solution(s) with meaningful use. Specifically, stakeholders helped the researcher (designer) to understand and interpret latent needs in order to design better/improved information services. The theories were aimed at facilitating

stakeholder/user involvement through active participation to create a patient-centred health care service

- **Methods:** The researcher used a variety of methods, including the SDR strategy, co-design methods, qualitative methods and agile methods to design effective and personalised services. SDR approach was adopted to enable the researcher to conduct a context-specific inquiry into the research problem, which included listening to the views of stakeholders and then involving them in creating the new service(s). This was to ensure the delivery of a design solution(s) with meaningful use in their context of use. The co-design process mainly involved ideation, conceptualisation and prototyping activities, which enabled the designer to partner with the users to include their perspective in knowledge development towards product development. Therefore, the co-design activities facilitated the inclusion of user feedback and ideas during the design process, thus leading to user-centred, participatory and co-operative designs (Thobias & Kiwanuka, 2018). Also, qualitative methods were used, including interviews and observation to obtain stakeholders' opinions, ideas, perceptions, attitude and beliefs, among others, to inform the design process towards the desired solution (Thobias & Kiwanuka, 2018)
- **Techniques:** Various techniques and tools were employed prior to and during the design process to deliver solutions with meaningful use. First, the researcher conducted stakeholder mapping through applying the snowballing technique to identify key stakeholders of maternal care in order to get the correct interpretation of new service requirements. Context analysis was then applied through site visits with group focus interviews to elicit the information requirements/needs of stakeholders. Site visits enabled the researcher to observe and analyse the entire research environment in which health facilities operate to gain more insight into the research problem. The researcher was able to understand the various technologies, tools and devices to be used in creating new services, including mobile technologies, Web technologies, cloud technologies and eHealth standards, among others
- A typical service blueprint for maternity services was used to identify various touch points, pain points and possible barriers based on the women's experiences in their search for information, which provided an opportunity to design better services. Also, the service prototyping technique was used whereby the researcher observed users' interaction with the new service in the context of use. This facilitated the necessary modifications to tailor the service towards the desired situation

14.4.3.2 Research sub-question 2.2

What are the considerations for the design of a functional ICT-facilitated maternal health information service that is personalised?

A number of factors were identified during the study, which influence the design of a personalised ICT-facilitated maternal health information service. These include stakeholder engagement, service contextualisation, data access, HIT utilisation, system/service integration, system quality and user-centred design.

The designer(s) should identify all relevant stakeholders and involve them in the design process in order to understand and interpret their requirements correctly. This involves the mapping of requirements for each stakeholder group based on the context of service (system) use in order to produce a meaningful user-oriented solution. Next, analyse the technological environment to understand the existing information infrastructure, including the competency of IT personnel and the users' computer literacy skills to understand the available capacity and technologies to employ. Data access and security should be managed with adequate controls and measures to protect health data in order to avoid the violation of clients' basic right of privacy. The utilisation of analytic tools should be taken into consideration to facilitate easy manipulation of data, including filtering and generating reports for decision-making. Services should be integrated across departments and beyond organisational boundaries to allow for collaborative health care, including referrals, which will promote the delivery of patient-centric services. Also, system quality should be ensured in order to improve customer experience, including specifications, affordability, maintainability, accessibility, usability, reliability, scalability, interactivity and responsiveness. Lastly a user-centred design approach should be employed involving active participating prototyping techniques and scenarios to create the service from the perspective of the end users.

14.4.4 Summarised answer to Research Question 2

The researcher employed a combination of theories, methods and techniques to create services with meaningful use in their context of use. These include the stakeholder theory and SDR strategy to facilitate stakeholder engagement through the design process using co-design, qualitative and agile methods, including prototyping, to elicit user requirements and contextualise new services. Stakeholder mapping, context analysis, service blueprints and prototyping techniques were used to create more user-centred electronic health information services. To design personalised ICT-facilitated health information services, important factors were taken into consideration, including data security for client privacy and confidentiality, as well as system/service integration and collaboration to facilitate patient-centric information services and communication. Being an underserved context with resource-constraints, affordable large-scale innovations/technologies were used, specifically CC alongside mobile and Web-based technologies and eHealth standards.

14.5 Chapter conclusion

In this chapter, answers were provided to research questions based on the study's key findings. In the next chapter, the contributions, reflections and conclusion of the study are presented.

Chapter 15: Contributions, Reflection and Conclusion

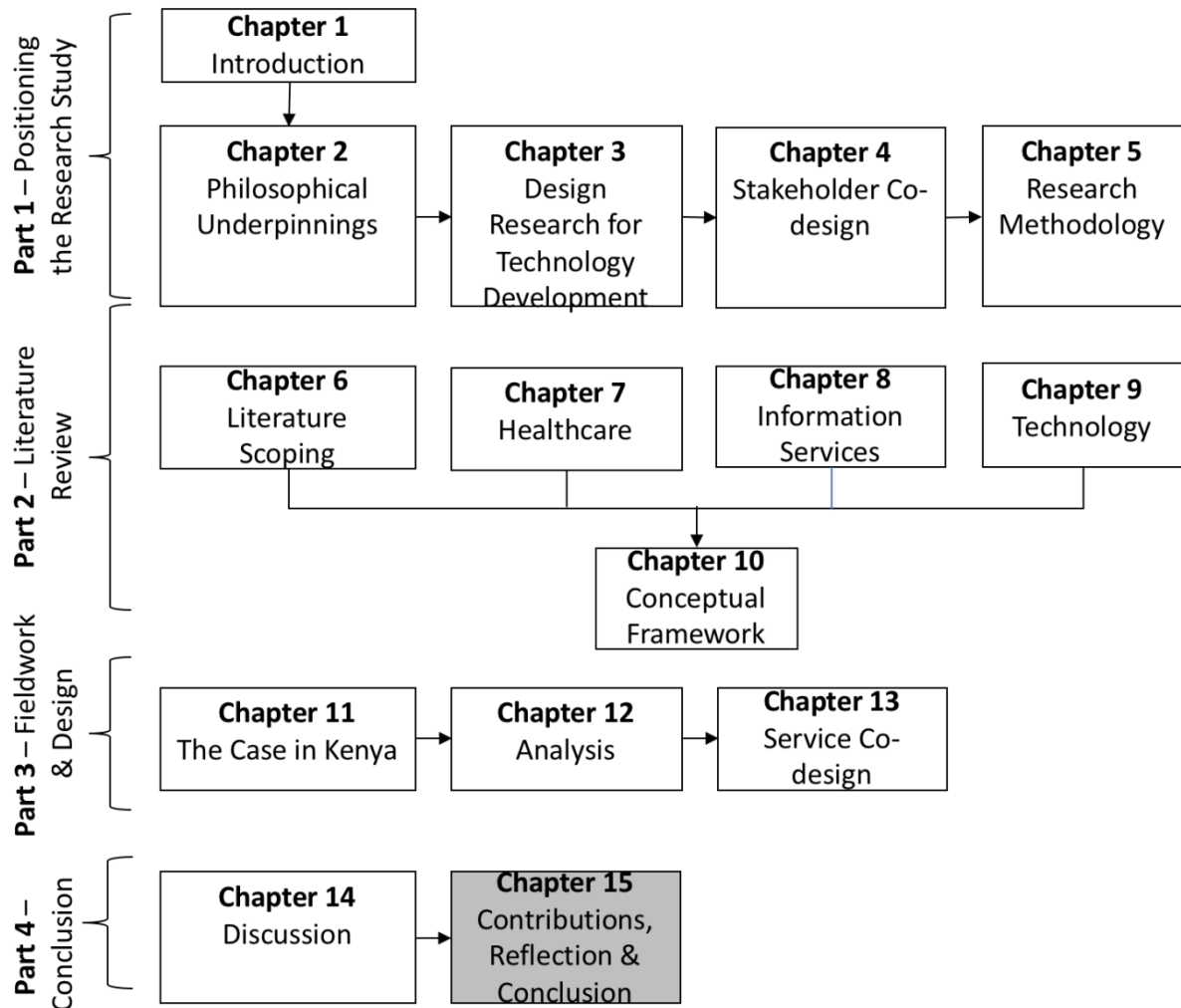


Figure 15.1: Thesis Layout - Chapter 15

15.1 Introduction

This chapter discusses the key aspects of the research, namely the summary of findings, technology and infrastructure for the proposed new services, research model, research outcomes and contributions, recommendations, study limitations, quality of research and recommendations for further study.

15.2 Summary of findings

According to research findings, there are various categories of stakeholders directly or indirectly involved in maternal health care services. These include women and their next of kin as service consumers, CHWs as the first point of contact for clients (pregnant women) at community level, health care providers (hospitals, health care professionals/caregivers and managers) who facilitate care delivery and relevant government departments (both County and National) as service providers. Different stakeholders have varying information needs based

on individual roles obtained from different sources, including print sources, people (colleagues, mothers, and health professionals), MOH guidelines, institutional records, mass media and the Internet. Therefore, the study found that the health care system is complex as it involves several stakeholder groups with varying information needs. As a result, there is a need for coordination and collaboration to deliver efficient services (Boore, 2018; KPMG, 2014; Many et al., 2016).

Information practices across health facilities are traditional-oriented as both paper-based records and verbal methods are mainly used to manage and communicate health information among stakeholders. The ANC booklet with recorded clinical notes is the main document used in providing maternal health education, which is in the custody of the client. Verbal communication comprises face-to-face conversations between clients and midwives during clinic visits, while mobile communication is used to do follow-up activities by caregivers. Unfortunately, these methods have shortcomings, including geographical barriers hence limited data access, retrieval, sharing and storage space, while it increases cases of data loss, damage and insecurity, and particularly client privacy and confidentiality (Turin, 2010; World Health Organisation, 2014). Furthermore, it leads to increased fragmentation of health services due to data silos created within individual facilities because of a lack of system/service integration, which leads to limited health care collaboration and subsequent operational inefficiency and staff unproductivity.

Major challenges experienced include poor governance and inadequate funding of health care infrastructure, causing serious resource constraints. In general, the overall health care infrastructure is insufficient due to acute shortages in terms of personnel, commodity supplies and the non-existence of ICT services in health facilities. The study therefore identified inadequate funding as one of the key challenges facing underserved contexts, which is also indicated in literature (Kenya, 2015; Turin, 2010; World Health Organisation, 2014), a situation that compromises health care delivery among underserved populations. ICT is perceived as a critical component by stakeholders to improve the quality of health care services. According to findings from both the study and literature, ICT has the potential to transform health care by making health care more digital, accessible, data driven, error free, collaborative and patient-centric/self-managing, and above all, reduced costs, among other benefits (Boore, 2018; Findikoglu & Watson-Manheim, 2016; John & Shenoy, 2014; Drury, 2005; Bantom et al., 2016). It was observed that ICT is not optimised to maximise its benefits towards achieving improved health outcomes, therefore confirming the argument by Røed (2012) that the implementation of ICT in health care delivery remains a challenge in developing countries.

