INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

by

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ABSTRACT

Medical imaging plays a pivotal role in delivering healthcare services. Despite its invaluable benefits, it also represents a major source of ionising radiation. The exposure of patients to increased amounts of ionising radiation is no longer a rare event, and there is a potential for radiation-induced injuries and cancers to develop. In the past, patient radiation safety was mostly driven by studies on average population dose, but these do not account for the unique, individual patient characteristics and their associated risks. As a potential solution, literature advocates for the implementation of individual patient radiation dose tracking (IPRDT) as an approach to strengthen the justification and optimisation principles associated with radiation safety. Although international efforts provide valuable input towards the implementation of IPRDT, little is known from the South African perspective. This study, therefore, explored how IPRDT could be achieved within the South African healthcare system, based on the perspectives of local stakeholders in patient radiation safety: radiographers, radiologists, and medical physicists.

Following ethical approval, a qualitative, exploratory, contextual, descriptive, and model development research design was employed to develop IPRDT guidelines for the South African healthcare system. A purposive snowball sampling method was used for selecting potential participants from the Western Cape Province of South Africa. Participants were invited for a once-off, semi-structured, one-on-one interview. The study yielded a total of 26 participants and represents the perceptions of 10 radiographers, 8 radiologists, and 8 medical physicists. Data saturation was reached in all three professional groups respectively; and the interviews were transcribed verbatim by an independent transcriber. A reflexive thematic analysis was used to organise and describe the data.

Four themes were developed from the data: 1) Knowledge and perceptions of IPRDT; 2) Factors affecting the implementation of IPRDT; 3) Considerations for clinical practice; and 4) A collaborative effort from stakeholders. Inductive reasoning allowed for a critical reflection on the collective story shared by the participants and led to the development of the central concept: A collaborative approach to create an improved and radiation-conscious environment. Following an analysis of the central concept,

relationship statements were established, and a model was developed and described. Following this, guidelines to operationalise the same model were developed through deductive reasoning.

This thesis presents novel findings and bridges the knowledge gap with a framework of guidelines to implement IPRDT that is tailored to the unique needs and considerations of the South African healthcare system. The study provides further insights into individual patient radiation safety and complements the notion and delivery of person-centred care and quality improvement initiatives within a continuously evolving field.

Keywords and phrases:

- Individual patient
- Radiation safety
- Medical imaging
- Ionising radiation
- Guidelines

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TABLE OF ABBREVIATIONS

ALARA	As low as reasonably achievable
BMI	Body mass index
CED	Cumulative effective dose
CPD	Continuous professional development
CQI	Continuous quality improvement
CT	Computed tomography
DAP	Dose area product
DICOM	Digital imaging and communications in medicine
DMS	Dose management system
DNA	Deoxyribonucleic acid
DoH	Department of Health
DRC	Directorate of Radiation Control
DRL	Diagnostic reference level
DTS	Dose tracking software
ED	Effective dose
EDLP	Dose-length-product-based effective dose
EHR	Electronic health record
EOD	Organ-dose-based effective dose
ER	Relative effective dose
HEI	Higher educational institution
HIS	Hospital Information System
HPCSA	Health Professions Council of South Africa
IAEA	International Atomic Energy Agency
ICP	Interprofessional collaborative practice
ICRP	International Commission on Radiological Protection
ICU	Intensive care unit
IHE	Integrating Healthcare Enterprise
IPRDT	Individual patient radiation dose tracking
ISRRT	International Society of Radiographers and Radiological Technologists
IT	Information technology

LNT	Linear no-threshold
mSv	Millisievert
NDoH	National Department of Health
NHI	National Health Insurance
PACS	Picture Archiving and Communication System
PBRCT	Professional Board for Radiography and Clinical Technology
PCC	Person-centred care
POPIA	Protection of Personal Information Act
QA	Quality assurance
QC	Quality control
QI	Quality improvement
RI	Organ-dose-based risk index
RIS	Radiology Information System
RSSA	Radiological Society of South Africa
SA	South Africa
SAHPRA	South African Health Products Regulatory Authority
SAQA	South African Qualifications Authority
SORSA	Society of Radiographers of South Africa
WCDoH	Western Cape Department of Health
WHO	World Health Organization

TABLE OF CONTENTS **PAGE**

DECLARATION i
CONFIRMATION OF EDITING ii
ACKNOWLEDGEMENTS iii
ABSTRACT iv
RESEARCH OUTPUTS, NOMINATIONS, AND FUNDING vi
TABLE OF ABBREVIATIONS vii
LIST OF FIGURES xvi
LIST OF TABLES xvii
LIST OF APPENDICES xviii

CHAPTER ONE 1
OVERVIEW OF THE RESEARCH 1
1.1. INTRODUCTION 1
1.2. BACKGROUND AND RATIONALE 2
1.3. THE SOUTH AFRICAN MEDICAL IMAGING CONTEXT 5
1.4. SIGNIFICANCE 7
1.5. STATEMENT OF THE PROBLEM 7
1.6. RESEARCH QUESTION 8
1.7. AIM 8
1.8. OBJECTIVES 8
1.9. PARADIGMATIC PERSPECTIVE AND PHILOSOPHICAL ASSUMPTIONS 9
1.10. THEORETICAL FRAMEWORK 12
1.10.1. Metatheoretical assumptions 13
1.10.1.1. Structure 14
1.10.1.2. Process 14
1.10.1.3. Outcome 14
1.10.2. Theoretical assumptions 14
1.11. PERSONAL REFLECTION 15
1.12. POSITION STATEMENTS 15
1.12.1. My position as a person 16
1.12.2. My position as a qualified diagnostic radiographer 16

1.12.3. My position as an educator 17
1.12.4. My position as a researcher 18
1.13. RESEARCH DESIGN AND METHOD 18
1.14. TRUSTWORTHINESS 19
1.15. ETHICAL CONSIDERATIONS 19
1.16. GLOSSARY OF TERMS 20
1.17. ORGANISATION OF CHAPTERS 22
1.18. CONCLUSION 24

CHAPTER TWO 25
RESEARCH DESIGN AND METHOD 25
2.1. INTRODUCTION 25
2.2. PURPOSE OF THE RESEARCH 26
2.3. RESEARCH DESIGN 26
2.3.1. Qualitative 26
2.3.2. Exploratory 27
2.3.3. Contextual 27
2.3.4. Descriptive 28
2.3.5. Model development 28
2.4. REASONING STRATEGIES 29
2.4.1. Deductive reasoning 29
2.4.2. Retroductive reasoning 29
2.4.3. Inductive reasoning 30
2.5. RESEARCH METHOD 30
2.5.1. Step 1: Concept analysis 30
2.5.1.1. Phase 1: Identify a central concept 31
2.5.1.2. Phase 2: Central concept definition and classification 42
2.5.2. Step 2: Relationship statements 43
2.5.3. Step 3: The development and description of the model 43
2.5.4. Step 4: Guidelines to implement the model 44
2.6. SCHEMATIC DIAGRAM OF THE RESEARCH PROCESS 44
2.7. TRUSTWORTHINESS 45
2.7.1. Dependability 46

2.7.2. Credibility 47
2.7.3. Transferability 47
2.7.4. Confirmability 47
2.8. ETHICAL CONSIDERATIONS 48
2.8.1. Ethical clearance 48
2.8.2. Permissions 48
2.8.3. Informed consent and voluntary participation 49
2.8.4. Anonymity and confidentiality 50
2.8.5. Benefits and risks 50
2.8.6. Integrity and trust 51
2.8.7. Protection of personal information 52
2.9. CONCLUSION 53

CHAPTER THREE 54
FINDINGS AND DISCUSSION 54
3.1. INTRODUCTION 54
3.2. PARTICIPANT DEMOGRAPHICS 54
3.3. THE COLLECTIVE STORY 56
3.4. THEMES AND SUBTHEMES 57
3.4.1. Theme 1: Knowledge and perceptions of IPRDT 58
3.4.1.1. Subtheme 1.1: Requirements for IPRDT 59
3.4.1.2. Subtheme 1.2: The purpose of IPRDT 62
3.4.1.3. Subtheme 1.3: Current practices and rationale for implementation 64
3.4.1.4. Subtheme 1.4: Perceived benefits 72
3.4.2. Theme 2: Factors affecting the implementation of IPRDT 74
3.4.2.1. Subtheme 2.1: Technology 75
3.4.2.2. Subtheme 2.2: Lack of available resources 76
3.4.2.3. Subtheme 2.3: Data-sharing relationship 78
3.4.3. Theme 3: Considerations for clinical practice 80
3.4.3.1. Subtheme 3.1: System specifications 81
3.4.3.2. Subtheme 3.2: A phased approach 87
3.4.3.3. Subtheme 3.3: Data management 89
3.4.3.4. Subtheme 3.4: Professional roles and responsibilities 96

3.4.4. Theme 4: A collaborative effort from stakeholders 100
3.4.4.1. Subtheme 4.1: Interprofessional collaborative practice 101
3.4.4.2. Subtheme 4.2: The patient as an equal partner 104
3.4.4.3. Subtheme 4.3: Legislative support and procedural guidelines 106
3.5. CONCLUSION 109

CHAPTER FOUR 110
A CONCEPTUAL FRAMEWORK FOR THE MODEL 110
4.1. INTRODUCTION 110
4.2. CONCEPT ANALYSIS 110
4.3. CENTRAL CONCEPT IDENTIFICATION 112
4.4. INDIVIDUAL CONCEPT DEFINITIONS 115
4.4.1. Definition of ‘collaborative’ 116
4.4.1.1. Dictionary definitions of ‘collaborative’ 116
4.4.1.2. Subject definitions of ‘collaborative’ 116
4.4.1.3. Defining attributes for ‘collaborative’ 116
4.4.2. Definition of ‘approach’ 117
4.4.2.1. Dictionary definitions of ‘approach’ 117
4.4.2.2. Subject definitions of ‘approach’ 118
4.4.2.3. Defining attributes for ‘approach’ 118
4.4.3. Definition of ‘create’ 119
4.4.3.1. Dictionary definitions of ‘create’ 119
4.4.3.2. Subject definitions of ‘create’ 119
4.4.3.3. Defining attributes for ‘create’ 120
4.4.4. Definition of ‘improved’ 120
4.4.4.1. Dictionary definitions of ‘improved’ 120
4.4.4.2. Subject definitions of ‘improved’ 121
4.4.4.3. Defining attributes for ‘improved’ 121
4.4.5. Definition of ‘radiation’ 122
4.4.5.1. Dictionary definitions of ‘radiation’ 122
4.4.5.2. Subject definitions of ‘radiation’ 122
4.4.5.3. Defining attributes for ‘radiation’ 123
4.4.6. Definition of ‘conscious’ 124

4.4.6.1. Dictionary definitions of ‘conscious’ 124
4.4.6.2. Subject definitions of ‘conscious’ 124
4.4.6.3. Defining attributes for ‘conscious’ 125
4.4.7. Definition of ‘environment’ 126
4.4.7.1. Dictionary definitions of ‘environment’ 126
4.4.7.2. Subject definitions of ‘environment’ 126
4.4.7.3. Defining attributes for ‘environment’ 127
4.5. A SUMMATIVE DEFINITION OF THE CENTRAL CONCEPT 127
4.6. CREATING CONCEPTUAL MEANING 129
4.6.1. A model case 130
4.6.2. A contrary case 131
4.7. CLASSIFICATION OF CONCEPTS 132
4.7.1. Who is the agent? 133
4.7.2. Who is the recipient? 134
4.7.3. What is the context? 134
4.7.4. What are the dynamics? 135
4.7.5. What is the procedure? 135
4.7.6. What is the outcome? 136
4.8. THE DEVELOPMENT OF RELATIONSHIP STATEMENTS 136
4.9. CONCEPTUAL MAP 137
4.10. CONCLUSION 138

CHAPTER FIVE 139
A MODEL TO GUIDE THE IMPLEMENTATION OF INDIVIDUAL PATIENT RADIATION DOSE TRACKING WITHIN THE SOUTH AFRICAN HEALTHCARE SYSTEM 139
5.1. INTRODUCTION 139
5.2. OVERVIEW OF THE MODEL 139
5.3. THE DESCRIPTION OF THE MODEL 141
5.3.1. The purpose of the model 141
5.3.2. Theoretical assumptions of the model 144
5.3.3. Theoretical definitions of the model concepts 145
5.3.4. Relationship statements pertinent to the model 148

5.3.5. The context of the model 149
5.3.6. The structure of the model 149
5.3.6.1. The structure of the context 150
5.3.6.2. A collaborative approach 151
5.3.6.3. To create an improved and radiation-conscious environment 154
5.4. THE OVERALL PROCESS OF THE MODEL 156
5.4.1. A collaborative approach 156
5.4.2. To create an improved and radiation-conscious environment 157
5.4.2.1. Structure 157
5.4.2.2. Process 158
5.4.2.3. Outcome 159
5.5. EVALUATION OF THE MODEL 160
5.5.1. Clarity 161
5.5.2. Simplicity 166
5.5.3. Generality 168
5.5.4. Accessibility 169
5.5.5. Importance 170
5.6. CONCLUSION 171

CHAPTER SIX 172
GUIDELINES TO OPERATIONALISE THE MODEL 172
6.1. INTRODUCTION 172
6.2. IPRDT GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM 173
6.2.1. Model component 1: A collaborative approach 177
6.2.1.1. Guideline 1.1: External and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation ... 179
6.2.2. Model component 2: To create an improved and radiation-conscious environment 182
6.2.2.1. Guideline 2.1: Create an enabling environment that models an organisational culture towards compassion and vigilance for patient well-being 182

6.2.2.2. Guideline 2.2: Follow a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards …….. 186
6.2.2.3. Guideline 2.3: An IPRDT solution that allows patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA..... 192
6.3. CONCLUSION..... 196

CHAPTER SEVEN..... 197
REFLECTIONS, CONTRIBUTIONS, AND FUTURE DIRECTIONS..... 197
7.1. INTRODUCTION..... 197
7.2. CONCLUDING THE RESEARCH PROCESS..... 197
7.3. LIMITATIONS..... 199
7.4. RECOMMENDATIONS FOR FUTURE RESEARCH..... 200
7.5. IMPLICATIONS FOR CLINICAL PRACTICE..... 201
7.6. ORIGINAL CONTRIBUTION..... 201
7.7. PERSONAL REFLECTIONS..... 202
7.8. CONCLUSION..... 202

REFERENCES..... 203

LIST OF FIGURES **PAGE**

Figure 1.1. A framework to guide healthcare organisations in implementing PCC through the Donabedian model of healthcare improvement 13
Figure 1.2. Steps in the model development process 19
Figure 2.1. Typical seating arrangement for the face-to-face interviews 36
Figure 2.2. Overview of the Braun and Clarke reflexive thematic analysis 39
Figure 2.3. Schematic diagram of the research process 45
Figure 2.4. Pictorial overview of the trustworthiness criteria applied 46
Figure 3.1. A visual representation of Theme 1 and its subthemes 58
Figure 3.2. A visual representation of Theme 2 and its subthemes 74
Figure 3.3. A visual representation of Theme 3 and its subthemes 81
Figure 3.4. Illustration of a basic, user-friendly display and operation 86
Figure 3.5. A visual representation of Theme 4 and its subthemes 101
Figure 4.1. Steps in the Walker and Avant's concept analysis process 111
Figure 4.2. The conceptual map 137
Figure 5.1. A model to guide the implementation of IPRDT within the South African healthcare system 140
Figure 5.2. The model context……..150
Figure 5.3. A collaborative approach 152
Figure 5.4. To create an improved and radiation-conscious environment 154
Figure 6.1. A framework to guide the implementation of IPRDT within the South African healthcare system 176
Figure 6.2. External and internal stakeholders in patient radiation safety..... 178

LIST OF TABLES **PAGE**

Table 1.1. Philosophical assumptions and their application 9
Table 1.2. Glossary of terms 20
Table 1.3. Organisation of chapters 22
Table 2.1. The Braun and Clarke reflexive thematic analysis applied 39
Table 3.1. Participant demographics and interview duration 55
Table 3.2. A summary of the themes and subthemes 57
Table 4.1. Defining attributes for 'collaborative' 117
Table 4.2. Defining attributes for 'approach' 118
Table 4.3. Defining attributes for 'create' 120
Table 4.4. Defining attributes for 'improved' 121
Table 4.5. Defining attributes for 'radiation' 123
Table 4.6. Defining attributes for 'conscious' 125
Table 4.7. Defining attributes for 'environment' 127
Table 4.8. A summary of the individual concepts' critical defining attributes 128
Table 5.1. Evaluator demographics 160
Table 6.1. Objectives, actions, and motivations for external and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation 179
Table 6.2. Objectives, actions, and motivations to create an enabling environment that models an organisational culture towards compassion and vigilance for patient well-being 183
Table 6.3. Objectives, actions, and motivations for following a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards 187
Table 6.4. Objectives, actions, and motivations for an IPRDT solution that allows patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA 193

LIST OF APPENDICES **PAGE**

APPENDIX A: PERMISSION TO USE THEORETICAL FRAMEWORK FIGURE . 248
APPENDIX B: INTERVIEW GUIDE 249
APPENDIX C: PARTICIPANT RESEARCH INFORMATION LETTER 251
APPENDIX D: PARTICIPANT RESEARCH CONSENT FORM..... 254
APPENDIX E: PARTICIPANT CONSENT FORM FOR AUDIO RECORDINGS.... 255
APPENDIX F: REFLECTIVE REPORT TEMPLATE..... 256
APPENDIX G: SIGNED TRANSCRIBER CONFIDENTIALITY AGREEMENT 257
APPENDIX H: ETHICAL CLEARANCE CERTIFICATE..... 258
APPENDIX I: DRAFT MODEL TO GUIDE THE IMPLEMENTATION OF INDIVIDUAL PATIENT RADIATION DOSE TRACKING WITHIN THE SOUTH AFRICAN HEALTHCARE SYSTEM…….. 259
APPENDIX J: MODEL EVALUATION FORM..... 260

CHAPTER ONE

OVERVIEW OF THE RESEARCH

"I did not think; I investigated. It seemed at first a new kind of invisible light. It was clearly something new, something unrecorded. There is much to do, and I am busy, very busy."

Wilhelm Conrad Röntgen

1.1. INTRODUCTION

Change is inevitable, especially in the rapidly growing field of medical imaging (Malamateniou, 2021:S58). Patient radiation safety within the medical imaging environment is linked with professional, ethical practice and, in recent years, has re-emerged as a topic of interest globally. The reason for this is due to the potential risk of patient-acquired, radiation-induced injuries and cancers (IAEA, 2024a). Estimating radiation-induced risks from lifetime exposure, however, remains complex and multifaceted (Loose & Wucherer, 2021:840). Literature suggests strengthening the current justification and optimisation practices associated with patient radiation safety (Frane & Bitterman, 2023). Individual patient radiation dose tracking (IPRDT) methods have been beneficial internationally (Seuri et al., 2013:771), but there is a paucity of evidence from a local perspective. This thesis delves into and unpacks the phenomenon of IPRDT, as perceived within the South African healthcare system, to offer new knowledge on this important topic.

Medical imaging represents a significant source of ionising radiation (Brambilla et al., 2020:2493). It plays a vital role in the delivery of care to a patient as it has the benefit of and supports the provision of a clinical diagnosis which may inform further patient management and treatment practices (Thierry-Chef et al., 2022:1). This benefit, however, is coupled with the potential risk of patient acquired, radiation-induced

injuries, including potential cancers (Kritsaneepaiboon et al., 2018:19). Due to this, patient radiation safety must be firmly established in ethical radiographic practice to limit harm (Lewis, 2022:14).

Soon after the discovery of X-rays in 1895 by Wilhelm Conrad Röntgen (Tsalafoutas et al., 2020:1), its application in healthcare service delivery was recognised as a medical success (Ribeiro et al., 2020:e25). Although the use of X-rays contributed significantly towards improved patient management and treatment outcomes, in 1896, just one year later, the first case of a radiation-induced skin burn was reported (Tsalafoutas et al., 2020:1). Following this observation, additional injuries and cancers were discovered, including the first radiation-induced cataract in 1897 and the first radiation-induced cancer in 1902 (Tsalafoutas et al., 2020:1). Historically, the realisation of potentially harmful, medically-induced radiation effects provided insight into the need for the profession to be regulated and for patient radiation risk management strategies to be explored (Jaschke et al., 2017:1131).

Chapter One provides the background and rationale of the study. The significance and research problem are outlined, followed by the research question, aim and objectives. Furthermore, the researcher's paradigmatic perspective, philosophical assumptions, and position statements are discussed. Concluding this chapter is the theoretical framework utilised as a lens to guide the study, a brief overview of the research design and method, the trustworthiness criteria, ethical considerations, and a brief outline of the subsequent chapters.

1.2. BACKGROUND AND RATIONALE

Radiographers who have undergone formal, tertiary-level education are responsible for performing medical imaging examinations (SA DoH, Directorate: Radiation Control, 2014:1). Radiographers apply radiation protection principles to ensure the patient dose is kept as low as possible and are legally obligated to adhere to the rules and regulations of their professional board and the scope of practice of the Health Professions Council of South Africa (HPCSA, 2020a:1).

In recent years, referrals for medical imaging examinations have increased, with a presumed increase in the cumulative individual radiation dose (Meyer et al., 2017:42; Brower & Rehani, 2021:1). This increase may be due to advances in imaging technologies, which include multi-detector, thin-slice computed tomography (CT) (Rehani, 2017:031206-1), positron emission tomography scanners (Talati et al., 2013:702), and lengthy, fluoroscopically-guided interventional procedures (Jaschke et al., 2017:1131). Other reasons may include self-referral for monetary gain among healthcare practitioners (Powell et al., 2019:69) and the practice of defensive medicine which has developed as a result of referring healthcare practitioners developing a fear of potential medical litigation (Kainberger, 2017:157-158).

The increased number of referrals for medical imaging examinations that make use of ionising radiation has the potential to increase the likelihood of patients developing radiation-induced injuries and cancers (Fabritius et al., 2016:1; Moloney et al., 2016:420; Kritsaneepaiboom et al., 2018:19; Fitton et al., 2019:288; Almujally et al., 2020:1; Demirel et al., 2020:1; Brower & Rehani, 2021:2-3). Ulanowski et al. (2019:305) further mention that this increased utilisation of medical imaging examinations and increased exposure to radiation has sparked a global concern about its long-term health risks.

In the past, policies for patient radiation safety were guided by studies of average population dose (Rehani, 2017:031206-1). In 1996, the International Commission on Radiological Protection (ICRP) introduced diagnostic reference levels (DRLs) to optimise patient radiation doses by monitoring procedure-specific radiation doses by patient group and geographical area. Martin (2016:211) explains the DRL concept as providing a standard range of radiation doses against which radiography departments can measure and compare their patients' radiation doses, thereby enhancing safety. Since 1996, DRLs have been implemented and used extensively (Meyer et al., 2017:442). However, it is noted that individual patient radiation doses should not be compared with DRLs, and DRLs cannot be applied to the individual patient to predict potential risk. This is due to the varying physical characteristics among patients (IAEA, 2024b).

Due to the complexity of individual patient dosimetry (Loose & Wucherer, 2021:840) and the absence of clearly defined maximum radiation dose limits for individual patients (Dixit, 2017:21), literature advocates the As Low As Reasonably Achievable (ALARA) principle (Dudhe et al., 2024:e60846), encouraging the justification and optimisation of all ionising radiation exposure (Fiagbedzi et al., 2022:146-151). This, however, does not address the potential risk for a patient to develop radiation-induced injuries and cancers due to accumulated radiation dose. To promote individual patient radiation safety, a method for tracking medical radiation exposure and dose was recommended (Chen et al., 2010:255).

The need for additional patient radiation protection measures was further supported by two patient radiation safety campaigns: the Image Gently (Image Gently, 2014) and Image Wisely (Image Wisely, 2024). These campaigns focus on specific patient subgroups to consider improved patient radiation safety measures. Following the introduction of the Image Gently and Image Wisely patient radiation safety campaigns, increased awareness of, and concern for, the individual patient's radiation safety during medical imaging examinations soon led to stakeholder discussions at a global level, which gave rise to the Bonn Call for Action in 2012 (WHO, 2024). The Bonn Call for Action highlighted the need for innovative patient radiation safety measures to be explored and implemented. Furthermore, it aimed to review advances in the field, potential challenges, and opportunities for the development of international recommendations (WHO, 2024).

The notion of IPRDT was first described by Professor Madan Rehani, a medical physicist, whilst he was employed at the IAEA. IPRDT is important as it may assist with the justification and optimisation principles associated with patient radiation safety during medical imaging. The practice of IPRDT entails keeping a dedicated record for each patient. Furthermore, if implemented, it may provide useful clinical information when considering further and safer medical imaging examinations for the individual patient, as necessary (Rehani, 2017:031206-1).

From an international perspective, many countries have explored and implemented IPRDT. Examples include, but are not limited to these: a project conceptualised by the IAEA in 2006 known as the Smart Card/SmartRadTrack (Rehani & Kushi, 2013:780-

782); a smartphone Radiation Passport developed to track the individual patient's radiation dose and potential adverse effects (Baerlocher et al., 2010:277-280); a Röntgenpass, which is a paper-based card that the patient carries with them (Rehani & Frush, 2010:754-755); and a nationwide electronic health archive that collects patient information from existing Picture Archiving and Communication Systems (Seuri et al., 2013:772) commonly known as the PACS.

From the literature reviewed for this research, it is evident that South Africa (SA) is not on par with the international movement, progress, or practice standards for IPRDT. Although there was a South African stakeholder group, the Society of Radiographers of SA (SORSA), in favour of IPRDT (Rehani et al., 2012:e968-e976), to date, a paucity of research exists on exploring, developing, describing, and implementing an IPRDT model that is responsive to the unique needs of the South African healthcare system. Research to develop and describe a model to guide the implementation of IPRDT within the South African healthcare system was thus deemed necessary.

1.3. THE SOUTH AFRICAN MEDICAL IMAGING CONTEXT

In SA, radiographers are regulated by the Professional Board for Radiography and Clinical Technology (PBRCT). The PBRCT functions under the HPCSA, a statutory body established by the Health Professions Act of 1974. The primary focus of the HPCSA is to protect the public and to guide the healthcare professions (HPCSA, 2024). The HPCSA published guidelines for good practice for all healthcare professionals registered with the Council, including radiography (HPCSA, 2020b). These guidelines are contained in 17 booklets and include obtaining informed patient consent, the National Patients' Rights Charter, patient record keeping, protecting and sharing sensitive patient information, and more (HPCSA, 2020b).

In addition to the HPCSA, radiographers, as users of medical X-ray equipment, are bound to the rules and regulations set out by the South African Health Products Regulatory Authority (SAHPRA), more specifically, its operational unit: Radiation Control (SAHPRA, 2025a). The primary responsibility of SAHPRA is to preserve human health, which, in the context of this study, includes patient radiation safety (SAHPRA, 2024). The Hazardous Substances Act (number 15 of 1973) (SA

Government, 2025a) and Regulations (number R1332 of 03 August 1973) (SA DoH, 2005) were implemented to govern the safe use of medical X-ray equipment. For those who use medical X-ray equipment, a code of practice was developed that stipulates the requirements and recommendations associated with the safe use of equipment. In the same code, reference is made to the probability of patients developing tissue damage and cancer because of potentially high levels of ionising radiation and chronic exposure to lower levels of ionising radiation, respectively. The SAHPRA thus rationalised the importance of using ionising radiation in the safest manner possible (SAHPRA, 2015:3).

Radiation safety is included in the clinical and theoretical components of undergraduate radiography training (Lewis et al., 2022:387). Higher education institutions (HEIs) in SA are bound by the South African Qualifications Authority (SAQA), which stipulates the exit level outcomes of the radiography qualification. The PBRCT, however, determines the minimum training standards, content, and exit-level outcomes. Patient radiation safety awareness and practice constitute an exit-level outcome (SAQA, 2024). Undergraduate radiography training in SA is generally offered full-time over four years (e.g., NMU, 2023; CPUT, 2024; DUT, 2024; UJ, 2024; CUT, 2025; UP, 2025), after which successful graduates can register for and commence with their twelve months of community service (SA DoH, 2024). After completing their community service, radiographers are deemed competent to practise independently, that is, without supervision (SA DoH, 2024).

Radiography services are offered to the citizens of SA in both the public and private healthcare sectors (HPCSA, 2020a:1). There are regulations relating to registered categories of public sector hospitals. Firstly, there are district hospitals that receive support from the general specialists of regional hospitals. These regional hospitals are limited to caring for patients in a particular province and receive referrals from district hospitals. The tertiary hospitals provide specialist-level services to the public and are not limited to a specific provincial border. Then there are central hospitals that accept patient referrals from all over the country. Lastly, there are specialised hospitals that are responsible for providing highly specialised services, for example, psychiatric, infectious diseases and rehabilitation services (SA DoH, 2012a).

Private practice radiography services are also rendered to the public of SA. The Society of Radiographers of SA (SORSA) developed a step-by-step guideline for opening a private radiography practice (SORSA, 2022). From personal experience, I have noted that private practice radiography services are growing significantly in the country and may take various forms. For example, there are imaging services provided in private hospitals' operating/surgical theatres by means of service-licensed agreements; there are privately owned medical imaging facilities that operate on a referral basis; and there are mobile imaging services that offer a variety of medical imaging modalities.

1.4. SIGNIFICANCE

Based on the evidence gathered in this study, it appears to be the first to provide local input on how IPRDT could be incorporated into the South African healthcare system. In this regard, the study contributes new knowledge to the field in response to needs tailored to the context of the South African healthcare system. A spotlight is placed on patient radiation safety in the medical imaging environment by exploring the implications and management of an IPRDT solution to track each patient's cumulative radiation dose over their lifetime. Furthermore, the study was aimed at enhancing and promoting patient radiation safety by developing a model that guides the implementation of IPRDT within the South African healthcare system.

1.5. STATEMENT OF THE PROBLEM

International platforms, such as the IAEA, are increasingly focused on IPRDT (IAEA, 2019a). This is due to modern era patients' growing concerns about an increased probability of exposure to ionising radiation (WHO, 2023). Additionally, it is understood that cumulative exposure to ionising radiation significantly increases the lifetime risk for a patient to acquire radiation-induced harm (US EPA, 2024). These potential consequences place patient safety during medical imaging under scrutiny and point to the need for further investigations (Rehani, 2017:031206-1). Internationally, for example, Nordic countries have already explored and implemented measures for tracking individual patient radiation doses (Staver, 2023). However, locally in SA, no IPRDT model or method has been identified at the investigation, development, or

implementation level. The need for research thus exists, with input from the relevant local stakeholders: radiographers, radiologists, and medical physicists. Input from these professional groups is considered a valuable initial investigation.

1.6. RESEARCH QUESTION

Based on the research problem, the following research question was developed:

- How can IPRDT be accomplished in SA?

1.7. AIM

This study aimed to explore how IPRDT could be achieved in SA. To fulfil this aim, the perspectives of radiographers, radiologists, and medical physicists were sought. Based on this understanding, a befitting implementation model was developed for the South African healthcare system. The intention was to strengthen the current justification and optimisation practices associated with patient radiation safety for medical imaging purposes and to potentially decrease the effective lifetime risk of individual patients developing radiation-induced injuries and cancers.

1.8. OBJECTIVES

Based on the research problem, question, and aim, the following three objectives were formulated:

1) To explore how IPRDT could be achieved according to the perspectives of radiographers, radiologists, and medical physicists.
2) To develop and evaluate a model for the implementation of IPRDT within the South African healthcare system.
3) To describe operational guidelines on how the model could be used to facilitate the implementation of IPRDT.

1.9. PARADIGMATIC PERSPECTIVE AND PHILOSOPHICAL ASSUMPTIONS

Ayton and Tsindos (2023:15) state that all research projects are set within a particular paradigm. The same authors explain a research paradigm as “a framework of beliefs, values, and methods”. A paradigm informs the researcher of the techniques chosen to collect and analyse the data. I selected the constructivist paradigm for this study, as it aligns with my philosophical assumptions. This paradigm acknowledges that the reality of each participant is constructed from their individual lived experiences (Shannon-Baker, 2023:380). Furthermore, it recognises the role of the researcher as a collaborator with participants in the co-construction of knowledge (Bogna et al., 2020:469).

Constructivism is a widely used paradigm in qualitative research and acts as a lens through which one can interpret, explore and discover new concepts, theories, and/or models (Chandra & Shang, 2016:92). In keeping with the constructivist paradigm, researchers tend to utilise semi-structured interviews to collect their data as it allows for a flexible environment which encourages the participants to elaborate on and explain their unique perspectives (Adom et al., 2016:5). This paradigm is well aligned to the overall design and method of the current study and allowed me to relate constructivism to the phenomenon under investigation. Table 1.1 provides an overview of how I applied the constructivist paradigm, given its ontological, epistemological, axiological, and methodological implications.

Table 1.1. Philosophical assumptions and their application

IMPLICATION(S)	ASSUMPTION(S) AND APPLICATION
a. Ontological implications	Ontology refers to the nature of reality (Shannon-Baker, 2023:380). In research, individual participants construct their realities through reasoning. Thus, the variety of perspectives being shared with the researcher may equate to multiple, varied realities (Holloway & Wheeler, 2010:20). Based on this understanding, I, as the researcher, had to protect the integrity of the data through active listening to reflect the participants’ realities adequately.

b. Epistemological implications	According to Shannon-Baker (2023:380), epistemology refers to the nature of knowledge, specifically what knowledge is, who creates it, and how it is created. Lincoln et al. (2018:221) state that new knowledge can be generated through participant-researcher interactions and their relationship. In this study, the expertise of professionals in medical imaging was explored to create new knowledge in patient radiation safety. The knowledge generated is considered new, as IPRDT is a relatively new concept for most in the field, especially locally. To create new knowledge, I conducted one-on-one, semi-structured interviews with the study participants to understand how they perceived the integration of IPRDT into the South African healthcare system. Using this interview style, I was able to ask follow-up questions to explore participants' perceptions in depth and make meaning of their ideas/answers.
c. Axiological implications	Axiology refers to the science of values and ethics (Kivunja & Kuyini, 2017:28). In the context of research, it aims to highlight the values of the researcher and their role in the process of creating new knowledge (Turin et al., 2024:e73249). As researchers, although we might attach different values to different experiences, no one person's values should be labelled as incorrect if they are not aligned with mine. The phenomenon under investigation in this study was likely to yield various opinions, informed by the diverse lived experiences of the participants within their unique professional roles and environments. Due to this, my axiological positioning involved incorporating and reflecting on my position as a person, a qualified diagnostic radiographer, an educator, and a researcher. In addition, I had to ensure that I adhered to the measures associated with the trustworthiness of the study. Gamage et al.

	(2021:1) state that one's values often play a role in selecting a research topic. In context, my decision to explore IPRDT was based on the premise of the bioethical principles of autonomy, beneficence, non-maleficence, and justice. I felt and valued the need to provide a safer patient experience and medical imaging environment. I also had to be cognisant of, understand, appreciate and analyse the benefits versus risks when patients are referred for medical imaging examinations, i.e., medical imaging examinations should be performed when there is clinical justification.
d. Methodological implications	Gray and Grove (2021:803) posit that methodology refers to a particular way in which researchers get to explore reality. This speaks to the decisions made within a process in which new knowledge is acquired and generated. In this study, I used the Chinn et al. (2022:139-180) steps for model development to develop a model that would guide the implementation of IPRDT within the South African healthcare system. This was achieved using a qualitative, exploratory, contextual, and descriptive research design.

Given the information presented in Table 1.1, I prepared myself to be open to various realities and experiences of each participant in relation to their unique roles, scopes of practice, and professional environments within the South African healthcare system. In doing so, and by having included the three participant groups, I was able to gather information-rich data from a broader perspective. All three participant groups are considered knowledgeable on ionising radiation and patient radiation safety as they are directly involved with this in the clinical environment. Furthermore, I acknowledge that this thesis is a collective representation of the participants' and my version of how IPRDT could be achieved and integrated within the South African healthcare system. The driving force behind my approach for this study was to seek an understanding of IPRDT from the participants' perspectives.

1.10. THEORETICAL FRAMEWORK

A theoretical framework is used to guide research and serves as what is also known as the “blueprint” of a study (Adom et al., 2018:438). It is developed from an existing theory suited to the field of study to generate new knowledge by guiding researchers in making sense of the data collected. Theoretical frameworks draw upon theoretical principles, constructs, and concepts of an underlying theory to demonstrate deeper meanings and relationships (Kivunja, 2018:46). The theoretical positioning of this study was informed by the work of Santana et al. (2018:430) in the implementation of person-centred care (PCC) theory (Kriksciuniene & Sakalauskas, 2022:4-7) through the constructs of the Donabedian model for healthcare improvement (Donabedian, 2005:691).

Across the globe, PCC has been assigned various labels, including terms like patient-centred care, relationship-centred care, personalised care, and user/client-centred care (Santana et al., 2018:430). Coulter and Oldham (2016:114) explain PCC as being the principle to guide how healthcare professionals should view patients, namely, as individuals and equal partners in their care. The same authors propose that PCC be deemed a multidisciplinary approach which is collectively adopted by multiple healthcare professionals when persons/patients seek their care. Kriksciuniene and Sakalauskas (2022:29) state that PCC, furthermore, comprises shared responsibility for the delivery of coordinated care and treatment.

In this study, the theory of PCC, suited to IPRDT, is viewed as a branch of personalised care delivered to a patient to improve patient safety within the medical imaging environment, and this occurs through making available a potential solution to monitor a patient’s lifetime radiation dose. Santana et al. (2018:429) postulate that practical implementation guidelines on PCC seem limited, despite the increased literature, so they subsequently developed a framework to guide stakeholders in exploring, implementing, and providing PCC within their unique healthcare environments.

Santana et al. (2018:429) used the Donabedian model for healthcare improvement (Donabedian, 2005:691) as their metatheoretical lens to underpin their framework. The latter comprises three constructs: 1) structure, 2) process, and 3) outcome. According

to the ACT Academy (2021), structure refers to the physical and organisational characteristics of the healthcare system and the environment itself. The process is focused on the care provided to the individual patient, and the outcome is the effect of the healthcare service on the patient's status and the population's outcome more broadly. The model developed by Santana et al. (2018:431) to guide healthcare organisations in providing PCC is illustrated in Figure 1.1.

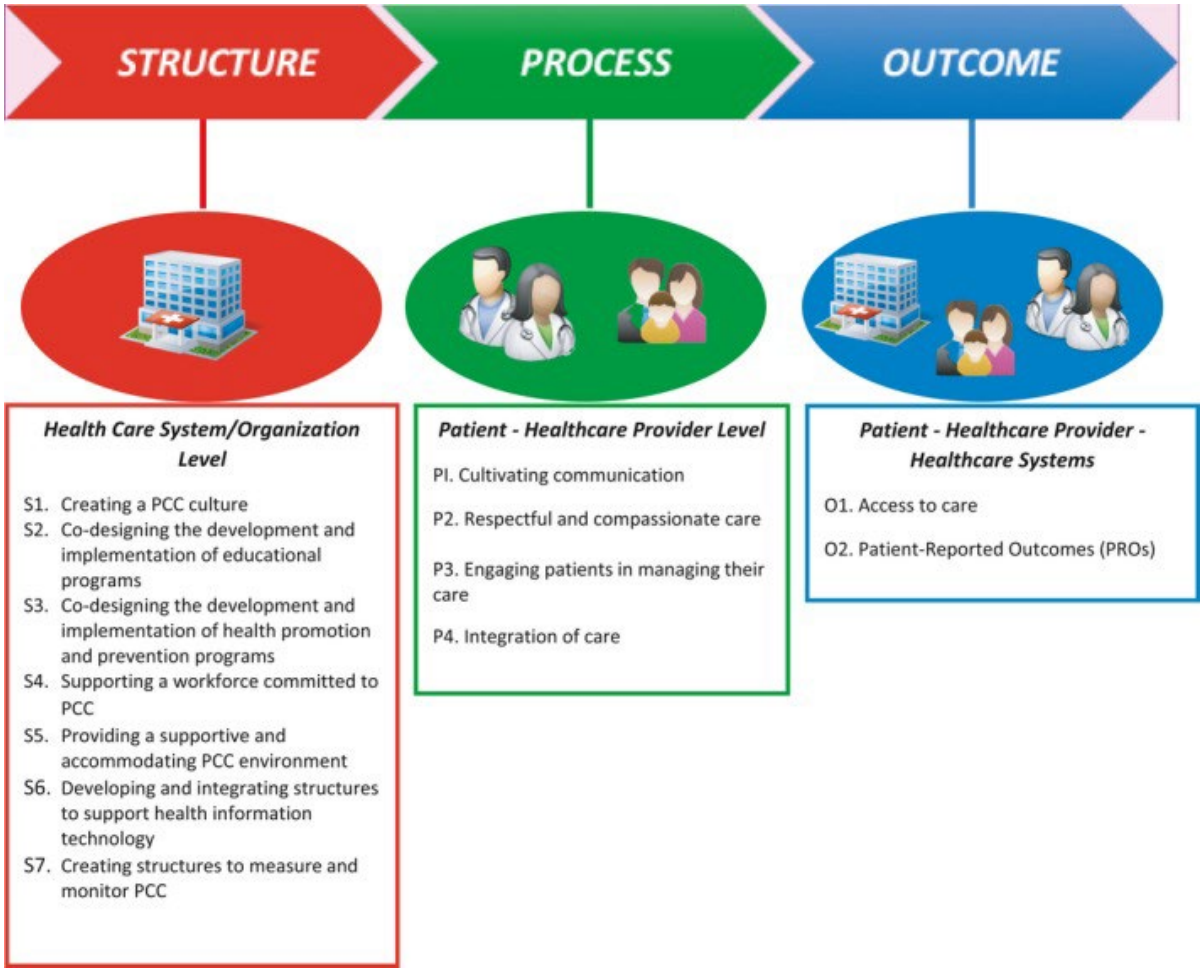


Figure 1.1. A framework to guide healthcare organisations in implementing PCC through the Donabedian model of healthcare improvement

(Used with permission: see Appendix A)

1.10.1. Metatheoretical assumptions

Merriam-Webster Dictionary (2024) defines a metatheory as a theory coupled with an investigation, analysis, or description of the same theory. This section aims to

demonstrate the relevance of the theoretical framework developed by Santana et al. (2018:429) to guide the implementation of IPRDT within the South African healthcare system.

1.10.1.1. Structure

Structure relates to the healthcare system and context in which PCC is provided. In this study, the system refers specifically to the South African healthcare system in which the medical imaging environment is located. This can also be viewed as the radiography department where IPRDT is implemented. This construct further emphasises how IPRDT can be accomplished in SA by exploring the organisational considerations.

1.10.1.2. Process

Process refers to an understanding of how IPRDT can be accomplished more broadly, following the structural preparation of the radiography department, and by including the patient as part of the service. It expands on the vision of how IPRDT can be achieved most accurately and effectively.

1.10.1.3. Outcome

The outcome refers to the implementation of an IPRDT solution in an environment that supports the delivery of PCC. This includes patient access to personalised, radiation-conscious medical imaging care within a healthcare system that enables sustainable patient radiation safety measures.

1.10.2. Theoretical assumptions

The following bulleted list of theoretical assumptions was generated from the literature. The theoretical framework by Santana et al. (2018:431) (Figure 1.1) was linked to an understanding of IPRDT and inspired these assumptions. Patient radiation safety practices are not just technical or scientific but also conform to PCC's holistic, organisational, and participatory principles. Additionally, to implement PCC, current

practices need to be explored and improved. The assumptions are presented in bullet form to capture my thoughts adequately.

- Each patient is unique in their identity, physical characteristics, sensitivities, and beliefs: biological, psychological, and socio-cultural. By tracking the individual patient's radiation dose, their physical health is supported and promoted while considering the potential psychosocial impact that it may have on their quality of life.
- IPRDT is a proactive form of risk management derived from evidence-based clinical practice and endorses adherence to ethical healthcare standards.
- IPRDT may require a multidisciplinary, collaborative approach for it to be implemented successfully and for it to be effective.
- Patients have the right to be informed about the benefits and risks of medical radiation exposure. They should subsequently be encouraged to partake in shared decision-making by participating actively in their medical care. This sharing can foster an environment of increased mutual respect, trust, and transparency within the healthcare system between the patient and the healthcare provider(s).

1.11. PERSONAL REFLECTION

Upon reflection, I consciously looked for potential relationships between the various constructs of the framework developed by Santana et al. (2018:431) and my understanding of IPRDT. The practical framework proposed by Santana et al. (2018:431) to implement and improve the delivery of PCC, together with the constructivist research paradigm, as discussed, was deemed the most appropriate lens through which to review the relevant literature and, in return, to provide the basis for my interpretations and methodological choices in this study.