Based on the study findings, there is a need to re-design health care service to improve delivery of maternal health care using ICT. Specifically, the study identified eight key considerations to be taken into account with designing ICT-facilitated health and wellbeing service to deliver meaningful maternal health care. These include data access, HIT utilisation, system implementation, service contextualisation, system/service integration, stakeholder engagement, system quality and user-centred design, which guided the design of a proposed design solution (model) for the research, which is cloud-based patient-centred health and wellbeing information architecture (CPHIA) to support maternal health care in an underserved context.

15.3 Technology and infrastructure for the new services

According to the research findings, a myriad of challenges face the delivery of efficient maternal health care in the research context. These include poor funding, hence resource constraints, fragmentation of health systems, poor health communication, lack of privacy and confidentiality and poor ICT infrastructure, among other issues. It is against this background that the research proposes the nature of the technological infrastructure to be a *person-centred health cloud service* with specific components and characteristics to improve the quality of maternal health care in the research context. This will be discussed next in terms of key technologies, data security and Internet connectivity.

15.3.1 Key technologies

Both cloud and mobile computing technologies were identified as key large-scale innovations to transform health care in an underserved context (Miah, 2017; Nyatuka & De la Harpe, 2019). CC was selected as a key technology due to its capability to address the problem of fragmentation through the provision of collaborative health care platform towards patient-centred health care in a cost-effective manner. Specifically, a private cloud service is recommended due to the sensitivity associated with the handling of health information, with security to be provided through the cloud platform. The cloud platform will be provided and managed by the government to transform health care in terms of reduced expenditure through the collaboration and sharing of resources (Heyeres et al., 2016). The main clients/users of the cloud service will include patients and health care providers (health professionals). Government/MOH and medical research institutions will also view data in the cloud for decision-making, disease surveillance and research. Also, mobile services were found to be the most preferred mode of ICT used in the research context, with evident higher penetration levels as opposed to other ICTs due to its affordability and convenience (Nyatuka & De la Harpe, 2019), and is thus critical for purposes of communicating health information. In particular, beside calling and sending SMSes, smart phones are used as a substitute for computers since one could access the Internet in the form of email services, social media, and

websites, among others; they therefore perform an important role in communicating/ sharing health information. Cloud-based mobile Web information architecture is proposed to provide patient-centred eHealth service in maternal care as illustrated in Figure 15.2.

15.3.2 Data security

To enhance data privacy and confidentiality, various measures and techniques will be applied to secure data in the cloud. Specifically, there two levels of security for data in cloud storage is proposed, both inside the cloud (cloud security service) and outside the cloud platform. Security inside the cloud will include the use of cloud-based firewalls and intrusion detection systems (IDSs), which will be used to monitor inbound and outbound traffic for anomalies. Security measures outside the cloud will involve the use of HTTP Secure (HTTPS), which uses cryptographic techniques to secure the data network to ensure safety during the transportation of data into and out of the cloud. There will be local data backup (local servers) on the client side to guarantee maximum data safety/security. To boost privacy and confidentiality levels, only the client(s) will have full access control over their PHR history in the cloud. Health professionals will however seek consent from the client/ patient to view the full PHR record, except for data generated at individual health facilities, which the service providers can access via a desktop computer(s).

15.3.3 Internet connectivity

Given the nature of inadequate technical infrastructure in the research context, which is characterised by regular power outages and unstable Internet connection, progressive Web applications with offline synchronisation capability (Smith et al., 2011) will be optimised to support business continuity in such occurrences. The API integration point will support the capturing of content offline with full synchronisation when services normalise (Smith et al., 2011). With appropriate user interface features, staff at health facilities will be able to capture and modify data offline. In addition, users will receive a reminder(s) to update offline edits on the local server to the cloud server whenever the Internet connection resumes. To achieve the above, individual health facilities will be local data servers to capture data locally before pushing it to the cloud.

15.3.4 Health systems interoperability

Being the most popular and widely used messaging eHealth standard internationally, the HL7 protocol will be used to support health information exchange between different applications, and in the communication and business process layers (Namli et al., 2009). Following its recent upgrading to HL7 FHIR, it has become the most ideal choice for local hospital communities to exchange health information (Bender, 2013). FHIR is one the latest health interoperability standards as it combines the best features of HL7's v2, v3 and CDA (Benson & Grieve, 2016). The standard also leverages the latest web standards, which makes

its implementation easier, thus reducing the cost as compared to other alternatives hence economic and clinical value. More importantly to note of the HL7 FAIR protocol is that it is generally well suited for use in mobile applications, cloud communications and EHRs, which are the key technologies adopted for the proposed solution (Benson & Grieve, 2016).

15.4 Research model

The proposed architectural design solution, namely the cloud-based PHR service in Figure 15.2, is aimed at supporting the delivery of maternal health and wellbeing services. The main users of the proposed new service include pregnant women and health care providers (health care providers). Also, the government/MoH will use data in the cloud to facilitate disease surveillance, decision-making and for clinical research. All health facilities must subscribe to the cloud service in order to facilitate data exchange between the local server and the cloud server for purposes of data interoperability. Upon the first ANC clinic visit/appointment at the health facility, the client (pregnant woman) will subscribe to the PHR service, whereby the client's National Health Insurance Fund (NHIF) number will be used as the unique and universal identifier (ID). During subsequent clinic appointments and treatment, the client's data are updated on the EMR in the local server, which is then pushed to the cloud. In the event of a referral to the referral facility (hospital), the NHIF number is used to access the client's maternal profile and referral details. An EMR is then generated at the referral facility for the client where after the data are pushed to the cloud server to update the PHR history. In this case, only the client will have access to the full PHR history containing data from different sources/facilities in cloud storage to protect the privacy of the client (Hu & Bai, 2014). Health care providers/personnel will view the PHR history through the consent of the client during client/doctor interaction at the point of care. Due to varying computing needs of different users, clients will mainly access their PHR data through mobile devices (which are more affordable) while health care providers and government authorities will use desktop computers (given the heavy computing demands) due to the nature of tasks to be undertaken.

As illustrated in the proposed model, health care providers will have unrestricted access to client EMR data generated in their respective local facility where the client receives treatment. Also, the government/MoH being the super admin will have direct access to anonymous client health data (medical records and aggregated data) to generate administrative reports for the purposes of disease surveillance, decision-making and clinical research. The main aim of the model is to protect the privacy of the patient, which has been generally earmarked as the major cause for poor and/or low adoption of eHealth interventions despite immense benefits associated with ICT innovations in health care.

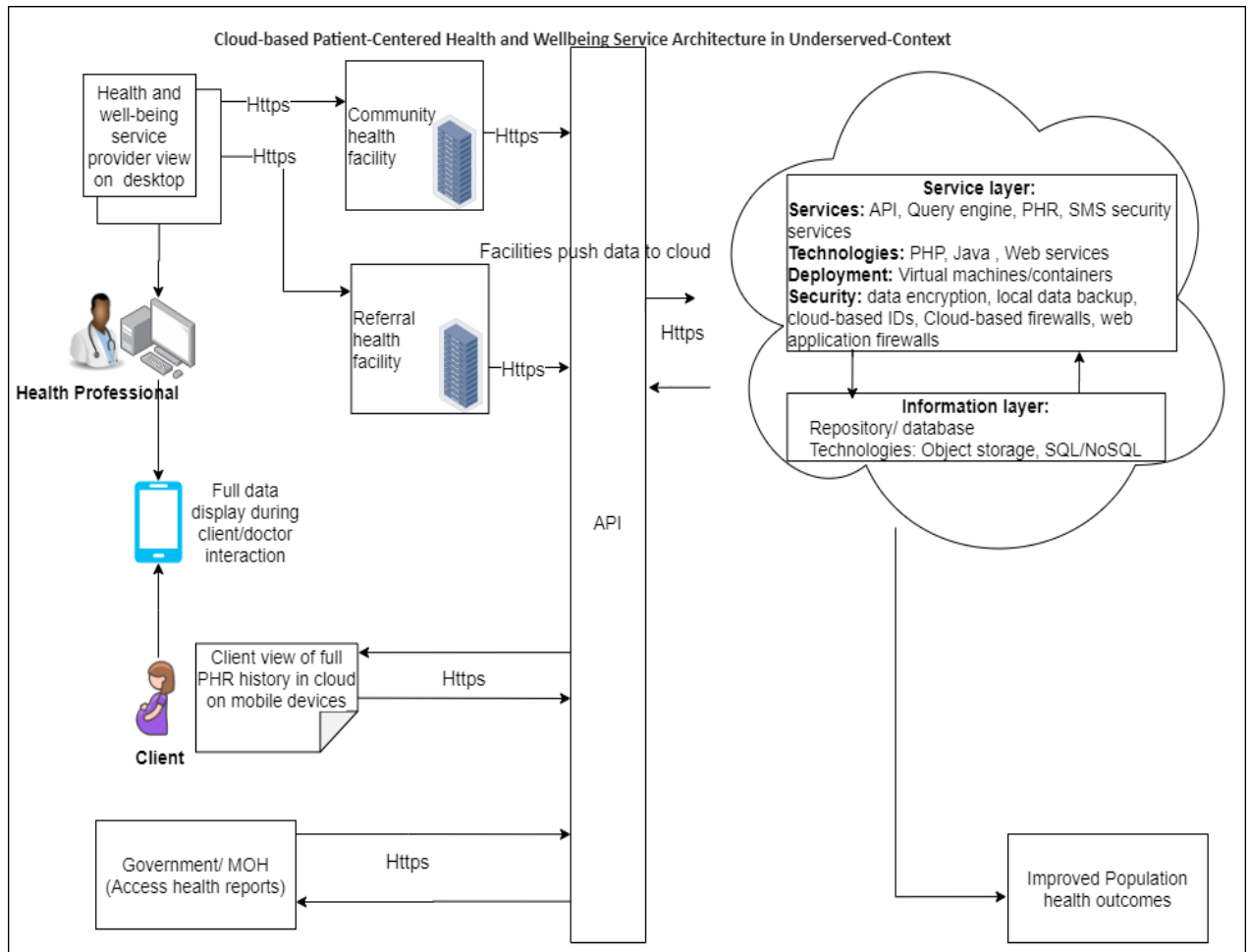


Figure 15.2: Cloud-based Patient-centred Health and Wellbeing Information Architecture (CPHIA) for maternal health care

15.5 Research outcomes and contributions

This sub-section describes the various contributions of the study, including the theoretical contribution and methodological contribution as well as the contribution to discipline knowledge and practice.

15.5.1 Theoretical contribution

Being interpretive-oriented research, the adoption of the SDR approach in this study is aimed at generating theoretical knowledge in terms of conceptual knowledge, descriptive knowledge and prescriptive knowledge (Niehaves, 2007; livari, 2007; Wang, 1997; Chandra et al., 2015; Wang, 1997).