1.12. POSITION STATEMENTS

A researcher's positionality in research can be explained as a conscious analysis of their identity and characteristics in an attempt to evaluate the effect it may have on the topic being researched (Wilson et al., 2022:44). Holmes (2020:1-2) concurs with the previous author and further stresses the importance of self-reflection as a tool for the

researcher to seek their role and their potential influence in the research process, more specifically, how this may affect the research design and interpretation of the data. Furthermore, the same author explains that, by positioning oneself in a research study, one can identify any preconceptions that one might have from previous personal or professional experiences. Based on the latter, I reasoned that I needed to practice reflexivity by including my position statements as a person, a qualified diagnostic radiographer, an educator, and a researcher. The following information represents my position statements concerning this research study.

1.12.1. My position as a person

I am a 36-year-old white male. I was born in Port Elizabeth, recently renamed Gqeberha, within the Eastern Cape Province of SA. I received primary, secondary, and tertiary education at public schools and universities. I have always had a keen interest in helping others, which is in keeping with my personality type, The Protector, as per the Myers-Briggs personality test (Personality.co, 2025). This led me to a career in Diagnostic Radiography. I was intrigued by the technology and the science behind the profession. This takes me back to the first day I spent in an X-ray department during my final school year while job shadowing. The X-ray machines, the real-time images, and the idea that I could be in control of something so powerful as medical radiation, ‘blew my mind’. Immediately, I realised the immense responsibility of those healthcare professionals working with medical radiation.

1.12.2. My position as a qualified diagnostic radiographer

After completing my National Senior Certificate, I left my parents’ house. This was to go to Cape Town (Western Cape Province of SA), where I was accepted to study a three-year National Diploma in Diagnostic Radiography in 2008. After completion, I was placed at a public hospital in Somerset East (Eastern Cape Province of SA) for 12 months of community service. In the same year, I registered for a Baccalaureus Technologiae Degree in Diagnostic Radiography in the Free State Province of SA. I completed this degree part-time over two years. After this, I was fortunate to occupy the positions of clinical radiographer at a public hospital and clinical instructor at a higher educational institution that offers radiography training (KwaZulu-Natal Province

of SA) whilst completing the Master of Health Sciences degree in Diagnostic Radiography, which I did in 2017.

Following this, I left my academic role and pursued a full-time clinical role in the private sector as a dedicated theatre radiographer. During this time, I completed a Postgraduate Diploma in Tertiary Education. Thereafter, a private corporate company appointed me as a sales and application specialist for medical imaging equipment. I completed a Professional Certificate in CT while employed in this position. After that, I left the sales and application specialist position for the role in which I am currently, a full-time diagnostic radiography lecturer. Given the above, I have prior work experience as a diagnostic radiographer in clinical practice in both the public and private healthcare sectors.

Patient radiation safety has always interested me, and I deem it necessary for SA to be on a par with international practice standards. I completed my undergraduate training at one of the country's larger academic hospitals where patient radiation safety was strictly enforced, a practice which I valued. Throughout the rest of my career, however, I have observed healthcare professionals who do not adhere to the basic principles of patient radiation safety, including radiographers and medical doctors. For me, this was genuinely worrisome, as I always found myself reflecting, 'Don't do unto others what you don't want others to do unto you', and 'What if this was a member of your own family being subjected to unnecessary and/or excessive radiation?'

1.12.3. My position as an educator

I am currently employed as a full-time diagnostic radiography lecturer in the Western Cape Province of SA, where I am involved in both the undergraduate training and postgraduate supervision of students. I teach physical science in the undergraduate curriculum as part of my workload. In my opinion, we, as radiographers, carry an immense responsibility when protecting the patient under our care. This is something that I aim to create more awareness about and also to instil in my students the same understanding and appreciation of patient radiation safety.

1.12.4. My position as a researcher

The researcher is considered the primary data collection agent during qualitative research. This is true of this study, as I conducted the interviews myself. Thus, I needed to reflect on my position and contribution to this study. These reflections form part of my position statements. During the interviews, I had to avoid influencing the participants' opinions with my personal or professional ideas. This is important, especially when conducting qualitative interviews, and forms part of the bracketing technique I applied. In addition to this, and whilst having analysed the study data, I incorporated Braun and Clarke's approach to reflexive thematic analysis (Braun & Clarke, 2022:5). This approach is discussed in more detail in Chapter Two (see 2.5.1.1).

1.13. RESEARCH DESIGN AND METHOD

The research design selected for this study was qualitative, exploratory, contextual, descriptive, and involved model development. The model was developed by following the Chinn et al. (2022:139-180) model development guidelines with these steps: 1) concept analysis; 2) relationship statements; 3) development and description of the model; and 4) guidelines to implement the model. Figure 1.2 visually displays the steps in the model development process, presented in the correct sequence. A complete account of the research process is provided in Chapter Two (see 2.6).

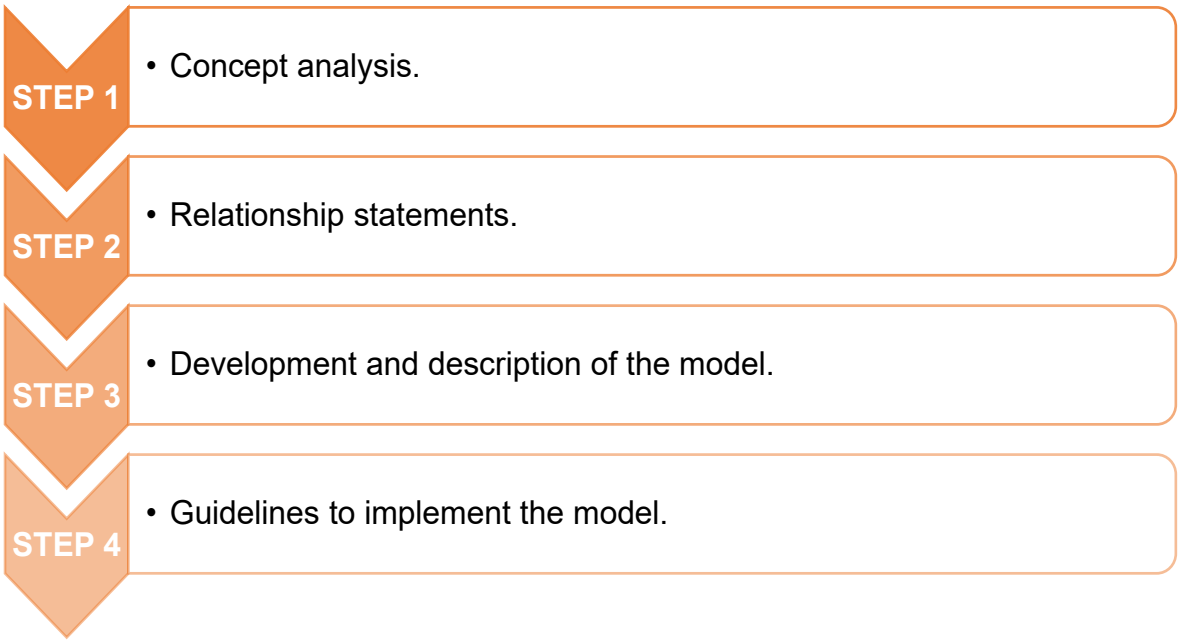


Figure 1.2. Steps in the model development process

1.14. TRUSTWORTHINESS

This study received guidance from Lincoln and Guba's measures of trustworthiness (Lincoln & Guba, 1985:289). Lincoln and Guba's trustworthiness model provides criteria suitable for qualitative research studies. The requirements include dependability, credibility, transferability, and confirmability. These criteria are described in more detail in Chapter Two (see 2.7).

1.15. ETHICAL CONSIDERATIONS

Brink et al. (2018:27-28) state that researchers must protect their human participants' rights. Furthermore, the same authors report that a researcher must always ensure that the benefit of their research study outweighs all potential risks. Chapter Two (2.8) provides an in-depth description and discussion of how these ethical standards and requirements were met.

1.16. GLOSSARY OF TERMS

For the reader to make sense of the study, a list of terms and their meanings is included. The glossary of terms is meant to give meaning to various concepts and their application in the study. The descriptions were formulated through a combination of literature explanations and the researcher's interpretation. Table 1.2 represents the terms and their associated definition (in no particular order) as a point of reference for this thesis.

Table 1.2. Glossary of terms

TERM	DEFINITION
a. Radiation exposure tracking	Accounting for the type and number of all the medical imaging examinations an individual patient has undergone (Rehani, 2017: 031206-1).
b. Radiation dose tracking	Accounting for the type, number, and radiation dose of an individual patient's medical imaging examinations (Rehani, 2017:031206-1).
c. Medical imaging examination	An imaging procedure conducted in a medical facility that makes use of ionising radiation, and which is performed by an appropriately trained and registered healthcare professional (SAHPRA, 2022a:4).
d. Individual patient	A person who receives personalised healthcare services based on their unique needs and characteristics (Radwin & Alster, 2002:54).
e. Referring practitioner	An appropriately trained and registered healthcare professional, responsible for referring a patient for a medical imaging examination that uses ionising radiation (SAHPRA, 2022a:4).

f. Radiographer	A healthcare professional in the field of medical imaging who is directly involved in delivering diagnostic services by utilising ionising radiation (ISRRT, 2021:1).
g. Radiologist	A medical doctor who has specialised in radiology to interpret medical imaging studies. Radiologists work closely with referring practitioners by providing them with written reports on the individual patient's radiological findings (RSSA, 2019).
h. Medical physicist	A medical physicist is a professional who has received postgraduate training in applying physics principles to prevent, treat, and diagnose clinical conditions/disorders. In doing so, medical physicists are directly involved in ionising radiation safety awareness and practices for staff, patients, and the public (IOMP, 2023).
i. Information technology professional	A person who has received formal training in information technology (IT) to create data networks and infrastructure for an organisation. Examples of the responsibilities of an IT professional include providing technical support and maintenance, as well as attending to system security (Indeed, 2025a).
j. Radiation-induced injury	Cellular tissue damage experienced by a patient following exposure to ionising radiation during a medical imaging examination (*Encyclopaedia Britannica*, 2024).
k. Radiation-induced cancer	A delayed medical complication associated with normal tissues following exposure to

	ionising radiation during medical imaging examinations (Braunstein & Nakamura, 2013:1).

1.17. ORGANISATION OF CHAPTERS

This section provides a discussion and overview of the structure and content of this thesis. Important to note is that a dedicated literature perspectives chapter is not included. Although literature relevant to the topic under investigation was consulted at the beginning, it was used primarily for the development of the study rationale, problem statement, question, aim, and objectives. This decision was jointly decided upon by the study supervisors and researcher for methodological reasons, and with reference to examples of doctoral theses that followed a similar research process (Naidoo, 2019:24; Thomas, 2024:32).

Although the study is influenced by literature on IPRDT from a global perspective, little is known about its potential application within the South African context. To bridge this knowledge gap, the researcher co-constructed new knowledge in the form of a theory with the study participants in the field. This is in keeping with the model development method employed in the current study, where I first had to observe and develop an understanding of the data before I could inductively develop and identify a central concept for further analysis (Figure 1.2). Table 1.3 demonstrates the organisation of chapters in this thesis.

Table 1.3. Organisation of chapters

CHAPTER	DESCRIPTION OF CONTENT
CHAPTER ONE: **Overview of the research**	This chapter provides the background and rationale of the research study, including the researcher's positionality. The research problem, question, aim, and objectives are presented with the guiding theoretical framework. This chapter also briefly describes the research design and

	method, trustworthiness criteria, ethical considerations applied, and an overview of the subsequent chapters.
CHAPTER TWO: Research design and method	A comprehensive account of the research design, method, and ethical considerations that were used to conduct this study is described in this chapter.
CHAPTER THREE: Findings and discussion	The participants' demographics and findings from the one-on-one semi-structured interviews are described. The findings are presented in themes and subthemes, with supporting literature demonstrating a critical analysis of the study findings.
CHAPTER FOUR: A conceptual framework for the model	This chapter presents the development of a conceptual framework for the model. Considerations on how IPRDT could be integrated within the South African healthcare system are discussed with a conceptual map.
CHAPTER FIVE: A model to guide the implementation of individual patient radiation dose tracking within the South African healthcare system	A model to guide the implementation of IPRDT within the South African healthcare system is presented visually. The model description, process, and outcome of an expert panel review are presented.
CHAPTER SIX: Guidelines to operationalise the model	This chapter describes the operational guidelines for the model to guide the implementation of IPRDT within the South African healthcare system.
CHAPTER SEVEN: Reflections, contributions, and future directions	The overall research process is evaluated and reflected on by the researcher. The findings are ultimately assessed for their contribution to clinical practice.

1.18. CONCLUSION

Medical imaging examinations utilise specialised equipment to contribute to patient management and improved patient outcomes. Radiographers play a vital role in healthcare service delivery. They are expected to carry out their professional duties in the safest manner possible to protect the patients they serve in a person-centred, holistic manner. It is evident from the literature reviewed that the notion of IPRDT is the current goal for patient radiation safety. Internationally, efforts are underway to achieve and establish this form of clinical practice. In SA, however, limited literature and practice prevail, thus presenting the need for further research. For this reason, a model development design was deemed appropriate to generate new knowledge in the field and to assist with the clinical integration of IPRDT in a local context.

CHAPTER TWO

RESEARCH DESIGN AND METHOD

“No research without action, no action without research.”

Kurt Lewin

2.1. INTRODUCTION

Experience in practice, combined with a preliminary analysis of the literature, identified an area of research that warranted further investigation. This area of research pertains to individual patient radiation dose tracking (IPRDT) within a local South African context. By engaging with the literature, an interview guide was developed to collect the necessary input from local stakeholders (Appendix B). The interview guide is representative of general and broad design considerations from international practice standards on IPRDT. Questions developed were based on these considerations solely to steer the data collection process, as the practice standards on IPRDT incorporate the perspectives of different countries that operate under various regulatory frameworks, so findings obtained from one country may not always be directly transferable to another.

Based on the problem statement, the following research question was identified: How can IPRDT be accomplished in SA? Stemming from the research question, a qualitative, exploratory, contextual, descriptive, and model development design was selected and deemed appropriate. This chapter discusses and explains the research design and method. Validation will be provided regarding how it addressed the problem statement and answered the research question.

2.2. PURPOSE OF THE RESEARCH

This research study aimed to understand IPRDT better and how IPRDT could be achieved according to the perspectives of radiographers, radiologists, and medical physicists. Based on this understanding, a model was developed to guide the implementation of IPRDT within the South African healthcare system. This was done to strengthen the current justification and optimisation principles associated with patient radiation safety and to potentially decrease the effective lifetime risk of individual patients developing radiation-induced injuries and cancers.

2.3. RESEARCH DESIGN

In general, research aims to solve problems by acquiring new knowledge. To generate new knowledge and to meet the standards of being reliable and valid, one's approach must be systematic (Asenahabi, 2019:77). A research design is therefore identified to showcase the key elements of a study to answer the research question (Leavy, 2017:5-7). The research approach for this study was a qualitative, exploratory, contextual, descriptive, and model development design. The following information unpacks each of these elements.

2.3.1. Qualitative

In qualitative research, the researcher becomes directly involved in the research process. This is by developing an understanding of the participants' realities based on a phenomenon (Holloway & Wheeler, 2017:3). Rather than quantifying the data, qualitative research uses textual data and gives a voice to study participants (Ormston et al., 2014:4). Therefore, the role of the researcher is to present the findings based on their understanding of the participants' perspectives (Holloway & Wheeler, 2017:3).

Corbin and Strauss (2015:5) state that qualitative research is valuable when exploring areas of interest with minimal to no information. A scarcity of literature examining the design considerations for implementing IPRDT in a local context has been found. Based on this understanding, a qualitative research design was deemed suitable.

2.3.2. Exploratory

Exploratory research assists the researcher to investigate and provide insight into a poorly understood phenomenon (Polit & Beck, 2018:11). This phenomenon is generally an area of interest where little evidence is available. The researcher can be seen as the explorer, following a rigorous, scientific inquiry process (Stebbins, 2012:2). An exploratory approach was deemed appropriate since IPRDT is a relatively new concept with little research evidence in South Africa (SA). The researcher aimed to explore this phenomenon locally to add to the body of knowledge in medical imaging and patient radiation safety.

2.3.3. Contextual

For a research study to employ the contextual element, it should demonstrate the relationship between the study participants and their environment (Mason & Dale, 2011:31). Corban and Strauss (2015:155) further state that, to understand a research phenomenon, it needs to be placed within the appropriate context. Without adding the contextual component, the relevance of the study and the researcher's level of understanding may be questioned. Holloway and Wheeler (2017:4-5) believe that the researcher needs to understand the research context, as only then can the information shared by the participants be fully comprehended.

Polit and Beck (2012:12) advise that a close interaction between the researcher and the study participants is necessary to develop an adequate understanding of the research phenomenon. For this study, the questions the researcher asked during the interviews were specific to the context of medical imaging examinations that use ionising radiation, a field in which the researcher himself and the participants hold professional roles. The participants could also share their ideas based on their experiences and understanding from working in the Western Cape Province of SA. These experiences and understanding provide another element of contextualisation in the form of giving a voice to local stakeholders on a global phenomenon and how it could be integrated within their daily practice and the regulatory framework. The participants are also considered key medical imaging and patient radiation safety stakeholders. Given these considerations, this study can be regarded as contextual.

2.3.4. Descriptive

A descriptive research approach aims to describe abstract ideas (Corbin & Strauss, 2015:12) by providing an in-depth narrative of the research phenomenon in its natural habitat (Gray, 2018:37) and by providing detailed descriptions of a specific occurrence (Corbin & Strauss, 2015:155) to answer the research question (Brink et al., 2012:112). Polit and Beck (2018:11) agree with these authors; in addition, they state that a descriptive research approach is valuable when little is known about a research phenomenon.

A descriptive element was added to how this study was approached. The reasoning behind this relates to the aim of the study. This study aims to gain an understanding of how IPRDT could be achieved and integrated locally, and to create and provide new knowledge on a phenomenon of which little is currently known. The newly acquired knowledge allowed the researcher to develop and describe the operational guidelines of a model to guide the implementation of IPRDT within the South African healthcare system.

2.3.5. Model development

Model development can be viewed as a method to create new knowledge (Havenga et al., 2014:149-156). Visually, through diagrams, mathematical notations, symbols, pictures, and text (Polit & Beck, 2012:128), it represents a real-life, researched phenomenon (Shafique & Mahmood, 2010:4). A model demonstrates direct and indirect relationships among important concepts (Havenga et al., 2014:149-156). A model is considered to have a significant role in the field of research to help understand complex and multifaceted phenomena better. Although at a glance, a model's overall appearance often appears less complex, it is representative of the collective findings of a research study (Shafique & Mahmood, 2010:4). The model development design was selected for this study as the intention was to develop new knowledge on a global phenomenon, but from a local context and perspective. The model may assist future stakeholders in developing and implementing IPRDT solutions.

2.4. REASONING STRATEGIES

Experience, problem-solving, and formal thought processes are the three pillars of understanding a research phenomenon. There are three types of reasoning strategies: deductive, retroductive, and inductive (Polit & Beck, 2012:11). All three types of reasoning strategies were employed in this research study and allowed for the model's development, description, and evaluation.

2.4.1. Deductive reasoning

Deductive reasoning enables the researcher to predict an outcome based on general information (Polit & Beck, 2012:11). In lay terms, it allows for a progression from general ideas to specific conclusions. For this study, deductive reasoning was necessary because the abstract concepts of the model required operational guidelines. The operational guidelines explaining how the model could facilitate the implementation of IPRDT were based on deductive reasoning.

2.4.2. Retroductive reasoning

Retroductive reasoning is considered a valuable analytical technique that allows the researcher to analyse a phenomenon by identifying real-life situations in which the concepts may exist (Meyer & Lunnay, 2013:1). Thus, it can also be seen as an effort to understand the factors involved for the phenomenon to occur (ACAPS, 2016:7). It involves a deliberate and rigorous approach to looking back at a phenomenon to find new ways to address a well-known problem, often by reconceptualising the problem itself. Given this study, retroductive reasoning was deemed an appropriate analytical technique since IPRDT attempts to promote the current justification and optimisation practices associated with patient radiation safety. Developing a model and a contrary case proved an invaluable exercise to create conceptual meaning of the summative definition of the central concept (Chapter Four, 4.6).

2.4.3. Inductive reasoning

Inductive reasoning lends itself to the researcher's personal observations to develop generalisations (Polit & Beck, 2012:11). The researcher must observe the data sets and develop generalisations. The generalisations are then used to describe the relationship between the observed subjects (Babbie, 2011:50). I used inductive reasoning to build on my personal reflections and observations of the study participants. This helped me understand the data better and led me to develop and describe the model. I also used inductive reasoning to formulate the central concept.

2.5. RESEARCH METHOD

Taylor et al. (2016:3) define a research method as seeking answers to research questions. The same authors further explain the concept as the chosen way research is conducted, considering its purpose, assumptions, and interests. For this research study, a model development method was identified and incorporated as the central element of the study methodology. The model was developed using the Chinn et al. (2022:139-180) model development guidelines. I selected these guidelines as it is an existing, well-known, tried and tested method used within healthcare research (e.g., Downing, 2017:157; Naidoo, 2019:24; Lewis, 2022:211; Thomas, 2024:32). The following steps were followed: 1) concept analysis; 2) relationship statements; 3) the development and description of the model; and 4) guidelines to implement the model (Chinn et al., 2022:139-180). The steps employed in the context of this research study will be further described and explained in the following text.

2.5.1. Step 1: Concept analysis

Baldwin (2008:50) states that a concept analysis adds to the scientific body of knowledge in the research field by clarifying words and concepts to develop a better understanding thereof. For this study, I embarked on a concept analysis to further inform the steps of the model development. The concept analysis was based on a central concept, which was identified based on my understanding of the combined qualitative themes generated from the data, and by using the inductive reasoning technique.

Step 1, the concept analysis, has two sub-phases. Phase 1 involved one-on-one semi-structured interviews with radiographers, radiologists, and medical physicists to explore how IPRDT could be achieved locally, according to their perspectives. From the findings, a central concept was identified. Then, during Phase 2, I defined and classified the central concept. Two well-known theorists, Walker and Avant, offer a systematic method for analysing concepts (2019:167-168). For the current study, I incorporated their steps into my concept analysis. The steps included selecting a central concept, determining the aims and purpose of the analysis, identifying the uses of the central concept, determining the defining attributes, and identifying a model and a contrary case.

The remainder of the model development steps by Chinn et al. (2022:139-180) were then followed and are discussed in more detail later in this chapter. These steps include describing relationship statements rooted within the central concept (Step 2), developing and describing the model (Step 3), and developing operational guidelines to implement the model (Step 4).

2.5.1.1. Phase 1: Identify a central concept

The following points present the methodological considerations I applied during the concept analysis. The study setting and target population, sampling method, recruitment strategies, inclusion and exclusion criteria, data collection procedures, and data analysis will be discussed during Step 1, Phase 1. The qualitative data I collected to identify the central concept were based on these considerations.

- ***Study setting and target population***

The study was conducted within the Western Cape Province of SA, targeting qualified, independent practice radiographers, radiologists, and medical physicists registered with the Health Professions Council of South Africa (HPCSA). As a reference point for this study, radiographers are described as medical imaging professionals responsible for producing medical images and using ionising radiation. This meant that radiographers from diagnostic radiography and nuclear medicine technology categories formed part of the target population. Radiologists are medical doctors who

have specialised in diagnostic radiology and are responsible for diagnosing medical conditions/pathologies by evaluating medical images. Medical physicists were described as professionals directly involved with the safe and effective use of ionising radiation in the medical imaging environment. Definitions of these professional roles, along with references, were introduced in Chapter One, section 1.16, in Table 2.1 listing the glossary of terms. The researcher conducted semi-structured, individual (one-on-one) interviews with these three categories of professionals, as they are considered key stakeholders in patient safety during medical imaging examinations. The research question and interview guide enabled the data collection process to be conducted from a Western Cape Province perspective.

- ***Sampling method***

The sampling method selected for this study was purposive snowball sampling. Purposive sampling is a collection of various strategies (Flick, 2018:433) chosen to fulfil a specific purpose in qualitative research designs (Palinkas et al., 2015:534). A snowball sampling strategy can be described as sampling from a known network of individuals who rely on personal and professional associations for potential referrals (Hesse-Biber, 2017:89-90).

Qualitative researchers often use purposive sampling to recruit participants who can provide in-depth and detailed information about a specific phenomenon under investigation (Palinkas et al., 2015:534) and to answer a particular research question (Flick, 2018:433). For this study, radiographers, radiologists, and medical physicists were purposively selected as participants against the determined inclusion criteria and to include a variety of contexts because these professionals are considered key stakeholders in patient safety during medical imaging examinations and are also knowledgeable about radiation dose. After completing the first few interviews, some participants voluntarily referred me to their colleagues, whom I then invited to participate in the study. The original study participants, therefore, assisted me in identifying more participants, and the current research was suited to a snowball sampling strategy. The sample size for each of the participant groups in this study, following data saturation, was: radiographers (n=10); radiologists (n=8); and medical physicists (n=8).

- ***Recruitment strategies***

At the time of the investigation (before data collection), 162 radiologists, 2,187 imaging radiographers, and 53 medical physicists registered with the HPCSA in the Western Cape Province (as per the HPCSA iRegister, available for public viewing). I contacted the participants in their personal capacity through social media and word of mouth. I did not recruit the participants based on their place of employment (e.g., exclusively the public or private healthcare sector), as this was not deemed significant/important for the research study findings. From the responses received, I then selected the study participants based on the inclusion and exclusion criteria. Interviews were scheduled with the approved participants at a time and place that was most convenient for them. All the interviews were scheduled so that they did not interfere with the participants' professional duties.

- ***Inclusion and exclusion criteria***

These are the inclusion criteria that were applied:

- Qualified radiographers, radiologists, and medical physicists registered with the HPCSA as independent practitioners.
- Living and practising in the Western Cape Province of SA.
- Practising in the public and/or private healthcare sector.
- Radiographers, radiologists, and medical physicists working at higher education institutions.
- Radiographers working as application specialists.
- Retired for no more than five years from practice in either the public or private healthcare sector.

The following represents the exclusion criteria that were applied:

- Radiographers, radiologists, and medical physicists who have lived and practised in the Western Cape Province of SA for fewer than twelve months. It was deemed

important that participants have adequate professional experience and an understanding of healthcare service delivery in the Western Cape.

- ***Data collection procedures***

Little is known about IPRDT as it is still an emerging area of interest in SA. In a local context, evidence in the body of knowledge about IPRDT and how it could be integrated is scarce. The only local indication of patient radiation dose tracking was found in a report published by the IAEA in 2012. In this report, the SORSA indicated that patient radiation dose tracking would be beneficial (Rehani et al., 2012:e968-e976). Based on this report, I conducted interviews to generate the data. According to Flick (2018:243), interviews, as a stand-alone method for data generation, work well to explore different perspectives and derive meaning from the data. In this study, I interviewed three participant groups based on their unique professional roles and environments in medical imaging and radiation safety.

I selected semi-structured interviews as my primary method for collecting the data. Hesse-Biber (2017:152) shares that semi-structured interviews rely on a set of questions to guide the flow of an interview, but, at the same time, this form of interviewing allows the interviewer to probe issues raised and give the participants some freedom to speak more about what is of interest and/or importance to them. This type of interview, therefore, allowed for a more natural conversation in my interviews and allowed the conversation to move in various directions. In the process, I could also explore all the relevant ideas with each participant.

Before the interviews, each study participant was provided with a research information letter (Appendix C), a research consent form (Appendix D), and a consent form for their interviews to be audio-recorded (Appendix E). These letters were provided to the participants either in person or via email. I ensured I was fully prepared for each interview and printed hard copies of the participant consent forms for them to sign at the interview.

I created a comfortable environment by welcoming each participant before starting the audio recording. I explained the purpose of the research study during this time. I

emphasised the importance of confidentiality and their right to withdraw from the study at any given time without any penalty and/or consequence. Before starting the audio recording, I also addressed the participants' questions or concerns. During this time, I provided participants with a light snack and a cold beverage for the face-to-face interviews. I paid attention to my outfit on the interview day and ensured it was not too formal but smart casual. Collectively, these considerations allowed the participants to be more relaxed and familiar with their environment.

The interviews were conducted using two methods: face-to-face or online (virtual). The participants decided on the interview date, time, and process (face-to-face or online) to ensure that the interview did not infringe on their working arrangements and was most convenient for them. The online interviews were conducted on virtual platforms such as Microsoft Teams and Zoom to accommodate the participants' preferences. I conducted the interviews personally as I was most familiar with the research topic and the interview questions. In addition, I was also familiar with the interview process. This made it easier for me to engage with the participants fully.

For those participants who completed face-to-face interviews, I first screened the venue for privacy, possible disturbances, and noise levels before starting the interview. I placed the audio recorder on the desk between the participant and me, ensuring clear and audible recordings. During the same interviews, all health and safety regulations and protocols (e.g., social distancing) were adhered to, as we were still living amid the COVID-19 pandemic. Figure 2.1 demonstrates the typical seating arrangement I used while conducting the face-to-face interviews.

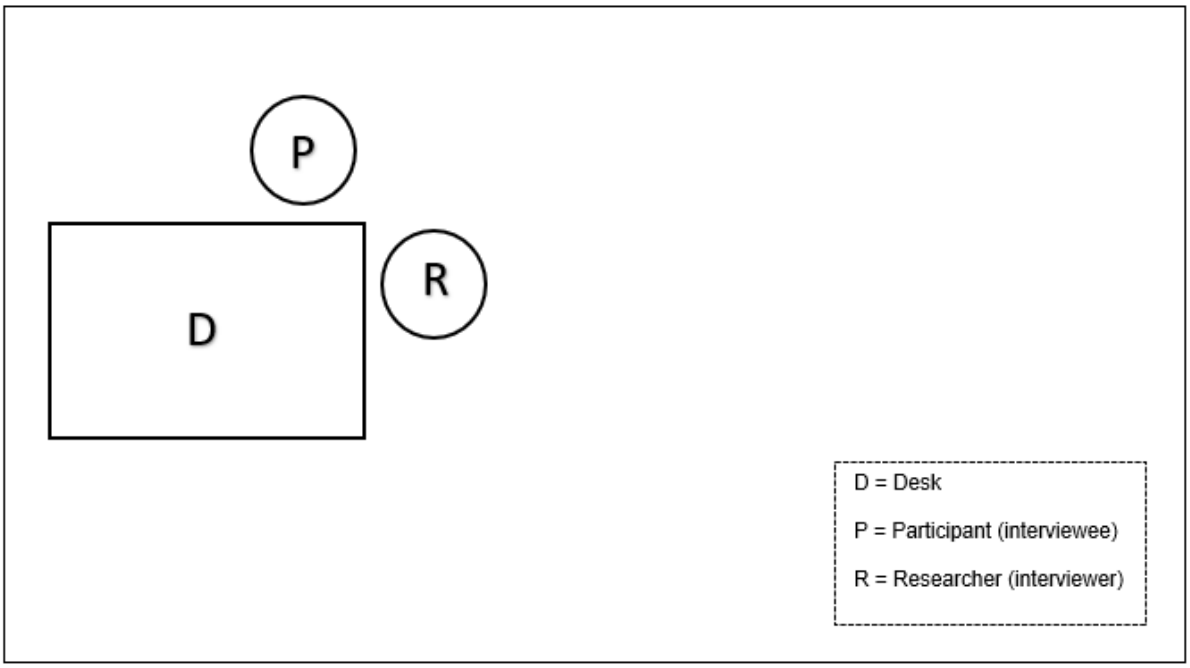


Figure 2.1. Typical seating arrangement for the face-to-face interviews

All venues in which face-to-face interviews were conducted were large enough to accommodate a desk and two chairs quite comfortably: one for the participant (interviewee) and one for me, as the researcher (interviewer). I rearranged the furniture to create a more intimate and comfortable space for the participants. I moved the desk into a position so I could sit next to, not across from, the participant, because indicating authority might have caused psychological barriers. The reasoning was to create a more relaxed environment and embed a sense of the interview following the footprint of an everyday conversation. In addition, this allowed me to maintain eye contact with the participants and to observe their overall body language. Those participants who preferred the online interview were requested to switch on their video functionality so that I could observe their facial expressions and body language as far as possible. I also had my video functionality switched on so that the participant could see me. Thus, even in the online interviews, I also tried to create as friendly an environment as possible.

An interview guide consisting primarily of open-ended questions was used. I believe open-ended questions carry more value, especially when exploring a new phenomenon in a local context. The guide allowed me to collect information-rich data

to produce new insight and ideas (Bearman, 2019:3-4). No written responses from the participants were accepted or included in the data analysis.

The interview guide was shared with each participant beforehand. I then asked probing questions based on the interview participants' answers. This was done so that I could get a better understanding of the information shared. I tried my best to ensure that the probing questions followed logically and were based on the ideas shared at the time. In addition to the probing questions, I used the paraphrasing technique to ensure that the information shared by the participants was understood. The interviews ranged between 11 and 81 minutes, with the duration directly dependent on the amount of information shared by each participant.

Throughout the interviews, I kept extensive field notes about the participants' body language, facial expressions, and tone of voice. These are considered essential observations necessary for qualitative studies (Flick, 2018:304; Mann, 2016:129). After each interview, I reflected on the data collected by completing a self-designed, reflective report template (Appendix F). This was done using bracketing. Bracketing is a qualitative research technique to prevent the risk of researcher preconceptions and bias during the research process (Tufford & Newman, 2012:80).

When conducting interviews that are not fully structured, it is also recommended that the researcher engage in debriefing sessions with their supervisor(s) and/or colleagues (Flick, 2018:305). I engaged with my study supervisors throughout the data collection process for debriefing. Mann (2016:258) states that debriefing allows the researcher to connect with their background and experience, as well as to discuss any unexpected challenges that could have emerged during the interview(s) and how that might have impacted the participant(s) and the researcher.

According to Mann (2016:16), there is a difference between reflection and reflexivity. A reflection can be explained as the researcher thinking about the interview after it has already happened, and this is considered an important, intentional activity. Qualitative researchers often use it to recall personal experiences, deliberate on them, and evaluate them (Mann, 2016:8). Having reflected on each of my interviews, I witnessed a new way of thinking and learning: reflexivity, which requires the researcher to

practise ongoing self-awareness throughout the research process (Mann, 2016:16). I practised reflexivity by keeping a detailed audit trail of all evidence throughout the study, practising reflection, and acting on my ongoing reflections.

- ***Data analysis***

As the study followed a qualitative approach, data saturation was applied throughout the data collection process (Guest et al., 2020:e0232076). Data saturation refers to data collection to the point where no new information arises (Moser & Korstjens, 2018:9). In general, qualitative studies require fewer than 10 participants. This number, however, is merely an estimate from the literature and should be carefully considered for each study, as the target population of each study is different (Moser & Korstjens, 2018:9). The study supervisors and I decided on the data saturation point for this study. Since the study targeted three unique participant groups, each group was interviewed until data saturation was reached. Data saturation assisted me with getting information-rich data from the three stakeholder groups based on their professional understanding, experiences, and recommendations.

Following the interviews with the participants, the audio recordings were shared with a transcriber. The transcriber was provided with a confidentiality agreement beforehand (Appendix G). McGrath et al. (2019:1002-1006) describe transcription as a process whereby the spoken word during an interview is converted into written text. Transcription enabled the data collected to be analysed by the researcher. Typically, transcriptions entail a word-for-word representation of the data, where the words are written in the exact order of the recording. This type of transcription is also known as verbatim transcription.

After all the transcripts were completed, a reflexive thematic analysis approach was used to organise and describe the data. Braun and Clarke (2006:87-93) first developed and explained the thematic analysis approach used in this study. Following the initial development of their approach, the same authors expanded on using it to include a reflexive understanding (Braun & Clarke, 2022:5). Figure 2.2 provides an overview of the Braun and Clarke reflexive thematic analysis phases applied in this study.

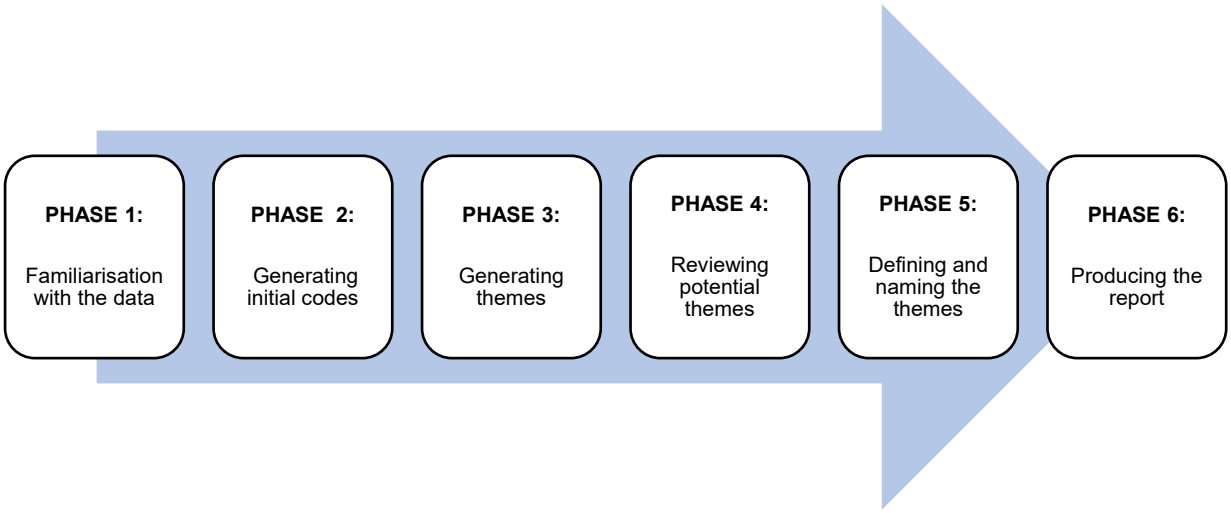


Figure 2.2. Overview of the Braun and Clarke reflexive thematic analysis

A reflexive thematic analysis requires a critical, reflective approach on the part of the researcher (Braun & Clarke, 2022:5) whilst identifying, analysing, and reporting on the themes identified from the data (Byrne, 2021:1392). Throughout the data analysis process, I had to produce new knowledge actively (Byrne, 2021:1393).

During the process, I first separately analysed the data from each participant group into codes. Each of the three groups was considered unique, with those professionals sharing their understanding, professional contribution, and experience in patient radiation safety. The transcriptions of the radiographers were the first to be analysed, followed by the radiologists and medical physicists. The following information (Table 2.1) details the Braun and Clarke approach to reflexive thematic analysis applied to this research study.

Table 2.1. The Braun and Clarke reflexive thematic analysis applied

PHASES	APPLICATION
PHASE 1: Familiarisation with the data	Phase 1 is the most crucial step, informing the remainder of the data analysis process. During this step, I immersed myself in the data to gain a thorough understanding. After the audio recordings were transcribed by an independent, outsourced transcriber, I first listened to each interview recording while reading the transcripts. By doing so, I

	practised active listening to develop an understanding of the ideas shared by each participant. I read and reread the transcripts, looking for potential meanings and patterns. I then reflected on my understanding of the data and created a summary for each transcript. The summaries assisted me in generating the initial codes.
PHASE 2: Generating initial codes	After I had worked through the transcripts and familiarised myself with the content, I converted the textual data into tables. Each table had separate columns. The first column was for the participant's direct, verbatim quotes, and the initial codes were in the next column. Codes are the building blocks of the data analysis process, comprising short, descriptive labels that represent a data set (Dawadi, 2020:66). Codes were also identified as information that might have relevance to the research question. The initial codes were identified from the quotes as data that, for me, stood out. I used manual coding, incorporating different colours to highlight potential patterns that emerged from the data. A different colour was used for each similar pattern/set of ideas. For this study, I used the latent coding technique: I tried to identify the different meanings, ideas, and assumptions from the data sets. This allowed for a more interpretive approach for me as the researcher, instead of the semantic technique, which focuses on the surface meanings of the data (Byrne, 2021:1397).
PHASE 3: Generating themes	During Phase 3, I had to re-focus my analysis to include a broader perspective of the initial codes, so I had to sort the initial codes into subthemes based on my interpretation and understanding of the data. I did this by combining codes with shared meaning into potential subthemes.
PHASE 4: Reviewing potential themes	Phase 4 allowed me to reflect on the combined subthemes generated from the three participant groups and to refine them into unique, overall themes. In doing so, I had to

	evaluate whether there was enough data to support the overall themes. I copied the subthemes into a table to align them with the overall themes. During this phase, I also reviewed the potential themes based on their quality, unique contributions, and boundaries.
PHASE 5: Defining and naming the themes	During Phase 5, the themes identified were further analysed by considering what they represented and how they answered the research question. After this, I labelled the themes individually with concise, easy-to-understand descriptions. Labelling accurately was considered an essential task, as the themes are the first indication to the reader of the story captured from the data.
PHASE 6: Producing the report	Phase 6 allowed me to analyse the final themes and write them up using an analytical narrative approach. While reporting the data analysis, I summarised the research findings and accounted for the story that the data had revealed. This was done by including evidence for the themes generated by including relevant data extracts. During this phase, I also paid attention to the order in which my overall themes were presented. Presenting the themes in the correct order was vital for sense; in other words, I had to convey them logically and meaningfully. Sequencing the themes also allowed me to reflect on the research question, and it formed the basis of my argument for developing guidelines for IPRDT that are responsive to local (South African) needs.

Following the data analysis, the themes were also aligned with the research objectives to answer the overall research question. The themes and subthemes were jointly agreed upon after I had presented them to my study supervisors. This was a necessary action to ensure that I had captured a true reflection of the participants' ideas. I then used inductive reasoning to formulate a central concept, based on my understanding of the themes generated. In doing so, I had to integrate the themes before identifying

the central concept. The central concept then informed the basis of the model development (Chinn & Kramer, 2011:188); and, for this to happen, I first had to define and classify the terminology of the central concept.

2.5.1.2. Phase 2: Central concept definition and classification

During Phase 2, I applied the remainder of Walker and Avant's concept analysis steps. In doing so, I had to ascertain the purpose of the analysis by explaining and defining the central concept. The definitions were identified by consulting dictionaries and subject literature sources. After the definitions were identified, they were evaluated for their use in developing the defining attributes of the central concept. The four rules identified by Copi and Cohen (1994:192-196) were utilised to guide the development of the defining attributes. These four rules are:

1) Indicate the attributes of the concepts together with their relationships.
2) Avoid too broad and too narrow definitions.
3) Do not use ambiguous or vague language.
4) The definition should be as confirmatory as possible.

Following this, a model and a contrary case with the defining attributes were constructed to demonstrate an ideal and opposite scenario of the central concept (Baldwin, 2008:50). To conclude the concept analysis, the central concept was classified using a well-known method by Dickoff et al. (1968:435). This method was applied by asking the following six questions:

1) Who is the agent?
2) Who is the recipient?
3) What is the context?
4) What are the dynamics?
5) What is the procedure?
6) What is the outcome?

Upon investigation of the method by Dickoff et al. (1968:415), I found that the agent is defined as the person who initiates the action, following which the recipient receives

the action from the agent. The context refers to the area in which the action occurs. The dynamics incorporate the agent's and recipient's internal motivation to attain the agent's preferred outcome. The procedure relates to the steps taken by the agent. The outcome is based on the agent's actions directed towards the recipient.

2.5.2. Step 2: Relationship statements

During this step, I described the relationship between the previously identified and defined concepts (Chinn & Kramer, 2011:19). This was necessary to develop the preliminary conceptual map for the model. According to Polit and Beck (2012:54), relationship statements demonstrate how one concept affects another. Chinn and Kramer (2011:19) agree with the previous authors; and further, they mention that the relationship statements can be simple and/or complex. The relationship statements added meaning to the interactions of individual concepts identified during Step 1.

2.5.3. Step 3: The development and description of the model

The information gained from Steps 1 and 2 formed the basis of the model development. The model was then described using the Chinn and Kramer descriptive components for theory development (Chinn & Kramer, 2022:164). The descriptive components used to describe the model were the following:

1) What is the purpose of the model?
2) On what assumptions does the model build?
3) How are the concepts defined within the model?
4) What is the nature of the relationships within the model?
5) What is the context of the model?
6) What is the structure of the model?

After the model was developed, a panel of experts evaluated it (Chapter Five, see 5.5). The panel of experts comprised researchers from the radiography, radiology, medical physics, and nursing professions. The members were selected based on their previously published work, thus making them experts in either patient radiation safety and/or model development. Evaluators from the radiography, radiology, and medical

physics professions are also seen as potential end-users of the model. The evaluation was done during an online meeting. The Chinn and Kramer components of theory evaluation were used to evaluate the model (Chinn & Kramer, 2011:196-205):

1) How clear is this model?
2) How simple is this model?
3) How general is this model?
4) How accessible is this model?
5) How important is this model?

2.5.4. Step 4: Guidelines to implement the model

Step 4 addressed the final objective of this study. Operational guidelines were described (Chapter Six, see 6.2) on how the model could be used to guide the implementation of IPRDT within the South African healthcare system.

2.6. SCHEMATIC DIAGRAM OF THE RESEARCH PROCESS

Figure 2.3 presents the research process for this study in the form of a schematic diagram. It also indicates at each step which study objective was met.

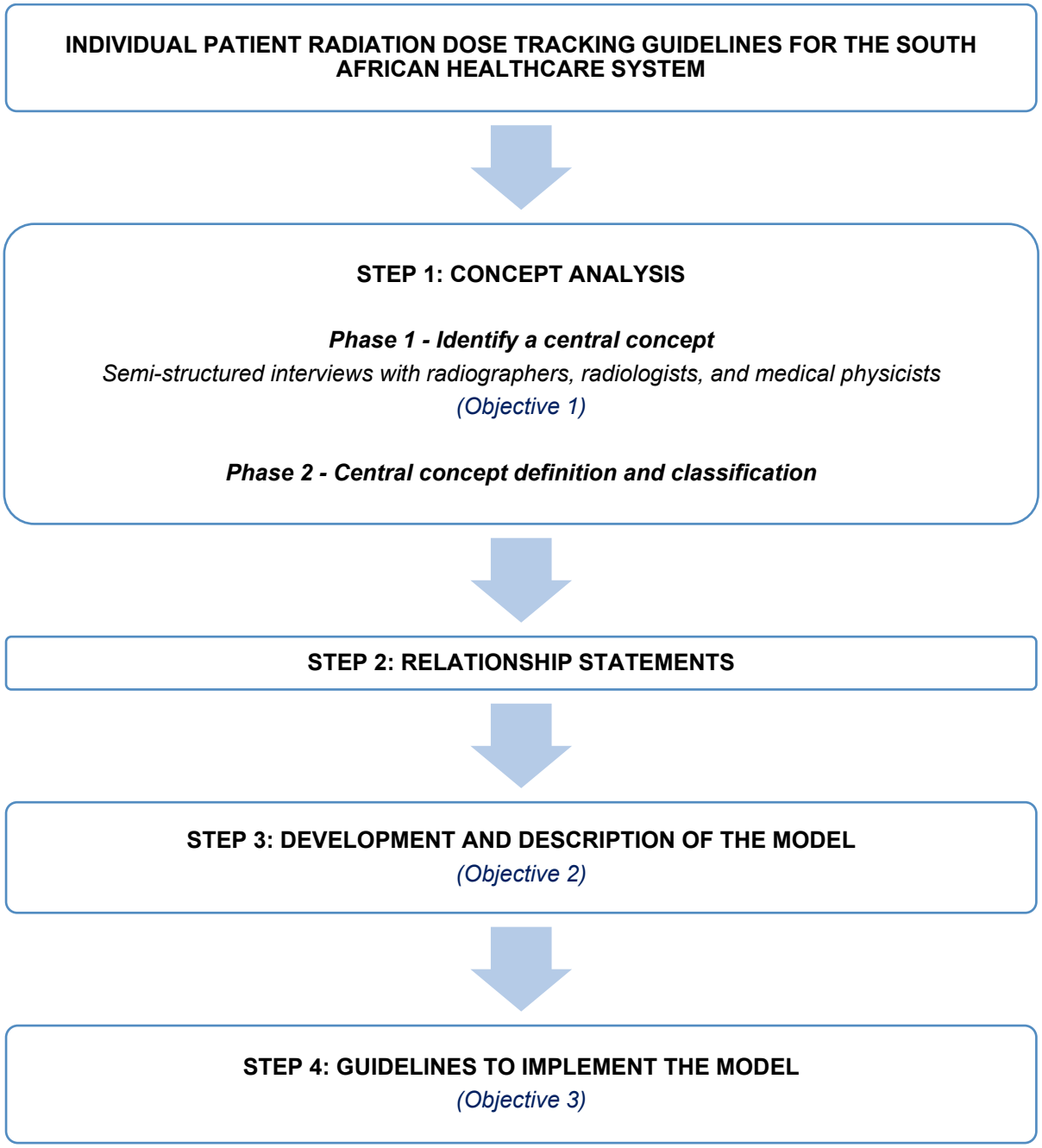


Figure 2.3. Schematic diagram of the research process

2.7. TRUSTWORTHINESS

Lincoln and Guba's criteria guided the trustworthiness of this study (Lincoln & Guba, 1985:289). The criteria applied included dependability, credibility, transferability, and confirmability. Figure 2.4 provides a pictorial overview of the trustworthiness criteria utilised in this study.

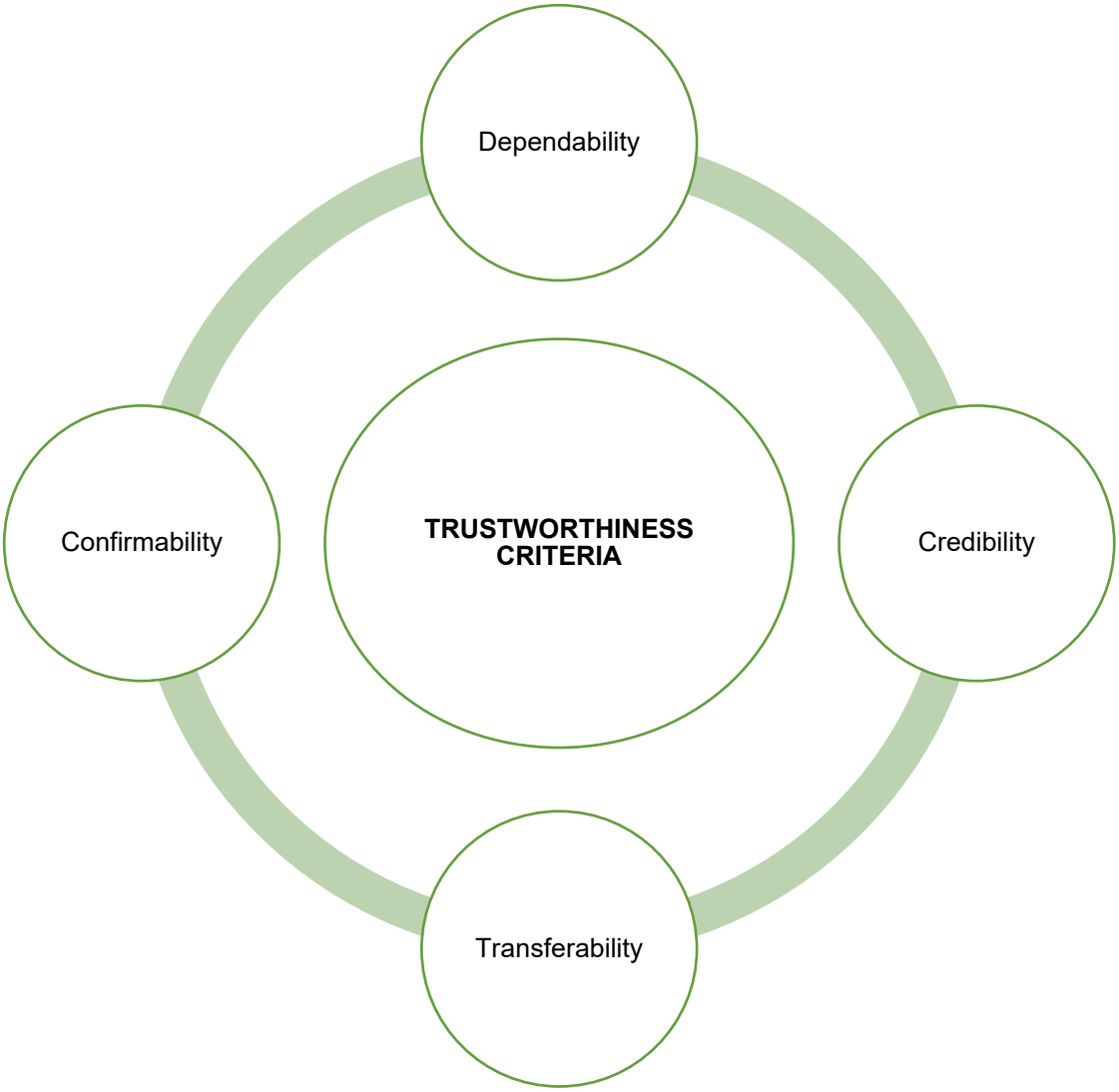


Figure 2.4. Pictorial overview of the trustworthiness criteria applied

The following information presents a discussion of the trustworthiness criteria and how these were applied to the current study.

2.7.1. Dependability

Dependability in qualitative research studies ensures that the results are accurate and consistent (Holloway & Wheeler, 2010:243). In this study, dependability was assured by the triangulation of the data collection process. Additional methods to ensure dependability were included by providing a detailed description of the research methods, including direct quotes when presenting the results, and by the researcher keeping a detailed audit trail of the study transcripts as evidence.

2.7.2. Credibility

Credibility represents the concept of internal validity (Holloway & Wheeler, 2010:243). For this study, prolonged engagement with the data, reflective notes, peer review, in-depth interviews, and member checking strengthened the credibility of the study. The researcher shared the study findings with the individual participants via email. These findings were in the form of a written document for participants' further input. The written document stipulated the key themes and subthemes generated from the raw data.

2.7.3. Transferability

Transferability refers to the capability of study findings to be transferred from one context to another (Holloway & Wheeler, 2010:243). Although generalisations are not the aim of qualitative research, the results were compared to those derived from studies in similar situations in other geographical settings, using a detailed description of the research process to evaluate transferability. Although this study was conducted with participants from the Western Cape Province of SA only, data were collected from both the public and private healthcare sectors. As a result, the same principles could apply and, ultimately, the model developed can be transferred to other parts of the country. This is because all nine South African provinces are part of the same healthcare system. It is acknowledged, however, that the public and private healthcare sectors differ in terms of their contexts, overall environments, working conditions, and resources. As such, transferability of the findings and the model may not be universal.

2.7.4. Confirmability

Confirmability ensures that the researcher's preconceptions have not influenced the findings and conclusions of a study (Holloway & Wheeler, 2010:243). For this study, confirmability was ensured by following specific steps to develop the central concept, themes, and their interpretations. Regular debriefing sessions with the study supervisors were held to prevent researcher bias. Detailed notes were kept of all the decisions made. Further, member checking and reflexivity were also employed to ensure the confirmability of this study.

2.8. ETHICAL CONSIDERATIONS

Ethics in health research can be described as a moral framework (Resnik, 2015) which is concerned with protecting and promoting the well-being of research participants (Flick, 2015:32). Booklet 13 of the HPCSA describes SA as a fertile ground for health research due to its developing nature and the large number of vulnerable populations (HPCSA, 2016:266). Due to this reason, the researcher's power must be controlled by making decisions that will not cause harm to their study participants (Houser, 2012:50).

As a locally registered healthcare professional, I followed and built the ethical basis of my research study on the HPCSA's ethical guidelines in health research and on those of the National Health Research Ethics Council (NHREC). This is important, as the study included human participants. The ethical principles of health research, as outlined by the HPCSA and the NHREC, were incorporated in this study (NHREC DoH, 2015:14-16; HPCSA, 2016:267-268). These statutory bodies guide healthcare workers and protect the public. The NHREC specifically focuses on providing guidance and direction to all research involving human participants. The following information presents the ethical considerations that were adhered to in the current study.

2.8.1. Ethical clearance

Ethical approval for conducting this study was obtained from the Cape Peninsula University of Technology's Faculty of Health and Wellness Sciences' Research Ethics Committee. The ethical clearance certificate, reference number CPUT/HW-REC 2021/H3, is included (Appendix H). Ethical clearance was obtained to ensure that the moral principles associated with human research participants in this study have been critically evaluated for adherence and approved before implementing the study.

2.8.2. Permissions

All participants were recruited within their personal capacities; therefore, no special institutional permission was obtained from the participants' places of work. Although

the participants drew on information from their workplaces, no data was gathered based on their current employment. The data collected during this study were based on the participants' understanding and interpretation of IPRDT.

2.8.3. Informed consent and voluntary participation

The participants were provided with background information to the study through a research letter (Appendix C) focusing on these areas: identification details of the researcher and the study supervisors; brief background on, and rationale for, the research study; an outline of the research procedures; the possible risks and discomforts; withdrawal from the study; financial implications; confidentiality; benefits; and, finally, details of persons to contact in the event of any problems and/or queries. This information is in keeping with the HPCSA's guideline, which states that all participants should be allowed to make an informed decision regarding their participation in a research study (HPCSA, 2016:267).

Furthermore, a research consent form for participation in the study (Appendix D) was provided to each participant before commencing with the interviews; there was also a research consent form for the interviews to be audio-recorded (Appendix E). In the case of face-to-face interviews, I printed the consent forms and had them ready at the time of the interview for participants to sign. For online interview participants, I emailed the consent forms to them beforehand. The participants were then requested to return their signed consent forms to me before the scheduled interview date and time. As part of the data collection process and at the beginning of each interview, I confirmed with the participants that they had been provided with an information letter, and they were allowed to ask any questions they might have. I also asked each participant to confirm that they had signed both the consent forms and if they were ready to proceed.

Based on the information provided in the consent forms, participation in this study was entirely voluntary, and the principle of autonomy was maintained. All participants were treated with respect, and informed consent was obtained from all the participants (NHREC DoH, 2015:14). Participants were also allowed to withdraw from the research study at any given time and without penalty or consequence. The study participants

were reminded of this throughout all preliminary communications leading to their scheduled interviews.

2.8.4. Anonymity and confidentiality

No identifiable details were requested from the participants or about the institutions where they were employed at the time. Therefore, the results ensured anonymity and confidentiality. This is in keeping with the HPSCA's guidelines, which state that human research participants have the right to privacy and confidentiality and must be protected at all times (HPCSA, 2016:268). The only details requested from the participants, besides the answers to questions, were those related to the participants' occupation. These details were needed to ensure the participants met the inclusion criteria for the study; in other words, if the participant was a radiographer, a radiologist, or a medical physicist. This information was also needed to evaluate the data for saturation in each participant group.

Furthermore, to protect the anonymity and confidentiality of the study participants, a confidentiality agreement (Appendix G) was entered into with the transcriber before the transcription of the audio recordings took place. This agreement made provision for the audio recordings shared with the transcriber to be kept confidential and not shared with anyone else. The terms of the agreement further included that the audio recordings would be deleted and returned to the researcher upon completion of each transcription.

2.8.5. Benefits and risks

When exploring the benefits and risks of a research study, one must remember that the potential benefits should always outweigh the possible risks (if any). A well-known principle, the principle of beneficence, must be considered for all research studies that include human participants (NHREC DoH, 2015:14). This principle, as per Fouka and Mantzorou (2011:5), can be described as an analysis of the potential benefits of the research study to both the study participants and the community at large.

None of the study participants received any form of remuneration for their participation. The interviews, however, were seen as a positive platform during which the participants could share their personal and professional experiences to promote the justification for, and optimisation principles of, patients being exposed to ionising radiation during medical imaging examinations. It is anticipated that the participants' input, in turn, will positively impact the community at large to prevent patients from being unnecessarily exposed to ionising radiation when referred for medical imaging examinations. In doing so, a possible decrease in the effective lifetime risk for patients to develop radiation-induced injuries and cancers could be imminent.

During the face-to-face interviews, all the health and safety regulations and protocols were adhered to, as we were still living during the COVID-19 pandemic. I screened the venue beforehand and ensured I had hand sanitiser readily available and surgical face masks. For adequate ventilation, I switched the air conditioners on where it was an option to do so. I opened the windows in venues with no installed air conditioning unit to allow fresh air circulation. Social distancing was also observed between the participants and me as I maintained a 1.5-meter distance. The principle of non-maleficence was therefore adhered to by avoiding harm to the study participants (NHREC DoH, 2015:14).

In addition, no form of emotional harm was experienced by any of the study participants, as the research topic was perceived to be of a harmless nature. Due to this, there was also no need for any planned referral processes for psychological support. The research study findings were based on the input obtained from the participants through interviews focusing on their professional knowledge and experience.

2.8.6. Integrity and trust

When conducting research, it is essential to consider the values of integrity and trust. These values can be portrayed in two ways: the integrity and trust of the researcher conducting the study, and the integrity and trust of the data collected. In this study, I applied the principle of justice during the recruitment process and when I analysed the data. Justice can be defined as an ethical concept that relates to the fair, unbiased,

and appropriate treatment of research participants (Polit & Beck, 2018:81). During the recruitment process, I applied a criterion-based, purposive sampling strategy, which allowed for fair and equal participation rights. All the information provided in the information letter and consent forms was adhered to for each study participant. The ethical integrity of the recruitment process was, therefore, maintained.

Given the requirement of integrity and trust for the data collected, I obtained, analysed, and reported objectively on the data. A combination of unique identification letters and numbers was assigned to each transcript/participant. This meant that no personal or identifiable information was divulged to anyone else, nor is it included in this thesis. This ensured that the principle of justice was maintained when working with the datasets.

I also arranged for in-depth discussions with the study supervisors to review the accuracy of my interpretation of the data. This ensured the integrity and trust of the researcher throughout the research process. Furthermore, I safeguarded all hard copy data under lock and key, and the soft copy data was stored electronically and kept under strict password protection throughout the study.

2.8.7. Protection of personal information

The Protection of Personal Information Act (mostly known in its abbreviated form: POPIA) is in place to contribute to the constitutional right of privacy. It further seeks to synchronise the processing of personal information within SA with that of international practice standards. The POPIA, in addition to all accounts of personal information, allows for specific provisions when it comes to research (Staunton et al., 2021:33). It is crucial for the researcher to be aware of the correct handling of personal information (Staunton et al., 2021:33) to meet the associated ethical standards. In other words, the collection, storage and intended use of data, as well as how it will be destroyed, must be considered. This is paramount during research and must be followed diligently to respect the privacy and confidentiality of the study participants. These aspects were adhered to in this study.

2.9. CONCLUSION

A detailed discussion relating to the research design and method employed in this study was presented in this chapter. The research design and method were carefully aligned to the research question to provide an overview of how IPRDT could be achieved and integrated within the South African healthcare system. The model will assist future stakeholders in developing and implementing their own unique IPRDT systems, methods, and tools. Last but not least, a detailed description of the trustworthiness of the data was provided, followed by an explanation of the ethical considerations that were observed whilst conducting the study. The next chapter presents the research findings. The participant demographics and their views on how IPRDT could be integrated into a local context will be described. The findings are then further discussed through a literature control.

CHAPTER THREE

FINDINGS AND DISCUSSION

"When you listen, it's amazing what you can learn. When you act on what you've learned, it's amazing what you can change."

Audrey McLaughlin

3.1. INTRODUCTION

Individual patient radiation dose tracking (IPRDT) within the South African healthcare system is a relatively new and unexplored phenomenon. This study explored the perspectives of radiographers, radiologists, and medical physicists in the Western Cape Province of SA on integrating IPRDT into the South African healthcare system. It further sought to develop and evaluate an appropriate model to guide the implementation of IPRDT. Although a variety of international IPRDT approaches exist (Chapter One, 1.2), the model developed as part of this research offers a contextually relevant pathway for stakeholders to implement IPRDT in South Africa (SA).

The previous chapter outlined the research design and method for the study. Chapter Three discusses the findings from the one-on-one, semi-structured interviews with the three participant groups. The data collection process lasted 18 months, from February 2022 to August 2023. Furthermore, the current chapter includes participant demographics, a collective story, themes and subthemes.

3.2. PARTICIPANT DEMOGRAPHICS

The total number of participants was 26, representing 10 radiographers, eight radiologists, and eight medical physicists. Each participant group had representation from both the public and private healthcare sectors. Table 3.1 summarises the relevant

participant demographics, the individual participant descriptive labels, and the interview duration. There is some variation in interview duration, mainly due to differences in participants' communication styles, with some providing more detailed answers and explanations than others. The abbreviation “G” refers to “group,” and “P” refers to “participant.”

Table 3.1. Participant demographics and interview duration

GROUP	PARTICIPANT NUMBER	PARTICIPANT DESCRIPTOR	GENDER	INTERVIEW DURATION
Radiographers (Group 1)	1	G1P1	Female	41 minutes
	2	G1P2	Female	65 minutes
	3	G1P3	Male	40 minutes
	4	G1P4	Female	81 minutes
	5	G1P5	Female	36 minutes
	6	G1P6	Female	69 minutes
	7	G1P7	Female	15 minutes
	8	G1P8	Female	23 minutes
	9	G1P9	Female	11 minutes
	10	G1P10	Male	21 minutes
Radiologists (Group 2)	1	G2P1	Female	20 minutes
	2	G2P2	Male	25 minutes
	3	G2P3	Male	15 minutes
	4	G2P4	Female	12 minutes
	5	G2P5	Male	21 minutes
	6	G2P6	Male	8 minutes
	7	G2P7	Male	19 minutes
	8	G2P8	Female	65 minutes
Medical physicists (Group 3)	1	G3P1	Male	42 minutes
	2	G3P2	Male	22 minutes
	3	G3P3	Female	48 minutes
	4	G3P4	Female	47 minutes
	5	G3P5	Female	33 minutes

	6	G3P6	Female	20 minutes
	7	G3P7	Female	41 minutes
	8	G3P8	Male	45 minutes

3.3. THE COLLECTIVE STORY

The participants' passion for radiation safety was evident. The need for a sustainable environment to strengthen such safety was clear. The participants shared their perceptions of what is needed to implement IPRDT and reiterated the purpose of IPRDT. Although in an environment where IPRDT is not practised, they shared a positive outlook and vision for change. This shared vision was evident and based on their past experiences. For example, they shared memories of patients who were subjected to unnecessary and excessive ionising radiation during medical imaging.

Although the participants expressed enthusiasm about the possibility of IPRDT, they identified potential enablers of, and barriers to, its implementation. Among these are the advances in current technology, such as patient information and communication systems, limited equipment, financial and human resources, and the need to support patient information during data-sharing between the public and private healthcare sectors. These factors were considered likely to impact the implementation of IPRDT.

Ultimately – following a phased implementation approach and starting small at the institutional level before provincial and national expansion – an automated, central database was recommended. Individual and specific patient datasets were deemed necessary for collection, recording, and processing. Access to these records, however, should be controlled, yet the records should be accessible to both the public and private healthcare sector stakeholders. An effective IPRDT environment should be multidisciplinary, given the varying professional roles and responsibilities in patient radiation safety. Support from healthcare information technology (IT) professionals is also needed.

An interprofessional collaborative approach was important for a shared radiation-conscious culture and environment. Professional awareness in the form of initial buy-

in from internal and external stakeholders, particularly individual patients, and continuous education opportunities, was deemed critical for the success of an effective IPRDT service. Furthermore, obtaining legislative and procedural support from the relevant regulators to assist with and drive a compulsory implementation of IPRDT was considered necessary.

3.4. THEMES AND SUBTHEMES

Table 3.2 presents the themes and subthemes developed by applying the reflexive thematic analysis approach of Braun and Clarke (2022:5). This process was explained in some detail in Chapter Two (Table 2.1).

Table 3.2. A summary of the themes and subthemes

THEME(S)	SUBTHEME(S)
1. Knowledge and perceptions of IPRDT	1.1. Requirements for IPRDT 1.2. The purpose of IPRDT 1.3. Current practices and rationale for implementation 1.4. Perceived benefits
2. Factors affecting the implementation of IPRDT	2.1. Technology 2.2. Lack of available resources 2.3. Data-sharing relationship
3. Considerations for clinical practice	3.1. System specifications 3.2. A phased approach 3.3. Data management 3.4. Professional roles and responsibilities
4. A collaborative effort from stakeholders	4.1. Interprofessional collaborative practice 4.2. The patient as an equal partner 4.3. Legislative support and procedural guidelines

The findings are presented as a narrative, with a descriptive summary of each theme and subtheme, followed by the participants' verbatim quotations and a literature discussion.

3.4.1. Theme 1: Knowledge and perceptions of IPRDT

The first question in the interview guide (Appendix B) aimed to ascertain the participants' understanding of IPRDT. Therefore, the theme arising from this question focuses on the participants' knowledge and perceptions of IPRDT. Participants referred to the requirements of IPRDT, along with a potential litigation concern, and, because of this, they conceptualised their perception of the purpose of IPRDT. Furthermore, they reflected on the need for IPRDT and its potential benefits for the medical imaging environment. Figure 3.1 is a visual representation of the relationship between Theme 1 and its subthemes.

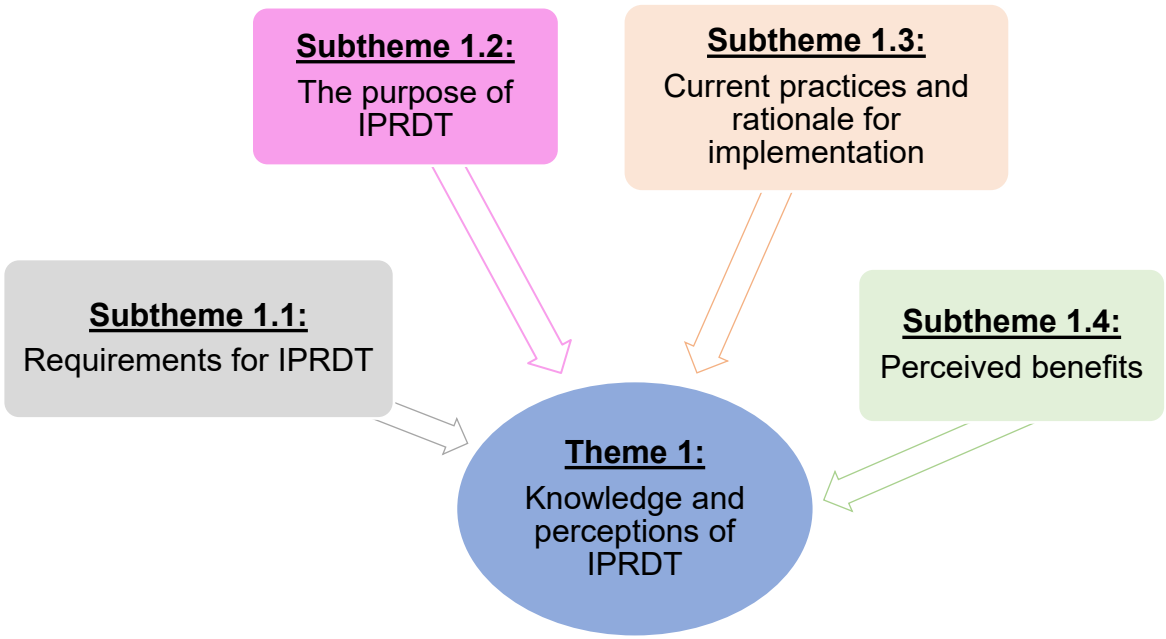


Figure 3.1. A visual representation of Theme 1 and its subthemes

3.4.1.1. Subtheme 1.1: Requirements for IPRDT

Participants perceived IPRDT as keeping an individual, lifetime health record for all patients, similar to the records for monitoring occupational radiation exposure. A common understanding among the participants was that this record should include information on all the medical imaging examinations using ionising radiation to which the individual patient had been exposed. In addition, the participants reasoned that, by accessing the individual patient's radiation dose data, a cumulative radiation dose value could be calculated to estimate and manage potential medical radiation-induced risks. These understandings are conveyed in the following direct quotes drawn from the data:

> *"So, my understanding of patient dose tracking is documenting radiation doses for every imaging procedure the patient undergoes."* ***G1P1***

> *"From cradle to grave. That would be the ideal situation that you track it from cradle to grave."* ***G1P4***

> *"All types of patients of all age groups should be considered."* ***G1P7***

> *"So every study for every patient will have a different radiation dose, so it will be individual in that sense. And also, I guess the tracking component is looking over time, what is the cumulative effect."* ***G2P1***

> *"I would say everything that requires ionising radiation. So the main ones are interventional, fluoroscopy definitely, CT, Mammo, and plain film. I don't think any ionising-related study should be excluded."* ***G2P2***

> *"So, it's a, it's a bit of a new concept for me, but how I understand it is you are basically tracking each individual patient over their lifetime regarding medical radiation."* ***G2P3***

> *"So, my understanding is basically that you would, for every patient, keep a dose record. In my mind, it would be a cumulative dose record from the first*

time that the patient actually had a procedure that uses radiation, well, ionising radiation. And with dates, times, basically, a lifetime record for the patient." ***G3P1***

"We are always tracked as radiation workers, but only recently, I think in the past decade, started to track patients, and I also know there are two ways of doing it. It's looking at the exposure records, just the imaging – how many images the patient's got and what modality, and then actually looking at the doses and what patients got from the type of imaging." ***G3P5***

An individual patient's health record can be explained through collecting and storing a patient's personal health information under a healthcare practitioner's care over an extended period, irrespective of the method or medium used to produce such a record (HPCSA, 2022). In context, the individual patient's health record should contain data on the patient's radiation exposure and the dose (Rehani, 2017:031206-1). The purpose of an individual patient health record is to provide evidence of the patient's care to assist healthcare practitioners in continuing their care (NHS England, 2025).

The continued exposure to ionising radiation has a cumulative effect. This is interpreted as the possibility of a patient, who has been exposed to multiple medical imaging examinations, having an increased risk of developing radiation-induced injuries and cancers (Jeukens et al., 2021:1). This notion links well with the findings of a paper published by Brambilla et al. (2020:2493) in which they revealed an urgent need for all stakeholders to address the concern surrounding patients who have received high amounts of cumulative radiation doses. Although epidemiological research has revealed that cumulative exposure to low-dose ionising radiation could place a person at risk for developing radiation-induced injuries and cancers (Tang, 2024:1), Walsh et al. (2020:4435) recommend that caution be applied when estimating its associated risk. The same authors, Walsh et al. (2020:4435), however, also believe that research should remain open to all considerations concerning the potential of radiation-induced injuries and cancers. The findings from the current study fit this notion well.

The participants further commented on the need for a single unit of measurement for radiation dose across the different imaging modalities. Although the participants referred to the effective dose (ED) measurement to indicate risk, they shared the understanding that it does not accurately represent the individual patient's absorbed radiation dose. The ED measurement was thus identified as a starting point, but with caution. The following quotes demonstrate the complexity of individual patient radiation dosimetry and the need for further research:

> *"I mean, you want to be comparing apples with apples. But ja, I mean, obviously, you want uniformity that's going to give you something that you can look at cumulatively."* ***G2P2***

> *"So, it does become difficult when you need to look, start looking at the accumulation of the dose based on the different exams. They have slightly different units in terms of measurement, and it's also, it's indicators – it's not saying the patient did get this amount of dose – it's saying based on the scan, this is what we expect the absorbed dose to the patient was, but it's not necessarily true."* ***G3P2***

> *"So, I think if you're going to compare like different modalities, different like cumulative doses and stuff, you will have to look at a unit to, like, something like the effective dose, which is not modality specific – it's a single quantity that can be calculated over multiple procedures. It represents the overall radiation to a patient from a procedure. But having said that, it's also not – it's not strictly speaking, like, it shouldn't be used as the matrix to individual patients, because it's in, I think the definition of an effective dose is that it's useful, like for setting population level risks."* ***G3P3***

> *"You'll have to look at the effective dose. But at least you're going to have an estimate, whereas, without a system like this, you have nothing."* ***G3P4***

> *"I guess in a perfect world, it would boil down to effective dose – that's the lowest common denominator for all the imaging modalities – but that might be quite ambitious. But, if a patient has had a CT scan at Clinic A and another CT*

scan at Clinic B, those doses should be added if you have an IPRDT system in place." ***G3P8***

It is noted in the literature that there is a need for a more accurate metric to calculate the individual patient's estimated risk from cumulative radiation (IAEA, 2019b; Jeukens et al., 2021:8). Knowledge of the same was shared by the participants in this study, though mainly from the medical physicists' group. A recent paper by Ria et al. (2024:1) reported an updated version of the ED aimed at estimating individual radiation-induced risk, known as the relative effective dose (ER), incorporating gender and age. Ria et al. (2024:1) applied the ER calculation to 8918 patients who underwent computed tomography (CT) examinations and compared it with the standard radiation risk metrics. They used the Monte Carlo method in which they calculated the ER, the dose-length-product-based ED (EDLP), the organ-dose-based ED (EOD), and the organ-dose-based risk index (RI) for each patient. It was concluded that the ER calculation yielded a more accurate depiction of individual patient risk.

3.4.1.2. Subtheme 1.2: The purpose of IPRDT

The participants shared strong affirmations regarding the purpose of IPRDT, as some participants (mostly medical physicists) expressed their concern about potential litigation should it be deemed necessary for a healthcare worker or department to be investigated for medical negligence in their prescription and/or use of ionising radiation during medical imaging examinations. IPRDT was believed to increase awareness of the potential risks associated with ionising radiation and, in return, complement the justification and optimisation principles related to patient radiation safety. The concerns raised and the purpose of IPRDT are demonstrated in these verbatim quotations:

"They can use it to either optimise their own radiation for radiation safety purposes. Also, you want to make people more aware of the radiation that's been used." ***G2P4***

"So if an individual patient had dose tracking and they were going to look at the dosage and, it may just make people aware that, you know, we must use radiation and look at risk versus benefits." ***G2P10***

"What I also foresee happening is, for example, if I looked at patient data and I see okay, they had a chest X-ray at a private hospital, and they had a chest X-ray at this government hospital, but the exposure parameters are much higher, that there is maybe some issue that boils down to okay, who becomes liable? Because then you realise okay, why was this chest X-ray at a much higher dose than my other chest X-ray? And I think the private hospitals might not necessarily want to be involved – especially if it includes the hospital name with dose information." ***G3P1***

"So, the only thing that I want to reiterate is just because there is a lot of like international tendency, or like some groups who focus a lot on patient dose tracking and using the patient dose data as a reason not to do something. So, I want to reiterate that it should never be just because a patient had a high cumulative dose for an interventional procedure; looking at the dose alone shouldn't influence whether you're doing a potentially lifesaving or indicated procedure. You're just trying to avoid duplication." ***G3P1***

"You could argue it's good medical practice; you could also argue it opens yourself up to potential liability issues if you've had some doctors who were working a little sloppy in the fluoroscopy and the Cath Lab or something, and the patient now realises this, you may have a couple of lawsuits on hand which make me wonder if they would actually even consider this – I don't know." ***G3P8***

A comprehensive individual patient health record indicates good clinical practice (Howarth & Gillespie, 2024). Patient health records may be used as evidence in suspected medical negligence and/or litigation cases (Medical Protection Society Limited, 2024). Tarkiainen et al. (2021:1) agree with the previous statement and further mention that a safe and beneficial medical imaging examination is the patient's right. The patient may also request more information should an incident have occurred and is allowed to submit a compensation claim (Tarkiainen et al., 2021:1).

The purpose of IPRDT, as perceived by the participants, however, aligns well with a verbatim statement made by Professor Madan Rehani: “The risk of not performing the examination should be part of decision-making” (Rehani, 2017:031206-3). This refers to the notion that IPRDT should not prevent a patient from receiving a justified examination. Experience from Finland revealed that they could avoid exposing four patients to unnecessary radiation due to IPRDT (Seuri et al., 2013:771-775). This was possible because they had access to each patient’s health record, which contained a detailed clinical history linked to their previous medical imaging examinations. The same authors reported that IPRDT allows for improved patient-centred care (Seuri et al., 2013:771), which is in keeping with the theory of person-centred care (PCC) in this study.

Upon reflection, Subtheme 1.2 reaffirms the sensitive nature of the topic and the need for this research to have been conducted. Further research, however, is needed and recommended to delve deeper into the medicolegal complexities of IPRDT.

3.4.1.3. Subtheme 1.3: Current practices and rationale for implementation

The participants expressed enthusiasm for IPRDT being explored for the South African healthcare system. They reflected on their lived experiences in the clinical environment and highlighted various reasons for implementing IPRDT. A concern was raised about their current poor record-keeping practices, especially regarding patient radiation dose data. This is because patient radiation dose data are stored on single workstations; and this data, they indicated, does not serve any purpose in the long term. Concerning their professional role, participants ascribed this concern to the need to be more accountable and responsible when keeping records of and working with ionising radiation.

> *“Well, there isn’t, how can I say now? Like a place where it’s individually recorded for each and every patient throughout our systems in clinical practice at the moment. What usually now happens, or what is happening now, is either in the register when the patient has a procedure or on the machines where the procedure is being performed, and that is all, and that’s why I see such a great opportunity with the study of yours.” **G1P3***

“I think we are sitting ducks because we do not keep records. People need to be accountable, and it's accountability that we are looking at. So now we are starting dose tracking. How more accountable can you be than when you track doses?” ***G1P4***

“Radiation exposure has a cumulative effect which can lead to detrimental health effects on patients, and therefore, it’s something we need to monitor, and as physicians or doctors administrating radiation, we also need to be responsible for, you know, the interventions that we perform on patients.” ***G2P7***

“It’s something that we’re not doing properly, and it’s something that I think is very important, and because of the relatively small doses in radiology, it gets put to the wayside – it falls to the wayside and doesn’t get much attention.” ***G3P4***

In 2010, a first-of-its-kind survey was administered in 85 countries to explore the availability of existing IPRDT systems, their usefulness, and the stakeholders' familiarity with IPRDT (Rehani et al., 2012:e968-976). Although none of the countries had implemented an IPRDT system nationally, there was significant interest in its conception. From the responses, 99 per cent of countries, including SA, were interested in developing an IPRDT system (Rehani et al., 2012:e968-976). Interestingly, in a study by Lewis (2022:199) in SA, a radiographer participant indicated the need to develop a national patient radiation dose register.

The Health Professions Council of South Africa (HPCSA) published a booklet to guide healthcare professionals in the country towards good practice (HPCSA, 2021:1-18). This booklet includes specific core ethical values and practice standards required by healthcare workers in the country. Among the values and standards identified as paramount is a healthcare professional acting in the best interest and well-being of a patient under their care. This includes adherence to the bioethical principles of beneficence, non-maleficence, and autonomy (HPCSA, 2021:2). Related to this study, there is reference to facilitating a strengthened, personalised approach to patient care by carefully evaluating the potential benefits and risks that a medical imaging examination may hold for the individual patient. The participants in this study reflected

on IPRDT as an opportunity to become more responsible and accountable for the use of ionising radiation. This notion is in keeping with the view expressed by the HPCSA that professional competence and self-improvement are critical skills (HPCSA, 2021:2).

The participants, furthermore, expressed apprehension that not all requests for medical imaging examinations are justified by referring healthcare practitioners, indicating the current possible over-servicing of patients. Stories of patient scenarios within the clinical environment are shared in the following quotations, providing detailed accounts of patients who underwent duplicate studies due to human error and personal preferences among radiographers to produce the perfect image. Due to these reasons, participants indicated a dire need for IPRDT to be implemented to promote and strengthen the justification and optimisation principles associated with patient radiation safety.

> *"So, radiographers would maybe repeat an X-ray to get it perfect according to the standard, but I think so many times we repeat unnecessarily."* ***G1P6***

> *"We felt as radiographers that that's unnecessary if nothing has changed with the patient, why are we doing this and everybody shouts, "It's just a chest X-ray, it's just one view", but in a month where a patient is for three weeks in the COVID ward having two chest X-rays a day, it adds up. Because, I mean, we see neonates, one-hour-old babies or one-day-old babies that are having chest X-rays and abdominal X-rays, CT scans, and in those instances, a lot of the responsibility also lies with the referring doctor to discuss with the radiologist alternative options to say, listen here, this baby is two days old, we need to exclude this pathology, what do you suggest?"* ***G1P6***

> *"You can't send the patient the next day for another chest X-ray with the same history – the radiographer is going to ask you why you want this, and at a tertiary hospital where radiologists are readily available and available 24 hours, we would flag that to the radiologist."* ***G1P10***

"I had a patient with a CT angiogram, and the CT scan was performed. So yesterday's date was the 29th of August. Four days previously, on the 25th of August, the patient had the same study – a CT angiogram of the abdomen and periphery. So, it extended from just above the diaphragm to the toes – an identical study for the same indication. Nothing had happened in between, there was no deterioration in the patient's clinical assessment to prompt, to actually justify, another study. And I think what happened in that case was that the patient, on the 25th of August – a Friday – was scanned, and the result was a comprehensive report. Someone must have put in another request on the Radiology Information System and the radiologist because the PACS system isn't a very user-friendly one at the district level hospital, and the radiologist didn't, wasn't able to, or didn't do, the two extra steps to see whether there was a previous study. So, this patient had a completely unnecessary study." ***G2P10***

According to Vom and Williams (2017:212), the justification process is crucial to safeguard a patient against unwanted radiation-induced effects. The International Atomic Energy Agency (IAEA, 2023a) advocates that the justification process should be carried out through consultation between the referring practitioner and the individual responsible for the examination. During this consultation, consideration must be paid to the following: the appropriateness and urgency of the request; the patient and radiation exposure characteristics; any relevant information from previous procedures; and the availability of referral guidelines.

A study conducted in Norway and Denmark explored radiographers' attitudes toward their role in the justification process of medical imaging examinations (Reitan et al., 2024:74). Their findings revealed that, although the radiographers considered their role in the justification process very important, they indicated that this responsibility should lie with the radiologists (Reitan et al., 2024:81). In the paper written by Vom and Williams (2017:212), it was recommended that a need exists to change the workplace culture to encourage radiographers to pursue a self-sufficient role in decision-making and justification to benefit the patients under their direct care. From the stories shared by the participants, it is evident that there are discrepancies in the facilitation of and adherence to the justification process in clinical practice. What was clear to me during the interviews was that this lack of justification caused an inherent,

morally driven whirlwind of emotions among some of the participants. This was evident in my reflective notes on changes in their tone of voice, facial expressions, and general body language.

The results from a study conducted in SA identified that approximately 25 per cent of patients receive more radiation than necessary during medical imaging examinations (Lewis et al., 2019:40). This speaks directly to the principle of radiation dose optimisation and the need to improve adherence. Lewis (2022:8) conducted a study targeting all radiographers in SA to explore the reasons behind suboptimal radiation protection practices and suggestions for improving practice. The same author developed a theory and model to facilitate a transformative radiation protection environment (Lewis, 2022:211); however, this model is limited to radiation protection adherence amongst radiographers and does not address the need to explore and implement an IPRDT system.

The participants indicated a trend in the increasing use of high radiation dose investigations. This trend was attributed to the current advances in medical imaging technology, specifically, the overlapping of different imaging modalities, commonly called ‘hybrid imaging’. The participants coupled this understanding with the expected increase in life expectancy among patients, placing them at a higher risk of developing radiation-induced injuries and cancer. These were deemed additional reasons for implementing IPRDT and are demonstrated in the following quotes:

> *“But now, it’s like radiation therapy, diagnostic, and nuclear medicine are merging, so the radiation doses are getting higher because these disciplines actually help and assist a patient's diagnosis and treatment so much. I do understand why it’s merging; I do understand it. It is a very important topic to cover, but I think dose tracking, going from now and into the future, is going to become of more importance because of this merging of fields and the technology.”* ***G1P2***

> *“So I mean with healthcare and modern technologies, the chances of people, I think, living longer are much higher. So, ja, we will definitely see the effects of radiation, so now would be a good time to get that data.”* ***G3P3***

Hybrid imaging offers improved diagnostic accuracy and confidence for potential diagnosis and increased patient comfort (Cal-Gonzalez et al., 2018:1). According to the IHME (2004), the life expectancy of the current younger generation is expected to increase, which supports the notion shared by participants that the younger generation may be exposed to more radiation compared to the older generation (IAEA, 2024a). Furthermore, they extrapolated the likelihood of increased referrals for similar medical imaging examinations, as hybrid imaging technologies may be more sensitive and specific in detecting medical conditions at an earlier stage (Tiwari & Bhavsar, 2023).