Conceptual knowledge in this case was generated in the form of the service concepts and service constructs during data analysis, of which the outcome include codes, categories, and data themes as well as the conceptual model for research (livari, 2007; Wang, 1997; Group Object Management, 2010). The proposed design model demonstrates the various components of secure, integrated ICT-facilitated PHR service in an underserved context,

namely: stakeholders (people, health care providers and government); technologies to be used (CC, mobile and web applications, among others) to enhance system/service integration and access to health data by stakeholders; and service interactions and information flows within health care ecosystem. Essential design considerations include: system/service integration through use of cloud technologies; patient privacy and confidentiality since the client controls access to their own health data; HIT utilisation through query engines, i.e. data analytics tools; and user-centred design, i.e. personalised services to empower patients. Other design considerations observed by SDR approach include service contextualisation and stakeholder engagement through co-design activity to interpret service requirements. Although the proposed design theory is used in design science research (DSR), the contribution in this study applies the same theory to SD in order to expand the design theory in order to also consider the design of services.

Descriptive knowledge was generated through interpretations of the research context during the problem understanding and problem solution stages, which reflected specific design considerations/characteristics of the proposed cloud-based PHR service. This involved making empirical observations (Wang, 1997) to identify the various components of the existing structure to describe how things are, i.e. the truth about the natural phenomenon. The researcher observed the social world and attempted to explain how people behaved and interacted with health care services in the research context hence descriptive knowledge (Simon, 1996).

Prescriptive knowledge, on the other hand, was generated and reflected through the co-design process, which comprised product knowledge as well as the technological rules and technical norms that were followed. Therefore, design knowledge was built in the context where it was put to use, whereby its products and results, as they materialised, contributed to further theoretical advances (De Figueiredo & Da Cunha, 2007; Wang, 1997). More so, a variety of theories were used, including interpretive IS field research theory, stakeholder theory, the SDR strategy, and the IS design theory, which were combined together (Gregor & Jones, 2007; Klein & Myers, 1999; Johnson et al., 2008; Moritz, 2005) to ensure a rigorous research process.

Most of the previous studies based their research on traditional (positivist) approaches geared towards identifying factors that influence the design of HIT innovations through the adoption of theories, which were then tested empirically, as opposed to this study, which is context specific. As such, this research generated themes (concepts) to explain the design characteristics for HIT innovations in the specific research context. The SDR approach focuses on the creation of innovation with purposeful development for a specific context, and it mainly

revolves around designing new or improving existing services to make them more useful, efficient and effective (Miah et al., 2013; Järvinen, 2007; Moritz, 2005).

15.5.2 Contribution to discipline knowledge

This study contributes to the existing body of knowledge in terms of the process used in applying the pragmatist SDR approach to develop the research model (CPHIA) in order to support the delivery of maternal health care in an underserved context. This study was intended to close the gap on the paucity of frameworks to guide the design of health and wellbeing services in underserved contexts, and particularly Africa, with specific focus on Kenya. This investigative study therefore attempted to bridge this gap identified in previous research. A new research model is proposed, which explains essential design considerations and components for ICT-facilitated innovations towards promoting personalised health and wellbeing services in an underserved context. Specifically, this model is more effective as it addresses the key challenges pointed out in literature, including fragmentation of health systems, violation of patient privacy and confidentiality. More importantly, the proposed solution attempts to bridge the gap in traditional models of care, which are institution-focused rather than focusing on people-centred care, whereby only clinicians collect, track, and utilise data generated in the hospital (Mishra et al., 2018) – the qualities lack in previous research/existing frameworks (Bukowski, 2016; John & Shenoy, 2014; Net Health, 2016; Heart et al., 2017; World Health Organisation, 2016b). It also contributes knowledge about using a co-design-oriented design process with the active involvement of all relevant stakeholders. Significantly, this research contributes to various disciplines of knowledge, including patient-centred care, ICT-facilitated technologies, information services in health care, and also design knowledge, which was gained through design methods as follows:

15.5.2.1 Patient-centred care

Knowledge was contributed in the patient-centred care domain using co-design tools and techniques whereby stakeholders were engaged throughout the design process with co-design activities, ideation and iteration. This process enabled products and services to be created from the perspective of the end-users (Du Preez, 2018), that is, according to individual taste and preferences since the researcher became an active participant. ICTs were used to facilitate information sharing and coordination among stakeholders, hence collaboration, which is a function of service/system integration towards providing patient-centred care (Tseklevs & Cooper, 2017).

15.5.2.2 ICT-facilitated innovations

Through application of the SDR strategy knowledge was contributed in terms of identifying and integrating various technologies considered appropriate to improve the delivery of personalised health services in the research context. Specifically, affordable and large-scale

innovations were adopted, namely cloud and mobile technologies alongside Web technologies to address challenges hindering health care delivery among underserved communities (Miah, 2017). Both CC and mobile technologies were adopted as more affordable technological innovations to help integrate health services in the context of use. While CC was used as a catalyst for integrating health care services (Manya et al., 2016), mobile technologies were adopted due to their affordability and popularity among underserved populations, as opposed to Web technologies. In addition, mobile technologies have the potential to support the delivery of personalised services, for example, tracking and monitoring personal data in the cloud as well as ensuring patient privacy and confidentiality. Web technologies, including desktop applications, are suitable for health care providers due to their higher capacity for data processing, that is, HIT utilisation, for example, through use of data analytics tools and machine learning techniques to enhance health reporting. A prototype service was developed using design methods, including co-design activities, i.e. ideation, conceptualisation and prototyping with iterations towards delivering the desired solution.

15.5.2.3 Information services in health care

The application of design methods produced a research model to facilitate the delivery of a new and improved health information service. The use of design methods and tools, i.e. co-design activities, prototyping and design iteration by stakeholders, enabled the accurate interpretation of user requirements for personalised ICT-facilitated information services. These include the identification of various service components, namely methods, constructs, and propositions, among others, that were used and/or applied towards producing desired services in the context of use. Specifically, the developed design model has the potential to overcome challenges associated with current (traditional) information practices, and specifically health care fragmentation (John & Shenoy, 2014; Manya et al., 2016; Sneha & Straub, 2017). The new improved services have the potential to support secure, integrated, personalised and ubiquitous data access, data sharing, and health communication and collaboration, hence evidence-based decisions. Also, data storage, retrieval and security, including patient privacy, are well taken care of.

15.5.2.4 Design knowledge

According to Windahl and Wetter-Edman (2019), design knowledge is created through design actions and movements between theory and practice through engagement in specific situations. Particularly, SDR is important when dealing with complex problems whereby integration is needed between physical artefacts, knowledge and interactions.

In terms of contributing to the design knowledge domain, the study brought about immense contribution since a co-design-oriented SDR strategy was used as catalyst to combine various aforementioned theories, methods and techniques to produce new services

(Simon, 1996; Malmberg et al., 2019). More importantly, the SDR approach was adopted because of its potential to facilitate a holistic, multidisciplinary and integrative approach towards innovation and improving current services to make them more meaningful to both consumers and organisations (Moritz 2005; Joly et al., 2019). Using the SDR strategy, the study promoted relationship building between the designer (researcher) and stakeholders through: (i) social networks by involving new people and institutions; (ii) trusting others, hence collaboration; (iii) the understanding of others through participatory, learning and reflection processes; (iv) identifying communities to be involved, thus creating a sense of belonging; and (v) distributing knowledge through the sharing of research outcomes as well as developing participant capacity of the system knowledge acquired during the research project (Walter et al., 2007).

15.5.3 Methodological contribution

The SDR approach was used to ensure contextualisation of the new services to make them meaningful in the context of use (Moritz, 2005). To achieve this, the study used a combination of methods to take advantage of the multidisciplinary nature of the SDR approach (Moritz, 2005), which allows the integration of various methods throughout the design process to create new innovative services that are compliant with principles of design. The methods used include stakeholder theory/mapping, qualitative/interpretive inquiry, co-design, and agile development (Thobias & Kiwanuka, 2018).

Stakeholder mapping was used to facilitate stakeholder engagement and active participation throughout the co-design process (Johnson et al., 2008). At the same time, IS design theory was used to ensure the application of, and adherence to design principles in the development of the prototype system/service (Gregor & Jones, 2007). Lastly, interpretive theory was also applied to enable the application of principles of interpretive field research in IS (Klein & Myers, 1999).

Qualitative methods used include interviews and participant observation to interact with participants to elicit and interpret stakeholders' perspective(s), opinions and propositions towards producing the desired new design solution (Klein & Myers, 1999).

The co-design process, on the other hand, involved conducting the study with continuous involvement of stakeholder participants to facilitate accurate interpretation of the nature of maternal health care services in their context (Crombie, 1996). By using a design research approach rather than the DSR approach, the researcher was able to gain better insights into the complex nature of the research context and the problem area. By focusing on understanding the problem situation first through the involvement of relevant stakeholders as they make sense of their situation and needs, the researcher was able to co-design a better

service for their context as shown in the proposed co-design-oriented SDR framework in Figure 15.3, which was initially presented in Chapter 4, section 4.8.

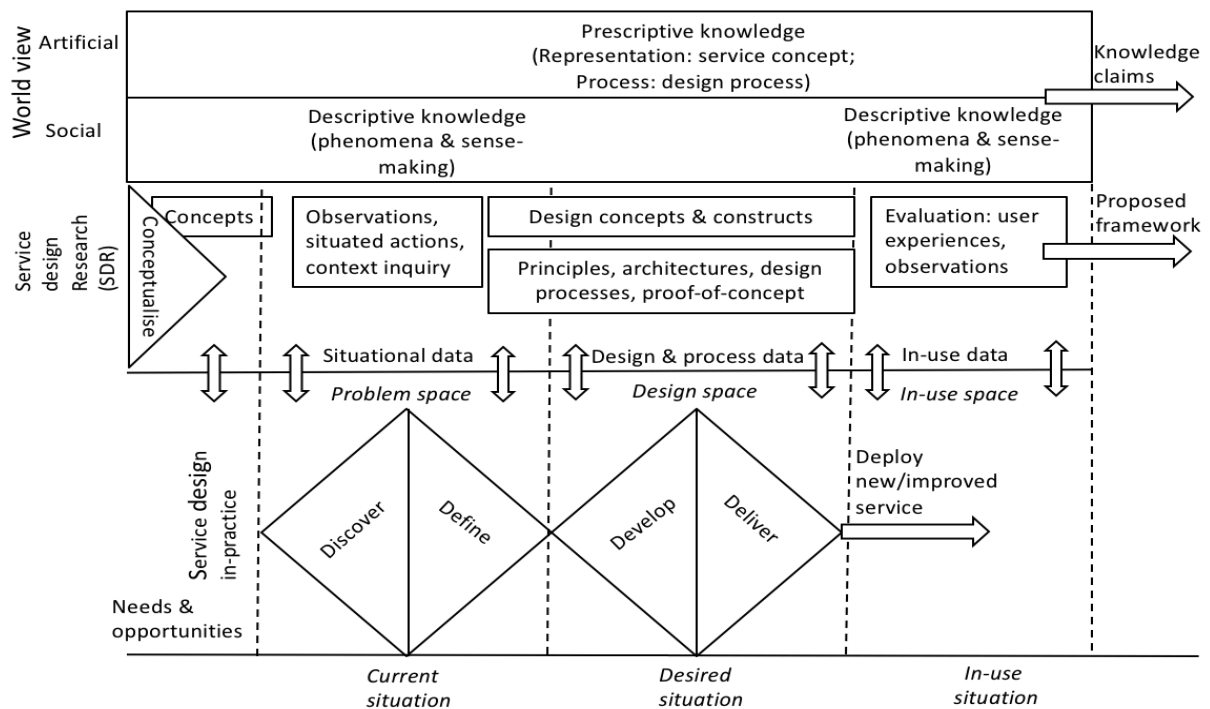


Figure 15.3: Paradigm representation of co-design-oriented SDR framework

This was achieved by moving back and forth between the two paradigms, hence the researcher was able to get the most from each phase, i.e. problem understanding through interpretive research and the co-design phase with a pragmatic approach for problem solving as depicted in the co-design process framework in Figure 15.3. The proposed co-design process framework may therefore be a major contribution for the design of technology-enabled new services.

Agile development was applied through prototyping to support the co-creation of services as continuous feedback was received from the stakeholder participants in a much faster and less expensive way (Khan et al., 2012).

Therefore, the application of both the SDR approach and concepts of stakeholder theory in the analysis and design of ICT-facilitated health and wellbeing information services in an underserved context meets the power of design techniques, i.e. the 4Ds of the double diamond, namely: discovery, definition, development, and delivery of services (Design Council, 2015), thus generating substantive theory. The use of the SDR strategy facilitated open exploration through contextual inquiry, thus depicting the development of various concepts showing their relationships leading to substantive theory, which can be used to explain issues related to the design of ICT-facilitated PHR services in under-resourced contexts. Most of the

existing studies on the design and implementation of HIT innovations are based on the positivist approach, which isolates phenomena from reality and thus they manipulate reality with variations in only a single independent variable to identify regularities in, and form relationships between some of the constituent elements of the social world.

Unlike the positivist approach, the SDR approach allows theory to emerge from the research context. The research is therefore significant as one among the few studies conducted to build SDR theory in an underserved context, and particularly in the development of IS artefacts, hence further research can be derived from the study.

Having used the SDR approach, which is trans-disciplinary, this study adds great value to the existing body of knowledge in terms of collaboration, which emphasises systems and interaction design towards solving and re-thinking complex challenges in providing solutions. It offers the opportunity for few narratives and discourses that naturally take the form of new experiences, services, or systems (Wagenfeld & Mitchell, 2013).

15.5.4 Contribution to practice

This study offer the stakeholders, which include including health care providers and health care consumers in underserved context(s), a key instrument to guide the design of technology-enabled health and wellbeing services from a SDR perspective. It adds to the critical issues to be looked into while designing services that include design characteristics, service concepts and components, among others. The usability and success of the framework in underserved contexts is underpinned by the SDR theory and collaboration among stakeholders, which is cognisant of the nature of health care services and the key drivers in the social structure, of which health care is a part of. A significant contribution of the research framework to inform the design of ICT-facilitated health services is its recognition of ICT capability in health care practice and within the circles of the social, economic, political, and cultural factors (World Health Organisation, 2016b). In addition, the framework contributes to a better understanding of designing HIT interventions from a SDR perspective. This provides an opportunity to information technology providers, health care providers and health care consumers, in particular, as the key stakeholders in HIS development in the health care sector (Korpela et al., 2013) to improve their professional practice in the design of ICT-facilitated health and wellbeing interventions. Lastly, the technology-enabled information service framework (CPHIA) will promote delivery of maternal health care to the service consumers (pregnant women) and service providers (hospitals/caregivers), hence improved users' experience.

15.6 Recommendations

Based on the study findings, the researcher recommends that both the National and County Governments should consider using the findings of this study to improve existing maternal health information services in public health facilities.

Having used the SDR approach in this study, which is context-specific, informative and detailed, the researcher recommends that other researchers utilise this approach in their studies. In addition, the SDR strategy has not been used in the local context prior to this study; it is therefore advisable that the local researchers in IS, particularly in health care design, use the findings of this study in future research.

Furthermore, the majority of ICT studies are based on the positivist approach, unlike this study, which is interpretivist-oriented. Therefore, the study provides an opportunity to other researchers in terms of systematic approach and procedure (i.e. a combination of various theories, methods and techniques) as a guide towards employing the SDR strategy in their future research.

15.7 Limitations of the study

In terms of the geographical scope, the study was mainly conducted as a case study of maternal health care services within Nairobi City County in Kenya, and therefore the findings may not be generalised in other regions and countries, which may not have similar characteristics as those of Kenya. Characteristics include population demographics, socio-cultural issues and health care infrastructure, which influence the behaviour of people seeking health care. Generally, little eHealth research has been conducted in underserved contexts, particularly Africa, as opposed to the developed world; thus, much published literature could be found in the local context to inform this study. A larger portion of existing literature originates from developed context(s). This study developed a conceptual framework for cloud-based patient-centered health and wellbeing services as a case of Kenya, which is a typical example of an underserved context, hence, the framework is yet to be validated in other contexts.

15.8 Research quality

According to Noble and Smith (2015), research quality is achieved by assessing both the reliability and validity of research instruments in either qualitative, quantitative and mixed methods research. Both reliability and validity are extremely important in research as these characteristics enhance the accuracy of research processes, tasks and the evaluation of research work (Adefioye, n.d.). The authors define reliability as consistency, stability and repeatability of results, whereby repeatability is related to equivalence, meaning the degree of agreement among researchers using a similar tool. Results are said to be reliable if similar or consistent results have been obtained in identical situations (Garrett & Seidman, 2011).

Reliability is directly related to the validity of the measure, and there are three important considerations when relating the two principals. In the first scenario, a test can be considered but not valid; secondly, validity is more important than reliability; and finally, the most important instrument should be both valid and reliable (Thatcher, 2010). Therefore, according to the third principle, the issue of reliability also needs to be addressed. This research was mainly qualitative; however, it also had some quantitative characteristics, particularly respondents' demographics, hence the researcher had to employ strategies to ensure validity and reliability for both qualitative and quantitative data.

15.8.1 Reliability of research

To begin with, the researcher verified all transcripts to rule out obvious errors, since it is common for a researcher to make errors during data transcription (Creswell, 2009). In the case of this research, interview transcripts were thoroughly checked to ensure no errors made during transcription went unnoticed before the processes of coding and interpretation commenced. In addition, the researcher applied critical thinking whereby various qualitative approaches were used while engaging participants to enhance the trustworthiness of the study, which helped him to create a new understanding of the problem space (Swartz & Parks, 1994). Specifically, contextual inquiry was conducted, embedded in the co-design-oriented SDR strategy through using prototyping methods. To enhance the quality of this research, the researcher attempted to integrate and apply general principles of design (Nagle & Sammon, 2020) and IS design theory as discussed in section 3.4 (Gregor & Jones, 2007; Gregor et al., 2020; Chandra et al., 2015), principles of interpretive field research in section 5.9 (Klein & Myers, 1999), and principles of the IPCHS framework as discussed in section 7.5 (World Health Organisation, 2016b).

Essentially, to ensure adherence to the design principles during the study, the researcher used the design process model, which involved research for design/ideation, concept design/conceptualisation, and detail design/prototyping (Salgado et al., 2017).

- **Research for design phase:** Involved data collection and analysis whereby ideas were gathered and analysed to inform the study. In-depth interviews, observation and literature reviews were used. For purposes of analysing the data, the barriers and opportunities identified as well as the user journey and ANC booklet (archetypes) were used alongside design principles to guide the process
- **Concept design phase:** Involved exploration and synthesis processes whereby co-design focus group discussions were used to evaluate preliminary ideas
- **Detail design phase:** Involved refinement of design concepts through prototyping to produce results, which was the final prototype service

The aforementioned processes, methods and techniques were adopted in the research to capitalise on the merits of DR to enhance the quality of research.

15.8.2 Validity of research

The validity of the research, on the other hand, was enhanced using various methods, including triangulation, which is a validation procedure comprising the use of different sources of data in an investigation in order to produce an understanding (Creswell, 2009). This involves crosschecking data to produce accurate results to guarantee certainty in data collection. This research used various methods, including interviews, observation, co-design, and prototyping as the main methods for data collection, alongside literature reviews, otherwise known as methodological triangulation (Creswell, 2009). The main reason for using various methods of data collection in this research was to supplement each other for data clarification in order to enhance the quality of the research.

The researcher undertook prolonged periods of field work to gain a deeper understanding of the phenomenon under investigation, and modified data collection tools where it was necessary (Creswell, 2009). This helped enhance the researcher's experience, which in turn improved the accuracy of the data collected and research findings, hence valid results. Also, concepts of stakeholder theory and SDR were employed in the research, which is multidisciplinary approach, while only the relevant stakeholders (participants) were directly involved in the investigative study on maternal health information practices across the various selected health facilities. The researcher made the assumption that only those participants who participated in the initial induction process of the research would provide constructive feedback throughout and therefore improve the reliability of research. Finally, the delivered design solution (cloud-based PHR service) was evaluated in practice, that is, in the research context, whereby the degree of meaningful use of the delivered innovation was tested and verified by stakeholders.

15.8.3 Reflection by the researcher

A researcher's self-reflection adds an honest narrative that wins the confidence of readers towards the research findings, and is therefore an important quality of research (Creswell, 2009). In this case, the researcher reported and clarified possible biases that were introduced in this study and how they were addressed as a validation procedure. Specifically, two main aspects were identified that could lead to potential bias, namely, the data collection methods and tools, and participant selection. Semi-structured interviews and observation were used to collect data. Interviews in particular could easily trigger 'confirmation bias', i.e. the informed opinion/hypothesis of the researcher (Oswald & Grosjean, 2004) could lead to expected specific answers to research questions. However, different stakeholder groups were engaged, whose responses were compared across the board to have a middle ground

maintaining the balance. At the same time, observation of the phenomena under study was made alongside interviews, which means triangulation was done to validate the participant responses (Creswell, 2009). The researcher conducted purposive sampling to select participants, whereby the snowballing sampling technique was used iteratively to identify relevant stakeholders in maternal health care services, based on personal judgment formed around a variety of criteria (Kumar, 2011; Guest et al., 2014). To minimise biases arising from the selection criteria, the researcher increased the number of participants and used observation to validate the responses provided by respondents.

Design by nature is reflective and the researcher reflected on the insights gained from the field; the methods used to encourage active participation of relevant stakeholders during the data collection and design; and the stakeholders' sense making of the data collection and design processes. Each data collection and design activity forms part of a design cycle that consists of planning, doing and reflecting to refine the design concepts, constructs and methods, if necessary, for the next iteration. The researcher therefore did not only reflect at the end of the study, but throughout the study as an important part of the research process.

15.9 Suggestions for further study

This research aimed to explaining the design considerations, process and service components of secure, integrated ICT-facilitated personal health information services for maternal care in an underserved context, specifically in Nairobi County, Kenya. The study was interpretive-oriented and therefore mainly employed qualitative methods to gather data, and thematic analysis to derive data themes, which informed the design of the CPHIA model.