Based on the conversations with the study participants, it was suggested that certain patient groups be considered high-risk users of medical radiation for closer monitoring. The data presented in the following quotations shows that specific patient groups include younger patients due to their increased sensitivity to ionising radiation, as well as patients diagnosed with chronic medical conditions and/or diseases:

> *"I think all patients, but maybe it would be a good idea to start with the younger children or the younger generation and then follow through throughout their lifetime."* ***G1P5***

> *"I would think of the chronic arthritis patients because lots of those patients will need hip and knee replacements, and they will keep on coming back."* ***G1P9***

> *"I'd probably recommend following patients from a young age. Obviously, that would make sense, especially where we are very conscious about radiation in children, seeing that they have effects later on."* ***G2P3***

> *"So I think pregnant patients and then cancer patients or patients with chronic malignancies, chronic inflammation, chronic conditions – probably just need to be red-flagged as potential high users going into the future."* ***G2P7***

> *"So, I think it's important for the younger generation more than anything else, but if you can implement it for younger, you can implement it for everyone, really."* ***G3P2***

The IAEA published a joint statement on the need for additional consideration of patients exposed to recurrent medical imaging examinations. This statement was co-authored with the Global Diagnostic Imaging, Healthcare IT and Radiation Therapy Trade Association (DITTA), the European Society of Radiology (ESR), the European Federation of Organisations for Medical Physics (EFOMP), Heads of European Radiological Competent Authorities (HERCA), the Image Gently Alliance, the International Society of Radiology (ISR), the International Organisation for Medical Physics (IOMP), the International Society of Radiographers and Radiological Technologists (ISRRT) and the World Health Organisation (WHO) (IAEA, 2021).

In addition, multiple papers have highlighted the need for specific patient groups to be monitored more closely (e.g., Johnson et al., 2014:161; Fabritius et al., 2016:1; Moloney et al., 2016:419; Kritsaneepaiboon et al., 2018:19; Fitton et al., 2019:287; Almujally et al., 2020:1). The main concern, as identified in these papers, is attributed to these patient groups being referred for regular follow-up medical imaging examinations. Among these groups are patients admitted to intensive care units (ICU) (Moloney et al., 2016:419). It was found that ICU patients are often subjected to an increased cumulative effective dose (CED) – only one per cent of the medical imaging examinations to which they were referred were non-ionising. The same paper concluded that a conscious effort must be made to mitigate any potential risk associated with medical radiation, especially for the younger population. A study that focused specifically on the sensitivity surrounding children diagnosed with heart disease revealed that, in complicated cases, their lifetime attributable risk (LAR) of developing cancer can easily reach up to six-and-a-half per cent above the baseline. This percentage was calculated based on recurrent medical imaging studies, including cardiac catheterisation and CT (Johnson et al., 2014:166). In Thailand, a study explored the CED and LAR of patients undergoing recurrent CT scans (Kritsaneepaiboon et al., 2018:19). From their findings, more than 50 per cent of the patients who sustained multiple injuries were classified as low risk. Notably, in the same study, however, patients under the age of 30 were reported to be at a higher risk for developing radiation-induced injuries and cancers in their lifetime (Kritsaneepaiboon et al., 2018:19).

Patients diagnosed with lymphoma were also reported to have an increased risk of developing associated radiation-induced injuries and cancer as these patients were subjected to regular and follow-up medical imaging examinations for cancer staging purposes, general surveillance, and prognosis (Fabritius et al., 2016:1). The post-operative cumulative radiation dose following lung transplantation in patients with cystic fibrosis was also investigated; revealing that these patients receive a mean CED of over 100 millisieverts (mSv) (Fitton et al., 2019:287). It was reported in the same study that one of the patients whom they had monitored more closely developed a radiation-induced lung adenocarcinoma nine years after their surgery (Fitton et al., 2019:287). Patients referred for CT lymphography were found to have significant variations in the CED due to the scan length and varying clinical indications (Almujally et al., 2020:3). However, the increased radiation dose to the organs within the primary radiation beam stood out as a concern of the same study, especially in the chest area.

Lastly, participants shared that patients tend to move around, whether relocating from one province to another, for work or pleasure, and that this contributes to the rationale for implementing IPRDT. This means that patients may seek care from a variety of healthcare practitioners and may be subjected to duplicated medical imaging examinations without the healthcare provider knowing or having access to the patient's previous health records to make an informed decision on how to manage or treat the patient in the safest manner possible:

> *"So ja, if a patient was living in the Eastern Cape or ja, say the Eastern Cape, they move to a different province then that information kind of stays behind, it doesn't get transferred with the patient."* ***G1P5***

> *"It's obviously got serious consequences if not tracked and especially with us, you know, the patients could, might be hopping borders and, you know, looking for second opinions, etc., and they don't necessarily relay what's being done elsewhere, so things are duplicated and that can obviously easily be prevented."* ***G2P2***

> *"I mean, the obvious thing would be that you want to try and avoid repeat exposures or, for example, patient X had a chest X-ray for this symptom. Two*

days later, he goes to another emergency centre, presents with the same symptom, and gets another chest X-ray because no one really knows about what previously happened." ***G3P1***

A bulletin published by the IAEA in 2017 echoes that IPRDT is necessary due to patients moving from one medical imaging facility to another without knowledge of the previous examinations and radiation dosage (Dixit, 2017:21). In SA, a recent migration trend indicates that the majority of male South Africans between the ages of 20 and 39, relocate for better work opportunities and living conditions. It was found that many individuals also migrate from rural areas to the cities in search of employment opportunities (Stats SA, 2023:7). This may be due to the country's high unemployment rate (World Bank Group, 2024), resulting in internal migration patterns in the country being primarily attributed to citizens seeking improved socio-economic opportunities (Stats SA, 2023:7).

From the above, it is understood that patients may seek care from various medical facilities and may thus be subjected to unnecessary and duplicated medical imaging examinations. To prevent this, a participant mentioned the option to factor in a standardised set of questions – a patient interview guide – for medical practitioners attending to a new patient in their practice. The purpose of this interview guide, as indicated in the following quotation, would be to ascertain whether the patient has had any previous medical imaging examinations:

"So, the patient will be asked if they had any medical imaging done at any other hospital. And then the patients, hopefully, they will be able to answer 'yes' to that question." ***G1P1***

3.4.1.4. Subtheme 1.4: Perceived benefits

Throughout the interviews, participants referred to various potential benefits associated with IPRDT. Current practices (see the previous subtheme) gave rise to the rationale for implementing IPRDT. Although the perceived benefits are closely related to the rationale, this subtheme focuses on presenting direct quotations and discussion pertaining to the tangible benefits of IPRDT. For example, improved

justification and clinical decision-making for proactive patient risk management were seen as potentially positive outcomes of IPRDT. The participants further reflected on the objectives of an effective quality assurance (QA) programme in which IPRDT may promote the effective use of available resources. Participants also considered that the individual patient's radiation dose data could be used to inform and develop local diagnostic reference levels (DRLs). Participants viewed this as important, seeing that limited DRLs are available in SA.

> *"So number one is obviously for patient safety, but then number two is also to be more rigorous in vetting scans, which will end up saving money in the long term, seems like a no-brainer. So, any dose that is unnecessary is too much and, ja, so you would require all the information for someone to make an educated decision."* ***G2P2***

> *"I think it is pivotal to protecting the patient. Not only protecting the patient but for the appropriate use of resources in a fully resourced institutional environment."* ***G2P10***

> *"So, to the patient, there can only be advantages to dose tracking. I utterly cannot see any disadvantage to a patient being tracked. Except, it does not mean that the patient can't get the study, because, as I said to you at the beginning of this, there's risk versus benefits. You must look at it. It doesn't mean that the patient isn't going to get that CT scan if the CT scan is required. It just means that we are going to take better care of our patients."* ***G2P10***

> *"I think if we – from a South African context, it might be useful if we can use that data, for example, if we look at diagnostic reference levels and we can potentially use the data to kind of at least see how our data compares to similar patient groups. So, right now, South Africa doesn't have published DRL data."* ***G3P1***

It is understood that IPRDT acts as a form of reassurance that there is increased accountability and responsibility for using radiation, which may improve the patient's confidence in the care provided (Rehani, 2017:031206-5). Additional benefits are

geared towards referring practitioners who request medical imaging examinations, e.g., improved justification and clinical decision-making support and communication with the patient, which compares favourably to the findings of the current study. Healthcare professionals performing the examinations may benefit through improved control over the equipment resources and the optimisation of their protocols; policymakers for protecting the general public; regulators for radiation safety compliance and audit purposes; researchers to address patient radiation safety challenges in the field by answering distinct research questions and to develop guidelines for best practice; as well as the industry, to facilitate partnerships with the relevant stakeholders in patient radiation safety (Rehani, 2017:031206-5).

3.4.2. Theme 2: Factors affecting the implementation of IPRDT

The current theme focuses on the participants taking a step back to envision the reality we would face when implementing IPRDT in SA. Figure 3.2 visually represents the relationship between Theme 2 and its subthemes:

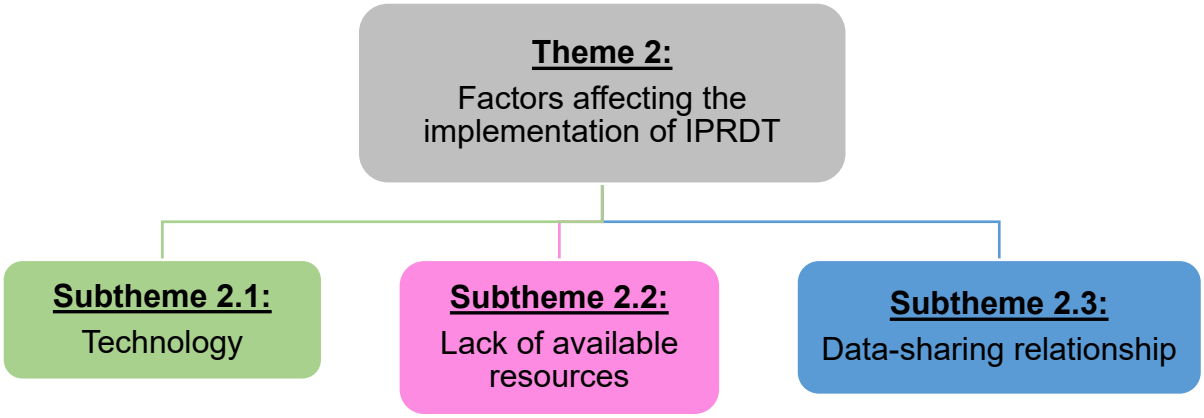


Figure 3.2. A visual representation of Theme 2 and its subthemes

The participants shared potentially negative (barriers) and positive (enabling) factors that could affect the implementation of IPRDT in SA. Although the reality of implementing IPRDT raised some concerns, the participants remained positive about its conception.

3.4.2.1. Subtheme 2.1: Technology

Participants recognised potential enablers from the equipment and software platforms currently used. For example, modern-day equipment can record the patient's radiation dose and exposure parameters for each medical imaging examination and develop a structured radiation dose report for information and communication systems sharing. As participants commented, these systems include the Picture Archiving and Communication System (PACS) and the Radiology Information System (RIS).

> *"So I like to think out of the box, and I know the IAEA had a little card that they wanted to introduce. I'm not so sure if that will work in South Africa because, you know, patients even lose their hospital cards, but with the PACS system, there must be a way, and our machines are much more sophisticated now. You know, they spoke about these plastic cards. Now it costs money; it costs additional money only to land up at a refuse dump."* ***G1P4***

> *"Most of the new technology and units come out with a DAP meter already built in. And then they will give, most of them will then give you a structured report of what the dosage was, and this you can also send them to the PACS".* ***G1P5***

> *"I think it's definitely a good initiative and I think it can, if, it would be great if it can be incorporated with existing systems like your PACS and your booking systems that already exist – having those communicate would be great."* ***G2P2***

> *"It doesn't necessarily have to be expensive – I think all those technological systems are already in place – they're just not merged onto a central committee or a central person that takes responsibility for that."* ***G2P7***

> *"I think it's possible for PACS to develop that itself, if it wanted to, because it has all the information there already – whether it's from the report or from the actual DICOM of the CT. So, if you track to PACS, maybe you can work with that and get it developed."* ***G3P2***

Tsalafoutas et al. (2020:5) mention that a carefully designed network architecture is paramount. Patient information systems such as PACS, RIS, and the Hospital Information System (HIS) have the potential to be integrated into a dedicated IPRDT system. PACS can receive essential patient data from the RIS and HIS, such as individual patient demographics, information about medical imaging examination appointments, and structured radiation dose reports. Sharing of this information is made possible through digital imaging and communications in medicine (DICOM) channels (DICOM, 2025).

Tshalibe et al. (2023:1) report that the number of PACS installations in SA over the last few years has increased significantly. Although its implementation started mainly in the private healthcare sector, most South African public hospitals have access to a mini PACS limited to one department. Furthermore, the first public healthcare sector hospital-wide PACS was installed in 2016. From a vendor perspective, however, some challenges were published from a qualitative methodological perspective regarding PACS implementation in the public healthcare system in SA (Abbas & Singh, 2019:324). Among the challenges identified, references were made to insufficient infrastructure, physical space, and system maturity. From their paper, an effort was made to create awareness among hospital managers and PACS stakeholders to mitigate these challenges and to support their successful implementation (Abbas & Singh, 2019:324).

The findings of the current study are further supported by a paper published by Rehani and Berris (2014:36), where design considerations for IPRDT templates were shared at the facility, national, and international levels. In their paper, the PACS was considered a feasible integration for IPRDT at the facility and national levels. The participants in the current study shared similar ideas. Managing cross-border operability is a bit more complicated internationally, and for this reason, an electronic health record (EHR) was deemed paramount (Rehani & Berris, 2013:3).

3.4.2.2. Subtheme 2.2: Lack of available resources

Participants shared their concerns regarding the availability of resources in the country. They indicated that SA's different provinces and health facilities are resourced

differently. Reference was made to the uneven provision of internet access and the diverse equipment and software platforms currently used, which may cause system connectivity and communication difficulties. In addition, limited human and financial resources were noted as potential barriers to implementing IPRDT.

> *"So I think one of the big challenges, I think it would be obviously in the digital age as, especially in rural hospitals that doesn't necessarily have, I think everybody has internet, but I don't know, maybe there are rural areas that do not have access to internet or that the internet's off or that kind of a thing, so that could be an issue because okay, we can't do it today because the internet was off but are you then going to remember to do it tomorrow? Or so I think that would be a big issue."* ***G1P6***

> *"But the big challenge in that regard is not every hospital uses the same software or the same vendor as we use [name]. Other people use [name] – so I think it would be ideal if everybody used the same platform; otherwise, you are going to have more glitches."* ***G2P1***

> *"So, there are many hurdles, it seems, and it is very ambitious to talk about implementing a dose tracking system at a national level because we have multiple provinces that are resourced in different ways that don't have inter-connecting PACS systems."* ***G2P8***

> *"I think it's a big project to undertake in South Africa where we have like limited manpower, limited resources, old machinery, and stuff like that, but I think it's something that can be done. I think it's important that everyone should report the same matrix so there's some sort of standardisation so that people know, like each institution should be responsible to report the correct, like matrix. Also, the cost of infrastructure, like who's going to pay for that, where is that funding going to come from?"* ***G3P3***

The findings from the literature compare favourably with the concerns shared by the participants. Lushiko (2022:113) suggests that an unequal distribution of equipment resources exists within the South African healthcare system. For example, in the public

healthcare sector, central, tertiary, and regional hospitals are considered well-resourced compared to the district and primary healthcare facilities, yet equitable access to radiological services is critical for the success of any healthcare system (Kabongo et al., 2015:2). This notion is supported by Lushiko (2022:114), who adds that SA's Constitution sees health as a fundamental right. For this reason, the government may be held accountable for creating equal access to care.

In the Strategic Plan 2020/21 – 2024/25, published by the South African Department of Health (DoH), the South African Government aims to build and increase healthcare infrastructure for improved service delivery (SA DoH, 2020b:23). This goal is partially driven by the recently approved National Health Insurance (NHI) Bill which is aimed to be implemented in a phased approach (SA DoH, 2020b:6). The South African DoH further states that it is in consultation with National Treasury to accelerate the delivery of healthcare infrastructure (SA DoH, 2020b:23), which includes patient management and health information systems (SA DoH, 2020b:24).

Support from the manager in a radiography department, with external assistance from a financial and human resources point of view, is necessary to create an environment that enables the implementation and integration of IPRDT. A healthcare system operating on a national archive or database like the NHI could provide the necessary infrastructure for a national, regional, and institutional IPRDT model in SA. However, this represents my opinion as a researcher in the field and has not been verified in the literature.

3.4.2.3. Subtheme 2.3: Data-sharing relationship

In addition to the limitations in resource allocation, another barrier to implementing IPRDT includes potential logistical challenges between the public and private healthcare sectors. The participants' view was that a collaborative effort between these two sectors, involving communication and information sharing, was imperative to produce an accurate and complete patient health record. The participants reflected on the public and private healthcare sectors working in isolation, noting the paucity of information sharing, a situation which may hinder the implementation and integration of IPRDT on a larger scale, as when there are moves to implement it across multiple

facilities. The following quotations demonstrate the current challenges and lack of patient data sharing between the public and private healthcare sectors:

> *"At the moment, in South Africa or, more specifically, the Western Cape, we don't have an integrated vendor-neutral archive where all the PACS systems are linked. So, if a patient receives a specific dosage from the government, then the government will hold that information, and if a patient goes to private, then the private will hold their information, and there's not a shared sharing between the two places of information."* ***G1P5***

> *"So they could maybe come up with an idea of where it can integrate with the government system, then it would be national for government and the private sector, because inevitably, whatever happens, what happens to the patient is they end up in a private hospital, but when their medical aid is depleted, they get transferred to a government hospital."* ***G1P10***

> *"I think it's a good idea, but I think it's going to be difficult in our setting, with our healthcare system, and also getting public and private to talk to each other. So, I mean, communication between the two sectors, you know, getting both on board, on a single system, poses a lot of challenges."* ***G2P1***

> *"We're completely blinded to what is happening in the public, in the private sector, and I think the patients, in Radiology, are having multiple investigations, and they come over into the state sector, and vice versa, and the patient doesn't get, always get discharged with any information, unless the patient verbally tells you, "Doctor, I had an investigation in private", you wouldn't know that, and then you'd have to try and obtain either a CD or contact the PACS Administrator and, have the images transferred onto our PACS system or by using a disc, uploading it to our PACS System. That's the only way. So somehow, if the patient, if dose tracking was going to happen and it was going to be a cumulative dose over the patient's lifetime, it would have to be able to transcend private and public institutions."* ***G2P8***

Hulsen's (2020:5) paper mentions that sharing sensitive data may prove difficult as there are often challenges and disagreements about who owns the data. In SA, a law known as the Protection of Personal Information (POPI) Act was promulgated on 01 July 2020 to promote the protection of personal information (POPIA, 2025). The POPI Act recognises that all individuals have the right to privacy, as per the Constitution of the Republic of South Africa, 1996, Section 14 (SA Government, 2025b). In this, the POPI Act mandates data collection, storage, sharing, and further use of personal data to regulate harmony between public and private entities (POPIA, 2025). It is interesting to note that patient records comprise patient-derived data, possibly departmental protocols, and reports from professional input (Batlle et al., 2021:1647). The sharing of patient data through a digital space is a challenging task and requires the development of a data-sharing relationship between the various entities involved in the process. This may be due to its IT and ethical complexity (Batlle et al., 2021:1653). From the participants' recommendations in this study, for IPRDT to be considered effective, there is clearly a need for patient information to be shared across multiple facilities. It can thus be assumed that sharing patient data through IPRDT in SA must adhere to the regulations defined in the POPI Act and that the developers of such a system must be well-acquainted with the Act. In addition, it is anticipated that a data-sharing agreement and/or terms of reference may also need to be explored due to the sharing of intellectual property, such as examination protocols and/or exposure parameters.

3.4.3. Theme 3: Considerations for clinical practice

Theme 3 was developed by considering the first and second objectives of this study. These objectives refer to how IPRDT can be achieved with a specific focus to guide the implementation of IPRDT within the South African healthcare system. Figure 3.3 visually represents the relationship between Theme 3 and its subthemes:

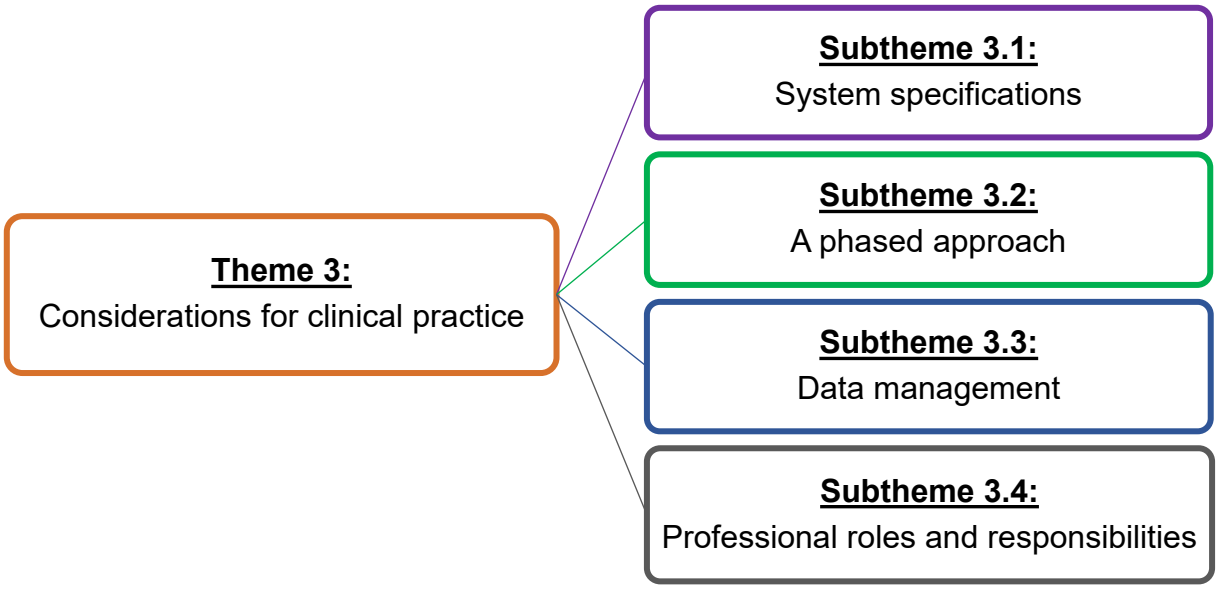


Figure 3.3. A visual representation of Theme 3 and its subthemes

Theme 3 describes the bulk of the information shared by the participants. This theme has four subthemes, each unique in view of the considerations for the South African healthcare system.

3.4.3.1. Subtheme 3.1: System specifications

The participants were clear on their preferences associated with the system specifications of IPRDT. An automated software functionality was recommended to receive and process information from the various medical imaging facilities' PACS systems into a single patient EHR. The reason for this was that the participants reflected on the need to digitise the IPRDT system, limit manual errors, and keep up with the current transformation of moving towards a paperless clinical environment.

> *"What I think would work is if, electronic health record, if we start implementing an electronic health record, which most of the other countries are moving towards, then on that, each hospital, whether it's private or government, can then share the patient's information and also their dosage information."* ***G1P5***

> *"We're living in a digital world, so you want to keep things as digital as possible. I mean, you could add a paper trail for completeness sake, but then again, that*

paper trail will get lost, so I think if you have a digital platform that is assessable nationally, ja, we shouldn't really be missing a step." ***G1P6***

"Well, first of all, you need to figure out how to capture it because you're not; you can't do this manually. If you want to do this manually in South Africa, it's not going to work. You don't want somebody to have to go manually into the things because, first of all, that doesn't happen, and secondly, then there is – prone to more errors. I think if you want to develop a system, then, especially a system that is going to be, hopefully, automatic." ***G2P1***

"Obviously, it would be amazing if there was software that could immediately, as you are inputting data into the scanner itself, that it's linked to a patient's profile, that's uploaded to their, you know, profile. But I think, for it to really be implemented and fool-proof, you want it automated as much as possible. So I think that should be predominantly software, but here and there, you might have to have something that is linking a machine to your PACS." ***G2P2***

"I think it can be automated very easily. Ja, you just need a database, I guess. I think most of these machines can measure; I mean, we are not measuring doses manually anymore. They can automatically upload it to a profile if needed. I think you can; if you can get it as automated as possible, it will be very valuable to us." ***G2P3***

"So if it's kind of automatically digital, then it would just kind of save time, so less like resources, manpower needed, and it's like less room for error as well." ***G2P5***

"So, ideally, what you want is you would want a system that doesn't necessarily rely on a lot of user input." ***G3P1***

"Is it going to be a paper-based system in which someone then needs to do data capture – it makes no sense. That doesn't make sense in the world we're living in now." ***G3P4***

A dose management system (DMS) organises activities to optimise and review patient radiation dose data for safety reasons, and IPRDT can be done manually or using an automated solution (Jasieniak et al., 2023:e13). Although automated systems may not always be available, the IAEA (2023b:29) recommends that healthcare facilities aim to automate IPRDT. In keeping with the findings of the current study, the IAEA (2023b:29) suggests that manual record-keeping of patient radiation exposure and radiation dose data is a time-consuming process that may lead to inaccuracies in the data-capturing process, for example, on Microsoft Excel software (Jasieniak et al., 2023:e13).

O'Donnell (2011:588-591) published a paper that described an automated method for gathering and distributing individual patient radiation exposure data. The Integrating Healthcare Enterprise (IHE) can facilitate a dedicated, stand-alone, national radiation dose database by incorporating the different vendor-based medical imaging systems through DICOM. O'Donnell (2011:588) further explained that imaging modalities are generally required to export patient radiation dose data at the end of the examination to one or more destinations/archives. For the archive(s) to comply, they must collect, process, and store the data so that it is available to the end-user of the system upon request/retrieval.

In addition to the recommendation of IPRDT being an automated software function, the participants suggested a central database to which the public and private healthcare sectors would connect, as depicted in the quotations that follow. The participants further indicated a need for specific hardware and software for the automated, central database. Among these are servers to host and store the patient data, network infrastructure for the hospitals to connect to the web-based central database, DICOM functionality, and basic computer workstations at the various hospitals from which the users of the system can gain access.

> *"So ideally, it should be something like a database or an entire system where the whole, that everybody uses, government, private practice, smaller practices, because I think also, for instance, dentists, they obviously also use radiation when they do X-rays of your teeth. So obviously that would also be – that also has to come onto your radiation record, so it has to be something*

where everybody that basically makes use of radiation equipment, should have access to." ***G1P6***

"I think there will obviously have to be a central database to where, which we can send the information to." ***G2P3***

"So ideally, if you could, I mean, if you have it in a central database, you could technically just query the data that you need." ***G3P1***

"So that's, I mean, there are many ways you can go about setting that up. I mean, you obviously have to have hardware as you want to have this database in a specific server somewhere – whether it's localised in each institution or if it's actually one server that is national – for example, PACS will have a central server somewhere that, for example, [name] and [name] will pull information from." ***G3P2***

"Well, I mean, it could consist of software and hardware because you need the servers to store the databases, and you need a network that connects the servers to the hospital network. Well, so, in terms of hardware, I don't think you need any additional equipment because it is on. It will be in your DICOM headers for the most part, like for the CT scanners, for the fluoroscopy – the later models, of course – it's all in the DICOM headers, and it can easily be taken; it's more software. For me, like the hardware and software that's needed is the network – it's the servers, it's the database management system, it's computers. The hardware – maybe extra computers, depending on where the database is accessed." ***G3P3***

"So I think, ja, if it pulls through the system, then obviously you will need some server or wherever they'll have to store the information." ***G3P7***

"So I think in a perfect world, any X-ray imaging that this patient undergoes, there would be some record of it, some central repository of the dose that was given." ***G3P8***

Zagoudis (2016) reveals that having a central repository is possible. Physical servers can be kept on or off-site, whilst other departments may have access to a cloud-based solution. The same author (Zagoudis, 2016) indicates that cloud-based systems may be easier to expand IPRDT over a collaborative network of users for access purposes. Additional radiation dose tracking software (DTS) solutions are the commercially available options noted in a publication by Jasieniak et al. (2023:e14). Among these are DOSE (by Qaelum), DoseM (by Infinitt), DoseMonitor (by PACS Health), DoseTrack (by Sectra), DoseWatch (by GE Healthcare), DoseWise (by Philips), OpenRem (by OpenRem), and Teamplay (by Siemens Healthcare). These systems vary regarding the imaging modalities they cover, and seven of the eight are paid-for options. The same authors (Jasieniak et al., 2023:e14) mention the need for the specifications of similar DTS systems to be developed carefully to support the continuous collection of data, irrespective of the equipment manufacturer, to conduct a preconfigured analysis of the data received, with customisable alerts and reporting functions.

Following the specific hardware and software requirements, a user-friendly display and operation were considered necessary technical specifications when accessing the central database. Participants commented on the visual representation of an individual patient, whereby the system user could select the different anatomical regions to view a detailed history of the patient's previous radiation exposures and radiation dose data in a specific anatomical region. For example, if you select the abdomen, a thorough history of prior imaging and radiation dose will be provided for that anatomical region. Should a patient be considered at risk for a radiation-induced injury or cancer, the system should also be designed in such a way that it would flag and alert the operator automatically. The operator can then conduct a further investigation to make an informed decision when referring the patient for another medical imaging examination. The following quotations capture the participants' thoughts and are followed by a self-developed diagram (Figure 3.4) to demonstrate a simplified example of a basic user-friendly display and operation:

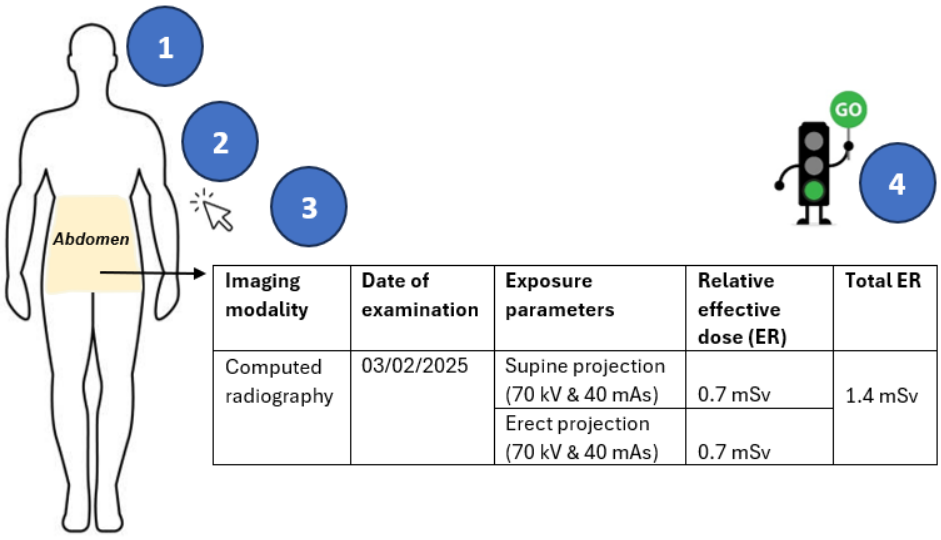
> *"People like to keep things simple, so the simpler and more self-explanatory you can keep it, the more effective it would be."* ***G1P6***

"So, my brain works well with colours. So, I always think we all understand a traffic light or a robot, so I think for patients that need, so if you use the green, orange and the red, so green patients would be patients that's kind of like in the less, what we worry less about, if I can say that like that. Orange patients would be the patients that we're monitoring them closely but they still, we're okay with them going ahead. And then the red patients would be the patients that we closely monitor." ***G1P6***

"So that would be, when you're talking to industry, whoever is going to develop the programme, it allows you to access the data – access to data is very important and, it needs to be user friendly." ***G2P8***

"I mean, so what I would visualise, it has to kind of make it easy for everyone, is technically if you a, you know, like a picture of a human, like a standard, even if it's like a little 3D model of a human and it basically just shows you, okay, it basically has little labels that tells you the head and neck region – this is the number of examinations performed on the patient in this region, in that region, in this region." ***G3P1***

There are various possible options for a user-friendly display. Figure 3.4 demonstrates an example of what the database interface could look like.



Imaging modality	Date of examination	Exposure parameters	Relative effective dose (ER)	Total ER
Computed radiography	03/02/2025	Supine projection (70 kV & 40 mAs)	0.7 mSv	1.4 mSv
		Erect projection (70 kV & 40 mAs)	0.7 mSv	

Figure 3.4. Illustration of a basic, user-friendly display and operation

In this example, after the end-user or operator has searched for the patient's profile and located it, a visual display of the patient's anatomical regions will be annotated and available (Step 1). The end-user or operator must select or click on the anatomical region of interest (Step 2) to see the patient's previous medical imaging examinations, exposure parameters, and radiation dose (Step 3). Step 4 will then indicate if the patient has been flagged as a high-risk user of ionising radiation and if further investigation is needed to justify and optimise the requested examination.

3.4.3.2. Subtheme 3.2: A phased approach

A phased integration of IPRDT was suggested, first on a smaller scale (e.g., at the institutional level) and then expanded for broader coverage (e.g., consecutively at provincial and then national levels). Some participants shared the need for IPRDT to be implemented and standardised internationally for it to be effective.

> *"So, I think national and then ultimately international would be preferred. If this was international, then you would have a record that would follow the patient around. Then, if a patient decides to go international or travel internationally, then there will be no loss of data because the data will follow or move with the patient."* ***G1P5***

> *"Actually, you should start small, that each hospital starts tracking their own, and eventually you can maybe do the province or the metropole region or those types of things to track, because we, if everyone doesn't play their role or help to do this, your results won't be true results. So if you start small and each hospital has their own thing then it will become easier for the bigger picture at the end."* ***G1P8***

> *"Well, it can't be only institutional because people move across institutions."* ***G2P1***

> *"I think if you have a very good plan on how to implement it on a small scale first, then it should be smoother than doing a national implementation."* ***G2P3***

"Now, if we are not tracking it nationally, we are shooting ourselves in the foot because now at [name] Hospital, we think, Oh, this is a new patient." ***G2P4***

"Ideally, national, because patients move all the time so, and keeping track of someone who already had too much in one of the other provinces, then you will know, and you might think of maybe should I do an ultrasound instead of a CT, you know, those are things that would influence your decision." ***G2P5***

"So then you and start small with it. You need to crawl before you walk and before you run. Otherwise, it's never going to work. So, start small." ***G3P4***

"Definitely, I think at an institutional level would already help, and I think that will make it easier to go to a national level, especially in South Africa. I think it's a bit difficult because we also have private and we have state and patients can move between the two, which might be challenging to start with." ***G3P5***

Limited literature reveals the order in which IPRDT should be implemented. Rehani (2017:031206-6) refers to the practicalities of implementing IPRDT at the institutional, provincial, and national levels. At the institutional level, a unique patient identification number and a PACS are needed to connect all the medical imaging modalities, irrespective of the vendor. At a multi-institutional level, the need exists for PACS-interconnected institutions to utilise the same patient identification number. A similar notion was identified nationally as an extension of PACS-interconnected coverage. Rehani (2017:031206-6) further mentioned that IPRDT, which expands over multiple institutions, requires careful consideration in view of data management.

In view of the individual patient's health record, a unique descriptive identifier for their profile was also deemed important by the participants in the current study, especially seeing that the patient's information may be integrated into a large-scale database across multiple facilities. The following quotations depict the participants' contextual reasoning of the same notion:

"I think in our setting basically just monitor or documenting the radiation exposure as measured by the machine and adding that to the studies, and that

becoming part of PACS and then that obviously tracks the patient with their unique clinical numbers through all the modalities, but that is only going to work in centres that have digital platforms." ***G2P1***

"So, I mean ideally, so in the Western Cape, it's relatively easy – they share folder numbers. So whether I'm admitted to [name] Hospital or [name] or [name], I'll keep the same folder number. So, on a provincial level, that's relatively easy because you can use a folder number, and it doesn't really share that patient ID number. On a national level, it's a different story because they would probably have to look at more of an ID number and date of birth situation, which has its own potential issues with, like, personal data." ***G3P1***

"I think the best is to probably have something like a dose registry where a patient is identified by a unique number, like an ID number, or maybe a hospital number or something that is unique to the patient. It's also depending on which level it's implemented, right?" ***G3P3***

3.4.3.3. Subtheme 3.3: Data management

Most participants indicated that IPRDT does not need a dedicated informed consent procedure. The participants reasoned that, if a patient consents to the medical imaging examination, it is implied that their radiation dose data will be collected and added to their lifetime health record for tracking purposes. Participants also referred to the POPI Act because radiation dose data is sensitive and needs to be safeguarded.

"Informed consent is definitely relative and very important, especially now with the POPI Act. So, if there was a way that a patient could give their consent electronically and sign, their record could be kept electronically, it is definitely important. I think when a patient arrives at a hospital and goes through their registration process, where they give their IDs and everything, there should be an additional thing they can sign and give consent to." ***G1P5***

"If you consent to the procedure, you consent to the data being captured. It's like if somebody draws blood to check your infective markers – the fact that you

agreed to the fact that somebody can draw the blood makes you agree to the fact that they can test for the infected markers – kind of thing. I think it is implied consent, so no, I don't think everybody should sign a little form before they walk in for an X-ray. Then we need a lot more staff. I think a little poster in the waiting area is enough because there is so much data that already gets collected when you do a scan that I don't think adding that data is necessarily part of informed consent." ***G2P1***

"I don't think they need to consent to their dose being tracked. There, I mean, not more than they would consent, you know, for you know, you can argue that they should give consent for their dose not being tracked. So, ja, I think that's on us to carry the burden of what is in the patient's best interests." ***G2P2***

"I believe if they consent to the procedure then they consent to us to track their doses." ***G2P3***

"I would think that the normal consent for the procedure should cover that, but it would probably be a wise idea to incorporate information about your radiation risk, both short-term as well as long-term." ***G2P6***

"If the data is used to basically look at patient care, I feel like it's, it doesn't necessarily need explicit informed consent, but maybe just informed consent in terms of procedure is okay." ***G3P1***

Although the participants of the current study do not necessarily recommend a dedicated informed patient consent procedure, the literature suggests that informed consent is still essential. For example, a paper published by Davies et al. (2021:1) explicitly states and argues the need to obtain informed patient consent for radiation risk examinations in the medical imaging environment from an ethical and legal perspective. In a report published by the ICRP (2018), patient radiation safety must be grounded in the ethical principles of dignity, prudence, justice, and beneficence/non-maleficence.

Given dignity and autonomy, the patient must be aware of the potential risk and be willing to accept it (ICRP, 2018; Davies et al., 2021:1). For prudence, although presently there are some debates and uncertainties over the exact risk of cumulative low-dose radiation, it is recommended that a pragmatic approach be used by referring to the linear no-threshold (LNT) model to explain radiation risks (ICRP, 2018; Davies et al., 2021:1). By instilling the principle of justice, the healthcare professional must ensure that similar risks are communicated to all patients, regardless of their pre-existing knowledge or understanding (ICRP, 2018; Davies et al., 2021:1). The principle of beneficence/non-maleficence should be exercised so that the patient is provided with the necessary information about the examination, but is allowed to be their own agent for evaluating it in relation to their beliefs and values (ICRP, 2018; Davies et al., 2021:2).

Davies et al. (2021:1) state that informed patient consent is fundamental to the notion of patients needing to be included in the decision-making process of their care and that one cannot assume that a patient consents to the associated risk of medically-induced radiation without educating the patient to make that informed decision. The participants of this study considered this notion of patient education on IPRDT to be necessary, and this is further explained under Subtheme 4.2. In a paper by Younger et al. (2019:e88), it was found that the disclosure of radiation risk during medical imaging examinations is often not done or done poorly. In the same paper, the authors refer to time management and the inconsistency of risk information as barriers to obtaining informed patient consent for medical imaging examinations. Upon reflection on the participants' views of the current study and the literature, informed patient consent for IPRDT should be considered essential and is needed.

A common understanding shared among the participants was the need for specific datasets to be collected and used for IPRDT purposes. What stood out for me was the need for a patient's contact details for follow-up purposes, in cases where they are to be flagged or considered to be at high risk for developing a radiation-induced injury and/or cancer.

> *"So, your patient name, your patient surname, your date of birth, maybe the address of the patient, a contact number, and then also like a folder number or*

any unique identifier for the patient, specific patient, so ja like a folder number." ***G1P5***

"I would say the date of the examination, the time obviously because some people are X-rayed more than once in a day and, as well as the type of examination that was done. How many X-rays were done for that examination – whether it's a chest X-ray, if you did one view or two views, and how many exposures you had per view or examination? And then I would also say the DAP, or the dose that was received, is important to record, ja." ***G1P7***

"I think it's the date of the examination, the age of the patient, and very important – I think the patient's weight – because that is where you will, especially where change in exposure will come in." ***G1P9***

"The reason for the examination, the justification by the radiologist, and that clinical information can also be accessed in conjunction with the PACS system as well, and all the information, all that information is also available digitally." ***G1P10***

"Ja. I mean, the more information, the better, but at the very least, you know, weight, body surface area, study, and the estimated dose that was delivered to acquire the study." ***G2P2***

"Ja, I think it's going to be more worthwhile if you can record the individual things because if you've got – for example – you know the tube settings for an exposure, even if that DAP was not calibrated correctly, you've got the settings, and you could recalculate the dose. So, I mean, it's like a backup thing. So if you've got all of that, weight, height, demographic information of the patient, and you've got the exposure parameters, and you've got whatever dose was recorded, then I think it just makes it easier to get to a total. Or more comprehensive – let's call it that. A more comprehensive, overall view of that patient's exposure." ***G3P4***

Similar suggestions are echoed in data from the IAEA, resonating with those of the participants of the current study (2023b:41-42). The IAEA lists considerations (in their Patient Radiation Exposure Monitoring in Medical Imaging, Safety Reports, Series No. 112) regarding the type of patient data to be collected for what they call ‘decision support systems’ (which, in the current study context, refers to IPRDT). Among the IAEA’s recommendations are procedure parameters that include the imaging modality used, the procedure, and the number of projections performed. Under patient parameters, the type of patient must be identified (i.e., adult, paediatric, in- or outpatient) and their individual characteristics (such as body mass index [BMI], gender, weight, and age). This information will enable the medical physicist to conduct a more accurate individual patient radiation-induced risk analysis if needed. The third consideration is the facility parameters, which include the identification and technical specifications of the imaging system that was used to produce the images, the room in which the examination was performed, the time of the examination, the name of the facility in which the examination was performed, details of the individual(s) who performed the examination, and the medical imaging protocol used.

In SA, similar guidance for health care professionals is provided, giving what type of data to collect and keep in individual patient health records (SAHPRA, 2022b:9-10). In the South African recommendations, however, in addition to those of the IAEA, a brief clinical indication for the examination is required, such as the number of repeated radiation exposures (if applicable) and a short statement of the diagnostic outcome of the examination. Furthermore, patient health records in SA must be kept up to date and be made available for inspection by the regulator, Radiation Control (SAHPRA, 2022b:9).

Due to individual patient health data being sensitive and confidential, the participants identified specific access control and data security measures for the proposed central database. For the healthcare professionals who form part of patient radiation safety and need access, the study participants suggested a standard username and password access control strategy, and a built-in software function to log the user profiles of those who have viewed specific patient data. These considerations are presented in the following quotations:

"So passwords for all the people that have access to these records should have their own specific login details. And then I also think a system like this, it's important to have a tracker that tracks who viewed the patients' records at each given time." ***G1P5***

"So any doctor that sends the patients for X-rays, usually doctors that are in clinics or the ward or anything like that, ICU wards – any wards in the hospital basically – so those doctors – it would be helpful for them to see how much the dose is. I also think that for the system, only radiographers, and obviously the physicist and our radiologist who report, should have access to this." ***G1P7***

"And if there should be a leak in the system where the patient information is leaked, that person can be tracked because, whenever you log in and whenever you log out, and whenever you look at any patient, it can always be tracked. So in terms of that, I'm sure the POPI Act would be happy with that." ***G1P10***

"Well, I think first of all radiation users – so anybody that gives any kind of radiation to a patient. Radiographers, radiologists, oncologists, orthopaedics – that kind of people. But then medical physicists because they know a lot more about the maths, all the tests, and all the stuff behind." ***G2P1***

Access control and data security measures for IPRDT purposes are echoed and recommended by researchers in the field (e.g., Fitousi, 2017:212; Alanazi et al., 2025:2). It is understood that the introduction of digital health patient information systems has increased the number of repositories that hold sensitive information, making them vulnerable to external threats. As examples, these threats may include unauthorised access and information disclosure (Cobrado et al., 2024:1).