A repeat of the same study may be undertaken in a different setting to compare the results to validate the findings of the study. More so, triangulation can be applied by using different methodologies such as mixed methods, surveys, questionnaires, and non-participant observation, among others, to conduct a similar study. The proposed co-design-oriented SDR (refer to Figure 4.2) and co-design SDR process (refer to Figure 4.3) frameworks need to be evaluated in other studies to establish their relevancy in ICT-facilitated information service design, and in domains other than the health and wellbeing domain.

These research findings are critical for the NCC Government in particular, and for Kenya's health care sector in general, as well as in other developing contexts similar to the Kenyan situation in re-designing public health information services. Therefore, further studies to contrast the findings of this research in related settings may trigger an immense contribution to existing literature, as it could help with finding similarities, which may lead to the generalisation of the research outcomes. In addition, further studies should be conducted to compare the findings of this study with those from developed contexts, particularly the

developed model to guide the design of ICT-oriented health information services. Finally, the research does not consider the in-use situation of the proposed new service (solution), hence it still needs to be further developed into a functional service for the particular situation. Therefore, it (the prototype service) needs to be implemented in practice to facilitate a post-evaluation further improvement.

15.10 Chapter conclusion

This chapter summarised the key aspects of the research, including the research model, research outcomes and contributions, recommendations, study limitations, quality of research and recommendations for further study.

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Appendix A: Introductory Letter for the Study



29th January, 2018

RE: Introductory letter for data collection

NYATUKA DANNY RONALD is registered for the DTech (ICT) degree at CPUT **217305315**. The thesis is titled: ***"A Framework for Cloud-based Patient-Centred Health and Wellbeing Services in an underserved-context: A Case of Maternal health care in Nairobi County, Kenya"***, and aims "to generate new knowledge, to be gained from understanding design characteristics for cloud-based patient-centred health and wellbeing services in an underserved context".

The supervisor(s) for this research is/are: Prof. Retha De La Harpe, Email: delaharpe@cput.ac.za, Telephone: +27 (0) 21 460 9057

In order to meet the requirements of the university's Higher Degrees Committee (HDC) the student must get consent to collect data from organisations which they have identified as potential sources of data. In this case the student will use group focus interviews, brainstorming, observation, participant information sheet, scenarios, and prototyping techniques to gather data.

If you agree to this, you are requested to complete the attached participant information sheet and consent form (an electronic version will be made available to you if you so desire) and print it on your organisation's letterhead.

For further clarification on this matter please contact either the supervisor(s) identified above, or the Faculty Research Ethics Committee secretary (Ms V Naidoo) at 021 469 1012 or naidoo@cput.ac.za.

Yours sincerely

A handwritten signature in blue ink, appearing to read 'Retha', is enclosed in a thin blue rectangular box.

Prof. Retha De La Harpe
Head (acting) Department of Research, Innovation & Partnership
Faculty of Informatics & Design (FID)
Cape Peninsula University of technology
Cape Town Campus

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P.O Box 652 Cape Town 8000 | Corner of Keizergracht and Tennant Street, Zonnebloem, Cape Town, South Africa

Appendix B: Participant Information Sheet and Consent Form

Introduction:

The proposed research seeks to establish the design of a personal health record (PHRs) for people from underserved communities based on their views of what would be relevant to them. The project will also consider the needs of the health care service provider to ensure that it supports the service provision in primary health care.

- (a) **Investigator:** Danny Ronald Nyatuka
- (b) **Institutional affiliation:** Cape Peninsula University of Technology (CPUT)
- (c) **Purpose of study:** This study is purely for academic purposes as a fulfilment of the requirements of the award of Doctor of Philosophy in ICT degree of CPUT.
- (d) **Participation and eligibility:** Only qualified health professionals will take part in this study, and is entirely voluntary as the decision is only at your discretion. If you decide to participate, you will be asked to answer interview questions by the investigator, who will lead you through to get information on health care service delivery. However, you are free to decline to take part in the study at any time without giving any reasons or explanation.
- (e) **Risks involved:** There are no risks in taking part in this study. All the information you provide will be treated as confidential and will strictly be used for research purposes and with your express permission.
- (f) **Benefits of participating:** The information will be used to improve delivery of health care services to underserved populations who are devoid of primary health care in Nairobi County, Kenya and beyond.
- (g) **Research data/information:** Only people concerned with this study will have access to your information and it will be kept anonymous and confidential. Research records including taped discussions will be stored in secure lockable cabinets until they are transcribed, then they will be destroyed. That information may be transcribed into our database but this will be sufficiently encrypted and password protected.
- (h) **Contact persons' details:** You can contact me directly, DANNY NYATUKA, at Strathmore University, or by e-mail (dnyatuka@strathmore.edu), or by phone (+254 (0) 720 353 425). You can also contact my supervisor, PROF. RETHA DE LA HARPE, at the Cape Peninsula University of Technology, Nairobi, or by e-mail (DeLaHarpeR@cput.ac.za) or by phone (+27 (0) 21 460 9057).

If you want to ask someone independent anything about this research please contact:

The Secretary–Strathmore University Institutional Ethics Review Board, P.O. BOX 59857, 00200, Nairobi, email ethicsreview@strathmore.edu Tel number: +254 703 034 375

I, _____, (individual participant) have had the study explained to me. I have understood all that I have read and have had explained to me and had my questions answered satisfactorily. I understand that I can change my mind at any stage.

Participation in the research study, please tick the boxes that apply to you:

☐

I AGREE to take part in this research

☐

I DO NOT AGREE to take part in this research

Storage of data/information collected

☐

I AGREE to have my collected information stored for future data analysis

☐

I DO NOT AGREE to have my collected information stored for future data analysis

I.....(name of participant/in charge), in my capacity as (*participant position in company*) at(*company name*) give consent in principle to allow MR. DANNY NYATUKA, a student at the Cape Peninsula University of Technology, to collect data in this company as part of his DTech (ICT) research. The student has explained to me the nature of his research and the nature of the data to be collected.

This consent in no way commits any individual staff member to participate in the research, and it is expected that the student will get explicit consent from any participants. I reserve the right to withdraw this permission at some future time.

In addition, the organisation's name may or may not be used as indicated below (Tick as appropriate)

	Thesis	Conference paper	Journal article	Research poster
Yes				
No				

Participant's Signature:..... **Date**.....

I, _____ (Name of person administering consent) certify that I have followed the SOP for this study and have explained the study information to the study participant named above, and that s/he has understood the nature and the purpose of the study and consents to the participation in the study. S/he has been given opportunity to ask questions which have been answered satisfactorily.

Investigator's Signature:..... **Date**.....

Appendix C: Project Information

Project Description:

How do we empower patients to be more involved in their personal health and wellbeing information services in healthcare services?



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AIM OF THE STUDY

The aim of this study is to explain design characteristics, process and service components of a patient-centered and secure ICT-facilitated health information service for maternal healthcare services in an underserved context.

COSTS & RISKS

There are no costs involved. Participants will not be reimbursed for activities or their participation. The study poses no danger, and there is no risk in taking part.

ACTIVITIES

Interviews & Information needs sheets: I would love to hear about your experiences with health information services, and talk about how these services may affect your health and wellbeing activities. For interviews I will meet you where you are most comfortable.

A workshop (if you would like to join) - analyzing design characteristics of secure ICT-facilitated health information services for maternal healthcare services, and imagining services that would work for you!

My name is Danny Nyatuka, and I am currently registered for a PhD qualification in ICT at the Cape Peninsula University of Technology. The study is titled: A framework for cloud based secure patient-centered health and wellbeing services in an underserved context: Case of Nairobi County, Kenya.

CONTACT DETAILS

Email: dan.nyatuka@gmail.com

Cell: 0720 353 425

The study: A Framework for Cloud based secure patient-Centered Health and Wellbeing Services in an Underserved-Context: A Case of Nairobi County, Kenya, is registered at the Cape Peninsula University of Technology, South Africa and is supervised by Prof R. de la Harpe (delaharper@cput.ac.za)

Appendix D: Interview Guide



Participant pseudo code:

INTERVIEW GUIDE FOR PARTICIPANTS

Thank you for making time out of your busy schedule to attend to me with regards to my interview request towards my study on maternal health and wellbeing information services in NCC, Kenya.

With your permission, I would like to request that I record our session so that I do not cause any forms of distraction while trying to capture the essence of our meeting today. Also, I'd like you to peruse the informed consent form and sign that you have understood the terms and conditions thereof and, can be applied at any time during and after the interview.

My name is Danny Nyatuka. I am a registered PhD student at the Faculty of Informatics and Design, Cape Peninsula University of Technology in Cape Town Campus, South Africa. I would like to have a discussion with you, in an attempt to understand the nature of **personal maternal health care information services** provided in your health facility and particularly to find out on how these services can be improved to enhance the quality of health care for women throughout the maternity pathway.

Introductory Question(s)

To begin with, could you introduce yourself by stating your name and the organisation you work in?

Demographic Questions

Please tick the appropriate option in the following questions:

1. What is your age?

21-30

☐

31-40

☐

41-50

☐

51-60

☐

> 60 years

☐

2. What is your highest qualification?

Certificate

☐

Diploma

☐

Degree

☐

Masters

☐

PhD

☐

3. What is your profession?

Clerk

☐

S/Worker

☐

Nurse

☐

C/Officer

☐

Doctor

☐

Community Worker

☐

Other (specify) _____

4. What is your current job position? _____

5. What is your work experience in the health care sector?

< 3 years

3-6 years

6-10 years

> 10 years

Interview Questions for Health Professionals

1. Please describe the various stages of maternal health care services provided in your health facility? For example prenatal, ANC and postnatal care, other (specify).
2. What kind of information do you require to execute your daily tasks?
3. Where do you normally find this information?
4. What is the nature of health information service(s) provided in your facility? (Manual, electronic or both?)
5. What media do you use to access and/or communicate this information (to colleagues and patients)?
6. What do you think about the use of ANC card?
 - (i) Do you feel the data elements in the card are relevant to your needs? Why (not)?
 - (ii) Which elements do you feel could be added or removed?
7. Please, can you describe your work activities on a typical day at your work station?
8. How are patients involved during their health care activity?
9. Please identify the different health care personnel, departments or institution(s) that your work activities require you to work with? (How do you interact during your work activities?)
10. How do you share health information with others (other health care personnel, patients, departments, other institutions)?
11. How do you share patient health information during referrals to another facility? (What media do you use and why?)
12. What is your opinion regarding maternal health information services currently provided at your facility? Poor, good or excellent (Why do you think so?)
13. How can these services be improved to enhance the quality of maternal health care in future?
14. Can you please describe existing ICT tools utilised in your facility? (How do these tools support your work activities?)
15. Can you describe your experience with the use of ICT tools in supporting your work activities, as opposed to paper/manual systems? (How regularly do you use these tools for your work activities?)
16. How does the use of ICT generally impact delivery of health care services at your facility?
 - (i) Is the impact positive or negative? (Why?)
 - (ii) What are key service interaction points during a client's maternity journey?
 - (iii) What are your pain points in using ICT tools during client care activity?

17. What data elements do you feel could be ideal for ICT-facilitated personal health information service?
18. What aspects of existing ICT tools should be improved to fit your work activities in future?

Interview Questions for CHWs

1. Can you describe the various stages of maternal care support services that you offer to clients (pregnant women) in your community?
2. What kind of information do you require in order to execute your daily tasks?
3. Where do you normally find this information?
4. What is the nature of health information services provided to the women in your community? (Manual, electronic or both?)
5. What media do you use to access or share this information (with colleagues and clients)?
6. What do you think about the use of the ANC card?
 - (i) Do you feel the data elements in the card are relevant to your needs? (Why?)
 - (ii) Which elements do you feel could be added or removed?
7. Please, can you describe your work activities on a typical day at your work station?
8. How are clients involved during their health care support activity?
9. Please identify the different health care stakeholders that your work activities require you to work with? (How do you interact during your work activities?)
10. How do you share health information with other stakeholders (colleagues, health care personnel, and clients, among others)?
11. How do you share information with clients when providing health care support services to them? (What media do you use and why?)
12. What is your opinion regarding maternal health information services currently provided in your community? (Poor, good or excellent?) (Why do you think so?)
13. What challenges are experienced in managing health information services in your community?
14. How can existing services be improved to enhance the quality of maternal health care in your community in future?
15. Can you please describe some of the ICT tools used in your community to share/communicate health information among stakeholders? (How do these tools support your work activities?)
16. Can you describe your experience with use of the ICT tools in supporting your work activities, as compared to paper/manual systems? (How regularly do you use these tools for your work activities?)
17. How does the use of ICT generally impact delivery of maternal health care services in your community?
 - (i) Is the impact positive or negative? (Why?)
 - (ii) What are the various service interaction points in client's maternity journey?
 - (iii) What are your pain points while using ICT tools at service interaction points?
18. What data elements do you feel could be ideal for an ICT-facilitated personal health information service?
19. What aspects of existing ICT tools should be improved to fit your work activities in future?

Interview Questions for Facility administrators

1. What is the capacity for your facility in handling clients (in-patient, out-patient)?
2. What is the total number of staff in your facility?
3. What is the average number of clients visiting your facility per day (through ANC clinic visits, labour and delivery and PNC)?
4. What is your role in the delivery of maternal health and wellbeing services in your facility?
5. What are your information needs concerning maternal health care services (that is, what kind of information do you normally need and why)?
6. What is the nature of health information service(s) provided in your facility? (Manual, electronic or both?) (Why?)
7. What contextual factors influence the nature of information services currently provided in your facility?
8. A part from maternal health care services, which other unit(s) do provide health services to maternal patients in your facility?
9. What policies (regulations) guide the creation, storage and sharing of patient health information during a referral? (How is the process conducted?)
10. What challenges do you face as management in efforts to provide better maternal health care information services?
11. In your opinion, how would you rate the services? (Poor, average, good, excellent? Why?)
12. Who are the relevant stakeholders in the delivery of maternal health and wellbeing services?
13. What is the current level of ICT adoption in your facility? (Low, medium, high? Why?)
14. How would you compare the use of ICT in providing health care information services as opposed to paper-based systems? (Which is better and why?)
15. How would you describe the impact of ICT in maternal health information services in your facility? Low, medium, high (Why?)
16. How could the services be improved to enhance the quality of health care?

Interview Questions for Clients (Women)

1. Where do you normally get information about your maternity care? (Sources e.g. doctor, nurses, traditional, family or friends, other (specify)).
2. Whom do/did you work with while seeking maternal health care services during:
 - (i) ANC (pregnancy period)?
 - (ii) Labour and delivery?
 - (iii) Postnatal period?
3. How often do you receive information that is relevant to your needs? (Prenatal, ANC and postnatal, other (specify)).
4. How do you receive information? (During visits to health facilities; support groups; home visits; maternal and child health clinic visits, other (specify)).
5. What media is currently used in providing health information? (Print, radio, TV, video, cell phone, Internet, face-to-face conversation (verbal), other (specify)).
6. Are you satisfied with the type of media used to communicate information? Why (not)?

7. What printed materials are currently used? (Books, magazines, brochures, charts, library, other (specify)).
8. In what language do you receive information? (Is it sufficient for your needs?)
9. How relevant is the information that you receive to your needs to know more? Why (not)?
10. How often do you participate in your care activities during clinic visits:
 - (i) Are you able to freely ask the nurse/doctor questions?
 - (ii) How does the nurse/doctor react when you do not visit the clinic as planned?
 - (iii) Do you feel you are given sufficient time during one-on-one discussions with the nurse/doctor?
11. Whom did you work with during your pregnancy period? (ANC, labour and delivery and postnatal stages)
12. How private is your health information or questions handled? (How easy is it to discuss personal concerns without being overheard)?
13. How well do people informing you listen to your questions and respond with good explanations?
14. What information do you receive when you are referred to another hospital? (Are the reasons for the transferal explained to you?)
15. How much do you trust the information you receive? (By whom?) (Why?)
16. How do you share information with others? (What media do you use?) Why (not)?
17. What do you think about the use of ANC card/booklet?
 - (i) Are the data elements in the card are relevant to your information needs? Why (not)?
 - (ii) What elements do you feel should be added or removed and why?
 - (iii) How can the card be improved to enhance the quality of maternal health care in future?
18. Do you feel information you receive is sufficient for your needs? Why (not)?
19. What ICT tools do you normally use to access information? (Consider mobile phone, computers, other (specify)).
20. How regularly do you use these tools?
21. Can you describe your experience in using these tools to access information as opposed to paper/manual systems? (What are the positive and negative effects?)
22. In your own opinion, which ICT tools can be utilised to improve delivery of maternal care?



Pseudo Name:

Demographic Questionnaire for Clients (mothers)

Please tick the appropriate option in the following questions:

1. How old are you?

<18 years	18-30years	31-40 years	41-49 years	>49 years
☐	☐	☐	☐	☐
2. What is your highest academic qualification?

High school or less	College level	University graduate	Post graduate
☐	☐	☐	☐
3. Employment status?

Employed	Self-employed	Unemployed
☐	☐	☐
4. What is your marital status?

Single	Married	Divorced	Separated	Widowed
☐	☐	☐	☐	☐
5. Do you belong to a medical aid?
Yes ☐ No ☐
5. Which health services do you use? Public ☐ Private ☐
6. How often do you visit a health facility? _____
7. Can you afford antenatal care? Yes ☐ Sometimes ☐ Not at all ☐
8. Which languages can you read? English ☐ Swahili ☐ Both ☐
10. What is your pregnancy status? Never been pregnant ☐ Not pregnant now ☐
11. If you are pregnant, how far are you? <3 months ☐ 3-6 months ☐ 6-9 months ☐
12. Is it your first pregnancy? Yes ☐ No ☐

Interview Questions for ICT Experts

1. Do you feel adoption of ICT would improve maternal health information services in health facilities as opposed to paper-based/manual systems? (Why or why not?)
2. What aspects of ICT tools could be used to guarantee better personal maternal health information services in the health care sector? (What technologies, skills/expertise would be needed?)
3. What contextual factors could be considered in designing ICT-facilitated health information services in an underserved context?
4. What could be design considerations for integrated secure ICT-facilitated services to enable individuals from underserved communities to access and track their personal health and wellbeing data?
 - (i) What ICT tools do you feel could be ideal in empowering clients and other stakeholders to access health information relevant to their needs? (consider both software and hardware)
 - (ii) What components do you feel are relevant for designing a secure ICT-facilitated PHR service? (E.g. Hardware, software, networking environment, and standards, among others)
 - (iii) What features of the various components already mentioned in part (ii) could be relevant for delivery of personalised health information services? (E.g. design, interfaces, usability, and network accessibility, among others)
 - (iv) How could the various components be integrated to provide improved personal health information services? (consider the architectural design and the various elements)
5. What kind of information do you feel should be included in personalised ICT-facilitated information service in maternal care?
6. What do you feel could be data security concerns associated with ICT-facilitated health care services?
7. How could clients be guaranteed security of their health data?
8. How could proposed information services be tested?
9. What challenges are likely to be experienced in design and implementation of proposed ICT-facilitated information services in an underserved context? (E.g. technological, socio-economic, and regulatory environment, among others)

Conclusion

Thank you for your time and attention, to make this discussion a success. Whilst the session was very informative:

- a) Do you have further additions that might have been skipped due to oversight?
- b) Do you have any questions for me?
- c) Do you think it is necessary for me to have this discussion with someone else you feel might be in a position to give more insights on my research title?

Appendix E: Memorandum Form



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Observation Form

Observation Form

To be used in conjunction with other recording methods. Note down key aspects that you observe before or during the research activity, or upon reflection. Indicate if you have asked the participant(s) about something you have noted.

Participant Code:

Research Activity:

Date:



The Person
Level of engagement, emotions, reactions to questions, body language etc.



The Place
Context, environment etc.



The Research Tool
Facilitating interaction, understandable, etc.



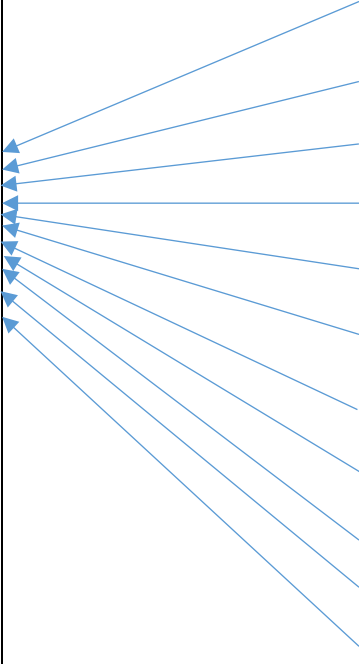
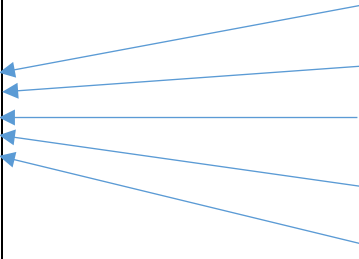
The Researcher
Behaviour, learning, reflective practice, etc.