Although the participants indicated that all stakeholders involved in patient radiation safety should have access to the database, they cautioned against patients having access, as it might create unnecessary fear. This notion was captured in the following quotations:

"I do think the patient needs to have access to that, but now the thing is, if they have access to that, it creates, it can actually create fear because if a patient will get their reading, they cannot interpret it or understand it, it creates fear, and a patient won't go for scans which will actually be beneficial for them. So, I think at the moment, I would say the data should be available to professionals." ***G1P2***

"Would I give patients access to their dose data? Probably not. And I feel like because that is essentially like Googling radiation exposure from X-rays and what the effects of radiation, and then going into like a spiral, because then I feel like you're opening up a whole can of worms." ***G3P1***

Guillerman (2014:444) refers to the importance of being cognisant of how radiation data and risk are communicated to a caregiver/parent/guardian in case the patient under examination is underage or a paediatric patient. In the same article, the author refers to a mind shift from imaging gently to imaging intelligently. The 'imaging intelligently' concept refers to the need for healthcare professionals to identify the communication needs of their patients and their preferred communication style, as each patient is different. For example, a patient's cultural background and prior medical history may require the professional to adapt information about a radiation risk when communicating with that patient. This emphasises the need for healthcare workers involved in patient radiation safety to communicate risk reassuringly to the patient. This same notion is shared by, for example, Reitan and Sanderud (2020:S84), Ukkola et al. (2020:e114) and Salerno et al. (2023:1).

To conclude the data management subtheme, one of the participants mentioned that consideration should be granted to further archive the profiles of patients who have passed away so as not to overpopulate the database. This may be important because of potentially limited data storage space:

"And then I think what's also important is there should be in this database, there should be obviously a room for patients that pass away, not to overpopulate the database because obviously there gets – babies born by the minute every day

and obviously people die as well by the minute every day so that would also be to kind of like – to stop that patient's record for instance." ***G1P6***

3.4.3.4. Subtheme 3.4: Professional roles and responsibilities

Participants considered it necessary for each radiography department to have a dedicated individual responsible for monitoring the operational requirements and efficacy of IPRDT. Furthermore, referring practitioners, radiographers, radiologists, medical physicists, and IT professionals were considered key stakeholders in IPRDT, each with their professional roles and responsibilities, as depicted in the following verbatim quotations:

"I think every single department needs a quality assurance radiographer, which looks to me like they are being phased out, and it is such an important part of any department – that quality assurance." ***G1P3***

"So, for recording the dosage, I think it's important that each radiographer that does this specific exam makes sure that it gets documented. Maybe it would be a good idea if radiologists then could be the ones, also, to have access to what the dosage is, and they can make an informed decision if they are going to proceed with a CT or fluoroscopy exam." ***G1P5***

"I think all of us need to be mindful. So, as a radiographer, you can maybe be like, this patient already had so many X-rays; is it really necessary for this one? Then flag it for a radiologist to approve." ***G1P5***

"I think it's such a big job at the end of the day; then I think it should be, there should be a position created for that person because if you're going to say it should be a radiographer when that radiographer is on leave or sick leave or whatever, then nobody's going to do it in that time that that person is not here." ***G1P6***

"So obviously, the radiographer is going to be involved on the most grass-roots level, you know, they're actually going to be looking at things before the patient

climbs onto the scanner bed. But I think there should be multiple levels, so you know, lots of our in-patient studies, for instance, are vetted by a registrar; I mean, we don't have the capacity to be looking at every scan that's booked. And once it's booked, you know, when they come for their dates, they are going to be scanned – at the moment. So the one thing is to have, you know, a block – if a patient arrives and you know, you see that they have had massive doses or a recent scan or whatever, then the radiographer can, you know, question it, but then, you don't need that question if the patient hasn't booked for anything in the first place. So if there is already a flag system just by the booking person, you know, who knows nothing about radiation, but the system says no kind of thing, you know, additional friction. Ja, it's difficult to weigh up kind of exactly where you want to increase friction and where you want to reduce friction in the system. But I think it will have to be at multiple levels. So the one would be at booking and the other, you know, on the actual table, and then the other would be retrospectively, you know, a unit manager. As far as the radiologist is concerned to actually look at overall levels and overall trends and so on." ***G2P2***

"I think later on, if you have enough, if you are working with big enough, large amounts of data, then you can have a person employed simply to be involved in the entire institution's dose tracking." ***G2P3***

"Yes, and like, tell them they're ordering certain like imaging modalities which enforce ionising radiation, so they should counsel those patients as well." ***G2P5***

"I also think that IT needs to be involved – so the PACS Administrator of each radiology department, together perhaps with the more systemic IT Administrators." ***G2P7***

"Well, the referring clinician, the radiographer, and the radiologist, because we are the receiving department, and it's – in fact, probably more the radiographer that needs to ensure that they're actually doing the capturing of the data. The radiologist's role in all of this, fortunately, is very similar to what's currently happening per procedure; it's when the dose report goes through and is captured on the PACS System that is the domain of the radiographer. The

radiologist isn't involved at all in ensuring that this is done, that it is being executed. The radiologist should be aware and should know that they should view this. So, we use the validation process, which, in the absence of individual patient dose tracking, is a substitute. And for studies that were inappropriate, either cancel them or recommend something, a different type of examination, or also to see whether the patient has had duplication of requests – also cancel it, because sometimes two requests for the same patient are placed, so we can cancel that. Sometimes, the patient has an appropriate request. Still, two modalities are requested, so, an ultrasound and CT scan, so we can actually cancel the one study, recommend one, and cancel the other. So you do the radiology report, and as they do in private, they put down the ICD code; instead of just putting down the ICD code in private, the cumulative radiation dose can be recorded as well – on this date, it is X amount. That's a very appropriate role for the radiologist." ***G2P10***

"So, I mean, I would think for the system to function, you would technically need some with a bit of like IT knowledge because you would someone to figure out, okay, why is it not pulling in data from PACS, or to actually be able to look at like a data kind of administrator person actually to see is the system functioning the way it's supposed to, where are the issues with it? So I mean, I think it's, it will be nice to have the input from radiologists and a radiographer and a physicist in a hospital. Still, I think the person who keeps this running is more like kind of the same in line as the person who would be like a PACS administrator or a – someone with a bit of an IT background. So I think it's a, it's very much a, like kind of a multi-disciplinary approach." ***G3P1***

"Yes, I think ultimately, it's the, it's the medical physicist's responsibility to analyse the dose data, right? To say like these are the risks, these are the procedures, and – but ultimately, it's the referring physician's responsibility because they have to justify why a medical examination is needed – a physicist can't do that." ***G3P3***

"So if you've got all of that, weight, height, demographics information of the patient and you've got the exposure parameters and you've got whatever dose

was recorded, then I think it just makes it easier to get to a total. Or more comprehensive – let's call it that. A more comprehensive, overall view of that patient's exposure." ***G3P4***

Referring practitioners should evaluate the patient's previous medical imaging and radiation history to strengthen their justification for requesting a new medical imaging examination. They are also advised to consult a medical imaging professional for guidance if needed (Rehani, 2017:031206-4). Radiographers, on the other hand, are seen as the custodians of medical radiation (WHO, 2020:20). From my experience as a qualified diagnostic radiographer, having worked in public and private healthcare sectors, patient referrals for medical imaging examinations do not always contain sufficient clinical information. Chilanga et al. (2022:1) agree with this personal observation; and further, they state that insufficient clinical information may negatively impact the patient's radiation safety.

Radiographers, in addition, are mandated to perform medical imaging examinations by optimising their image acquisition techniques (HPCSA, 2020a:2), following which, after the examination, it is the radiographer's responsibility to ensure that an accurate patient health record is maintained. Interestingly, a study by Shungube and Khoza (2024:1) that explored radiation protection compliance among radiographers in Eswatini (Southern Africa) revealed that radiographers tend to decide whether or not they want to comply with radiation protection, thus labelling it a personal choice. Given IPRDT, the participants of the current study clearly stated that everyone needs to participate for IPRDT to be effective.

A dedicated position for patient radiation safety should be incorporated within the departmental organogram. The purpose of having a dedicated radiation safety officer appointed per radiography department is to monitor the usage of ionising radiation in medical imaging, limit and prevent unsafe practices, develop corrective actions, and implement those corrective actions (Morgan & Konerth, 2021:1). Willemse et al. (2020:e1) agree with this, adding that radiographers in charge of departmental QA activities are often faced with challenges that may hinder their performance and adherence to the prescribed quality control tests. These challenges relate to allocating

dedicated time, staffing, training, and budgeting. To assist with overcoming these challenges, managerial support was recommended.

Limited literature on the role of the radiologist in IPRDT was found. However, based on the findings of the current study, it is recommended that the radiologist form part of a validation process by reviewing the requested imaging examinations. This responsibility is considered especially important if the IPRDT system flags the patient as potentially being at risk due to a high cumulative radiation dose. During the validation process, the radiologist was also considered best suited to advise on alternative medical imaging examinations, if necessary (Emmerson & Young, 2023). Following the completion of an imaging examination, it was recommended by the participants that provision be made in the radiologist's report to record the individual patient's radiation dose for the specific examination and their cumulative radiation dose, which would be available on the central IPRDT database.

Medical physicists must have access to the individual patient's previous radiation exposure at the click of a button to conduct further risk calculations (Rehani, 2013:763; Tsalafoutas et al., 2020:13). Rehani (2013:764) reported that the system should automatically alert the medical physicist to a patient who may be considered at risk of developing a radiation-induced injury and/or cancer.

3.4.4. Theme 4: A collaborative effort from stakeholders

IPRDT requires a collaborative effort between the professionals involved in patient radiation safety and the patients themselves. On the professional side, stakeholders must first be aware of the fundamentals of IPRDT, their roles and responsibilities, and the potential benefits, before their buy-in can be obtained. Awareness campaigns and efforts toward educating the stakeholders on individual patient dosimetry were considered critical by the participants, who also further reflected on the need for the patient to be educated on IPRDT, keeping in mind that it should not create unnecessary fear. Patients were encouraged to participate actively in their care by asking questions to establish a dialogue with the professionals attending to them. Lastly, participants reflected on the need for legislative and regulatory support to

implement and adhere to IPRDT. Figure 3.5 represents the relationship between Theme 4 and its subthemes:

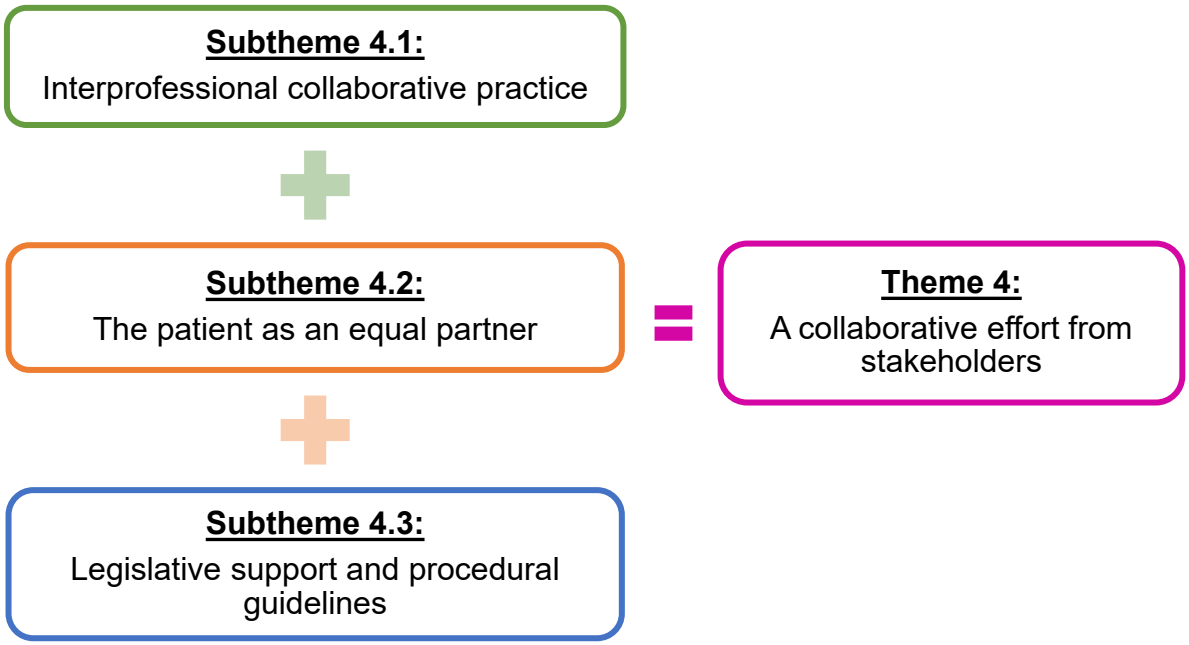


Figure 3.5. A visual representation of Theme 4 and its subthemes

3.4.4.1. Subtheme 4.1: Interprofessional collaborative practice

Although some contextual similarities exist with Subtheme 3.4, the current subtheme is focused on the collective function of the professionals involved in IPRDT. Participants revealed that, for IPRDT to be effective, there is a need for the professionals involved in patient radiation safety to work in unison, as a team, by fostering a culture of shared responsibility, in addition to their other roles and responsibilities. Furthermore, continuous education opportunities were deemed essential to keep up to date with, and understand the realities and controversies of, individual patient radiation dosimetry and risk prediction.

> *"I think ongoing information sessions and reminders for people; I think that would go a long way. They need to be made aware of the consequences of them forgetting to document or not documenting as they should, how that affects the entire process at the end and makes the entire dose tracking process ineffective. The important thing to mention is that they also need to*

understand what the information means because if they see the numbers, they won't know what it means. They won't know when to start being concerned about the possible radiation effects." ***G1P1***

"It's education, its information. Ultimately, at the end of, it is overall patient treatment, and now we've just added the radiation protection avenue into it. So, we have quite a module if you draw pictures." ***G1P4***

"So, I think at the end of the day, it's the responsibility of the entire radiology practice, so it's absolute teamwork that should come together to do this work." ***G1P6***

"If everyone doesn't play their role or help to do this, your results won't be true. If you do have a system in place, the only thing is that the people don't like change – especially here. They are very full of nonsense. They don't want extra admin; they don't want change." ***G1P8***

"Ja, I think just to raise awareness and have perhaps annual sessions within the department – both the radiographers and radiology staff. Explain to us so we can understand the whole concept and be aware of radiation, long-term doses in particular." ***G2P6***

"Awareness – create awareness. Ja. So I think that would be a very big part of it – it's to create awareness of the reality of the risk associated with low dose – it's not nothing." ***G3P4***

"So I think starting the starting point is awareness and education, and to get the buy-in." ***G3P4***

From the findings, interprofessional collaborative practice (ICP) in IPRDT is key. ICP is also considered a key element in PCC, the theoretical framework identified for the current study (Gantayet-Mathur et al., 2022:1), because of the varied roles and responsibilities of the professionals working together toward increasing the patient's radiation safety under their combined care. ICP can be described as a variety of

professionals working together towards a common goal in a shared space to deliver optimal care (White-Williams & Shirey, 2022:1). The current study identified the professionals as referring practitioners, radiographers, radiologists, and medical physicists. The shared space can be seen as the radiography department, and the common goal is to enable a personalised, radiation-safe environment for every patient.

As mentioned by the participants in the current study, staff may be resistant to change. A similar finding was noted in the literature (Drejeris & Drejeriene, 2022:1011). The same paper mentions that resistance to change happens before innovation is implemented (Drejeris & Drejeriene, 2022:1012). It is understood that resistance to change is often powered by limited human resources (WHO, 2025). The same sentiments were shared: participants reflected on the common behaviour of workers resisting change in the clinical environment, as they do not want more work. This may also explain why participants recommended an automated IPRDT system with minimal manual input, as described in Subtheme 3.1. What stood out in the paper by Drejeris and Drejeriene (2022:1012) is that management's responsibility is to support and encourage their staff to accept, embrace, and contribute to innovation. In the current study, management could be seen as the radiography manager.

Given the knowledge and understanding of patient-related radiation risks, the IAEA, as an example, administered a multinational web-based survey to referring practitioners. The results showed that 70.9 per cent of respondents were uncomfortable when questioned by their patients about the risks of medical radiation (Rehani & Berris, 2012:1). A similar study conducted in India investigated the attitudes and knowledge of medical specialists on medical imaging radiation dose. It revealed that a mere 10.5 per cent of the respondents made use of existing referral guidelines and that most of them (>55 per cent) possessed insufficient knowledge about the associated risks and concerns from medical radiation (Singh et al., 2015:398). Further studies revealed inadequate knowledge and awareness of patient-related radiation risks among orthopaedic surgeons (Bukhary et al., 2021:35-40) and radiology staff (Alotaibi & Alnafea, 2017:1; Aldahery, 2023:1) in Saudi Arabia, as well as among medical and dental students in Canada (Mengnjo et al., 2019:1).

Upon reflection, this lack of awareness among referring practitioners of radiation-induced injuries and cancers opens a window for an increase in the number of requests for medical imaging examinations on patients and, subsequently, the possible overutilisation of ionising radiation. Continuous training can be conceptualised as lifelong learning and can thus also be linked directly with continuous professional development (CPD) activities (Mlambo et al., 2021:1). Periodic training was supported in the literature by Alotaibi and Alnafea (2017:1). It is anticipated that an improved understanding of individual patient radiation dosimetry and the need for IPRDT will increase the buy-in of the professionals involved and, subsequently, their adherence to delivering this vital service.

3.4.4.2. Subtheme 4.2: The patient as an equal partner

Patient awareness and education on IPRDT were considered significant. Participants indicated that patient involvement should be increased and that they should be supported, as they have a vested interest in their care.

> *"Explain to the patient the importance of why it would be helpful to keep a record of what the dosage is that they receive throughout their lives."* ***G1P5***

> *"I think in terms of involvement, it needs to be the patient as well because the patient needs to know this is happening and why it's happening and need to have an invested [sic] interest in it because otherwise, why are we doing it if we're not helping the patient?"* ***G2P1***

> *"So I think patient awareness needs to be part of it as well because if patients are not aware, sometimes we'll get a patient and they're here and we say like, 'Do you know why you're here?' They're not even sure why they're here – they just say the doctor said I must come here – they don't even know what exam it is that they are coming for. So that needs to be a little bit more structured as well. So, there needs to be more patient involvement and patient awareness. Currently, in some busy practices, it's probably not happening, and it's kind of, so that's a bit of physician awareness as well. But for patient awareness – it has to be initiated by them, and then because they can be the ones to start*

questioning what we are doing and why we are doing it. Because right now, I could do all my studies today and not even say anything to a patient – just say, "Hi" and just do the study, and get away, because there is no accountability, there is no consent, there are no forms, there is nothing. But, like, probably it's good to explain to a patient this is what we are doing, and this is why we are doing it, and this is what we are trying to look for or not, and so the patient has an understanding of what we are doing. So a patient radiation awareness campaign would be needed." ***G2P5***

"And so the patient needs to be alerted to the fact that they have now received this cumulative dose that is approaching a critical level." ***G2P10***

It is clear from the findings of this study that patient knowledge, understanding, and involvement in IPRDT are needed. This holds true as the literature suggests that patients are generally unaware of ionising radiation-induced risks (e.g., Ricketts et al., 2013:208; Sweetman & Bernard, 2019:110; Ribeiro et al., 2020:e25; Bastiani et al., 2021:1). Ricketts et al. (2013:208) surveyed patients exposed to multiple medical imaging examinations to ascertain their knowledge of radiation exposure and its accompanying risks. Their study revealed that 92 per cent of the patients were not informed about potential radiation-induced risks and that their perceptions of potential risks were false. Due to this, the same authors advocated for the need to educate the public about radiation exposure and its associated risks.

In a similar study conducted by Sweetman and Bernard (2019:110), only 22 per cent of patients understood that ionising radiation has the potential to inflict radiation-induced injuries and cancers. The same study by Sweetman and Bernard (2019:110) revealed that the internet was highly scored as a source of information for patients' questions about medical radiation. This may make patients ill-informed of the associated risks of medical radiation and may lead to their not wanting to continue with, or partake in, the medical imaging examinations proposed by their healthcare provider(s). To improve this, the participants in the current study recommended that patients become equal partners in their care by being more involved, conversing with their healthcare provider(s), and asking questions. Evidence suggests that patients want to discuss benefits versus risks when ionising radiation is used in medical

imaging and be part of the decision-making process (e.g., Thornton et al., 2015:545; Ria et al., 2017:57; Zener et al., 2018:30; Ribeiro et al., 2020:e27-e28). Moore et al. (2017:662) point to the notion of the patient becoming more involved by emphasising a professional-patient relationship, which is also in keeping with the theory of PCC. The same authors (Moore et al., 2017:672) state that the theory of PCC could transform clinical practice and the care provided to the individual patient. To achieve this, however, a need exists for a change in one's thinking to allow for the opportunity, time, and space for this partnership (Moore et al., 2017:672).

3.4.4.3. Subtheme 4.3: Legislative support and procedural guidelines

External to the radiography department, legislative support was considered imperative for implementing IPRDT from the DoH. Participants revealed that sufficient evidence exists to support a mandated form of clinical practice, extending to all individuals and departments who own ionising radiation medical equipment in public and private healthcare sectors. However, for IPRDT to be mandated, the participants further indicated that input and permission from the local regulators would need to be obtained.

> *"It would be nice if it became something that was mandatory by our Health Department because then there's no way around it; then government and private have to consent to it and abide by it."* ***G1P5***

> *"Ja, I mean, it's, ja, it's something that, that I think has the weight behind it to be mandated nationwide."* ***G2P2***

> *"So you have to get all your clearances by the appropriate regulators in order to actually have your system usable."* ***G3P2***

Broadly put, legislation is a term used to describe laws that affect everyone (*Merriam-Webster Dictionary*, 2025a). Conversely, regulations refer to pre-determined rules to assist workers registered with a regulatory body (*Collins Dictionary*, 2025a). According to Rehani and Brady (2022:1), the need for IPRDT to be regulated is not a new concept, and other researchers have raised it before (Brenner & Hricak, 2010:208-

209; European Union, 2013; IAEA, 2014:23). Policies to mandate IPRDT, however, have remained unchanged because it is thought that a regulated practice may impede the benefits of using ionising radiation (Rehani & Brady, 2022:1). Rehani et al. (2020:1828) and Brower and Rehani (2021:1), however, raise a concern: that the potential risks of ionising radiation during medical imaging examinations have now reached a point where strategic planning to address patient radiation safety is an urgent need and so should be prioritised.

The participants further focused on the need for policies and standard operating procedures to be developed to guide those individuals who are directly involved in patient radiation safety. IPRDT was viewed as a function that should occur as part of the standard workflow and should be embedded in departmental practice and culture.

> *"This should be part of the normal workflow."* ***G1P7***

> *"There should be documents or policies in place and guidelines which we can then follow to guide the doctors as well."* ***G1P8***

> *"So at the end of the day, we have a standard operating procedure, so when the new doctors come in, technically – in a perfect world, they should be orientated where they say you need to do A, B, C, and D first before you can ask for a CT scan. So normally, when they call for the CT scan, they would have done A, B, and C, and they would know that the exam would be justified."* ***G1P10***

> *"I would absolutely support the development of dose tracking on individual patients because my everyday practice of validation for the last, I don't know how many years – ten years – has been ultimately to protect the patient and decrease radiation dose to the patient – without something formal implemented like a dose tracking system in place to help me and guide me."* ***G2P10***

The World Health Organisation (WHO), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and the IAEA collaboratively published a safety series in response to the lack of international guidelines on IPRDT. In their

publication, references are made to the collection, recording, and analysis of IPRDT data. The same report also advocates for stakeholders to explore and consider developing IPRDT methods in their countries (IAEA, 2023b). The only indication for IPRDT from the International Commission on Radiological Protection (ICRP) was a statement that referred to the importance of monitoring patient radiation dose for fluoroscopy examinations (ICRP, 2010). A paper published by Stecker et al. (2009:S263) reported on guidelines for managing patient radiation dose, which could further support the development of procedural guidelines for IPRDT. In their guidelines, reference was made to the following essential steps: preprocedural planning (e.g., training, equipment, and patient consent); intraprocedural management (e.g., radiation monitoring, radiation dose minimisation techniques); and postprocedural care (radiation dose documentation and patient follow-up). Qaelum (2023) suggests that, before implementing the IPRDT system, healthcare providers should establish a patient radiation safety programme. Specific protocols and provisions for training the stakeholders involved in patient radiation safety should be developed in the same programme, similar to those of a departmental QA programme.

No current legislation exists for IPRDT in SA, and the same can be said for procedural guidelines on IPRDT. The only rules that were found that speak specifically to the safety of patients in the medical imaging environment are those from the South African Health Products Regulatory Authority (SAHPRA, 2015:14-16). In this document, reference is made to these rules: to practise the principles of justification and optimisation; to minimise repeat medical imaging examinations by referring to previous patient records; to be cognisant of DRLs; and to consider safer medical imaging alternatives (SAHPRA, 2015:14-15). In addition, the following statement was made: “All medical applications of ionising radiation must be managed in such a way that radiation doses to occupationally exposed person and members of the public do not exceed the specified dose limits” (SAHPRA, 2015:14).

In a paper published by Herbst (2012:50), a concern was raised about the legislative framework surrounding patient radiation safety in SA. It was mentioned that the legislation does not enable improved patient radiation safety opportunities, thus placing South African citizens at risk. It is clear that SA is not on par with international patient radiation safety trends and that guidelines need to be developed to implement

IPRDT in the South African healthcare system. The current study aimed to bridge this gap.

3.5. CONCLUSION

The one-on-one semi-structured interviews allowed me to develop an understanding of IPRDT from a combined perspective of radiographers, radiologists, and medical physicists in the Western Cape Province of SA. Their input assisted me in exploring and appreciating the complex nature of individual patient dosimetry and radiation-induced risks. Furthermore, I had an opportunity to focus on the current realities that face the medical imaging environment and how these may affect the implementation and integration of IPRDT within the South African healthcare system.

IPRDT should embody a formal structure and follow a methodical process to achieve the desired outcome. What stood out was the need for an enabling clinical environment where healthcare professionals involved in patient radiation safety can collaborate, reflect on, and be critically conscious of their unique roles. Without this, IPRDT may not be as effective. Chapter Four describes the conceptual framework for the model to guide the implementation of IPRDT within the South African healthcare system.

CHAPTER FOUR

A CONCEPTUAL FRAMEWORK FOR THE MODEL

“As for the future, your task is not to foresee it, but to enable it.”

Antoine de Saint Exupery

4.1. INTRODUCTION

The previous chapters provided an overview of the research study, the research design and method, the study findings and the discussion. Chapter Four reports on the first and second steps of Walker and Avant's (2019:167) model development process presented in Chapter Two (2.5.1 & 2.5.2). This is the concept analysis and relationship statement development. The chapter then concludes with a conceptual map that informs the basis for developing and describing a model to guide the implementation of individual patient radiation dose tracking (IPRDT) within the South African healthcare system.

4.2. CONCEPT ANALYSIS

A concept analysis is a method employed in research to add meaning to a central concept identified from empirical research data (Gunawan et al., 2023:406). A central concept is defined as a key point or core idea that is representative of a collective work, which the researcher aims to pursue (Foley & Davis, 2017:70). In adding meaning to the central concept, its characteristics are explored by breaking it down into its basic elements to gain a deeper understanding (Smith & Mörelius, 2021:1). In the same process, meaning is added to the central concept by clearly defining its purpose for the development of new practices (Kyler & Taff, 2020:406). Hellman (2024:11) further explains that conducting a concept analysis is essential for generating new scientific knowledge and advocates following a known method,

thereby lending credibility to the end product. Identifying a central concept in this study was acknowledged as the first step of Walker and Avant's (2019:167) concept analysis, a trusted and recognised methodological step in health sciences research. The concept analysis steps applied to this research are presented in Figure 4.1. and has reference to the discussion in Chapter Two (2.5.1). The same process has previously been applied across a variety of radiography-related research areas, for example: to facilitate the teaching of caring to radiography students (Naidoo, 2019:41); to facilitate radiation protection among radiographers (Lewis, 2022:110); and to facilitate the resilience of radiography students (Thomas, 2024:33).

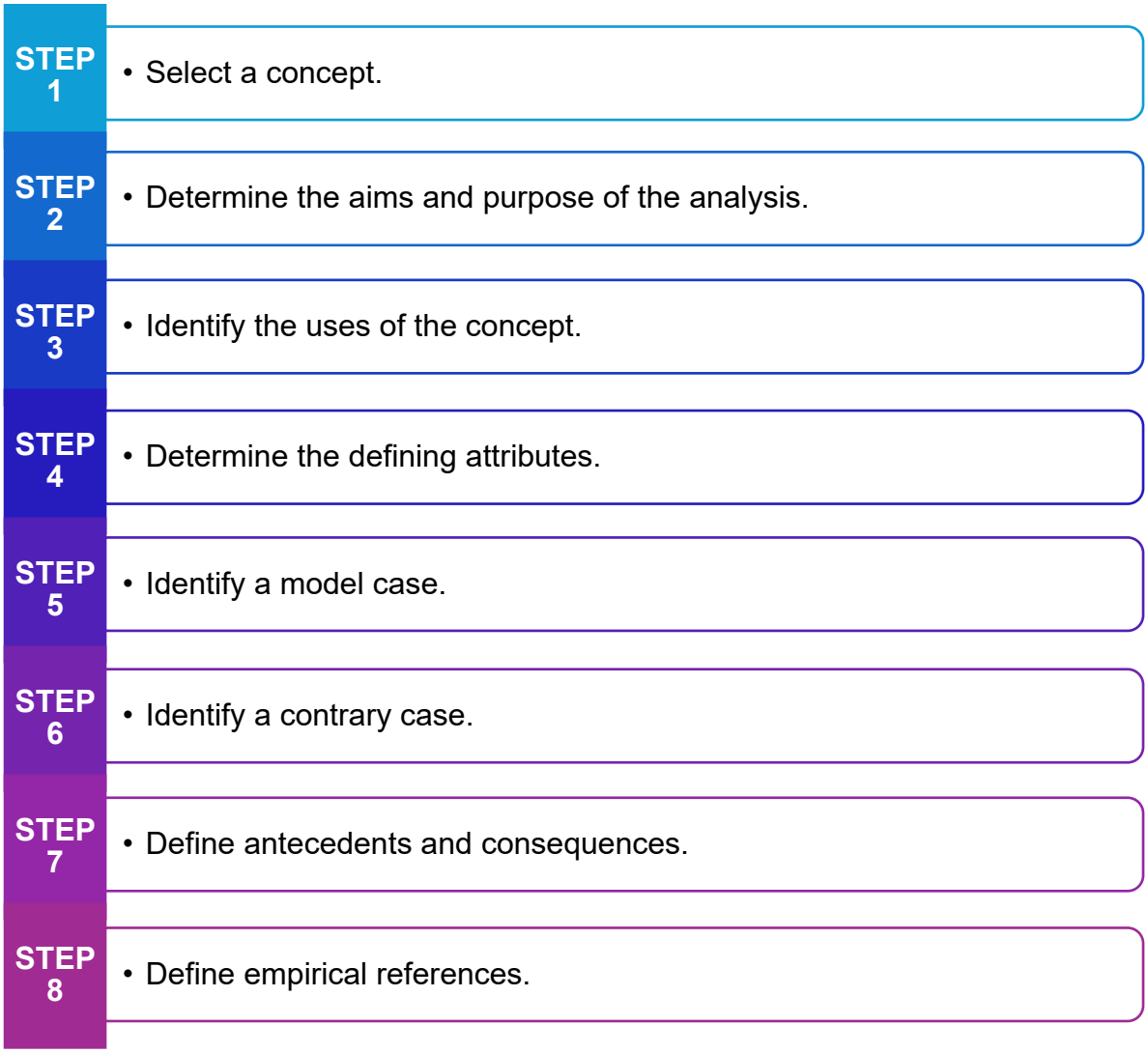


Figure 4.1. Steps in the Walker and Avant's concept analysis process

(Walker & Avant, 2019:167)

4.3. CENTRAL CONCEPT IDENTIFICATION

To identify the central concept (Figure 4.1, Step 1), I reflected on the findings presented in Chapter Three to answer the research question: How can IPRDT be accomplished in SA? The central concept was developed by applying inductive reasoning to find a common thread throughout the combined themes. During this process, I had to remain cognisant of my position in the study. In the context of this study, my 'position' refers to my position as a person, as a qualified diagnostic radiographer, as an educator, and as a researcher, to prevent personal bias and preconceptions (Chapter One, 1.11). Furthermore, I depended on my reflective notes to assist me in identifying the central concept to ensure further reflexivity. The following information presents my overall reflections on the themes for the identification of the central concept.

Theme 1 focused on the participants' knowledge and perceptions of IPRDT. The development of a comprehensive, electronic patient health record that is inclusive of their medical imaging and radiation dose data was understood as a requirement to facilitate IPRDT. As part of the record, an accurate and interpretable cumulative radiation dose value and indicator to estimate potential risk were recommended. Despite some participants expressing concern about the record and its potential for litigation, a shared vision and understanding of the need and purpose of IPRDT was reiterated. The implementation of IPRDT was seen as a positive change as it will promote and strengthen the principles of justification and optimisation in patient radiation safety for improved clinical decision-making. This stems from the participants having indicated a current lack of responsibility and accountability for patient radiation safety among the internal stakeholders of patient radiation safety; a significantly increased number of referrals for medical imaging examinations that make use of ionising radiation; suboptimal justification and optimisation practices; and insufficient record-keeping. The participants also emphasised the importance of increasing professional awareness about the risks of ionising radiation for medical imaging purposes.

Theme 2 included the factors that affect the implementation of IPRDT. For example, the use of existing technology, such as the Picture Archiving and Communication

System (PACS), Hospital Information System (HIS), and Radiology Information System (RIS), was encouraged. The participants referred to the public and private radiography departments being resourced differently. Limited resources, human and financial, for example, were considered potential barriers, especially for the public healthcare sector, which relies on support from the Department of Health (DoH). To alleviate and mitigate some of the current challenges, radiography managers were considered important to assist with the creation of an internal environment that would enable the implementation of IPRDT. Furthermore, a need was identified for the public and private radiography departments to work together, as patients tend to migrate and may seek medical imaging care from both healthcare sectors. This collaboration was also deemed necessary to maintain a complete patient record, which is necessary for the offering of an effective IPRDT service. To bridge this challenge, the development of a data-sharing relationship between the public and private healthcare facilities was recommended.

Theme 3 identified considerations to guide the implementation of IPRDT within clinical practice. An automated software solution linked with the radiography department's PACS to a central database was suggested to produce an electronic patient health record. It was considered preferable for IPRDT to be facilitated in the digital space and for it to be automated as far as possible to limit potential human error during manual patient radiation dose capturing. Furthermore, a user-friendly interface was suggested with background algorithms and alert functions. Although each radiography department is to implement IPRDT, implementation was recommended on a national scale because, at that level, patient records were considered to be the most complete and accurate for estimating potential radiation-induced risks. Specific patient data were recommended for collection, storage, and processing, with access limited to referring practitioners, radiographers, radiologists, medical physicists, and IT experts, each with their professional roles and responsibilities.

Theme 4 focused on the need for stakeholders in patient radiation safety to make a collaborative effort to work as a team towards the implementation of IPRDT. It was evident that, to implement IPRDT, a multi-professional approach – supported by both external and internal stakeholders – is essential. In the process, awareness should be created among the stakeholders, and ongoing educational opportunities facilitated,

due to the complex nature of individual patient dosimetry and the recent developments in IPRDT, which is still in its infancy within the South African healthcare system. Similarly, patients should be included as equal partners in their care by encouraging them to engage in conversation with their healthcare provider(s) and form part of the decision-making process. In this way, the patient is placed at the centre of the IPRDT service. The participants further suggested the need for regulatory support, external to the radiography department, to mandate the clinical practice of IPRDT at a national level, and to be supported with the provision of procedural guidelines, which are currently lacking in the South African healthcare system.

From my reflections, what became clear is the necessity of collaborative involvement of both external and internal stakeholders in patient radiation safety for the effective implementation of IPRDT within the South African healthcare system. The rationale for implementing IPRDT is clear: to improve the way the justification and optimisation principles are currently practised in the clinical environment. The implementation of IPRDT should be mandated at the national level for it to be effective; and it requires the creation of a single-patient electronic health record that accounts for all the medical imaging examinations that use ionising radiation performed on the patient. Furthermore, by implementing IPRDT, stakeholders would become increasingly conscious of the potential radiation-induced risks for the patient. Medical imaging services that use ionising radiation are offered in both the public and private healthcare environments, so their shared involvement is key.

Thus, whilst identifying the central concept, I carefully considered and selected each word to ensure its relevance and transferability to similar contexts. Furthermore, all four themes were collectively viewed through the lens of the theoretical framework developed by Santana et al. (2018:430), Chapter One (subheading, 1.10), to conceptualise IPRDT within the research setting. Based on this understanding, the central concept, "**A collaborative approach to create an improved and radiation-conscious environment**," was identified to develop and describe a model to guide the implementation of IPRDT within the South African healthcare system.

4.4. INDIVIDUAL CONCEPT DEFINITIONS

The second and third steps in the concept analysis process by Walker and Avant (2019:167) include determining the aims and purpose of the analysis and identifying the use of the central concept. For this study, I first separated the central concept into individual concepts to enhance my understanding of each before reaching a summative definition of the central concept (Naidoo, 2019:41; Lewis, 2022:110; Thomas, 2024:33). For this purpose, the following individual concepts were identified from the central concept: collaborative, approach, create, improved, radiation, conscious, and environment.

Recognised online dictionaries and peer-reviewed subject definitions were used to demonstrate the various uses of the individual concepts. Dictionary definitions were utilised as a reliable source to explore and gather the fundamental meaning of the individual concepts, and subject definitions were interpreted to develop a more comprehensive understanding of their contextual application. In conducting these searches, I further explored the derivatives of each individual concept, for example, collaborative in its imitative forms: collaborate and collaboration. Definitions were obtained by consulting relevant literature through the following search engines: Google, Google Scholar, and Research Gate. All sources were published in English.

Determining the defining attributes is the fourth step in the concept analysis process of Walker and Avant (2019:167), as depicted in Figure 4.1. This was achieved by identifying the essential attributes and more broadly related attributes for each individual concept. An attribute can be defined as a general quality or feature of someone or something; and an essential attribute is considered an attribute that holds great importance for the person or thing under investigation (*Collins Dictionary*, 2025b). Although there is an association, related attributes provide additional context and information about someone or something (Wheeler et al., 1982:489). The following information (in 5.4.1 to 5.4.7) aims to define the individual concepts through dictionaries and subject literature. The essential attributes are indicated in **bold,** and the related attributes have been <u>underlined</u>.

4.4.1. Definition of ‘collaborative’

4.4.1.1. Dictionary definitions of ‘collaborative’

The word ‘collaborate’ dates back to the 1870s and is derived from the Latin verb “collabōrāre.” The prefix “col” refers to **doing something together**. It is generally used positively by **two or more parties working together** successfully by sharing and developing each other’s ideas (Dictionary.com, 2025a). Furthermore, as a verb, ‘collaborate’ is defined by *Collins Dictionary* (2025c) as something in which **individuals or groups work together** on a joint project. Hawley (2023:42) defines collaboration as essential to producing new knowledge by transferring and developing skills to benefit future practice. According to Keyton et al. (2008:377-378), collaboration should also be viewed as a structured process to support collaborative interaction. Hawley (2023:40-41) further ascribes collaboration as embodying a mindset or attitude to **work together in a shared space** by sharing knowledge to make decisions and achieve a shared goal.

4.4.1.2. Subject definitions of ‘collaborative’

Radiography-related searches for the word collaborative via the Google search engine revealed approximately 14,400,000 results. From the results, I selected peer-reviewed scientific publications. Snaith (2012:270) refers to collaboration as **a multi-professional environment** in which learning takes place with others to deliver evidence-based patient care. The same author mentions that collaboration is a continuous process to evaluate and improve a service being offered. Johnson et al. (2025:434) indicate that collaboration can foster teamwork to deliver effective patient care and **bring together various healthcare professionals**. Collaboration, furthermore, can promote effective communication and create a shared vision among healthcare team members (Mudadi et al., 2024:9).

4.4.1.3. Defining attributes for ‘collaborative’

Table 4.1 summarises the defining attributes that emanated from the dictionary and subject definitions of ‘collaborative’.

Table 4.1. Defining attributes for ‘collaborative’

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ Doing something together. ▪ Two or more parties working together. ▪ Individuals or groups work together. ▪ Work together in a shared space. ▪ A multi-professional environment. ▪ Bring together various healthcare professionals.	▪ Sharing and developing each other’s ideas. ▪ Essential to producing new knowledge by transferring and developing skills to benefit future practice. ▪ A structured process to support collaborative interaction. ▪ Sharing knowledge to make decisions and achieve a shared goal. ▪ Learning takes place with others to deliver evidence-based patient care. ▪ Continuous process to evaluate and improve a service being offered. ▪ Foster teamwork to deliver effective patient care. ▪ Promote effective communication and create a shared vision.

4.4.2. Definition of ‘approach’

4.4.2.1. Dictionary definitions of ‘approach’

The earliest known use of the word ‘approach’ dates to between 1150 and 1500 when it was classified as a verb (*Oxford English Dictionary*, 2025a). According to *Cambridge Dictionary* (2025a), ‘approach’ refers to **a way to deal with something** and to get closer or nearer to what one wants to do. *Merriam-Webster Dictionary* (2025b) builds on this definition: to ‘approach’ one needs **to consider and take preliminary steps to create and accomplish** a particular purpose. Thesaurus.com (2025a) shares

similar meanings and adds that approaching something refers to **how you arrive at** your intended purpose or destination.

4.4.2.2. Subject definitions of 'approach'

Singh (2023:1) refers to radiography as an approach to producing a medical image. The International Atomic Energy Agency (IAEA) published the proceedings of an international conference held in Bonn, Germany, in 2015, detailing the need for a holistic approach towards setting the scene for the next decade in radiation protection. Their approach included the need for a partnership between the government, the public, educators, researchers, and international agencies. Also, they define their approach as **identifying, implementing, and encouraging potential solutions through leadership** and **coordinating procedures and activities** (IAEA, 2015:6). Roberts (2017:499) explains that patient radiation safety is changing from a provider-centred approach to being more patient-centred. Montazeran et al. (2020:310) agree and add: new approaches are needed to improve system quality and patient radiation safety practices, for which they recommend teamwork and continuous training.

4.4.2.3. Defining attributes for 'approach'

Table 4.2 summarises the defining attributes that emanated from the dictionary and subject definitions of 'approach'.

Table 4.2. Defining attributes for 'approach'

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ A way to deal with something. ▪ To consider and take preliminary steps to create and accomplish. ▪ How you arrive at. ▪ Identifying, implementing, and encouraging potential solutions through leadership.	▪ To get closer or nearer to what one wants to do. ▪ The need for a holistic approach. ▪ Patient radiation safety is changing from a provider-centred approach to being more patient-centred.

▪ Coordinating procedures and activities.	▪ New approaches are needed to improve system quality and patient radiation safety practices.

4.4.3. Definition of ‘create’

4.4.3.1. Dictionary definitions of ‘create’

Merriam-Webster Dictionary (2025c) defines ‘create’ as **bringing something into existence**, **investing in a new form**, and **producing** or bringing about by a course of action or behaviour. As a verb, create is defined as **generating, making, and prompting something new**. *Reverso Dictionary* (2025a) builds on this understanding and further states that creating refers to **the design or invention of something new**. Similarly, Vocabulary.com (2025) describes creation as **an act whereby something is produced for the first time**; and *Oxford English Dictionary* (2025b) understands it as preparing for and causing someone to do something.

4.4.3.2. Subject definitions of ‘create’

Laurisz et al. (2023:363) mention that co-creation is essential in the design process of healthcare solutions. Developing a partnership between healthcare professionals and patients is recommended for sustainability, increased acceptance, trust, adaptation, and efficiency of the service delivered. Relevant to health sciences education, SU (2022:3) indicates that knowledge is created, shared, and translated to enhance healthcare delivery to various communities. The value of co-creation in health sciences education is to protect human rights and to maintain and uphold ethical practice and professionalism. In a book by Smith et al. (2013:255), the authors refer to the need for healthcare organisations to create a new culture of care. In doing so, it is understood that healthcare organisations will improve patient care practices by introducing new practice methods and standards. The same authors note the sharing of resources as a strategy to create a new and shared culture of care. The same authors note that organisational factors directly impact the quality of care delivered to a patient and, subsequently, patient outcomes.

4.4.3.3. Defining attributes for ‘create’

Table 4.3 summarises the defining attributes that emanated from the dictionary and subject definitions of ‘creating’.