Appendix F: Mapping Interview Questions with Theoretical Themes

Mapping Health Professionals' Responses		
Theoretical Themes		Interview questions
1.1: Stakeholders in maternal health information services (T1)	←	IQ1
1.2: Maternal health information needs (T2)	←	1Q2
1.3: Current maternal health information practices(T3)	←	IQ3
	←	IQ4
	←	IQ5
	←	IQ6
	←	IQ7
	←	IQ8
	←	IQ9
	←	IQ10
	←	Q11
1.4: Challenges to personal health information management(T4)	←	IQ12
1.5: Perceptions on potential maternal health information services (T5)	←	Q13
	←	Q14
	←	Q15
	←	Q16
	←	Q17

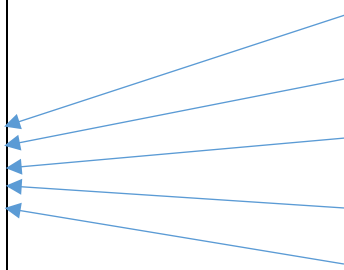
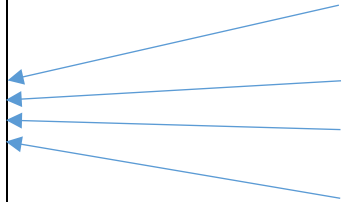
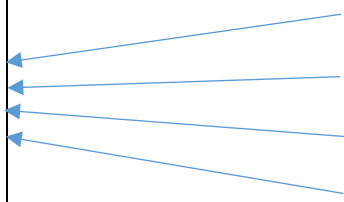
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 IQ7=7 IQ8=8 IQ10=9 IQ11=10 IQ14=11 IQ15=12
 1Q6=13 IQ12=14 IQ13=15 IQ16=16 IQ17=17

Mapping CHW/Vs' Responses		
Theoretical Themes		Interview questions
1.1: Stakeholders in maternal health information services (T1)		IQ9
1.2: Maternal health information needs (T2)		IQ2
1.3: Current maternal health information practices(T3)		IQ1
		IQ3
		IQ4
		IQ5
		IQ6
		IQ7
		IQ8
		IQ10
		IQ11
		IQ15
		IQ18
1.4: Challenges to personal health information management(T4)		IQ13
1.5: Perceptions on potential maternal health information services (T5)		IQ12
		IQ14
		Q16
		Q17
		Q19

KEY

IQ9=1 IQ2=2 IQ1=3 1Q3=4 IQ4=5 IQ5=6
 IQ6=7 IQ7=8 IQ8=9 IQ10=10 IQ11=11 IQ15=12
 1Q18=13 IQ13=14 IQ12=15 IQ14=16 IQ16=17 IQ17=18
 IQ19=19

Mapping Facility Administrators' Responses		
Theoretical Themes		Interview questions
1.1: Stakeholders in maternal health information services (T1)		IQ1
		IQ2
1.2: Maternal health information needs (T2)		IQ3
		IQ4
		IQ5
		IQ6
		IQ7
1.3: Current maternal health information practices(T3)		IQ8
		IQ9
		IQ10
		IQ11
1.4: Challenges to personal health information management(T4)		IQ12
1.5: Perceptions on potential maternal health information services (T5)		IQ13
		IQ14
		Q15
		Q16

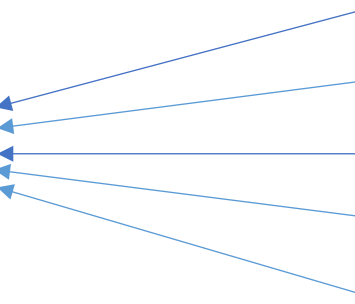
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 IQ1=7 IQ6=8 IQ7=9 IQ9=10 IQ13=11 IQ10=12
 1Q14=13 IQ15=14 IQ11=15 IQ16=16

Mapping Women's Responses		
Theoretical Themes		Interview questions
1.1: Stakeholders in maternal health information services (T1)		IQ1
1.2: Maternal health information needs (T2)		IQ2
1.3: Current maternal health information practices(T3)		IQ3
		IQ4
		IQ5
		IQ5
		IQ7
		IQ8
		IQ9
		IQ10
		IQ11
		IQ12
		IQ13
1.4: Challenges to personal health information management(T4)		IQ14
1.5: Perceptions on potential maternal health information services (T5)		IQ15
		IQ16
		Q17
		Q18
		Q19
		Q20
		Q21
		Q22

KEY

IQ11=1	IQ1=2	IQ2=3	1Q3=4	IQ4=5	IQ5=6	IQ7=7
IQ8=8	IQ10=9	IQ14=10	IQ16=11	IQ19=12	1Q20=1	IQ21=14
IQ6=15	IQ9=16	IQ12=17	IQ13=18	IQ15=19	IQ17=20	IQ18=21 IQ22=22

Mapping ICT Experts' Responses		
Theoretical Themes		Interview questions
1.3: Current maternal health information practices (T3)		IQ1
1.4: Challenges facing health information Management (T4)		IQ2
1.5: Perceptions on potential maternal Health information services (T5)		IQ3
		IQ4
		IQ5
		IQ6
		IQ7
1.6: Design considerations for ICT-facilitated maternal health information services (T6).		IQ8
		IQ9

KEY

IQ5=1 IQ9=2 IQ1=3 1Q2=4 IQ3=5 IQ7=6
 IQ8=7 IQ4=8 IQ6=9

Appendix G: Data Categories and Themes

Categories and data themes generated from initial codes from health professionals' responses with corresponding theoretical themes

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information Stakeholders	Medical Engineers, Medical Officers, Clinical Officers, Nurses, Nutritionist	Health professionals	Stakeholders	1
Information Stakeholders	Medical schools and referral hospitals	Health institutions	Stakeholders	1
Information Stakeholders	ANC, PNC, Laboratory, Pharmacy, X-rays, Out-Patient Department, Theatre	Hospital departments	Stakeholders	1
Information Stakeholders	Mothers/clients/patients, relatives	• Clients • Relative	Stakeholders	1
Information Stakeholders	Work with CHW/Vs and Community Health Assistant (CHA) to reach out and educate pregnant women in various households, and advise them to attend ANC clinic	CHWs	Stakeholders	1
Information Stakeholders	Management, counsellors, domestic workers, subordinate staff	• Management • Domestic Staff • Counsellors • Subordinate staff	Stakeholders	1
Information Stakeholders	Student nurses	Medical students	Stakeholders	1
Information needs	Gestation period, professional knowledge and skills	• Gestation period • Professional knowledge	Information needs	2
Information needs	Obstetric and gynaecological history, vital signs	Obstetric and gynaecological history	Information needs	2
Information needs	Client bio-data, contact details	contacts	Information needs	2
Information needs	Family history, parity, occupation, education level	• Family history • Socio-economic status	Information needs	2
Information practices	Prenatal care, ANC care, labour and delivery, post-natal care	Maternal care services	Information services	3
Information practices	Client herself, ANC booklet, trainings, Continuous Medical Education, Next of kin/partner, laboratory tests	Personal health information	Information sources	4
Information practices	Training, experience, seminars/ workshops, colleagues, CHW/Vs	Information sources	Information sources	4
Information practices	Patient file, referral letter	Information sources	Information sources	4
Information practices	Ministry of Health (MOH)	Information sources	Information sources	4
Information practices	Manual and partly electronic	Information media	Information services	5
Information practices	Patient file, Mother and Child booklet (ANC booklet)	Manual documentation	Information services	6
Information practices	Facility mobile phone	Information media	Information services	6

Patient-Centered Health and Wellbeing Information Services

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information practices	Charts, seminars/workshops and face-to-face discussions	Information media	Information services	6
Information practices	Health information/education sessions, record activities of the day, patient transfers	Routine activity documentation	Information services	7
Stakeholder Information needs	Providing HIV and AIDS counselling	Routine activity documentation	Information services	7
Information practices	Admit new clients, medical tests, physical examinations, patient prescriptions, treat, baby deliveries, monitor patient progress, referrals, discharge clients and prepare handover report	Routine activity documentation	Information services	7
Information practices	Chance to express themselves, one-on-one sessions	Self-expression	Personalised information service	8
Information practices	Responsibility to manage the Mother and Child booklet	Booklet management	Personalised information service	8
Information practices	Doctors explain to them the care they need	Client involvement	Personalised information service	8
Information practices	Share with the patient their care management details	Client involvement	Personalised information service	8
Information practices	Health education talks, making the client aware of reasons for the kind of care given	Client awareness	Personalised information service	8
Information practices	seek client consent	Client consent	Personalised information service	8
Information practices	Monthly reports, daily registers, ANC booklet/patient file, verbal consultation, handover report	Information sharing methods	Collaborative information service	9
Information practices	WhatsApp, CME, memorandums, the Nursing CARDEX, IQCARE system	Information sharing methods	Collaborative information service	9
Information practices	Clinical notes in ANC booklet, phone call/text	Information sharing methods	Collaborative information service	9
Information practices	Emails, consultations among colleagues, OJT in reaches, outreaches, seminars/workshops/staff training	Information sharing methods	Collaborative information service	9
Information practices	ANC booklet	Information sharing methods	Health communication	10
Information practices	A referral report/letter, phone call, partograph	Information sharing methods	Health communication	10
Information practices	Staff/nurse accompany client to the referral facility	Information sharing methods	Health Communication	10
Information practices	Mobile/smart phones, WhatsApp	Existing ICT tools	Information services	11
Information practices	Computers, photocopying machines, printer, TV	Existing ICT tools	Information services	11
Information management challenges	There are No EMRs, no computers for staff, no computer literacy training	Information infrastructure	Service provider	12
Information management challenges	Computer system is incomplete, use of personal phone is costly	Information Infrastructure	Service provider	12
Information management challenges	No privacy for the client	Patient privacy and confidentiality	Data access	12

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information management challenges	Clients have no way of communicating back to hospital	Communication system	Health communication	12
Stakeholder perceptions	Mother and Child booklet is very educative, has a lot of important information	Health information and education	Information services	13
Stakeholder perceptions	Booklet graphs bring confusion, fading ink, language	Information content	Health system	13
Stakeholder perceptions	Booklet confidentiality is not guaranteed	Patient confidentiality	Data access	13
Stakeholder perceptions	Inadequate supply of the booklet	Supplies	Service provider	13
Stakeholder perceptions	Booklet lacks confidentiality, language barrier and loss/damage	Patient confidentiality Communication	Service provider	13
Stakeholder perceptions	Clients do not read ANC booklet, gets lost/damaged, information go missing	• User requirements • Loss of information	Information services	13
Stakeholder perceptions	System cannot generate reports	Analytic tools	HIT utilisation	14
Stakeholder perceptions	Phones have improved communication	Information infrastructure	Service provider	14
Stakeholder perceptions	Paper documentation too much, space is a big problem, security of records not guaranteed	Infrastructure	Service provider	14
Stakeholder perceptions	Poor retrieval, lack space, information confidentiality and misplacement of files	Infrastructure	Infrastructure	14
Stakeholder perceptions	System is complex, no training is done and no personnel to manage data	Infrastructure	Service provider	14
Stakeholder perceptions	We need computers to reduce paperwork, employ more clerks to do data entry	Information infrastructure	Service provider	15
Stakeholder perceptions	Recruit IT personnel, install fixed telephone extension for effective communication	Information infrastructure	Service provider	15
Stakeholder perceptions	Integrate information systems	Integration	System/service integration	15
Stakeholder perceptions	Positive impact although not sufficient since only phone is used	Information infrastructure	Service provider	16
Stakeholder perceptions	Positive impact since the IQCARE system prompts and alerts staff	Information infrastructure	Service provider	16
Stakeholder perceptions	Implement electronic services for easy capturing of data and tracking	Quality Health care	Service provider	17
Information management challenges	There are no EMRs, no computers for staff, no computer literacy training	Information infrastructure	Service provider	12

Categories and data themes generated from initial codes from CHW/Vs' responses with corresponding theoretical themes