Table 4.3. Defining attributes for ‘create’

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ Bringing something into existence. ▪ Investing in a new form. ▪ Producing. ▪ Generating, making, and prompting something new. ▪ The design or invention of something new. ▪ An act whereby something is produced for the first time.	▪ Bringing about by a course of action or behaviour. ▪ Preparing for and causing someone to do something. ▪ Co-creation is essential in the design process of healthcare solutions. ▪ Knowledge is created, shared, and translated to enhance healthcare delivery to various communities. ▪ A new culture of care. ▪ New practice methods and standards. ▪ To create a new and shared culture of care.

4.4.4. Definition of ‘improved’

4.4.4.1. Dictionary definitions of ‘improved’

As a transitive verb, *Merriam-Webster Dictionary* (2025d) defines ‘improve’ as **enhancing the value and quality of something** or, in simple terms, **to make something better**. *Reverso Dictionary* (2025b) adds to this understanding: that by improving something, it is **made to be more effective**. As an intransitive verb, ‘improved’ is characterised by **advancing and progressing with what is desirable**, **making beneficial amendments**, and **adding to something currently in existence** (*Merriam-Webster Dictionary*, 2025d). Thesaurus.com (2025b) suggests that

improving means **remedying a lack of something** or acting based on a felt need. Generally, improvement fits well with **bettering a process**. *Longman Dictionary of Contemporary English Online* (2025) also mentions that **changes must be made to improve something**.

4.4.4.2. Subject definitions of 'improved'

Allam et al. (2024:2) assessed the radiation safety compliance and awareness of healthcare workers in Egypt. In their paper, the implementation of innovative technologies towards the careful use of ionising radiation has **the potential to positively impact** and improve radiation safety practices. In a study in Tanzania, East Africa, Sakafu et al. (2023:66) suggest that strategies must be developed to enhance radiation safety. The methods in their paper include professional education, improved adherence to the justification principle, and promoting a radiation awareness culture. In South Africa (SA), the Department of Health (DoH) published a Quality Improvement (QI) Guide towards improving patient care, providing a working definition of quality improvement (SA DoH, 2012b:5-6). In their definition, QI refers to **attaining the best possible results** with the resources at hand, through activities or processes designed to improve service delivery continuously. The best possible results in the same guide refer to meeting previously set standards and implementing reliable guidelines.

4.4.4.3. Defining attributes for 'improved'

Table 4.4 summarises the defining attributes that emanated from the dictionary and subject definitions of 'improved'.

Table 4.4. Defining attributes for 'improved'

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ Enhancing the value and quality of something. ▪ To make something better. ▪ Made to be more effective.	▪ Acting based on a felt need. ▪ Improve radiation safety practices. ▪ Improved adherence to the justification principle.

▪ Advancing and progressing with what is desirable, making beneficial amendments. ▪ Adding to something currently in existence. ▪ Remedying a lack of something. ▪ Bettering a process. ▪ Changes must be made to improve something. ▪ The potential to positively impact. ▪ Attaining the best possible results.	▪ Promoting a radiation awareness culture. ▪ Activities or processes designed to improve service delivery continuously. ▪ Meeting previously set standards. ▪ Implementing reliable guidelines.

4.4.5. Definition of 'radiation'

4.4.5.1. Dictionary definitions of 'radiation'

'Radiation' is **an invisible process** (*Cambridge Dictionary*, 2025b) through which **energy is emitted through waves and particles** (Dictionary.com, 2025b). According to YourDictionary.com (2025), radiation can be defined as the act of irradiating something or someone. A similar definition is described by *Collins Dictionary* (2025d), with an additional understanding that large quantities of radiation have the potential to cause illness and death. *Oxford English Dictionary* (2025c) agrees with the previous statement, adding that radiation is considered powerful and potentially dangerous, as it can damage cells, and its exposure can be linked to cancer.

4.4.5.2. Subject definitions of 'radiation'

The IAEA (2025) defines 'radiation' as a broad term encompassing **energy that moves from one point to another**. Depending on the type of radiation exposure, different measures should be applied to protect the human body from it. The IAEA (2025) continues to explain that there are two types of radiation: non-ionising and ionising. **Non-ionising radiation** has less energy compared to **ionising radiation** and is thus unable to change the structure of an atom or molecule. It has the potential,

however, to produce vibration and heat, which poses minimal risk to those exposed. **Non-ionising radiation includes visible light and radio waves** (IAEA, 2025). On the other hand, ionising radiation carries enough energy to change the structure of an atom or molecule (IAEA, 2025). It can be produced by electronic generators or radioactive material (SAHPRA, 2025b). **Ionising radiation includes X-rays and gamma rays**. The interaction between radiation and the object being exposed produces 'ions', making it clear where the name 'ionising radiation' comes from (FANR, 2025). Ionising radiation has the potential to damage cells and organs and, in some cases, may cause death (Puckett et al., 2023). Although ionising radiation is beneficial for medical imaging, it should be used correctly and with minimal exposure (IAEA, 2025).

As a reference point for the current study, only ionising radiation that makes use of X-rays for medical imaging purposes is considered relevant.

4.4.5.3. Defining attributes for 'radiation'

Table 4.5 summarises the defining attributes that emanated from the dictionary and subject definitions of 'radiation'.

Table 4.5. Defining attributes for 'radiation'

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ An invisible process. ▪ Energy is emitted through waves and particles. ▪ Energy that moves from one point to another. ▪ Non-ionising radiation. ▪ Ionising radiation. ▪ Non-ionising radiation includes visible light and radio waves. ▪ Ionising radiation includes X-rays and gamma rays.	▪ The act of irradiating something or someone. ▪ Large quantities of radiation have the potential to cause illness and death. ▪ Considered powerful and potentially dangerous, as it can damage cells. ▪ Exposure can be linked to cancer. ▪ Ionising radiation carries enough energy to change the structure of an atom or molecule.

	▪ Ionising radiation has the potential to damage cells and organs and, in some cases, may cause death. ▪ Although ionising radiation is beneficial for medical imaging, it should be used correctly and with minimal exposure.

4.4.6. Definition of 'conscious'

4.4.6.1. Dictionary definitions of 'conscious'

Cambridge Dictionary (2025c) defines being 'conscious' as **noticing the existence and presence of a particular thing or person by thinking and knowing**. From a determined and intentional interpretation, being conscious can also be ascribed to putting forth an effort to make a decision. When used after nouns and adverbs, conscious refers to **a person knowing and being concerned about something**. *Collins Dictionary* (2025e) adds that being conscious of something **makes you notice and realise it is happening**. When a conscious decision is made, for example, it is done deliberately with the person giving it their full attention. In addition, being conscious, you are aware of your thoughts, surroundings, and the collective thoughts and feelings of other individuals and groups (Dictionary.com, 2025c).

4.4.6.2. Subject definitions of 'conscious'

In a study by Naderi et al. (2021:450), **consciousness can be linked to awareness**. Their study mentioned that requests for unnecessary medical imaging examinations can be limited by increased patient awareness about the different medical imaging modalities and radiation exposure. Kalantari et al. (2024:1) conducted a concept analysis of conscience-based care. They argued that conscience is the foundation and cornerstone of clinical practice, impacting the professional decision-making process and patient care quality. Buta (2022:103) refers to consciousness in medical science as a realisation by a healthcare professional that they have the power to do both good

and bad, similar to moral virtues. Blain-Moraes (2028:1) refers to consciousness as **a subjective phenomenon that can vary between individuals**.

4.4.6.3. Defining attributes for 'conscious'

Table 4.6 summarises the defining attributes that emanated from the dictionary and subject definitions of 'conscious'.

Table 4.6. Defining attributes for 'conscious'

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ Noticing the existence and presence of a particular thing or person by thinking and knowing. ▪ A person knowing and being concerned about something. ▪ Makes you notice and realise it is happening. ▪ Consciousness can be linked to awareness. ▪ A subjective phenomenon that can vary between individuals.	▪ Putting forth an effort to make a decision. ▪ The person giving it their full attention. ▪ Being conscious, you are aware of your thoughts, surroundings. ▪ Increased patient awareness about the different medical imaging modalities and radiation exposure. ▪ Conscience-based care. ▪ The foundation and cornerstone of clinical practice, impacting the professional decision-making process and patient care quality. ▪ A realisation by a healthcare professional that they have the power to do both good and bad.

4.4.7. Definition of ‘environment’

4.4.7.1. Dictionary definitions of ‘environment’

The environment can be classified as **internal** (Indeed, 2025b) and **external** (*Collins Dictionary*, 2025f). The internal environment refers to organisational culture, work processes, technology, dynamics, and management. It further represents the elements that make up the organisation, such as teamwork abilities, organisational objectives, and goals (Indeed, 2025b). A similar notion is conveyed by *Encyclopaedia Britannica* (2025), which defines environment as **the conditions surrounding someone or something**, affecting one’s health, growth, and progress. According to *Cambridge Dictionary* (2025d), not only does the environment include the working environment, but also the home environment, which directly impacts how effective you are and how you feel about something. *Merriam-Webster Dictionary* (2025e) further states that the environment directly influences individuals and communities.

4.4.7.2. Subject definitions of ‘environment’

Searching “how to create a healthcare environment” via the Google search engine revealed approximately 988,000,000 results. Most sources speak to a positive working environment for healthcare professionals (e.g., Harrison et al., 2022:13; Kupietzky, 2023; The Workforce Development Trust, 2025) and the need for a safe environment for the individual patient (e.g., Marsden, 2015:23; ISQUA, 2020; Lucas et al., 2023:1). Stone et al. (2008:57) suggest that a safe and quality health care environment can be created. This notion is in keeping with the central concept of the current study: that implementing IPRDT can potentially strengthen the current practice of justifying and optimising the radiation dose within the medical imaging environment. Stone et al. (2008:57) further mention that maintaining a safe environment demonstrates compassion and vigilance for patient well-being. It is understood that, to improve patient safety, one needs first to learn and understand the potential causes that could place a patient at risk and, thereafter, embark on designing and developing a system to better care for the patient (Stone et al., 2008:57-58).

4.4.7.3. Defining attributes for ‘environment’

Table 4.7 summarises the defining attributes that emanated from the dictionary and subject definitions of ‘environment’.

Table 4.7. Defining attributes for ‘environment’

ESSENTIAL ATTRIBUTES	RELATED ATTRIBUTES
▪ Internal. ▪ External. ▪ The conditions surrounding someone or something.	▪ Internal environment refers to organisational culture, work processes, technology, dynamics, and management. ▪ Represents the elements that make up the organisation, such as teamwork abilities, organisational objectives, and goals. ▪ The environment directly influences individuals and communities. ▪ A positive working environment for healthcare professionals. ▪ The need for a safe environment for the individual patient. ▪ A safe and quality health care environment can be created. ▪ Maintaining a safe environment demonstrates compassion and vigilance for patient well-being.

4.5. A SUMMATIVE DEFINITION OF THE CENTRAL CONCEPT

Reflecting on the combined defining attributes of the individual concepts (Tables 4.1 to 4.7) allowed for the identification of critical defining attributes. Critical defining attributes in this study were interpreted as the absolute and compulsory characteristics that each of the individual concepts must possess to apply to the context. The

collective inclusion and presentation of essential, related, and critical defining attributes is considered to be a unique contribution rendered in this doctoral thesis. Table 4.8 presents a summary of the critical defining attributes identified for each individual concept.

Table 4.8. A summary of the individual concepts' critical defining attributes

INDIVIDUAL CONCEPT(S)	CRITICAL DEFINING ATTRIBUTES
Collaborative.	▪ Working together in a shared space. ▪ Structured process.
Approach.	▪ Coordinate procedures and activities. ▪ Solution.
Create.	▪ Bringing into existence. ▪ New practice methods and standards.
Improved.	▪ The potential to positively impact.
Radiation.	▪ Ionising radiation.
Conscious.	▪ Awareness.
Environment.	▪ External. ▪ Internal. ▪ Organisational culture. ▪ Compassion and vigilance for patient well-being. ▪ Individuals and communities.

The dictionary and subject definitions of the individual concepts were used to guide the development of a conceptual definition of the central concept. In doing so, meaning was created for the central concept in this study. The conceptual definition represents the summative definition of the central concept by illustrating all of the critical defining attributes listed in Table 4.8. The critical defining attributes are indicated with double underlining. The central concept definition of "**A collaborative approach to create an improved and radiation-conscious environment**" refers to:

External and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation by creating an enabling

environment that models an organisational culture towards compassion and vigilance for patient well-being. This can be achieved by following a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards in the form of an IPRDT solution, allowing patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA.

4.6. CREATING CONCEPTUAL MEANING

A model and a contrary case were developed to differentiate the summative definition of the central concept, which also speaks to the collective story shared by the participants (Chapter Three, 3.3). Essential and related defining attributes are included in both cases to add further meaning to the summative definition of the central concept (Khalili & Heydari, 2023:27). This refers to steps 5 and 6 of the concept analysis process by Walker and Avant (2019:167).

Chinn et al. (2022:144) posit that the researcher's interpretation of the central concept is demonstrated by presenting a model case. The model case, in context, thus represents the researcher's understanding of what could be done to guide the implementation of IPRDT within the South African healthcare system, stemming from the current study findings. The contrary case represents the opposite of the central concept (Juanamasta et al., 2021:434), by following a similar notion and purpose as the model case.

By including both a model and a contrary case, different perspectives are shared, which, in turn, strengthen the study findings. Furthermore, this inclusion recognises the role of the researcher as a collaborator in the co-construction of new knowledge with their study participants. This feature aligns well with my constructivist paradigmatic perspective (discussed in Chapter One). The following information presents the model and the contrary case towards guiding the implementation of IPRDT within the South African healthcare system.

4.6.1. A model case

The radiography department within a tertiary academic (public healthcare sector) hospital in SA experienced a significant increase in patient referrals over the last five years for medical imaging examinations that use ionising radiation. The qualified radiographers employed in the department brought this to the attention of the radiography manager, based on their concern that many of these requests were not clinically justified. Upon further investigation, the radiography manager also noticed a dramatic increase in the department's reject analysis rates. Through the guidance provided by the NDoH, and as part of a collaborative effort with the South African Health Products Regulatory Authority (SAHPRA) and the Health Professions Council of South Africa (HPCSA), the radiography manager was able to implement an effective IPRDT solution to strengthen the justification and optimisation principles associated with patient radiation safety and subsequently created an improved and radiation-conscious environment.

The implementation of IPRDT as a **potential solution** to the need for a safe environment for the individual patient was achieved by the NDoH (**external** stakeholder) and the manager of a radiography department (**internal** stakeholder) **working together** towards the shared goal of improving system quality and patient radiation safety practices. This was done by following a structured process to support the **coordination of procedures and activities** within both the radiography department and the NDoH, and by continuously evaluating and improving the service being offered.

The radiography manager created **awareness** of IPRDT and obtained the buy-in from their **internal** stakeholders at an organisational level by putting forth an effort and **bringing together various healthcare professionals** to help them realise that they have the power to do both good and bad and that their medical imaging environment directly influences the individuals and communities they serve. In doing so, the radiography manager created an organisational culture from a provider-centred approach to being more patient-centred by introducing new practice methods and standards to their team. This included improved measures for obtaining and storing evidence of informed patient consent, and creating and maintaining an individual

patient healthcare record that includes the individual patient's lifetime exposure and cumulative radiation dose information.

The NDoH, within its position of authority and **leadership**, provided support to the radiography department by working alongside it to **take preliminary steps to create**, **accomplish**, and maintain a safe environment that demonstrates compassion and vigilance for individual patient well-being. This was considered to be the foundation and cornerstone of clinical practice, impacting the professional decision-making process and patient care quality. Further input was sought from the NDoH's public entity, the SAHPRA, and the statutory body, the HPCSA. This was considered essential to producing new knowledge by transferring and developing skills to benefit future practice. In context, this new medical imaging environment now allows for patient access to personalised radiation-conscious care within a healthcare system that models an effective IPRDT solution.

4.6.2. A contrary case

The manager of a private healthcare sector radiography department in SA received communication from the NDoH, stating that they have been placed under a formal investigation due to a suspected patient medical negligence claim. This complaint is from a patient who initially wrote to the HPCSA via their online whistleblower service. The patient, following the diagnosis of an early-onset chronic condition, presumably received a cumulative radiation dose that exceeded 100 mSv from recurrent computed tomography examinations at the young age of 20 at the same department and has now been diagnosed with a radiation-induced skin injury on his abdominal region. The NDoH proposed to the radiography manager that they work together to create an improved radiation-conscious environment by implementing an IPRDT solution. The radiography manager arranged a special meeting to discuss this situation by inviting the internal stakeholders of patient radiation safety in the hospital: the heads of the radiology and medical physics departments, an in-house referring practitioner, and their PACS coordinator, for input.

Following the discussion during this meeting, the radiography manager (**internal** stakeholder), on behalf of the **various healthcare professionals**, responded to the

NDoH (**external** stakeholder) that they were offended to have been placed under investigation. They resisted taking the offer to **work together** with the NDoH to change their **procedures and activities** by introducing new practice methods and standards. As a result, they failed to improve their radiation safety practices by not implementing a **potential solution** to further protect their future patients from **ionising radiation** and thus placing other individuals and communities who seek care at the same hospital at risk for developing radiation-induced injuries. The need for a safe environment for the individual patient was disregarded, and no effort was put forward. As the investigation continued, it was found that there were no records of informed patient consent, which suggests that the patient was not made aware of the potential risks of **ionising radiation**. This was considered a direct infringement of the patient's human rights and demonstrated poor ethical practice, accountability, and responsibility. The patient was not adequately educated about the requested medical imaging examinations and was not included in the decision-making of their care. The department had difficulty accounting for the patient's lifetime **radiation** exposure and cumulative **radiation** dose information without the **existence** of a comprehensive healthcare record, as it had routinely replaced its CT scanner during the last 20 years. The outcome of the investigation revealed that the hospital demonstrated an unsafe medical imaging environment and a poor organisational culture, as they did not want to benefit their future practice by collaborating with the NDoH in implementing IPRDT to strengthen their justification and optimisation practices.

4.7. CLASSIFICATION OF CONCEPTS

To conclude the concept analysis process by Walker and Avant (2019:175), Steps 7 (to define antecedents and consequences) and 8 (to define empirical references) were applied using the classification of concepts technique proposed by Dickoff et al. (1968:415-435). Applying and understanding these steps is essential as they clarify the significance of the central concept in practice. The following information presents the classification of concepts in the current study.

4.7.1. Who is the agent?

To answer this question, I reflected on who would ultimately be responsible for the implementation of IPRDT and who would be the driving force behind the implementation of IPRDT within the South African healthcare system. I revisited the data and the collective story and identified the agent as the NDoH through its public entity, the South African Health Products Regulatory Authority (SAHPRA), and its statutory body, the Health Professions Council of South Africa (HPCSA). The NDoH, in the context of this study, is viewed as an external stakeholder in patient radiation safety. Furthermore, the NDoH was carefully selected based on study participants' suggestions that ultimately, IPRDT should be integrated at the national level for it to be effective. This was perceived as an important consideration for clinical practice (Theme 3, Subtheme 3.2) in which one of the participants said, “Now, if we are not tracking it nationally, we are shooting ourselves in the foot because now at [name] Hospital, we think, oh, this is a new patient”. This notion suggests that the individual patient's healthcare record should depict a comprehensive history of all the medical imaging examinations performed, and not just the data from a single department. In addition, the participants deemed it essential for the NDoH to impose legislation towards practising IPRDT most accurately and effectively (Theme 4, Subtheme 4.3). The NDoH, in context, holds this power to impose legislation for healthcare service delivery. It was also deemed important for the relevant regulatory bodies to develop IPRDT procedural guidelines, which are not available at present.

Thus, the purpose of the SAHPRA and HPCSA was taken into consideration upon including them as members of the NDoH to assist with the implementation of IPRDT within the South African healthcare system. The SAHPRA is responsible for ensuring the health and well-being of humans, in the context of its operational unit: Radiation Control (SAHPRA, 2025a), whereas the HPCSA is responsible for protecting the public and for guiding the professions to uphold and maintain professional and ethical standards.

4.7.2. Who is the recipient?

To answer this question, I asked: Who is directly affected by the implementation of an IPRDT solution within the South African healthcare system? For this study, the model is designed for use by the NDoH to guide the public and private practice radiography departments in SA towards the implementation of an IPRDT solution. More specifically, in the radiography department, the radiography manager will utilise this model to lead the implementation of IPRDT by creating an internal environment that models compassion and vigilance for patient well-being. Within the South African context, the radiography manager may hold the following titles: deputy director radiography, assistant director radiography, chief and head radiographer, and practice manager.

The radiography manager and patient were deliberately excluded as the direct recipients of the model for a variety of reasons, as explained in the text that follows. The radiography manager is responsible for collaborating with the SAHPRA and the HPCSA to implement an effective IPRDT solution in their department; thus, the radiography department (medical imaging environment) is the direct recipient of the IPRDT solution. Although it is presumed that the patient may benefit from the implementation of an IPRDT solution, they are also not seen as the direct recipients of the IPRDT solution. It is reasoned that a patient seeking medical imaging care, following the implementation of an effective IPRDT solution, will gain access to an improved and personalised radiation-conscious service rendered by the radiography department where IPRDT was implemented. The purpose of the model is also not applicable for use by the patients themselves, as the model is developed to guide the implementation of IPRDT within the South African healthcare system – specifically in those environments where ionising radiation is being used for medical imaging purposes – through a collaborative approach among the professional stakeholders.

4.7.3. What is the context?

To answer this question, I asked: In what context will IPRDT be performed? In this study, IPRDT will be implemented and performed within the South African healthcare

system. Both the agent and the recipient of this model, through their collaborative efforts, form part of the South African healthcare system.

4.7.4. What are the dynamics?

To answer this question, I asked: What is the rationale behind implementing IPRDT within the South African healthcare system? The need for guidance for the external and internal stakeholders in SA to implement IPRDT is due to the international progress in improving patient radiation safety (other countries have already embarked on implementing IPRDT). Given this, SA is not on par with the global movement, progress, and practice standards for IPRDT, as no research has been conducted to explore, develop, describe, or implement an IPRDT solution that is responsive to the unique needs of the South African healthcare system. This notion is supported by the findings of this study, as participants reflected on the associated risk of a presumed higher cumulative radiation dose experienced by individual patients. Concern was evident in the participants' stories that referred to individual patients being exposed to unwarranted ionising radiation in the medical imaging environment, a lack of professional responsibility and accountability due to poor patient radiation exposure and dose record-keeping practices, as well as the presumed increased probability of high-risk patient groups developing radiation-induced injuries and/or cancers. The participants recommended a collaborative effort from the South African stakeholders (external and internal) to work together to achieve this new form of clinical practice.

4.7.5. What is the procedure?

To answer this question, I asked: How can the NDoH assist the radiography departments in SA to implement an IPRDT solution within the South African healthcare system? The procedure reflects the guiding considerations in the form of a model to guide the implementation process of IPRDT, as recommended by empirical research findings. The agent and the recipient are considered key stakeholders in patient radiation safety and hold the necessary expertise and authority to effect this change.

4.7.6. What is the outcome?

The outcome of this model refers to the successful implementation of an effective IPRDT solution through a collaborative stakeholder effort within the South African healthcare system, taking into account the guiding considerations posed by local stakeholders in patient radiation safety. In turn, patients in SA will gain access to personalised radiation-conscious care that has the potential to impact individuals and communities positively within SA.

4.8. THE DEVELOPMENT OF RELATIONSHIP STATEMENTS

The development of relationship statements constitutes the second step of the model development guidelines as discussed in Chapter Two (2.5.2). The purpose of the relationship statements is to explain how the identified concepts relate to one another. The relationship statements, as identified and discussed during the classification of concepts section, are:

- The NDoH, in conjunction with the SAHPRA and the HPCSA, collaborates with the radiography departments in SA to create an improved radiation-conscious environment by implementing an effective IPRDT solution within the South African healthcare system.
- Concerned about the current radiation safety practices in the South African healthcare system and its presumed long-term effects on the South African population, radiography departments in SA collaborate with the NDoH, the SAHPRA, and the HPCSA by following a structured process to coordinate their procedures and activities to create an improved medical imaging environment with a shared focus on compassion and vigilance for patient well-being.
- In a leadership position, the radiography manager plays a pivotal role in this changing environment by further collaborating with, creating awareness of, and obtaining buy-in from the internal stakeholders to implement IPRDT.
- Upon implementing an effective IPRDT solution, the justification and optimisation principles associated with patient radiation safety are promoted and enhanced, thus reducing the likelihood of individual patients developing radiation-induced injuries and/or cancer.

4.9. CONCEPTUAL MAP

Figure 4.2 illustrates the conceptual map developed after classifying the concepts and developing their relationship statements. While creating the conceptual map, I reflected on the stories shared by the participants.

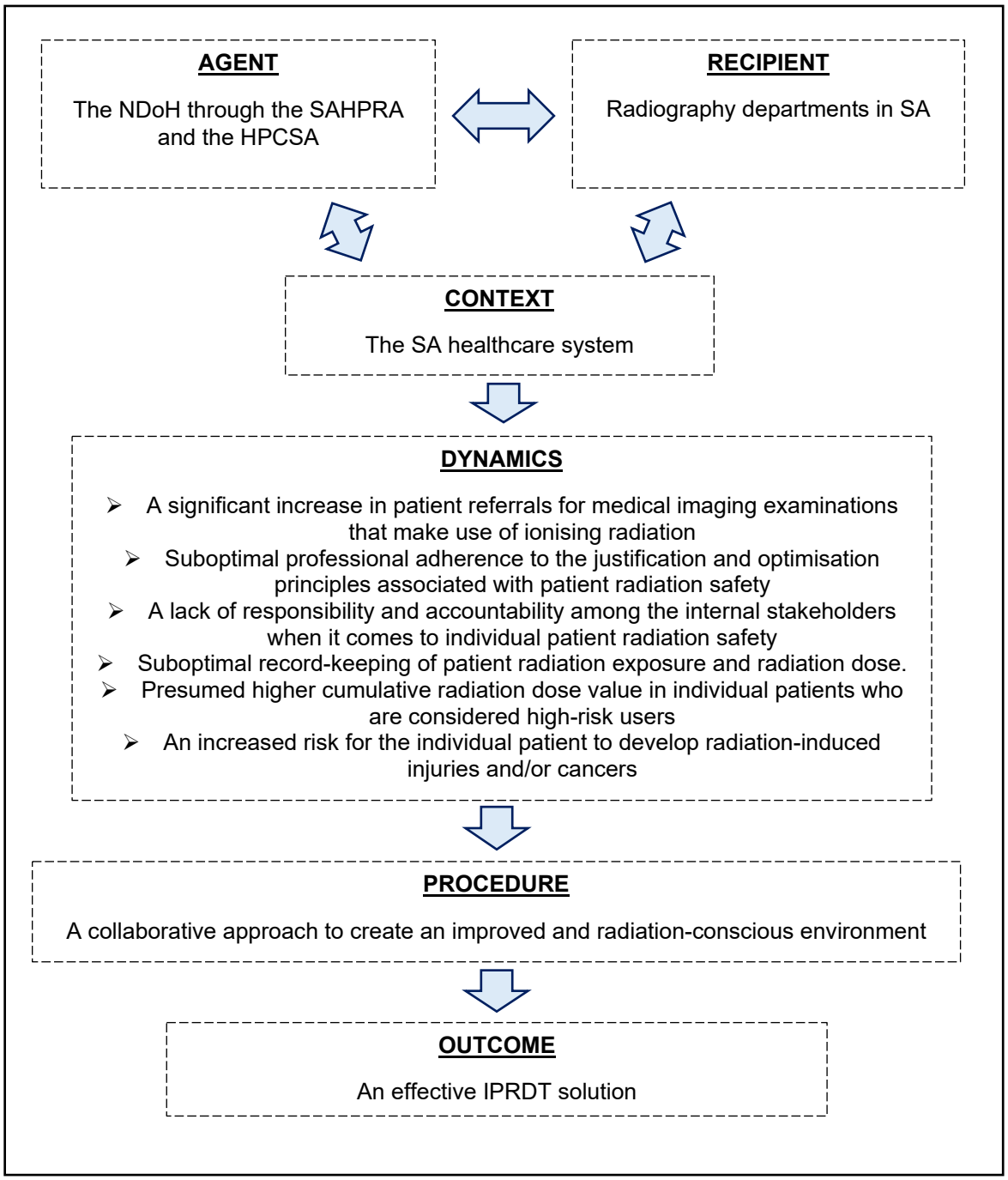


Figure 4.2. The conceptual map

4.10. CONCLUSION

This chapter aimed to identify and define the central concept using dictionaries and sources from the subject literature. In doing so, as the researcher, I was able to develop summative definitions of the various uses of the central concept. Conceptual meaning was established by presenting a model and a contrary case. The central concept was classified by identifying the agent, recipient, context, dynamics, procedure, and outcome. This led to the development of relationship statements and a conceptual map towards developing a model to guide the implementation of IPRDT within the South African healthcare system. The next chapter presents the development of the model, its description, process, and evaluation.

CHAPTER FIVE

A MODEL TO GUIDE THE IMPLEMENTATION OF INDIVIDUAL PATIENT RADIATION DOSE TRACKING WITHIN THE SOUTH AFRICAN HEALTHCARE SYSTEM

"Research is creating new knowledge."

Neil Armstrong

5.1. INTRODUCTION

The conceptual framework presented in Chapter Four enabled the development of a model to guide the implementation of individual patient radiation dose tracking (IPRDT) within the South African healthcare system. Chapter Five shares the third step of the model development process (Chapter One, Figure 1.2), the model's development and description. The visual objects included in the model are described in terms of structure, colour, and what they symbolise contextually. The chapter concludes with the model process and the outcome of its evaluation by a panel of experts.

5.2. OVERVIEW OF THE MODEL

An overview of the model to guide the implementation of IPRDT within the South African healthcare system is presented in Figure 5.1.

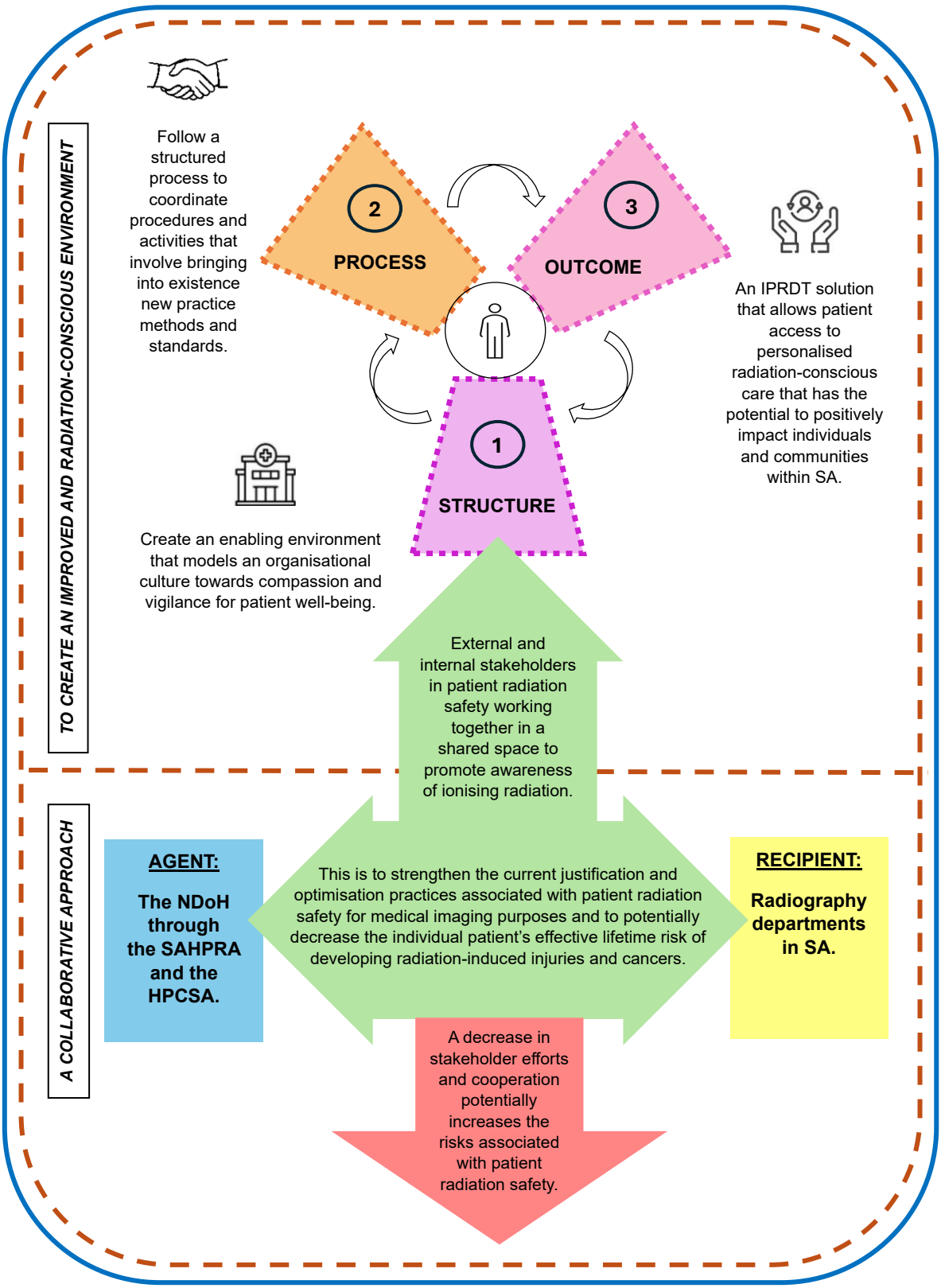


Figure 5.1. A model to guide the implementation of IPRDT within the South African healthcare system

By establishing a collaborative approach towards a common goal, the National Department of Health (NDoH) facilitates the implementation of an IPRDT solution through the Radiation Control operational unit of the South African Health Products Regulatory Authority (SAHPRA) and the Health Professions Council of South Africa (HPCSA). The implementation of IPRDT is recommended for the radiography departments in SA. The NDoH, inclusive of the SAHPRA and the HPCSA, was identified as an external stakeholder of patient radiation safety to the internal radiography departments in SA. To create an improved and radiation-conscious environment, three steps are included. These represent practical reflections developed from empirical research findings to guide the implementation of IPRDT within the radiography departments in SA. The three steps further demonstrate the application of the theoretical framework discussed in Chapter One (1.10) by including these constructs: 1) structure, 2) process, and 3) outcome.

The implementation of an effective IPRDT solution intends to strengthen the current justification and optimisation principles associated with patient radiation safety in medical imaging. It further aims to limit patient exposure to potentially unwarranted ionising radiation, for which there is a presumed possibility of patients developing radiation-induced injuries and/or cancers. In doing so, it provides patients with access to personalised and radiation-conscious care within the medical imaging environment.

5.3. THE DESCRIPTION OF THE MODEL

The model is described in this section by following the suggestions of Chinn et al. (2022:164). The description includes: the purpose of the model, the theoretical assumptions of the model, its theoretical definitions, the nature of the model relationships, its context, and structure.

5.3.1. The purpose of the model

The purpose of the model is to provide a theoretical framework in the form of guidelines for the implementation of IPRDT within the South African healthcare system and, more specifically, within the radiography departments of SA. As a point of reference, the radiography departments referred to in this model represent both the public and private

radiography departments throughout SA. Although it was developed for radiography departments, this model can be adapted and utilised to be inclusive of other areas where ionising radiation is being used for medical imaging purposes. This aligns with the selection of the word “environment” that forms part of the central concept.

Literature demonstrates that international efforts have resulted in the implementation of effective IPRDT solutions (e.g., Baerlocher et al., 2010:277-280; Rehani & Frush, 2010:754-755; Rehani & Kushi, 2013:780-782; Seuri et al., 2013:772). In SA, however, no contextual guidelines exist to support radiography departments in implementing IPRDT. Thus, empirical research findings based on the unique reality of the South African healthcare system and its needs for implementing IPRDT were required. The current study aimed to provide this information.

The rationale behind, and purpose of, IPRDT for the South African context was made clear by the participants of this study: to strengthen the current justification and optimisation practices associated with patient radiation safety in the medical imaging environment and not to define maximum radiation dose limits for individual patients. It is about creating initial awareness of current practices and the rationale behind implementing IPRDT that ultimately leads towards an improved and radiation-conscious environment. Care should be taken not to instil unnecessary fear in patients about the use of ionising radiation in medical imaging. Hence, patients should be well informed and included as equal partners in their care.

A lack of available resources may create potential barriers to implementing IPRDT, particularly in the public healthcare sector (Ntusi, 2024). Similar concerns were shared by the participants in the current study. A collaborative approach between the NDoH and the public radiography departments in SA is considered essential to overcome these barriers. It is anticipated that the NDoH will need to support the public radiography departments in SA by providing the necessary infrastructure and allocating the required financial and human resources. This is because public radiography departments in SA receive their financial budgets from the DoH, and a possible increase in these budgets would need to be considered for the implementation of IPDRT at a national level. Conversely, private radiography

departments are generally self-funded and will need to acquire the necessary resources through their funding mechanisms.

From the findings, the successful implementation of an effective IPRDT solution depends on a collaborative approach between the external and internal stakeholders in patient radiation safety. External stakeholders are viewed as functioning outside of the radiography department and can include public entities and statutory bodies under the control of the NDoH. For example, support should be provided to both the public and private radiography departments in SA through a mandated (gazetted) form of clinical practice, the development of procedural guidelines, and a data-sharing relationship. Internal stakeholders include the professionals directly involved in patient radiation safety within the radiography departments in SA. These include referring practitioners, radiographers, radiologists, medical physicists, and information technology (IT) experts. The managers of the radiography departments throughout SA, upon receiving support and guidance from the NDoH, would be responsible for preparing their internal environments toward the successful conceptualisation and implementation of an IPRDT solution.

The participants stated the need for the DoH to be involved. It is for this reason that the NDoH was selected as the agent (external stakeholder) to exercise its agency in patient radiation safety practices and to live up to its mission, which is the continuous improvement of the quality and sustainability of the services offered by the South African healthcare system (SA NDoH, 2024a). The radiography departments in SA were determined as the recipients in this model, as the departments are directly affected by its integration, and they will receive new practice methods and standards when an IPRDT solution is implemented.

Ultimately, the purpose of this model relates to a proactive form of patient radiation dose risk management to limit the probability of patients developing radiation-induced injuries and/or cancers due to a presumed suboptimal adherence to the justification and optimisation of ionising radiation for medical imaging purposes. Implementing an IPRDT solution is thus interpreted as a compass to guide and support ethical decision-making, with reasonable caution, in clinical practice. The model, together with its operational guidelines (Chapter Six), is a unique output and contribution of new

knowledge in the field of patient radiation safety that emanated from this study. It is a first-of-its-kind, innovative contribution to the South African healthcare system that provides a model developed from local stakeholders' perceptions on patient radiation safety.

5.3.2. Theoretical assumptions of the model

Model assumptions are generated to guide meaningful theoretical interpretations (Chinn et al., 2022:160). The identification and application of the paradigmatic perspective and philosophical assumptions, coupled with the metatheoretical and theoretical assumptions of the study more broadly, were discussed in Chapter One (1.9, 1.10.1, and 1.10.2). The metatheoretical assumptions of this model draw on the practical application of the person-centred care (PCC) theory through the theoretical constructs of the Donabedian model for healthcare improvement, namely: structure, process, and outcome (Santana et al., 2018:431).

Structure refers to the activities that need to take place within the healthcare system at the organisational level. In the context of the model, structure is assumed to refer to the South African healthcare system and the radiography departments (medical imaging environment). To achieve an optimally functioning structure, an enabling environment should be created. This would need to occur logistically through the acquisition of the necessary resources to facilitate IPRDT, and by creating an improved radiation-conscious culture among the internal stakeholders through education and professional development opportunities. It is reasoned that not having the relevant and adequate resources to implement and practice IPRDT, and not having the buy-in from a workforce committed to delivering an IPRDT service, will result in an environment in which the individual patient may be at an increased risk for developing radiation-induced injuries and/or cancer. It is thus understood that preparing the environment both logistically and culturally, and at an organisational level, is essential for the effective implementation of an IPRDT solution.

Process, in the model, considers the coordination of procedures and activities at the healthcare provider and patient level, to improve the current patient radiation safety practices. It refers to a structured process of introducing new practice methods and

standards. For example, now that the environment at the organisational level is prepared for IPRDT, how are we going to perform this task in the most efficient and sustainable manner? This step covers the need for legislative support, the development of procedural guidelines, the establishment of a data-sharing relationship between the public and private healthcare sectors, as well as including the patient as an equal partner in their care. These are considered important for the effective integration of an IPRDT solution within the South African healthcare system.

The third assumption (outcome) refers to having implemented an effective IPRDT solution that allows patient access to personalised radiation-conscious care, which has the potential to have a positive impact on individuals and communities within SA. The positive impact refers to a proactive form of patient radiation dose risk management being implemented. The effectiveness of the IPRDT solution can be determined by closely monitoring patients who are considered high-risk users of medical radiation and by reporting on the patient cases where it has proved useful, similar to the paper published by Seuri et al. (2013:771-775). Furthermore, in monitoring the effectiveness of the IPRDT solution, it is reasoned that the following questions may need to be answered: ‘Does the patient possess a comprehensive, lifetime health record in which their previous radiation exposure and cumulative radiation dose data are recorded?’ and ‘Are these taken into account when justifying new requests for medical imaging examinations?’ Furthermore, if justified: ‘Are these examinations optimised in such a way that it is beneficial to the individual patient, based on their unique clinical history?’

5.3.3. Theoretical definitions of the model concepts

This section presents the theoretical definitions of the model concepts and the central concept to establish a conceptual framework for developing relationship statements. This is considered important to establish and provide meaning for guiding the implementation of IPRDT within the South African healthcare system. These definitions can be adopted, adapted, and transferred to other environments where ionising radiation is being used for medical imaging purposes.

The individual concepts were defined by incorporating essential and related attributes (Chapter Four, 4.4). The essential attributes are presented in **bold**, and the related attributes are underlined. The individual concepts are considered the building blocks for the development of the model. The individual concepts (collaborative, approach, create, improved, radiation, conscious, and environment) are, for the purpose of this model, defined as follows:

- ***Collaborative***

Within **a multi-professional environment**, **bring together various healthcare professionals** to share knowledge, make decisions, and achieve a shared goal to benefit future practice by delivering evidence-based patient care.

- ***Approach***

To consider and take preliminary steps to create and accomplish an effective IPRDT solution to improve system quality and patient radiation safety practices from a provider-centred approach to being more patient-centred.

- ***Create***

Investing in a new and shared culture of care by bringing about a course of action or behaviour in the form of new practice methods and standards.

- ***Improved***

Making beneficial amendments to improve radiation safety practices by promoting a radiation awareness culture to meet previously set standards.

- ***Radiation***

An invisible process by which **ionising radiation** is created in the form of **energy that moves from one point to another**. Although beneficial for medical imaging, it is considered powerful and potentially dangerous and should be used correctly and with

minimal exposure by adhering to the “as low as reasonably achievable” (ALARA) principle.

- ***Conscious***

A subjective phenomenon, and cornerstone of clinical practice, which means that it is essential to understand and be **aware** of your power to do both good and bad. Thus, putting forth an effort to make a decision to improve patient care quality and practice conscience-based care.

- ***Environment***

External and **internal** stakeholders in patient radiation safety working together towards an organisational objective to maintain safe and quality health care.

As for the central concept, critical defining attributes were identified (Chapter Four, Table 4.8) to develop a summative definition. The critical defining attributes in the summative definition of the central concept have a double underlining. This approach of presenting essential, related, and critical attributes, whilst being a unique addition to this doctoral work, is considered critical for the contextual application of the central concept for the intended purpose of the model to guide the implementation of IPRDT within the South African healthcare system.

The central concept served as the foundation to develop the model and was thus translated directly into the model itself. The central concept was included by means of text in the model to indicate and differentiate between two important model components. These include “a collaborative approach” and, subsequently, the steps “to create an improved and radiation-conscious environment”. Furthermore, parts of the summative definition of the central concept were assigned to both model components where relevant.

“**A collaborative approach to create an improved and radiation-conscious environment**” was identified as the central concept of this study to develop and describe a model to guide the implementation of IPRDT within the South African

healthcare system. For the purpose of the model presented in this study, the central concept, as defined in Chapter Four (4.5), is:

External and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation by creating an enabling environment that models an organisational culture towards compassion and vigilance for patient well-being. This can be achieved by following a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards in the form of an IPRDT solution, allowing patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA.

5.3.4. Relationship statements pertinent to the model

Chinn et al. (2022:150;164) state that presenting the relationship statements pertinent to the model is important to convey their value and connected nature, which, in turn, assists with providing structure to the model. The relationship statements for the model to guide the implementation of IPRDT within the South African healthcare system are:

- Stemming from a need to strengthen the justification and optimisation principles associated with patient radiation safety, the NDoH, through the SAHPRA and the HPCSA, facilitates the collaborative approach with the radiography departments in SA to implement an effective IPRDT solution.
- Both external and internal stakeholders in patient radiation safety hold active roles and combine their efforts to promote awareness of ionising radiation in medical imaging by creating an improved and radiation-conscious environment.
- Together, the external and internal stakeholders work together by considering and taking preliminary steps to make beneficial changes in the form of new practice methods and standards towards achieving structure, a process, and a desired outcome.
- The South African healthcare system is empowered through the creation of an improved environment that provides patient access to personalised radiation-conscious care to individuals and communities within SA.

5.3.5. The context of the model

Chinn et al. (2022:150) state that the model should be placed in context to uncover further meaning. The context of the model developed in this study refers to the environment where it will be implemented. In this instance, the context relates to the South African healthcare system in which IPRDT will be implemented through a collaborative approach between the NDoH and the radiography departments in SA. IPRDT is a relatively new and emerging area of clinical practice, which, to the best of my knowledge, has not yet been explored within the South African healthcare system.

5.3.6. The structure of the model

This section provides more detail on the visual construction of the model, as presented in Figure 5.1, by explaining its individual structures, colours and symbols. A description of the structure, colours and symbols conveys an understanding of the assumptions underlying the model, its relationships, and the study findings. The structural development of the model was inspired by Moyo et al. (2023:1-10), who developed a psychosocial support model for healthcare workers during a pandemic. The methodological approach used by Moyo et al. (2023:1-10) includes the model development steps by Chinn et al. (2022:139-180) and the Donabedian model for healthcare improvement.

The model is representative of a journey to create an improved medical imaging environment through the acquisition of relevant resources and to achieve improved radiation consciousness. The model is further structured as having two main components: “a collaborative approach” and “to create an improved and radiation-conscious environment”. The collaborative approach represents the joint effort between the NDoH and the radiography departments in SA. The second component articulates the steps for developing and implementing an effective IPRDT solution. A further and more detailed discussion of the model structure is presented in the information that follows.

5.3.6.1. The structure of the context

The structure of the context of the model is depicted in the borders, as seen in Figure 5.1, and the inferred illustration is shown here in Figure 5.2.

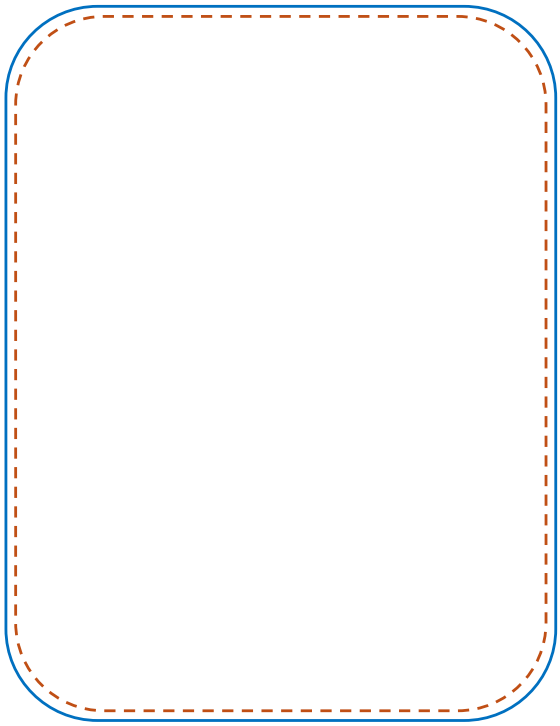


Figure 5.2. The model context

The South African healthcare system (the inner border represented by brown dashes) is depicted as a system that is open for integration with the global healthcare environment (blue, solid border) that surrounds it. This refers to the understanding that the citizens of SA may potentially travel to countries outside of their own, and during their travels, they may require medical imaging care in the global healthcare environment. Thus, to increase the effectiveness of the IPRDT solution to be implemented in SA, it is rationalised that international patient radiation exposure and radiation dose data should be included in the South African citizen's lifetime healthcare record.

Brown was selected to represent the South African healthcare system as it resembles an earthy colour that promotes a sense of belonging, security, and comfort (Lisjak,

2019). These attributes are considered essential for the South African patient who has been referred for a medical imaging examination that uses ionising radiation, knowing they are in safe hands whilst being attended to. Blue was selected to represent the global healthcare environment, as it is a colour often associated with reliability, stability (Cherry, 2024a), and trust (Su et al., 2019:269). These are considered important attributes when forming partnerships, which, in this context, refers to the potential integration of the South African healthcare system within the global healthcare context for IPRDT purposes. The borders of both the South African healthcare system and the global healthcare environment are depicted with rounded corners, which typically symbolise approachability and safety (Turner, 2025).

White was chosen to depict the model background, and it represents transparency and new beginnings (Growers, 2024). Transparency is used here in the sense of IPRDT being an ethical practice to maintain a lifetime patient health record to which all relevant stakeholders should have access. This is made possible by the establishment of a data-sharing relationship between the public and private healthcare sectors, whose duty it is to manage the individual patient's radiation dose risk optimally. The notion of new beginnings refers to the creation and implementation of an IPRDT solution, which requires change through implementing new practice methods and standards.

5.3.6.2. A collaborative approach

The collaborative approach by the NDoH and the radiography departments in SA is symbolically illustrated by the bidirectional and upward green arrows at the bottom of the model (Figure 5.3).

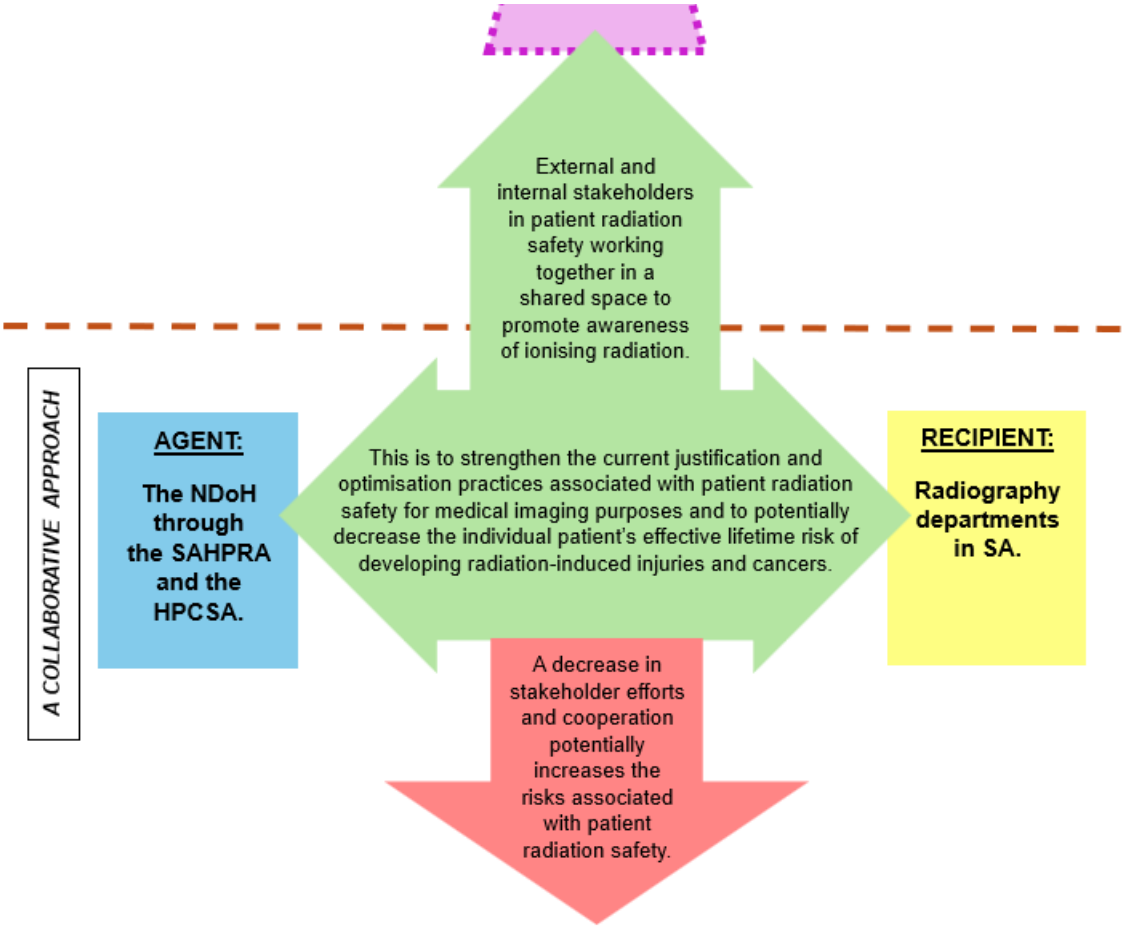


Figure 5.3. A collaborative approach

The NDoH is placed in a blue square, representing efficiency, trust, intellect, and wisdom (White, 2023). It is my opinion that, for the collaborative approach to be effective, the radiography departments should place their trust in the NDoH to drive this initiative and to give the necessary guidance to develop and implement an effective IPRDT solution. With the NDoH representing intellect and wisdom, I acknowledge the expertise of the operational unit: Radiation Control within the South African Health Products Regulatory Authority (SAHPRA) as a public entity to regulate the implementation of IPRDT and the Health Professions Council of South Africa (HPCSA) as a statutory body to provide education and professional development opportunities, as well as for the development of procedural guidelines to practise IPRDT.

The radiography departments in SA are placed in a yellow square, signifying caution and the need for vigilance in their use of ionising radiation. Yellow is generally used

for the same purpose as it is perceived to draw attention, making it effective for radiation warning signs (SAHPRA, 2009).

The collaborative approach between the external and internal stakeholders to implement IPRDT is illustrated by bidirectional green arrows symbolising a merge of the colours blue and yellow. By using green, the collaborative approach symbolises attributes such as growth, development (Kasztelan, 2017:487), and compassionate care (Crossroads Hospice, 2025). Similarly, green signifies a positive change in the direction of the collaborative journey to create an improved and radiation-conscious environment. The bilateral arrows overlap the blue (agent) and yellow (recipient) square shapes and symbolise those stakeholders working together towards a shared goal. This is followed by an upward-pointing green arrow, which points out the direction and purpose of their collaborative efforts. The upward-pointing arrow overlaps and connects with the first step to create an improved and radiation-conscious environment. The collaboration is initiated by the stakeholders seeking mutual support to improve the current radiation safety practices within the South African healthcare system.

Below, and attached to the combined shape of green arrows, is a red arrow that points in the opposite direction to the collaborative journey intended to create an improved and radiation-conscious environment. Red was chosen for this arrow as it symbolises danger (IxDF, 2025) and supports the notion that a breakdown in the collaborative approach will not bring about the desired change. Thus, there will be no change in the currently presumed suboptimal practice standards, potentially increasing the individual patient's effective lifetime risk of developing radiation-induced injuries and cancers due to a potentially dangerous amount of cumulative radiation.

A dashed horizontal line was included to demarcate the two model components and to emphasise the importance of the collaborative approach. The size difference between the two components is of importance, with the second component being bigger to support the notion that this is where all the time and effort are needed to work through and implement the three steps. The green arrow pointing upwards transcends from the collaborative approach component into the second component of the model by crossing over the dashed line. Thus, the collaborative effort should not be seen as

a separate function on its own, nor as being on the outside of the improved and radiation-conscious environment, but rather as the responsibility of the external and internal stakeholders to maintain their combined effort whilst creating the improved and radiation-conscious environment. It is perceived that, without an effective collaborative relationship and the active participation between both the NDoH and the radiography departments in SA, the implementation of IPRDT may prove challenging.

5.3.6.3. To create an improved and radiation-conscious environment

The steps that need to be followed to create an improved and radiation-conscious environment are symbolically illustrated in the upper aspect of the model (Figure 5.4).

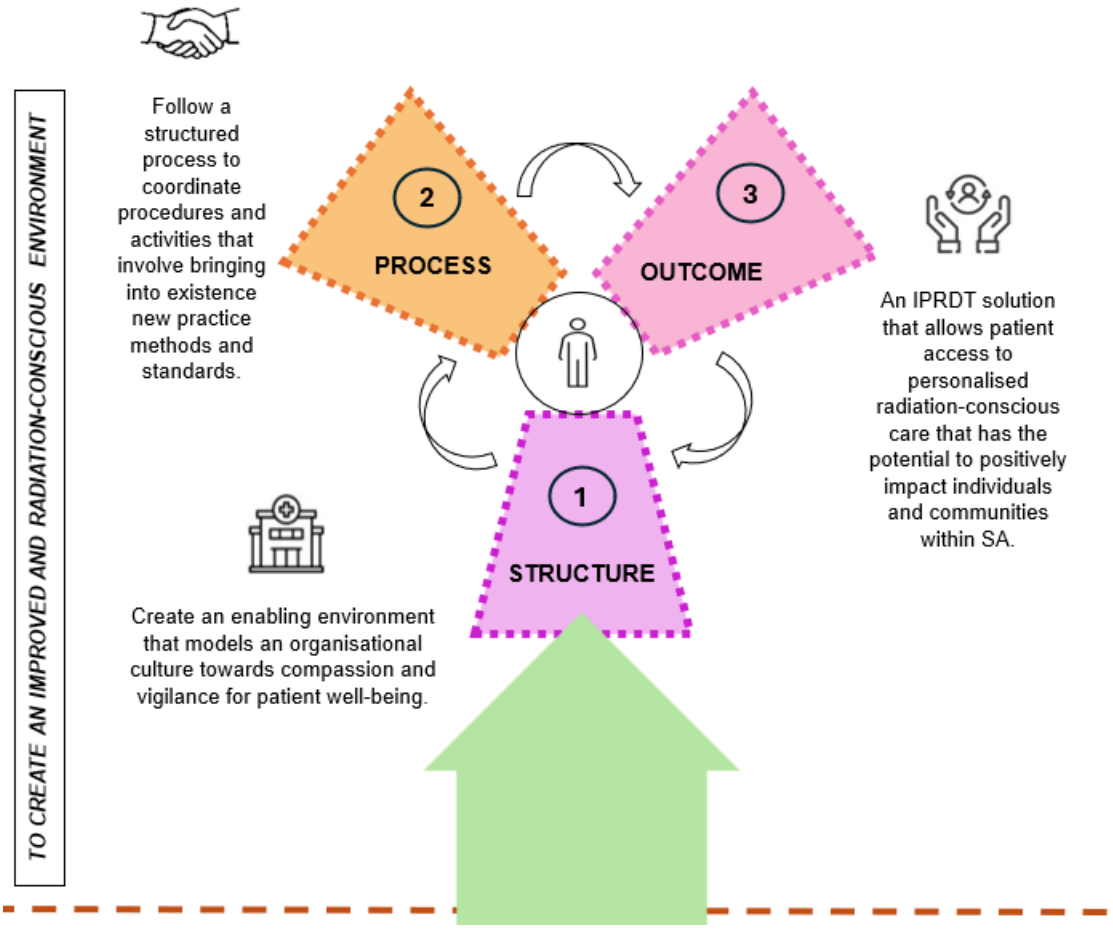


Figure 5.4. To create an improved and radiation-conscious environment

The three steps were intentionally numbered to indicate a guiding sequence for implementing IPRDT. Collectively, the three steps are visually represented by the

international symbol for radiation, also referred to as a trefoil. This includes a circle in the centre (source of radiation) surrounded by three identical radiating blades (the different types of radiation: alpha, beta, and gamma) (Michelena, 2023). The trefoil is generally used to signal the presence of ionising radiation and prompts caution and adherence to the principles of radiation safety (US EPA, 2025).

In the context of the model developed, the central circle holds an icon representing a person at the centre of the IPRDT service. The person being depicted as central further emphasises the connection between PCC and the implementation of IPRDT. I carefully considered the selection of this icon to be gender-neutral and inclusive of all patients. Attached directly to the circle are the steps that need to be followed to create an improved and radiation-conscious environment. The steps attached directly to the circle are to demonstrate the interconnectedness of the steps to implement PCC through IPRDT.

Step 1 refers to the organisational structure and preparation of the environment itself. This step is represented by the colour purple, which typically symbolises creativity, intuition, ambition, and inspiration (Cherry, 2024b). I envision creativity as necessary for those involved to be resourceful during the planning phase; and intuition, ambition, and inspiration reflect the effort put forth to create this new and improved environment. An icon in the form of a simplified building representing a single radiography department was added; and this step refers specifically to preparing the radiography department for the implementation of IPRDT.

Step 2 refers to the process that needs to be followed at the level of the healthcare provider and patient. This process step is depicted using orange, which is often associated with optimism and making connections (McLean, 2023; LVJ, 2025). To me, this refers to both the external and internal stakeholders working together to bring about a positive change by implementing new practice methods and standards in a shared space and towards a shared goal. Adjacent to the process step is a basic icon that represents a traditional handshake, which symbolises a trusting relationship between the healthcare providers and patients, and their shared investment in IPRDT.

Step 3, the outcome step, is depicted using pink, representative of a gentle and nurturing approach, compassionate care, and hope (WindowSight, 2025). In context, this represents the NDoH and radiography departments in SA being successful in their combined effort to have created an improved and radiation-conscious environment by implementing an effective IPRDT solution. This step is further represented by an icon in which two caring hands (the NDoH and the radiography department) are holding a figurine of a patient, pointing to the need to promote patient radiation safety within the South African healthcare system. Like the circled icon at the centre of the radiating blades, this figurine represents a gender-neutral patient.

Descriptive text, translated from the definition of the central concept and representing the overarching guidelines for the three steps, has been added next to each radiating blade. Actions on how to achieve these guidelines are presented in Chapter Six. All three steps possess a slightly darker and dotted border to symbolise the dynamic relationship between the steps. It is anticipated that structural improvements may lead to improvements in the process, which, in turn, may lead to improved patient outcomes. Between the radiating blades, arrows were added, suggesting that, for the delivery of effective and sustainable personalised radiation-conscious care, all three steps must be monitored and evaluated on a continuous basis during their implementation.

5.4. THE OVERALL PROCESS OF THE MODEL

The overall process of the model is described in this section, starting with the collaborative approach and ending with the steps to create an improved and radiation-conscious environment.

5.4.1. A collaborative approach

The collaborative approach refers to external and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation. Their collaborative partnership is grounded in stakeholders seeking mutual support and commences following the realisation of the need to improve the current

patient radiation safety practices by developing and implementing an effective IPRDT solution. Together, they now enter the next component of the model.

5.4.2. To create an improved and radiation-conscious environment

The second component of the model includes the steps for implementing IPRDT within the South African healthcare system. In the first component, the NDoH and radiography departments in SA come together with a shared vision and goal. This vision and goal are now put into action by creating an improved and radiation-conscious environment. The steps that need to be followed are inclusive of the actions that need to be taken to prepare the organisation (structure), for the development of new practice methods and standards (process), and the achievement of an effective and sustainable IPRDT solution (outcome). By implementing these steps, it is reasoned that an improved and radiation-conscious environment will be achieved, capable of minimising the potential risks associated with patients in need of medical imaging care. This can be achieved by creating a comprehensive, individual patient lifetime health record that accounts for all the ionising radiation medical imaging examinations that the patient underwent. This record would strengthen the current justification and optimisation principles associated with patient radiation safety through informed and subsequently improved clinical decision-making. Similar records are paramount in fostering a sense of increased professional responsibility and accountability, which are perceived to be lacking in current practice. The following information aims to unpack each step towards creating an improved and radiation-conscious environment.

5.4.2.1. Structure

To provide structure, radiography departments should prepare for the implementation of an IPRDT solution. The workforce (internal stakeholders) at ground level should be prepared by creating an organisational culture geared towards compassion and vigilance for patient well-being. According to Mannion and Davies (2018:1), an organisational culture in the healthcare context refers to a group of people working together in a manner where they share similar ways of thinking. Mannion and Davies (2018:1) further highlight that creating an organisational culture is essential as it could

drive the change needed to achieve improvement initiatives. Simpson et al. (2019:2) agree with this notion and add that an organisational culture has the potential to establish supportive relationships. From the findings of the study, supportive relationships hold importance through teamwork, also referred to as interprofessional collaborative practice. Additionally, a supportive relationship is important if the NDoH and radiography departments are to work together to implement an effective and sustainable IPRDT solution. As part of this relationship, consideration should be given to educating the internal stakeholders and providing continuous professional development opportunities.

The organisation, furthermore, should be prepared logistically by evaluating its current resources and identifying needed resources. Effectively managing the organisation's logistical intricacies is considered essential to sustain operational efficiency and uphold quality patient care (Mazumdar & Mazumdar, 2023:236). Harrison et al. (2021:85) state that healthcare quality improvement initiatives, typically focused on patient accessibility, timeliness, effectiveness, patient-centredness, safety, and efficiency, are increasingly gaining momentum. The role and responsibility of the NDoH within the structural domain is to support the radiography departments in SA through the identification, provision, and allocation of the required resources for implementing IPRDT, where relevant.

5.4.2.2. Process

This step is focused on the process that should be followed to track the individual patient's radiation dose. This process entails coordinating the procedures and activities, and bringing into existence new practice methods and standards to be proactive in managing patient-related ionising radiation risks within the medical imaging environment. The NDoH, as an external stakeholder, is seen as being responsible for the provision of legislative support and the development of procedural guidelines for those healthcare professionals directly involved in IPRDT. Included in these guidelines, actions should be developed for including the patient as an equal partner in their care. Additional support from the NDoH is needed to establish a data-sharing relationship between the various radiography departments in SA to enable the implementation of IPRDT at the national level.

5.4.2.3. Outcome

After having meticulously followed the first two steps, the third and final step towards creating an improved and radiation-conscious environment speaks to the outcome. Firstly, by creating, at the organisational level, an enabling environment that models compassion and vigilance for patient well-being; and secondly, by following a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards, the anticipated outcome would be an IPRDT solution that allows patient access to personalised, radiation-conscious care that has the potential to have a positive impact on individuals and communities within SA.

To determine whether the outcome was achieved satisfactorily, the effectiveness of the IPRDT solution that was implemented in the radiography department will need to be evaluated. This is in keeping with the theoretical framework developed by Santana et al. (2018:431), who refer to reviewing patient cases that demonstrate improved patient outcomes. In context, this refers to improved clinical decision-making and proactive radiation risk management. The creation of an improved and radiation-conscious environment is envisioned as a continuous process of healthcare improvement and largely depends on the effort put forward by the external and internal stakeholders involved in patient radiation safety. This makes the overall model process dynamic in nature, meaning that the steps may need to be revisited to improve/strengthen the IPRDT solution that has been implemented.

Important to keep in mind is that the purpose of the model developed in the current study is to guide the implementation of IPRDT within the environment of the recipient. In doing so, guidelines on how to operationalise the model are presented in Chapter Six. The model, therefore, does not prescribe the facilitation of IPRDT in detail, as the different radiography departments in SA may be resourced differently and much may depend on the level of healthcare services offered. It is for the same reason that the conceptual map in Chapter Four (Figure 4.2) describes the outcome as an effective individual patient radiation dose tracking “solution”. What is clear from the findings, however, is that, for it to be considered effective, IPRDT should ultimately be implemented at the national level, with the sharing of relevant patient data.

5.5. EVALUATION OF THE MODEL

An online session to evaluate the draft model (Appendix I) was facilitated using Microsoft Teams. After careful consideration, 11 panel members were invited based on their knowledge and experience in model development and/or patient radiation safety. Of the 11 panel members invited, all attended the session. The evaluators included representation from SA, Nigeria, and the United Kingdom, allowing for a broader, international interpretation of the model's purpose and relevance. During the session, I presented the background and rationale for the study, the research process, a summary of the findings for each theme and subtheme, the concept analysis, and the development of the model, its description, and its process. To conclude the session, time was devoted to evaluators' comments and questions.

Following the session, the panel members were requested to provide written evaluations. I facilitated this process by developing a model evaluation form (Appendix J) that included a weblink to a Google Form. Participation was voluntary, and no identifying information was collected, other than each evaluator's years of experience in model development and their area of expertise (profession). Although some evaluators indicated "none" for model development experience, they possessed expertise in patient radiation safety, which was considered equally important given the study context. The Form gathered their written comments on the clarity, simplicity, generality, accessibility, and importance of the model, as recommended by Chinn et al. (2022:170-176). Of the 11 panel members who attended the session, seven evaluators completed the written evaluation. While this number may be considered low, the evaluators' input overall was considered meaningful and of high quality. The evaluators' demographics are presented in Table 5.1.

Table 5.1. Evaluator demographics

EVALUATOR (E) DESCRIPTOR	MODEL DEVELOPMENT EXPERIENCE (NUMBER OF YEARS)	PROFESSION AND TITLE
E1	More than seven years	Radiography, Dr.
E2	None	Radiography, Dr.
E3	More than seven years	Nursing, Prof.

E4	None	Radiography, Dr.
E5	None	Medical physics, Dr.
E6	Between three and five years	Radiography, Dr.
E7	None	Radiology, Prof.

Overall, the model evaluation process proved constructive. Minor amendments to the draft model were recommended during the online discussion and written evaluations. As part of the process to refine the model, I reflected on the discussions that were held during the online model evaluation session and engaged with the written feedback from the evaluators. After having included the panel members' feedback, the model was jointly agreed upon by the study supervisors and me. The following information presents an overview of the model evaluation criteria, direct quotations from the evaluators' written evaluations, my reflections, background to what was discussed during the online session, as well as the changes incorporated into the model.

5.5.1. Clarity

Clarity can be ascribed to the consistency of the central concept, which informs the development and description of the model and is established by evaluating the structural and semantic elements of the model (Chinn et al., 2022:171-174). To achieve clarity, I applied the central concept and its summative definition to the model components and steps.

> *"Consider if it's the best idea to have the green arrow point up straight into the outcome, which seems to be the last stage of the model process. You also have a 'heading' at the top = To create an improved and radiation-conscious environment, which looks like that's your outcome, but then there is a different outcome midway through the model, which is confusing. Make it clear who is going to facilitate this collaborative approach! Consider the agent and recipient roles. Should the DoH not be the facilitator??"* ***E1***

In Figure 5.1, the positions of the steps in the trefoil were rearranged to accommodate the upward-pointing green arrow from the collaborative approach to point towards and

make contact with the first step (structure) and not the last step (outcome). The “heading” was kept as it demonstrates the translation of the central concept to the model for consistency. I acknowledge, however, why this might have caused confusion. The purpose of the “heading” is to identify the first model component (a collaborative approach) and does not form part of the steps indicated by the trefoil. To avoid confusion, I moved it to the left-hand side of the model, added a border, and rotated it into a vertical position to label/indicate the first model component.

The comment on the potential need to identify a facilitator for the collaborative approach, whilst carefully considering the agent and recipient roles, proved invaluable. This is because, during the online discussion, reference was made to the SAHPRA and the HPCSA not being represented in the model. Specifically, it was mentioned that the SAHPRA’s operational unit, Radiation Control (SAHPRA, 2025a), should be referred to in the model description (5.3) and process (5.4). These changes were also made and are included in the blue square that represents the agent. The model is thus recommended for use by the NDoH to initiate the implementation of IPRDT within the South African healthcare system, and for its public entity (the SAHPRA) and statutory body (the HPCSA) to assist by providing further regulatory support. Following a presentation of the model to the same structures, it is hoped that the model will be recognised and adopted by the NDoH as a structured approach to guide the radiography departments in SA towards implementing an effective IPRDT solution. An attempt has been made to convey this more clearly throughout the description of the model.

> *“It is quite clear in terms of the drivers to improve patient care and experience. It would benefit from some further considerations. The model focuses on the positives of individual patient radiation dose tracking (IPRDT) but does not represent the risks. It is not clear who is responsible for monitoring doses and taking action when they reach unacceptable levels, nor is there an indication of what that level might be, so it's not clear what benefit the patient receives from IPDRT. It is assumed that IPRDT will improve organisational culture, attitudes, and compassionate care, but the model doesn't demonstrate how it will do that more effectively than existing processes required by the legislative framework around justification and dose optimisation. It would be helpful to mention the*

relevance of dose in the context of image quality when communicating with patients. I appreciate that it is not intended for patients to own these data, but I assume they are entitled to know if asked. The model does not include the risk introduced if referrers, who may have access to an individual's cumulative dose, may be dissuaded from referring them for an appropriate test, choosing a test involving non-ionising radiation that might be less appropriate. In summary, it would be helpful to illustrate both the benefits and risks of this model." ***E2***

E2 raised very important and relevant points, demonstrating their knowledge of patient radiation safety. It is important to note that the structure of a model presents a broad overview of the study findings through the central concept and its summative definition as the building blocks of the model. The finer details, as recommended by the evaluator for illustrative purposes, are covered in the study findings and discussion (Chapter Three) and in the guidelines to operationalise the model (Chapter Six). The model was developed for a specific purpose, namely, to guide the implementation of a potentially effective IPRDT solution at the national level, in response to the research question.

In response to the model not demonstrating how it will improve the existing processes as required by the legislative framework around justification and dose optimisation, it is argued that, by implementing an effective IPRDT solution, the current justification and optimisation practices and processes will be improved. Evidence of the same has been published in the literature (Seuri et al., 2013:771-775). The model illustrates this understanding in the word-based elements of the central concept and its summative definition. Furthermore, how IPRDT could improve current practice is explained throughout the description of the model, which includes an explanation of the symbolic and contextual meaning of the shapes, colour choices, and icons used, as well as the model process.

It is acknowledged, however, that there are risks associated with IPRDT. For example, the risk about the possibility of referring practitioners being dissuaded from referring patients for appropriate medical imaging examinations. It is argued that, as part of IPRDT, the risk of not requesting a clinically justified, ionising radiation medical imaging examination should also be taken into consideration. The same is mentioned

in a publication by Professor Madan Rehani (Rehani, 2017:031206-3), who first described and conceptualised the notion of IPRDT. To mitigate this potential risk, the provision of education and continuous professional development opportunities, and the development of procedural guidelines for the internal stakeholders (professionals directly involved in patient radiation safety) are covered in the model guidelines. Furthermore, it is recommended that the patient be included as an equal partner in the decision-making process. The purpose of IPRDT is to improve the current practices associated with patent radiation safety, thus leading towards improved radiation-consciousness and avoiding unnecessary fear.

Similarly, in response to the comment about who is responsible for monitoring patient radiation dose and who is responsible for taking action when it reaches unacceptable levels, and the question of what these levels may be, is accounted for in the model guidelines. The professional roles of the individuals involved in patient radiation safety have been determined through the study findings and literature. Important to keep in mind is that the purpose of IPRDT is not to advocate for, nor to develop, patient radiation dose limits. With reference to the patient not having access to the record, and that they should have the right to ask, this is acknowledged. It is reasoned that the average patient will not necessarily understand or be able to interpret the data presented in the record themselves, hence the importance of including the patient as an equal partner in their care. Actions on how to communicate risk in the most effective manner are included in the guidelines to operationalise the model.

The need to include the potential risk for the patient is acknowledged for illustrative purposes in the model. The model was amended by adding a red arrow that points in the opposite direction of the stakeholders' combined efforts to improve the current patient radiation safety practices within the South African healthcare system (Figure 5.1). It is anticipated that patients will be at an increased risk of developing radiation-induced injuries and/or cancers if the actions and steps associated with a collaborative approach to create an improved and radiation-conscious environment are not followed. It is further reasoned that, in current clinical practice, a lack of responsibility and accountability for patient radiation safety persists. This was evident through the stories shared by the study participants, and it was verified in the literature. Hence, the

need to improve the existing processes is deemed critical; and, as a potential solution, the literature suggests tracking the individual patient's radiation dose.

> *"Model is clear except for a few areas that need alignment to make it meaningful."* ***E3***

During the online discussion, E3 suggested that the bidirectional green arrows in the bottom aspect of the draft model overlap with the agent and recipient to improve the illustrative meaning of their collaboration. This was considered important as there were distinctly open spaces between the bilateral green arrows, the agent, and the recipient. The model was subsequently amended to represent this more clearly.

> *"It is clear, but referring physicians as the first point of contact for patients should be reflected due to their role in the justification process."* ***E4***

The professional role and responsibilities of referring practitioners are considered critical for the effectiveness of an IPRDT service. Their involvement in IPRDT is included under Step 1, by creating an enabling environment that models an organisational culture towards compassion and vigilance for patient well-being; and this is expanded on in Step 2, which includes the development of procedural guidelines to practise IPRDT.

Other comments on the model are included here:

> *"Graphically clear, rigid, and representative of what was investigated. At first glance, it is obvious what the model is about."* ***E5***

> *"The intention behind the model is clear, and how the component parts relate is well thought through."* ***E6***

> *"Very clear and well-conceived."* ***E7***

5.5.2. Simplicity

Simplicity refers to the number of concepts introduced in the model and their interrelationships (Chinn et al., 2022:174). Due to the complex nature of IPRDT and the understanding that it may be a new concept for many, an attempt was made to simplify the model as far as possible. In doing so, however, it was considered important for the interpreter of the model not to lose focus on the rationale behind the implementation of IPRDT and how it could be achieved.

> *"It is simple, but could include an option for what happens when collaboration breaks down?"* ***E1***

In response to this observation, I amended the draft model to include a visual demonstration of this potentially negative outcome. This decision was motivated by the emphasis placed on the need for a collaborative approach throughout the model description and process; and by similar feedback from the second evaluator concerning the clarity criterion, which speaks to the potential risk for the patient. A red arrow pointing downwards, thus illustrating the opposite of what is symbolised by the upward-pointing green arrow (growth, development, compassionate care, and a positive change), was added.

> *"Assuming only positive outcomes, the model is simple to understand, but it is argued that it is not sufficient to focus on benefit when the risk of tracking cumulative dose is an important factor."* ***E2***

Although E2 raised a valid concern, the study highlighted the risks linked to tracking a patient's cumulative radiation dose, and it is recommended that these risks should be considered when developing procedural guidelines (process step). While cumulative dose values can help predict potential risks, they should be used with caution because current risk prediction models are limited and do not fully account for individual patient differences. It's important to note that this model focuses on how IPRDT could be integrated into the South African healthcare system. It does not advocate for the setting of strict limits on cumulative radiation doses for patients. Rather, the recommendation is to assess each flagged case individually, and where the expected

benefit of the examination outweighs the potential radiation risk, the medical imaging examination or procedure should be performed. Participants in the study emphasised that the goal of IPRDT is to support better clinical decision-making by providing clearer insight into a patient's radiation exposure history. This leads to the strengthening of the principles of justification and optimisation in radiation safety, while avoiding unnecessary fear.

> *"Model is simple and understandable."* ***E3***
>
> *"It is simple, can be read and understood."* ***E4***
>
> *"Easy to follow and understand."* ***E5***
>
> *"The organisation of the model visually is not getting the intended message across well. The first issue is the two-part separation, which creates complexity that is unnecessary and detracts rather than facilitates simplicity. I would like to suggest the following. How about organising the model in a vertical plane? The agent at the top, the trefoil component in the middle of the model, and the recipient at the bottom. The green arrow's content is already captured by the trefoil visual, and some of the wording accompanying this part can be amended to accommodate the content in the green arrow. Then the green arrow should be removed. I think the above can help with better integration of the intention/goal of the model."* ***E6***

In response to E6's suggestion, it should be noted that the separation of the model into two components was deliberately done to translate the central concept into the model itself, and by emphasising the importance of both functions: the need for a collaborative approach, *and* the steps that need to be taken to create an improved and radiation-conscious environment. If the model had to be rearranged with the agent and recipient at opposite ends, the first component of the central concept (a collaborative approach) would lose its visual value/meaning. The text in the green arrow represents part of the summative definition of the central concept, similar to the text that was added to Steps 1,2 and 3 in the second component of the model. By removing the text in the green arrow, it is argued that the summative definition of the central concept is

not consistently translated into the development of the model, reducing clarity. Furthermore, part of the text added in the green arrow demonstrates the rationale behind the need to implement IPRDT. Removing the green arrow would remove the symbolic meaning and purpose of the collaboration, as well as important attributes, such as “growth”, “development”, compassionate care”, and “positive change”.

The last comment was:

> *“Very simple.”* ***E7***

5.5.3. Generality

Chinn et al. (2022:174) explain the generality of a model for applicability in a variety of environments. Most evaluators concurred that the model is general and that it can easily be adapted and applied to similar contexts.

> *“General enough to implement widely.”* ***E1***

> *“Acknowledging the limitations of the illustrative nature of the model, it could be improved by making the benefit to the patient more central.”* ***E2***

The suggestion by E2 about the benefit to the patient needing to be more central is already included in the model by means of the text placed within the green arrows, to strengthen the current justification and optimisation practices associated with patient radiation safety for medical imaging purposes and to potentially decrease the individual patient’s effective lifetime risk of developing radiation-induced injuries and cancers. Additionally, the patient, as a “person”, is included in the second component of the model in the form of an icon and is placed at the centre of the IPRDT service for the benefit of patient access to personalised, radiation-conscious care. This was deliberately done, as IPRDT is seen as a form of PCC. Two basic icons are also visible and give further meaning to the process and outcome steps. Both these icons symbolise the benefit of IPRDT to the patient and form part of the model description.

> *“It is general.”* ***E3***

"It is general; it applies to all patients undergoing procedures involving the use of ionising radiation." ***E4***

"Applicable to the area it was designed for, across all imaging modalities." ***E5***

"The model is applicable to radiography only, but could be transferable to other contexts worldwide in my view, as it is generic enough for consideration in other contexts. Other contexts' enactment/implementation of the model can be easily made context specific." ***E6***

"Broadly applicable." ***E7***

5.5.4. Accessibility

The accessibility of the model is ascribed to its practical application to achieve its purpose that stems from the research findings (Chinn et al., 2022:175). Overall, most evaluators found the model accessible:

"It is accessible if someone could facilitate this collaboration." ***E1***

This comment by E1 has been addressed and responded to under the clarity criterion.

"I have no reference for how the colour and mood representations were derived. Apologies if I missed that. Assuming the colours would be identifiable to those with visual impairment or reading difficulties." ***E2***

In response to the previous comment, the model expresses my views as a qualitative researcher, and how I interpreted the findings is illustrated in the model.

"Model is accessible and will be easy to apply for its intended purpose." ***E3***

"I think it is accessible to all patients for radiological investigation involving the use of ionising radiation." ***E4***

"If it can be supported by regulatory authorities, it will be accessible to all licensed facilities." ***E5***

"In principle, the message of the model is accessible, but because of the limitations related to simplicity, its accessibility is also hampered." ***E6***

The previous comment of the same evaluator has been addressed and was responded to under the simplicity criterion.

"Certainly accessible." ***E7***

5.5.5. Importance

The importance and value of a model are determined by its ability to bring about a desired change (Chinn et al., 2022:176). The model developed and described in this study stems from evidence-based clinical practice and the need to improve the same. All evaluators considered the model to be important.

"Very important for the profession and for patient safety." ***E1***

"The model is very important to influence decision makers, as it will require a considerable national investment. It should clearly identify the positive impact on the patient and the drive to reduce inconsistent care, waste of resources, and social inequality." ***E2***

The positive impact on the patient comment has been addressed and was responded to under the generality criterion for the same evaluator. As for the remainder (to reduce inconsistent care, waste of resources, and social inequality), these do not align with the purpose of the model, which is to guide the implementation of IPRDT to have a positive impact on individuals and communities of SA. Nonetheless, it is anticipated that these benefits will follow the implementation of an effective IPRDT solution.

Other comments were:

"This model is important for the practice of clinical radiography." ***E3***

"It is important as it will aid in individual radiation dose tracking." ***E4***

"Very important, for patients, regulators, and health care practitioners, primarily to reiterate the importance of ALARA." ***E5***

"Very significant, as this is another strategy that can help the profession take heed of the ethico-legal imperative of keeping radiation exposures to individuals as low as reasonably achievable." ***E6***

"Could make an important contribution to health care and radiation safety in this country." ***E7***

5.6. CONCLUSION

Chapter Five shared the development and description of the model to guide the implementation of IPRDT within the South African healthcare system. The model was achieved from the study findings from the one-on-one, semi-structured interviews conducted with radiographers, radiologists, and medical physicists within the Western Cape Province of SA. Furthermore, the overall process of the model and the outcome of the expert panel evaluation were presented. The next chapter presents and discusses the guidelines to operationalise the model.

CHAPTER SIX

GUIDELINES TO OPERATIONALISE THE MODEL

"The value of an idea lies in the using of it."

Thomas Edison

6.1. INTRODUCTION

Changes within healthcare are considered constant (Barrow & Annamaraju, 2022). As such, healthcare organisations need to be open towards, and continuously adapt to, new practices and policy reforms (Nilsen et al., 2020:1). The implementation of individual patient radiation dose tracking (IPRDT) within the South African healthcare system is an example of a needed change in healthcare service delivery. Changes in healthcare service delivery, although challenging, are often driven by factors such as evolving norms, values-based ethical practice, and the need to increase patient involvement (Nilsen et al., 2020:1).

The implementation of IPRDT within the South African healthcare system is interpreted as a form of transformational change. Sligo et al. (2019:237) explain transformational change in healthcare as a large-scale shift in its operational activities, driven by changes in its structure and systemic culture. The same authors (Sligo et al., 2019:237) elaborate on the purpose of transformational change within the healthcare sector: to support service delivery that is consistent, safe, and of high quality. The fundamental principles and rationale behind implementing IPRDT are no different. Transformational change is also viewed as a shift towards a more person-centred approach, which aligns well with the theoretical framework in this study. The next paragraph outlines the content in the current chapter.

Chapter Five presented the development and description of the model to guide the implementation of IPRDT within the South African healthcare system, followed by an expert panel evaluation. Chapter Six focuses on the guidelines for operationalising this model, which is also the final step in the model development process. The guidelines provide collaborative, structural, process, and outcome considerations co-constructed by the study participants and the researcher. This chapter fulfils the third, and final research objective presented in Chapter One (1.8).

6.2. IPRDT GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

Guidelines can be compiled within a framework to specify actions intended to achieve a desired outcome. These guidelines are typically based on research findings to provide clarity, comparability, and rigour (Wang et al., 2018:1). Mousa et al. (2024:3) agree with this statement and further highlight the importance of evidence-based guidelines in guiding healthcare systems to translate research into practice. According to De Leo et al. (2023:1-2), guidelines for clinical practice are essential for improving the quality of care in healthcare systems, as they provide empirical evidence to healthcare decision-makers on how best to support and guide clinical practice.

Additionally, involving the relevant stakeholders in the co-creation and implementation of interventions in the healthcare sector is encouraged by regulatory authorities as it presents a more reliable solution to achieve the desired and positive change (Leask et al., 2019:2). Rousseau and Ten Have (2022:1) agree with the previous authors; and they further advocate that changes in healthcare service delivery should take into account the relevant scientific, organisational, and stakeholders considerations. The same was achieved in the current study, as local stakeholders in patient radiation safety were included as participants, and the findings were contextualised using relevant literature.

The model presented in Chapter Five (Figure 5.1) is recommended for use by the NDoH as a guide to initiate the collaborative approach and to support the implementation of IPRDT within radiography departments in South Africa (SA), both the public and private healthcare sectors. Support is needed by the South African Health Products Regulatory Authority (SAHPRA), more specifically, Radiation Control,

and the Health Professions Council of South Africa (HPCSA) through the Professional Board for Radiography and Clinical Technology (PBRCT). Following the mandate of IPRDT within the South African healthcare system, the aforementioned structures take on supporting roles to work with and support the radiography departments more directly. It is recommended that the guidelines be adapted and used in other environments where ionising radiation is being used for medical imaging purposes.

The model represents an idealistic and top-down approach, and its immediate implementation may not be easily achievable. The national roll-out of a mandated form of IPRDT in the South African healthcare system, however, increases the effectiveness of the IPRDT solution by maintaining a patient health record that transcends geographical boundaries and is most accurate to facilitate improved clinical decision-making. With an incomplete record, the purpose of IPRDT would not be achieved satisfactorily. Furthermore, if IPRDT is not mandated by the NDoH, its implementation will be regarded as optional, and, because of this, not all stakeholders will abide by it. Literature suggests that patient radiation safety during medical imaging has reached a point where there is a need for urgent intervention (Rehani et al., 2020:1828; Brower & Rehani, 2021:1). External stakeholder support is thus essential to assist the internal stakeholders in creating an improved and radiation-conscious environment.