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information Stakeholders	Clients, relatives, Community Chairman, Assistant Chief, Health care managers (Facility-In-Charge), CHAs and CHW/Vs, nurses, MOH	- Community leaders - Local administration - Health care managers - Community workers - Health professionals	Stakeholders	9
Information needs	HIV/AIDs and PMTCT, breast feeding, maternal health and danger signs	- Communicable diseases - Preventive care	Information needs	2
Information needs	MCH guidelines, nutrition, water sanitation and hygiene and population	- Guidelines - Preventive care	Information needs	2
Information practices	We do home visits for health talks and advise to attend ANC clinic	Community health service	Community health information service	1
Information practices	CHEW, CHA, colleagues, trainings and seminars, and Internet	- Trainings and seminars - Colleagues - Internet	Information sources	3
Information practices	Mapping and household registration	Community mapping	Information sources	3
Information practices	Hard copy and electronic	Manual and electronic services	Information services	4
Information practices	Verbal, i.e. phone call, face-to-face and email conversations, printed material	- Oral - Reading - Written	Health communication	5
Information practices	Mother and Child booklet very instrumental/educative, recognised as a legal document	Educative	Information services	6
Information practices	Referral and follow up on clients, an outreach to the community, distribution of commodities	Routine activity documentation	Information services	7
Information practices	Conversations with question/answer sessions to clarify issues	Question answer/answer sessions	Personalised information services	8
Information practices	Phone calls, WhatsApp, emails, paper and internal meetings	Information sharing methods	Collaborative information service	10
Information practices	Phone calls, email, paper, health talks and house hold visits	- Oral - Written - Face-to-face	Health communication	11
Information practices	Phone, computers and modem	Existing ICT tools	Information services	15
Information practices	Documenting household data	Community profiling	Information services	18
Information management challenges	There is no airtime and Internet	Infrastructure	Service provider	13
Stakeholder perceptions	The manual information system is bulky...sometime it makes it almost impossible to access information	Information management	Service provider	12
Stakeholder perceptions	Mothers give out their Mother and Child booklet	Patient privacy and confidentiality	Data access	12
Stakeholder perceptions	Sometimes facilities lack the mother child booklet	Commodity supplies	Service provider	12

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Stakeholder perceptions	Services should be digitised to make referencing easier	Infrastructure	Service provider	14
Stakeholder perceptions	A mobile phone is not heavy and it saves time, but it requires airtime and data bundles particularly for a smartphone	Resource provision	Service provider	16
Stakeholder perceptions	Electronic devices save cost and time	Infrastructure	Service provider	17
Stakeholder perceptions	Ensure Internet connectivity, availability of airtime, data bundles, maintenance, and staff training	Infrastructure	Service provider	19

Categories and data themes generated from initial codes of Facility Administrators' responses with corresponding theoretical themes

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information Stakeholders	Patients, caregivers, CHW/Vs, Community, referral hospitals	• Clients • Community • Referral hospitals	Stakeholders	1
Information Stakeholders	County Government, the National Government, the University of Maryland, USAID, PEPFER, Management	• Government • Partners • Health professionals • Management	Stakeholders	1
Information Stakeholders	Lab, Pharmacy, OPD, Comprehensive Care Clinic (CCC), HIV Counselling	Internal units/ departments	Stakeholders	2
Information needs	Updates, monthly reports, number of deliveries per month, staffing	• Daily activities • Monthly reports	Information needs	3
Information needs	Policy guidelines, health records and tools	• Policy guidelines • Health records	Information needs	3
Information needs	Oversee HR capacity, logistics and resource planning and budgeting	• Staffing • Budgetary requirements • Supplies	Information needs	3
Information needs	Supervising staff, ensuring adequate supplies	Supervision	Information needs	4
Information needs	Coordination of health care activities/ operations, planning,	• Coordination • Planning	Information needs	4
Information needs	We see 54,000 patients annually and about 100 baby deliveries per month	Statistical data	Information needs	7
Information Practices	Computers are available at the facility but they are not being used	Computer use	Service provider	8
Information Practices	During emergency, the client is accompanied by a staff to give information and also one must fill the referral form or Mother Child booklet and partograph during labour	Referral Communication	Health communication	10
Information Practices	We mainly emphasise on professional training and code of conduct	Information policy	Service provider	10
Information Practices	Records department, health statistics, MOH and County head office	Information policy	Service provider	10

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information Practices	ICT adoption is low	ICT adoption	Service provider	11
Information Practices	Mainly a referral phone is issued by partners	Information and communication management	Health communication	11
Information management challenges	We experience many problems, including lack of ICT equipment, loss/damaged/misplacement of records, shortage of staff, lack of IT training for staff	Inadequate infrastructure	Service provider	12
Information management challenges	Our challenges include lack of supplies e.g. Mother and Child booklet hence clients lack access to essential information in the booklet... and also problems of care discontinuity as well as creating public awareness	Commodity supplies	Health system	12
Information management challenges	There is lack of space to store records, lack of ICT infrastructure, lack of IT staff training, shortages of staff, retrieval of print information	Inadequate health infrastructure	Service provider	12
Information management challenges	Lack of resources/funding	Resources	Health system	12
Stakeholder perceptions	Adoption of ICT in this facility is just medium, i.e. 50%	ICT adoption	Service provider	13
Stakeholder perceptions	Impact of ICT is low since only mobile phone is used to communicate information	Information and communication	Health communication	14
Stakeholder perceptions	Services in this place are poor because the necessary support is not available	Service delivery	Service provider	15
Stakeholder perceptions	Services can be improved by automation and training staff in IT literacy	Automation and staff training	Service provider	16
Stakeholder perceptions	Improve ICT infrastructure, train staff in ICT and ensure global automation of departments	Information infrastructure	Service provider	16
Stakeholder perceptions	Implement ICT fully	ICT implementation	Service provider	16

Categories and data themes generated from initial codes form client responses with corresponding theoretical themes

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information stakeholders	Spouse and other family members	Family members	Stakeholders	1
Information stakeholders	Colleague mothers, neighbours and CHW/Vs	Community Health services	Stakeholders	1
Information stakeholders	Nurses, the midwife, doctors and matron	Caregivers/Health professionals	Stakeholders	1
Information needs	Mother's health condition, expectations and time to conceive	Prenatal care information	Information needs	2
Information needs	Pregnancy signs and risks, complications, labour signs	ANC care information	Information needs	2

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information needs	Nutrition and diet, maternity clothes and shoes	ANC care information	Information needs	2
Information needs	Baby shopping/clothes, hygiene and safety for baby and mother	Postnatal care information	Information needs	2
Information needs	Transport and emergency services	ANC care information	Information needs	2
Information needs	Breast feeding, immunisations	Postnatal care information	Information needs	2
Information practices	Nurse and midwife at ANC clinic	Health professionals	Information sources	3
Information practices	Family members, experienced mothers, relatives and CHW/Vs	Community health services	Information sources	3
Information practices	Internet/social media like YouTube, Viusasa, Google	Internet/social media	Information sources	3
Information practices	Mother and Child booklet, magazines, posters	Print sources	Information sources	3
Information practices	Through radio, TV and magazines continuously	Continuous	Information services	4
Information practices	Visits to ANC/PNC clinic on a monthly basis	Monthly	Information services	4
Information practices	One-on-one discussions with the nurse	• Face-to-face conversation • Oral	Health communication	5
Information practices	Received during ANC and PNC visits	ANC and PNC visits	Health communication	5
Information practices	Mother and Child booklet and magazine and posters	• Print media • Reading • Written	Health communication	6
Information practices	TV, radio, mobile phone	• Mass media • Verbal • Oral	Health communication	6
Information practices	CDS	• Verbal • Oral communications	Health communication	6
Information practices	Books, magazines, charts and posters	Written	Health communication	7
Information practices	English and Swahili languages are used	Language of communication	Health communication	8
Information practices	Participate during ANC/PNC clinic visits	Client participation	Personalised information service	9
Information practices	Nurse answers my questions	Question/answer sessions	Personalised information service	9
Information practices	Reasons are explained in case of a referral	Reasons explained	User-centred design service	9
Information practices	One-on-one discussions/meetings	Oral communications	Information services	11
Information practices	WhatsApp, and print material	Written communication	Information services	11
Information practices	Mobile phone	Mobile technologies	Information services	12

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Information practices	Internet and mainly WhatsApp, YouTube	Internet technologies	Information services	12
Information practices	Mobile phone is used daily	Daily	Information services	13
Information practices	TV and radio programmes used sometimes	Sometimes	Information services	13
Information practices	Rarely use WhatsApp, YouTube	Rarely	Information services	13
Information management challenges	Lack of Internet connectivity	Infrastructure	Service provider	14
Information management challenges	Mother and Child booklet not available	commodity supply	Service provider	14
Information management challenges	Services are not 100% free	Universal Health Care Coverage (UHC)	Health system	14
Information management challenges	I do not have Linda Mama card	Maternal health care programmes	Health system	14
Information management challenges	No community health programmes	community health services	Health system	14
Information management challenges	Long queues during clinic visits	Infrastructure	Service provider	14
Information management challenges	Lack of sitting space and chairs to sit on	Infrastructure	Service provider	
Stakeholder perceptions	Include all languages	Language barrier	Quality health service	15
Stakeholder perceptions	Doctor's notes are not readable	Legibility	Quality health service	15
Stakeholder perceptions	Nurses are harsh	Mistreatment	Quality health service	15
Stakeholder perceptions	Information is relevant but negative sometimes	Credibility	Quality health service	16
Stakeholder perceptions	Information not confidential	Patient privacy and confidentiality	Data Access	17
Stakeholder perceptions	Nurses are always in a rush	Service delivery	Quality health service	18
Stakeholder perceptions	Nurses contribute 90% of complications	Service delivery	Quality health service	18
Stakeholder perceptions	I do not trust information received 100%. The doctors told me "no head of the baby" and others said "they are twins"... but I finally delivered one child	Trustworthiness	Quality health service	19
Information practices	Only the nurse/doctor understands what is written in the booklet	System quality	Quality health service	20
Information practices	Not 100% sufficient but It is just good	Service delivery	Quality health service	21

Theoretical Themes	Initial Codes	Categories	Data Themes	IQ
Design considerations	Phone, computers, WhatsApp, radio and TV	System components	Service Contextualisation	22
Design considerations	Smart phones can improve communication	Smart technologies	Service Contextualisation	22
Design considerations	Phone is the easiest and fastest way of communicating information	Smart technologies	Service Contextualisation	22

Appendix H: Technical Editing and Proofreading Certificate

4 June 2021

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RE: CERTIFICATE - TECHNICAL EDITING AND PROOFREADING OF DOCTORAL THESIS

I, the undersigned, herewith certify that the technical editing and proofreading of the Doctoral thesis of Danny Ronald Nyatuka, "*A FRAMEWORK FOR CLOUD-BASED PATIENT-CENTRED HEALTH AND WELLBEING SERVICE IN AN UNDERSERVED CONTEXT: CASE OF MATERNAL HEALTH INFORMATION SERVICES IN KENYA*", has been conducted and concluded.

The finalised thesis was submitted to Mr Nyatuka on 4 June 2021 and cc'd to Prof Retha de la Harpe.

Sincerely



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DTech: Information Technology
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South African Translators' Institute (SATI)