For the NDoH to make a decree on this model, considerable effort is needed for its recognition. As a researcher who is knowledgeable about this topic and who developed the model, I aim to create and increase awareness of the study findings via a scaffolded approach and in an attempt to have it noticed by the NDoH. Creating awareness of IPRDT among the local and internal stakeholders in patient radiation safety is essential to introducing this relatively new concept. To do this, I will present the model at relevant workshops, professional society seminars and/or conferences. Following this, I will reach out to: the provincial Western Cape Department of Health (WCDoH), in the province in which the study originates; to Radiation Control (at the SAHPRA); and to the PBRCT (at the HPCSA) to request their input and obtain their buy-in, before reaching out to the NDoH through the same structures. Only with the NDoH's recognition of the model will the guidelines be considered for implementation within the South African healthcare system. It is acknowledged, however, that this may

imply a slower rollout pace for IPRDT. As a potential alternative approach, consideration could be given to implementing IPRDT at the institutional level first. Demonstrating its effectiveness within a single institution could serve as a strong motivator for broader adoption.

The model has four overarching guidelines derived from fractions of the summative definition of the central concept. The first model component, a collaborative approach, houses the first guideline and refers to the external and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation. Mutual support is sought to form a working relationship to navigate the three steps of the second model component, to create an improved and radiation-conscious environment. The second, third, and fourth guidelines, respectively, consider the organisational preparation of the environment (structure), the coordination of procedures and activities that involve bringing into existence new practice methods and standards (process) and the outcome – whereby an effective IPRDT solution that allows patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA – has been implemented. All four guidelines are detailed through objectives, actions, and motivations. I relied on the findings from the current study, deductive reasoning, and the support of relevant literature to develop the guidelines. Further descriptions have been added in the form of a narrative throughout the chapter in support of the guidelines.

Figure 6.1 presents a summarised diagram of the framework to guide the implementation of IPRDT within the South African healthcare system. It is reasoned that this framework provides one perspective/answer to the research question on how IPRDT can be accomplished in SA. It is acknowledged that other researchers might have interpreted the implementation of IPRDT within the South African healthcare system differently due to their previous experiences and understanding. The framework elements demonstrated in Figure 6.1 are explained in more detail in the text that follows.

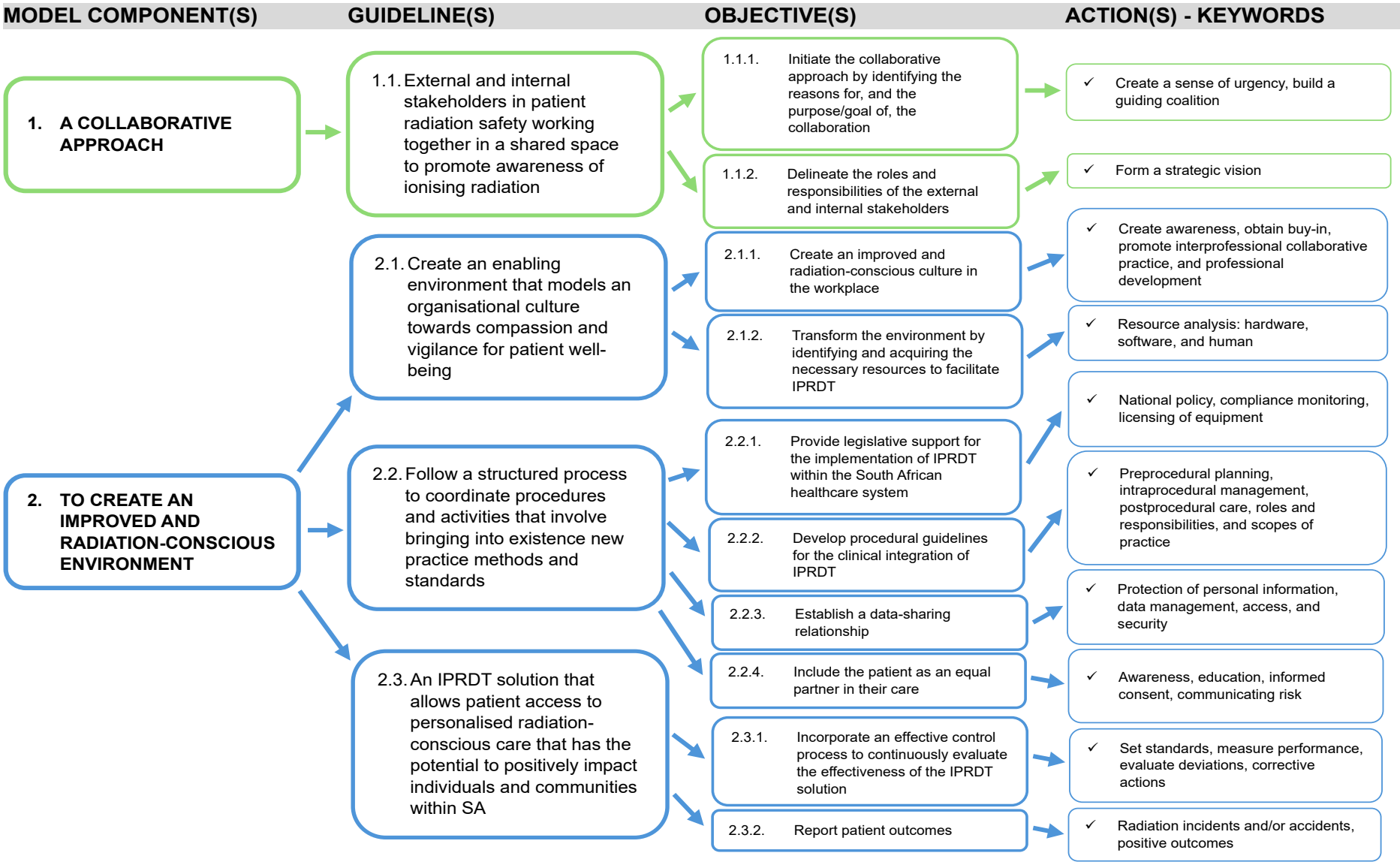


Figure 6.1. A framework to guide the implementation of IPRDT within the South African healthcare system

6.2.1. Model component 1: A collaborative approach

IPRDT requires multiprofessional involvement, and its implementation should thus consider the roles and responsibilities of all the stakeholders involved. Establishing a collaborative approach is considered the point of departure for the external and internal stakeholders to work together to create an improved and radiation-conscious environment. Important to note, and as a point of reference, both the external and internal stakeholders in patient radiation safety have an active role to play towards the implementation of an effective IPRDT solution. The same notion forms part of the guidelines to operationalise the model, and specific roles and responsibilities were allocated to these stakeholders, where relevant.

The external stakeholders, inclusive of the NDoH, its public entity (the SAHPRA), and statutory body (the HPCSA), are considered to have legislative and regulatory influence over the operational activities in the radiography department. The internal stakeholders refer to the radiography managers and professionals who are directly involved with the functioning of the radiography department at the ground level. More specifically, these are the healthcare professionals responsible for attending to the patients for medical imaging purposes, and those who assist with the daily tasks associated with IPRDT.

To achieve the implementation of an effective IPRDT solution, it is recommended that the stakeholders in patient radiation safety begin their collaborative journey through the process of developing a shared vision and goal to benefit future practice. The SAHPRA, the HPCSA, provincial health departments, and radiography department managers, who are considered occupants of leadership roles, hold the necessary authoritative power to bring about this positive change within the medical imaging environment by following the NDoH mandate to implement IPRDT. Figure 6.2 depicts a self-developed organogram to identify and demonstrate the hierarchical positions of the relevant external and internal stakeholders within the South African healthcare system.

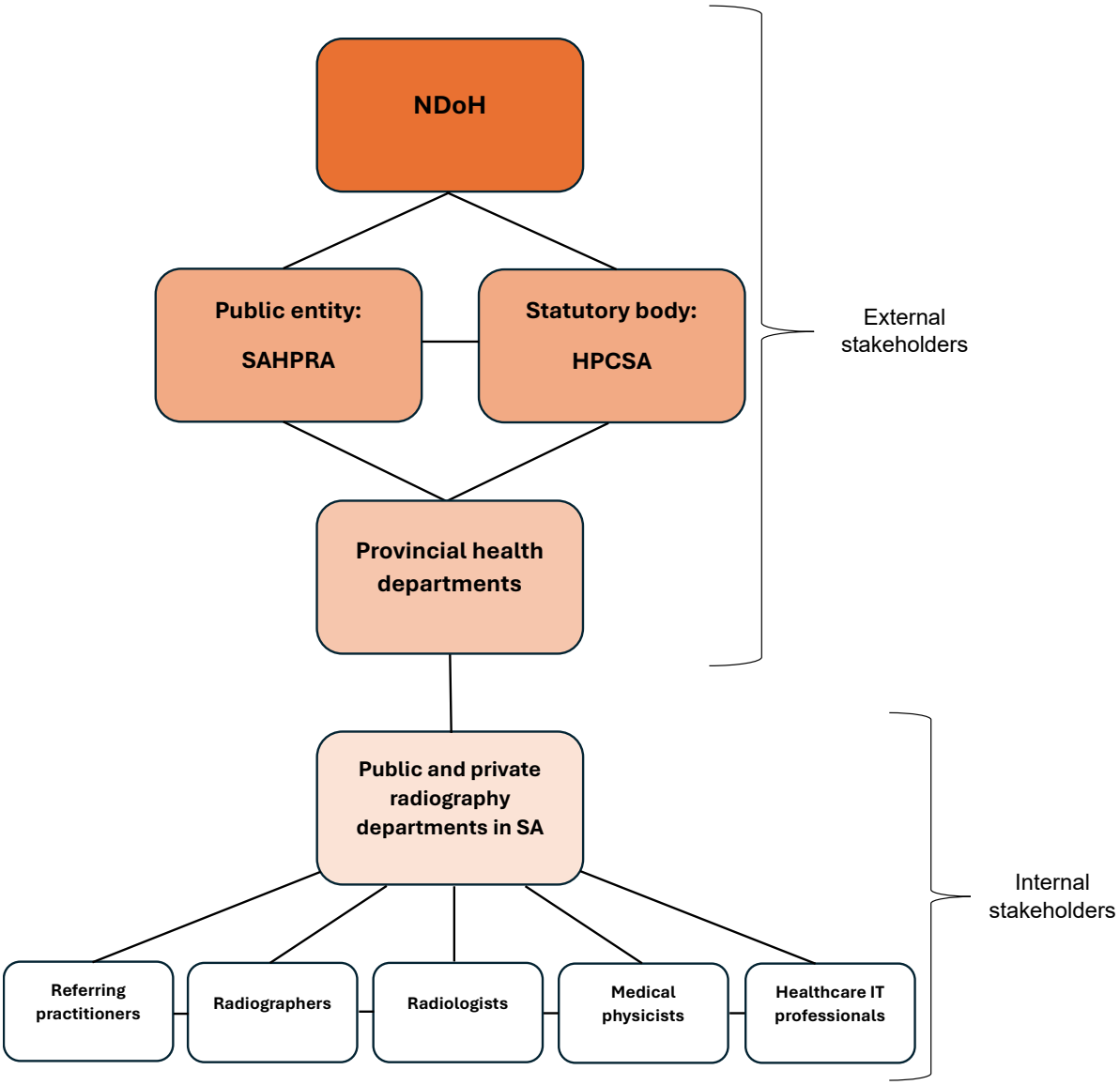


Figure 6.2. External and internal stakeholders in patient radiation safety

Implementing IPRDT at the national level is acknowledged as a significant task, as there are potential resource constraints, and IPRDT is a relatively new concept for many in the field. The model offers broad guidelines for the NDoH to consider as they initiate a mandated form of practice towards the implementation of an IPRDT solution within the South African healthcare system, across the public and private healthcare sector radiography departments. Thus, for the implementation of the model to have a chance at success, a national and collaborative investment is required from all the relevant stakeholders (external and internal). The first guideline of the model is presented and explained further in the text that follows.

6.2.1.1. Guideline 1.1: External and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation

Loban et al. (2021:1) report that multi-stakeholder partnerships in healthcare are increasingly being embraced with the participation and support of the government. In context, the participants suggested that the DoH be involved to mandate and provide support for the implementation of IPRDT throughout SA. The same authors (Loban et al., 2021:1) further state that a multi-stakeholder partnership is helpful when addressing complex healthcare phenomena and holds several strategic advantages, such as the achievement of a desired outcome that is typically perceived to be challenging and ineffective through individual efforts. Tuyishime et al. (2025:7) build on this understanding by highlighting the importance of open communication and information-sharing when embarking on a multi-stakeholder collaborative approach, in addition to the need to foster trusting relationships through transparency. These factors are considered essential for IPRDT to be effective. Buy-in from the NDoH, the SAHPRA, HPCSA, provincial health departments, as well as adherence from all the radiography departments in the country, is essential to bring about this change. Table 6.1 presents the two objectives associated with the first guideline, the actions to achieve these objectives, and their motivations.

Table 6.1. Objectives, actions, and motivations for external and internal stakeholders in patient radiation safety working together in a shared space to promote awareness of ionising radiation

OBJECTIVE 1.1.1. **Initiate the collaborative approach by identifying the reasons for, and the purpose/goal of, the collaboration**
ACTION(S)
▪ Following a realisation concerning the presumed suboptimal adherence to the justification and optimisation principles associated with patient radiation safety for medical imaging purposes, the relevant external and internal stakeholders, as referred to in Figure 6.2, agree to meet.

- The meeting is facilitated in the form of a stakeholder engagement workshop, and invitations are extended throughout the radiography departments in SA.
- The concept of IPRDT is introduced to create awareness of global trends in patient radiation safety, and the findings from local research are shared. This is deemed an important benchmarking exercise when planning to implement IPRDT. The attendees are asked to reflect on, then provide input on, their current patient radiation safety practices for medical imaging purposes.
- The need to implement IPRDT is rationalised by sharing reasons for its implementation, along with the perceived benefits and potential challenges.

MOTIVATION(S)

Stakeholder engagement workshops hold a variety of benefits: promoting inclusion and bringing together a variety of perspectives of those who hold direct interest (Maurer et al., 2022:6). The stakeholder engagement workshop is regarded as an opportunity to promote awareness of ionising radiation within a shared space between external and internal stakeholders in patient radiation safety through open discussions and information sharing. Although Nilsen et al. (2020:1) are of the opinion that change often contradicts one's need for a stable environment, Gagnon et al. (2024:2) suggest that quality improvement projects in healthcare have been more successful when the relevant stakeholders are involved in the discussions and decision-making processes. The same authors (Gagnon et al., 2024:2) further state that continuously involving stakeholders throughout the process is critical to the success of the change initiative, as they can address challenges as they arise and make timely decisions. In the context of this model, the same notion is shared: the relevant stakeholders in patient radiation safety are included at the national level, and their input is heard; and then they are part of the collaborative approach to create an improved and radiation-conscious environment through implementing an effective IPRDT solution.

OBJECTIVE 1.1.2.
Delineate the roles and responsibilities of the external and internal stakeholders

ACTION(S)

- Following the stakeholder engagement workshop, the broad roles and responsibilities of the external and internal stakeholders are identified as per

the information presented in this section. This is important when stakeholders embark upon the activities of the next model component. ▪ The NDoH is deemed responsible for mandating the implementation of IPRDT within the radiography departments in SA across both the public and private healthcare sectors. ▪ The Radiation Control operational unit under the SAHPRA provides regulatory support to the NDoH through its existing policies and involvement with the public and private sector radiography departments. ▪ The PBRCT, under the auspices of the HPCSA, provides guidance by developing procedural guidelines for integrating IPRDT into clinical practice. ▪ The provincial health departments lend their ongoing support to the radiography departments in view of resource management, where relevant. ▪ The managers of the radiography departments are responsible for ensuring that their departments adhere to the regulations posed by Radiation Control (SAHPRA) and the procedural guidelines provided by the PBRCT (HPCSA).
MOTIVATION(S)
The success of this initiative depends largely on the active involvement and mutual support of both the external and internal stakeholders, and upon following the steps in the second component of the model. It is considered important for the stakeholders to reflect on their involvement in the delivery of an IPRDT service; on their professional roles and responsibilities in view of patient radiation safety and ethical practice standards; and on the patient as being at the centre of all this.

The NDoH, the SAHPRA, the HPCSA, the provincial health departments, as well as the radiography managers across the radiography departments across SA, can be considered the agents of change towards implementing IPRDT within the South African healthcare system. Agents of change can be explained as individuals within leadership positions upon whom their subordinates rely for navigating complex dynamics (Joseph, 2023:1). Based on this understanding, the first three steps of the change management theory by Kotter (Kotter International Inc., 2025) are relevant and confirmatory of the first guideline, its objectives, actions, and motivations. The three steps refer to creating a sense of urgency and building a guiding coalition (to achieve the first objective), and forming a strategic vision (to achieve the second objective). The same steps have been

included in the guideline framework (under the actions column on the far right-hand side of Figure 6.1). It is thus recommended that Kotter's theory be used as a form of guidance by the previously mentioned change agents to assist with and support the implementation of IPRDT within the South African healthcare system.

6.2.2. Model component 2: To create an improved and radiation-conscious environment

I acknowledge the complexity of IPRDT due to the need for a more accurate metric to calculate individual patient radiation risk from cumulative radiation. What is clear, however, is the need to improve current patient radiation safety efforts. The same was highlighted by the Bonn Call for Action (WHO, 2024), where an international plea was put forth for countries to develop and implement effective, sustainable, and innovative solutions to strengthen their current justification and optimisation practices. Selected countries abroad were able to implement IPRDT as a potential solution in response to the Bonn Call for Action. Finland published positive outcomes following the implementation of an IPRDT solution that covers 33 of their radiography departments, demonstrating its success (Seuri et al., 2013:771). The same authors (Seuri et al., 2013:771) shared that, because of IPRDT, they were able to review their patients' unique radiation dose records to avoid unnecessary exposures, and that the same records shared valuable insight which assisted them in improving their radiation dose optimisation practices. I further acknowledge that starting something new may prove challenging, especially on a national scale, but also that inaction guarantees no change (Potthoff et al., 2022:2).

The following information explains and discusses the remainder of the model guidelines, together with their individual objectives, actions, and motivations.

6.2.2.1. Guideline 2.1: Create an enabling environment that models an organisational culture towards compassion and vigilance for patient well-being

The second guideline speaks to achieving structure within the radiography department and has two objectives (Figure 6.1). Winasti et al. (2023:1) state that an optimal

organisational structure serves as an enabler for an organisation to achieve its goals. In context, organisational structure refers to creating an improved and radiation-conscious culture through education and by providing ongoing professional development opportunities, as well as transforming the radiography departments by acquiring the necessary resources to facilitate IPRDT. Table 6.2 presents the two objectives associated with the second guideline, the actions to achieve these objectives, and their motivations.

Table 6.2. Objectives, actions, and motivations to create an enabling environment that models an organisational culture towards compassion and vigilance for patient well-being

OBJECTIVE 2.1.1. **Create an improved and radiation-conscious culture in the workplace**
ACTION(S)
▪ The Radiation Control (SAHPRA) is responsible for: - Developing and rolling out national IPRDT awareness campaigns. In doing so, partnerships with existing radiation safety campaigns in the country, e.g. AFROSAFE RAD (AFROSAFE, 2025), can be considered. ▪ The Education, Training and Registration Committee appointed by the PBRCT, under the auspices of the HPCSA, is responsible for: - Developing minimum training standards and providing educational opportunities (formal and informal) to actively registered healthcare professionals directly involved in IPRDT. - Advocating for IPRDT as a form of interprofessional collaborative practice. ▪ The radiography managers are responsible for: - Leading and managing their department's daily operations and functionality, whilst adhering to the relevant quality, safety, and regulatory standards. In context, this refers to abiding by the regulations of IPRDT. - Creating a safe environment for patients who seek medical imaging care from their departments. This includes incorporating IPRDT as part of the departmental quality assurance (QA) programme.

- Supporting their workforce to partake in the IPRDT educational opportunities.

MOTIVATION(S)

Creating a workplace culture is considered the responsibility of those in leadership positions (James, 2019), who should encourage team effort (Performance Health Partners, 2025). Furthermore, Bayot et al. (2024) opine that workplace culture has the potential to create either a supportive or unsupportive environment. Tran et al. (2023:1) agree with the previous authors and further explain that the significance of having a positive workplace culture is to foster collaboration, continuous learning, professional satisfaction, and improved outcomes. In context, the goal of creating an improved and radiation-conscious culture is a definite shift towards greater compassion and vigilance for patient well-being. An improved and radiation-conscious culture should be created prior to transforming the radiography department with the necessary resources to implement an IPRDT solution. Obtaining the buy-in from the workforce carries significant weight, and any signs of workforce resistance should be managed before introducing changes in the department.

OBJECTIVE 2.1.2.

Transform the environment by identifying and acquiring the necessary resources to facilitate IPRDT

ACTION(S)

- At the departmental level, the radiography managers are responsible for identifying, evaluating, and optimising the resources in their departments to prepare for the implementation of an IPRDT solution. Support may be required from the provincial health departments, where relevant. It is recommended that the following resources be in place for IPRDT purposes:

  i. Hardware and software:
  - All ionising radiation medical imaging equipment should have dose monitoring capabilities, for example, have a Dose Area Product (DAP) meter installed, and be Digital Imaging and Communications in Medicine (DICOM) compatible to develop a structured radiation dose report for sharing with healthcare information and communication

systems. These systems, more specifically, include the Hospital Information System (HIS), Radiology Information System (RIS), and Picture Archiving and Communication System (PACS).

- The availability of HIS, RIS, and PACS to facilitate an electronic patient health record, as opposed to manual radiation dose capturing.
- An automated software functionality that can share patient radiation exposure and dose data on an external platform that will act as a central repository or national patient radiation dose database/registry.
- A carefully designed network architecture that includes stable internet access to connect and communicate with a national patient radiation dose database/registry.
- Basic computer workstations, with the relevant hardware and software, for the internal stakeholders to access the national patient radiation dose database/registry. It is reasoned that access to this database/registry could also be facilitated by using the existing computer workstations throughout the hospital in which the radiography department is located.

ii. Human resources:

- Identify a dedicated individual or team responsible for implementing and monitoring the IPRDT solution within the department. Included in this team, healthcare IT professionals are essential.

- At the national level, the development and implementation of the national patient radiation dose database/registry is considered the responsibility of the NDoH and the SAHPRA. This is because of the need for the same platform to be centralised and accessible by both the public and private radiography departments throughout the country for the most accurate and complete patient health records. To achieve this, the following resources are recommended:

  - A user-friendly and easy-to-understand software interface developed as part of the national patient radiation dose database/registry.

- Automatic, built-in data processing algorithms and alert functions to indicate/flag high-risk users who may potentially be at risk for developing radiation-induced injuries and/or cancers. - Physical servers and/or a cloud-based solution can be among the potential solutions for the national database/registry. - Identify a dedicated team at the national level who will be responsible for implementing, monitoring, and maintaining the operational aspects of the national database/registry. It is again essential for healthcare IT professionals to be included in this team.
MOTIVATION(S)
To transform the radiography department, a resource analysis is recommended. For a healthcare system to function optimally, Rajan et al. (2022:78) suggest that the necessary resources be made available. According to Ebugosi and Olaboye (2024:1489), having access to the necessary resources is essential for patient access to quality care. Upon reflection of the central concept's summative definition, patient access to quality care has the potential to have a positive impact on their health outcomes, in context, through the delivery of personalised radiation-conscious care. Upon implementing the resources, the radiography departments will be able to connect with and communicate the relevant patient data to the national patient radiation dose database/registry for IPRDT purposes.

6.2.2.2. Guideline 2.2: Follow a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards

The third guideline refers to the second (process) step in the model. As part of the assumptions of the model, this step considers the mandated implementation of IPRDT and that procedural guidelines be developed to support a robust and sustainable IPRDT service. Furthermore, a data-sharing relationship between the public and private radiography departments should be established, and the patient should be included as an equal partner in their care. Table 6.3 presents the four objectives associated with the third guideline, the actions to achieve these objectives, and their motivations.

Table 6.3. Objectives, actions, and motivations for following a structured process to coordinate procedures and activities that involve bringing into existence new practice methods and standards

OBJECTIVE 2.2.1. **Provide legislative support for the implementation of IPRDT within the South African healthcare system**
ACTION(S)
▪ The NDoH mandates the implementation and clinical integration of IPRDT throughout the South African healthcare system, within the public and private sector radiography departments, by instating a national policy. ▪ Whilst developing the national policy, consideration should be given to its alignment with the global standards and recommendations in patient radiation safety and IPRDT. This is important to enable the potential integration of IPRDT with the international countries' healthcare systems. ▪ The SAHPRA (Radiation Control) is responsible for administering regulatory standards for IPRDT and, subsequently, monitoring the compliance of the radiography departments with the national policy. This is carried out by factoring in IPRDT requirements for the licensing of ionising radiation-emitting medical imaging equipment and by conducting departmental inspections/audits. ▪ The HPCSA (PBRCT) is responsible for amending the radiographers' professional scope of practice. As for the other internal stakeholders, their professional boards are responsible for amending their scopes of practice accordingly. Subsequently, the necessary approval must be sought from the Minister of Health.
MOTIVATION(S)
The NDoH possesses the authoritative power to mandate IPRDT. The implementation of IPRDT is most effective at the national level to maintain individual patient health records that are accurate for informed, improved clinical decision-making. The SAHPRA, in its capacity as a public entity, possesses the regulatory power to manage the recipients' adherence to the policies set in place by the NDoH. The role of the HPCSA in providing support in amending the relevant stakeholders' scopes of practice is due to the scope of practice being a legal

document that defines the boundaries under which healthcare professionals are permitted to practice.

OBJECTIVE 2.2.2.

Develop procedural guidelines for the clinical integration of IPRDT

ACTION(S)

- Procedural guidelines are developed by the Professional Practice Committee of the PBRCT under the auspices of the HPCSA for the clinical integration of IPRDT.
- Procedural guidelines for IPRDT should, at a minimum, address the following elements: preprocedural planning, intraprocedural management, and postprocedural care (Stecker et al., 2009:S263).
- The following information presents the minimum guidelines for practice by the internal stakeholders, that is, their professional roles and responsibilities.

i. Actions by the referring practitioners:

- Critically review the patient's previous medical imaging and radiation dose history (IPRDT record) as part of the justification process and before requesting a new ionising radiation medical imaging examination.
- If unsure about the way forward, consult with a medical imaging professional for further guidance, e.g., a radiographer or radiologist.
- During the consultation process, the referring practitioner should discuss IPRDT with the patient in such a manner that it does not create unnecessary fear.
- Referring practitioners are to encourage active conversation with the patient and involve them in the decision-making process for medical imaging examinations.

ii. Actions by the radiographers:

- As the custodians of ionising radiation for medical imaging purposes, radiographers must actively review the clinical history and indication for the ionising radiation medical imaging examination that has been requested and query those referrals that do not include any clinical

history. Referrals that are believed not to be clinically justified should also be investigated further.

- Work carefully by optimising the use of ionising radiation for each clinically justified medical imaging examination.
- Ensure that the necessary patient data has been shared with the national patient radiation dose database/registry after completing each patient examination.

iii. Actions by the radiologists:

- Provide support in reviewing and approving the clinically justified ionising radiation medical imaging examinations that are referred to the department, when needed by the referring practitioner, and if queried by the radiographer.
- Advise the referring practitioner on the potential use of alternative, non-ionising radiation imaging examinations where relevant/necessary.
- Record the individual patient's cumulative radiation dose value in the radiology report for each medical imaging examination performed. This information should be visible and retrievable from the national patient radiation dose database/registry.

iv. Actions by the medical physicists:

- Following notification of an alert on the national patient radiation dose database/ registry, conduct a more detailed radiation-risk analysis. As an example, the individual patient's relative effective dose could be calculated. This will assist the referring practitioner and radiologist with improved clinical decision-making when justifying a new medical imaging examination, as well as the radiographer to optimise their radiation dose protocols.

MOTIVATION(S)

The development of procedural guidelines for the clinical integration of IPRDT is considered the "blueprint" of IPRDT practice. The involvement of the Professional Practice Committee is invaluable for informing quality practice standards and ethical behaviour. This is in keeping with one of the HPCSA's functions, whereby it

aims to guide the professions through professional and ethical practice standards (HPCSA, 2025). From the study findings, procedural guidelines will aid the integration of IPRDT within the standard departmental workflow and are also beneficial for guiding new personnel entering the department.

OBJECTIVE 2.2.3.

Establish a data-sharing relationship

ACTION(S)

- The NDoH, with the support of the provincial health departments, is responsible for developing and implementing a data-sharing agreement between the public and private sector radiography departments throughout the country.
- Upon developing the data-sharing agreement, consideration must be given to the Protection of Personal Information Act and data ownership, which may include departmental intellectual property, for example, the sharing of imaging protocol information through the national patient radiation dose database/ registry.
- Access to the national patient radiation dose database/registry must be limited to the relevant internal stakeholders (Figure 6.2), each with their own unique username and password. It is recommended that access to the database should not be extended to the patient.
- Specific patient data must be collected and built into their individual health records, hosted within the national patient radiation dose database/registry. The following data, at a minimum, is recommended:

  - Patient identification details (full names, surname, date of birth).
  - The age of the patient (presumed to be an automatic calculation).
  - The biological gender of the patient.
  - The weight and height of the patient.
  - The clinical indication/justification for the requested examination.
  - The patient's contact information, for follow-up purposes, should be included if their profile is flagged as a high-risk user, and if radiation-induced risk needs to be communicated.

- A unique patient identification number to locate their profile on the national patient radiation dose database/registry, similar to the notion of the conventional hospital folder number.
- The date and time of when the medical imaging examination was performed. The time was considered important as some patients may undergo more than one imaging examination on the same day, and also for the medical physicist when calculating potential radiation-induced risks.
- The type of medical imaging examination performed.
- The number of imaging projections and/or sequences performed.
- The number of repeated imaging projections and/or sequences.
- The radiation exposure settings/parameters for each projection and/or sequence.
- The DAP-reader measurement for each projection and/or sequence.
- A basic description and technical specifications of the imaging equipment used.
- Basic identification details of the department where the medical imaging examination was performed, for example, the name of the institution, geographical area, and province.

MOTIVATION(S)

A data-sharing relationship between the public and private healthcare sector radiography departments is considered critical for the effectiveness of the IPRDT solution. It supports the notion of having an up-to-date individual patient health record as a potential enabler for improved clinical decision-making. Furthermore, this agreement will allow for the protection of sensitive patient data.

OBJECTIVE 2.2.4.

Include the patient as an equal partner in their care

ACTION(S)

- Both the external and internal stakeholders in patient radiation safety are considered responsible for educating the patient on IPRDT, within their legal scopes of practice, and based on their professional roles and responsibilities.
- Patient awareness and education on IPRDT are paramount. Potential ways to facilitate this include patient radiation safety campaigns, such as the development of educational flyers and posters on IPRDT. These posters can

then be displayed and shared throughout the radiography departments in SA, in both the public and private sectors. ▪ Obtain informed patient consent for tracking their cumulative radiation dose. This should be built into the existing standard informed consent procedures at the departmental level. ▪ Potential risks, when flagged, should be discussed with the patient, regardless of their pre-existing knowledge and/or understanding of IPRDT. ▪ Attention should be given to how potential radiation risks are conveyed; for example, these should be communicated in a reassuring and effective manner and take into account the patients' language preference, their medical history, and cultural beliefs.
MOTIVATION(S)
Including the patient as an equal partner in their care resonates with the practical implementation of the person-centred care (PCC) theory, through the theoretical constructs of the Donabedian model for healthcare improvement (Santana et al., 2018:431).

6.2.2.3. Guideline 2.3: An IPRDT solution that allows patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA

The fourth guideline refers to the third and final step in the model (outcome). It is essential to establish specific objectives to determine the effectiveness of the IPRDT solution that was implemented. As a point of reference for this guideline, the concept of "continuous quality improvement" (CQI) is introduced to enhance understanding of quality healthcare and provide a backdrop against which the corresponding actions and motivations were developed. The SA NDoH (2024b) defines CQI as "the combined and ongoing efforts of stakeholders in the health system to make changes that lead to better patient outcomes and better system performance". According to Hill et al. (2020:2), CQI has gained significant interest in healthcare, not only to improve the quality of care provided to the patient, but also to optimise the use of available resources, thus reducing unnecessary costs. Upon reflection, these findings from the

literature link well with the model evaluation feedback provided by the second evaluator under the importance criterion (Chapter Five, 5.5.5).

Endalamaw et al. (2024:2) state that effective healthcare should aim towards achieving and maintaining the overall well-being of individuals and communities. According to Seyed Alitabar (2025:1), the overall well-being of patients can be analysed by incorporating the biopsychosocial model of healthcare. The same model is seen as a holistic approach towards improved patient care by taking into consideration the interconnectedness of the individual patient's biological, psychological, and social healthcare factors. In context, this links well with the first theoretical assumption described in Chapter One (1.10.2). Endalamaw et al. (2024:2) further acknowledge the complex dynamics and facets often associated with healthcare service delivery, such as patient access, safety, the coordination and integration of PCC, and quality monitoring.

Table 6.4 presents the two objectives associated with the final guideline, the actions to achieve these objectives, and their motivations.

Table 6.4. Objectives, actions, and motivations for an IPRDT solution that allows patient access to personalised radiation-conscious care that has the potential to positively impact individuals and communities within SA

OBJECTIVE 2.3.1. **Incorporate an effective control process to continuously evaluate the effectiveness of the IPRDT solution**
ACTION(S)
▪ At the departmental level, an effective control process for continuously monitoring the quality and effectiveness of the department's IPRDT practices can be built into the QA programme. This is typically developed by the radiography manager or radiation safety officer appointed in the department. ▪ Whilst incorporating IPRDT in the department's QA programme, consideration should be given to the following: 1) setting standards, 2) measuring the actual performance, 3) evaluating potential deviations, and 4) taking corrective actions (Du Toit et al., 2010:230).

- At the departmental level, reports detailing the effectiveness of the IPRDT process should be developed for internal review at regular time intervals. This is important to monitor and compare trends in patient outcomes (positive and negative) following the implementation of IPRDT.

MOTIVATION(S)

Keup (2025) believes that organisational functions are only as good as the ability to exercise control over them. Applying control is considered the responsibility of leadership (CliffsNotes, 2025). By incorporating an effective control process in the radiography department, the IPRDT solution and service provided can be monitored more closely for its performance and effectiveness. The following information presents a further discussion/motivation in support of the four control steps:

- Standards for IPRDT refer to the already mentioned national policy developed by the NDoH to mandate the implementation of an effective IPRDT solution across all the radiography departments in the country (legislative standard). To measure the actual performance of the legislative standard, the NDoH must monitor the progress of IPRDT implementation within the South African healthcare system. In addition to the national policy, further legislative standards refer to the regulations developed/prescribed by the SAHPRA, for example, the approval/licensing of equipment with IPRDT capabilities, and conducting departmental inspections/audits.
- Departmental inspections may include an analysis of potentially improved adherence to justification and optimisation. SAHPRA is deemed responsible for measuring the actual performance of these activities. Conversely, professional standards refer to the procedural guidelines developed by the HPCSA to which the relevant internal stakeholders must adhere. Radiography managers can incorporate the IPRDT roles and responsibilities of their workforce into their performance management and appraisal procedures.
- The legislative and procedural standards, upon reflection, were addressed in the process step. Potential deviations can be evaluated by conducting further investigations where non-compliance with the previously mentioned

standards was identified. In the event of non-compliance, it is recommended that further input be collected from the internal stakeholders based on their perceptions, experiences, and suggestions related to the IPRDT process. At the departmental level, input can be gathered through discussions during departmental meetings, having IPRDT as a standing item on the departmental meeting agendas. The relevant stakeholders can also be invited to attend these meetings. The input collected can be used to improve the organisational structure and/or the coordination of procedures and activities as part of the process.

- It is encouraged that feedback also be collected from the patients who seek medical imaging care in the various departments, based on their inclusion and experience in the IPRDT service provided. This can be facilitated by including questions pertaining to IPRDT within the standard, anonymised patient satisfaction feedback forms. Following the feedback from both the professional stakeholders and the patients, the radiography manager should consider their suggestions for implementation to improve the departmental IPRDT process. The radiography manager can also communicate feedback/changes to the SAHPRA and HPCSA where relevant, keep detailed records/logs on their improvement initiatives, and update the departmental QA programme accordingly.

OBJECTIVE 2.3.2.

Report patient outcomes

ACTION(S)

- At the national level, feedback mechanisms through which patient outcomes can be reported by the radiography departments should be considered. The radiography department manager and/or medical physicist are responsible for reporting patient radiation incidents/accidents and potential risks to the SAHPRA, similar to the current regulatory guidelines (SAHPRA, 2022c:1-13).
- Patient outcomes can further be reported through published works by conducting research on the IPRDT solution and process implemented within the South African healthcare system, similar to the case reports published in Finland by Seuri et al. (2013:771).

MOTIVATION(S)
Reporting of patient outcomes is an important method to support the notion of ongoing quality improvement related to healthcare service delivery. Furthermore, similar measures may ensure that the patient's radiation dose is kept as low as reasonably achievable. The latter may potentially increase professional accountability and responsibility, which seemed to be lacking in current practice, according to the findings of the current study.

6.3. CONCLUSION

The guidelines presented in this chapter provide practical considerations for the relevant stakeholders to assist them in approaching the implementation of the model within the South African healthcare system. Following the researcher's efforts to create awareness of the model, it is recommended that the NDoH, through the provincial health departments, recognise these guidelines and use them to strengthen the justification and optimisation principles associated with patient radiation safety. The next chapter, Chapter Seven, concludes the research study.

CHAPTER SEVEN

REFLECTIONS, CONTRIBUTIONS, AND FUTURE DIRECTIONS

"What would life be if we had no courage to attempt anything?"

Vincent van Gogh

7.1. INTRODUCTION

In Chapter Six, I described the guidelines to support the implementation of individual patient radiation dose tracking (IPRDT) within the South African healthcare system. It is proposed that these guidelines be adopted by the National Department of Health (NDoH) to initiate and drive a collaborative approach to create an improved and radiation-conscious environment at a national level through a mandated form of practice. Chapter Seven concludes the research process by describing the implications of the findings for improved radiation safety and ethical clinical practice. It further explains the challenges faced, the limitations, and recommendations. Following this, the original contribution of the study, followed by my personal reflections, is described.

7.2. CONCLUDING THE RESEARCH PROCESS

This study adopted a qualitative, exploratory, contextual, descriptive, and model development design, allowing me to become directly involved in the research process. This was important to develop an understanding of how IPRDT can be accomplished in SA. The participants shared their lived experiences, expert knowledge of patient radiation safety, and their views on the implementation of IPRDT. The understandings gained led to the synthesis of a central concept that informed the development of a model to guide the implementation of IPRDT within the South African healthcare system. The goals of the model are to strengthen current justification and optimisation practices for patient radiation safety and, potentially, to decrease the individual

patient's effective lifetime risk of developing radiation-induced injuries and cancers. The model was developed by following the four steps of Chinn et al. (2022:139-180): 1) a concept analysis, 2) the development of relationship statements, 3) the development and description of the model, and 4) guidelines to implement the model.

Step 1 included two phases: the identification of a central concept (Phase 1) and the development of a definition for the central concept and its classification (Phase 2). To achieve Phase 1, semi-structured one-on-one interviews were conducted with a purposively selected sample of qualified, actively registered radiographers, radiologists, and medical physicists from the Western Cape Province of South Africa (SA). In context, these professionals were considered knowledgeable about patient radiation safety for medical imaging purposes. A total of 26 participants took part in the study, during which their interviews were audio-recorded and transcribed for thematic analysis. The data were analysed throughout the data collection process, and the results were shared with the study supervisors at regular intervals. The following four themes were developed: 1) Knowledge and perceptions of IPRDT; 2) Factors affecting the implementation of IPRDT; 3) Considerations for clinical practice; and 4) A collaborative effort from stakeholders. Following this, a central concept was developed inductively by reflecting on the study participants' collective story alongside my reflective notes. The final central concept was, "**A collaborative approach to create an improved and radiation-conscious environment**."

During Phase 2 of the concept analysis, Step 1 was achieved by determining the aims and purpose of the analysis and identifying the use of the central concept before reaching a summative definition. This was facilitated by identifying the essential and related attributes for each individual concept (collaborative, approach, create, improved, radiation, conscious, and environment). This was achieved by conducting dictionary and subject/context-specific definitions. To conclude the concept analysis process, the central concept was classified using the technique by Dickoff et al. (1968:415-435) to determine the model agent, recipient, context, dynamics, procedure, and outcome. In Step 2 of the model development process, relationship statements were formulated to demonstrate the connections between the model elements. Four relationship statements were developed to aid in its simplicity. The relationship

statements allowed me to develop a conceptual map of the model, which paved the way forward for following the research process.

The third step allowed for the visual construction of the model to translate the central concept and its summative definition. The model was further described, referring to its purpose, theoretical assumptions, theoretical definitions, its context, and structure. To conclude this step, a panel of experts evaluated the draft model on the basis of its clarity, simplicity, generality, accessibility, and importance, as recommended by Chinn et al. (2022:170-176). Following the feedback received, amendments were made.

During the final step, guidelines for operationalising the model were developed deductively. These guidelines were developed for use by the NDoH to initiate a collaborative approach to create an improved and radiation-conscious environment by mandating the implementation of IPRDT within the South African healthcare system. Four guidelines were extended and derived from the summative definition of the central concept.

7.3. LIMITATIONS

This study did not encounter any significant challenges. The scope of the study and the recruitment process, however, can be considered as challenges. In view of the scope, I had to set clear boundaries for the study purpose, focusing on medical imaging examinations using ionising radiation. From a local perspective, little is known about IPRDT; thus, this model (Chapter 5, Figure 5.1) is deemed new. Through its development, the model serves as a starting point for the South African healthcare system to create an improved and radiation-conscious environment, in an attempt to reduce the presumed likelihood of individual patients developing radiation-induced injuries and/or cancers. Although the recipient of the model is limited to radiography departments, it is reasoned that the model can easily be adapted, transferred, and applied to other settings where ionising radiation is being used for medical imaging purposes. The same notion was echoed during the evaluation of the model. Recruitment, furthermore, was achieved at a slow pace, which delayed the data collection process. Potential participants were possibly dissuaded from participating

due to their busy work schedules and their unfamiliarity with the dynamics of research interviews.

Three limitations of the model were identified during engagement with the expert panel members. The first limitation was that no patients (or public) were included (as the users of ionising radiation medical imaging examinations), nor referring practitioners (due to their critical role in the justification process), or healthcare information technology (IT) professionals (for their knowledge and involvement in healthcare information and communication systems). While this was not an intention for this study, it is anticipated that exploring the perceptions of IPRDT in SA among these groups of individuals would contribute towards a broader understanding, representative of all the internal stakeholders in patient radiation safety.

The second limitation refers to the study focus being limited to ionising radiation medical imaging examinations for diagnostic purposes, and that it did not explore the inclusion of therapeutic radiation dose that is deliberately delivered to a patient. It is reasoned, however, that should it be considered advisable to include therapeutic radiation doses, these could potentially be integrated into the individual patient's lifetime healthcare record for dose tracking purposes.

The final limitation was that this study focused on the input from professionals within a single province of SA. It was suggested by an expert that a larger and more representative population across the country would have been preferable for increased transferability of the findings. Due to the contextual nature of the study, however, it is argued that similarities exist between the nine provinces in SA.

7.4. RECOMMENDATIONS FOR FUTURE RESEARCH

Although the model addressed the lack of guidelines for the implementation of IPRDT that is unique to the South African healthcare system, further research may be necessary to accommodate the previously identified study limitations. It is recommended that patients and referring practitioners be consulted on their perceptions of IPRDT, as well as healthcare IT professionals, for their input on the practical development and integration of a solution through the digital space.

Additionally, therapeutic radiation doses will need consideration to determine whether or not these have a place in the system. Obtaining a sample representative of all nine provinces in the country is something to consider for further studies in this area. Further research may also be needed to determine the medicolegal complexities associated with IPRDT. From this study, it relates to having access to a comprehensive, individual patient health record detailing each ionising radiation exposure and subsequent radiation dose, and stems from the participants being concerned about the risk of potential claims against medical negligence should a patient develop a radiation-induced injury and/or cancer. There could be other possible medico-legal issues that were not raised in this study, and further research focusing on this topic could offer valuable insights.

7.5. IMPLICATIONS FOR CLINICAL PRACTICE

The model responds to the need for guidelines to implement IPRDT within the South African healthcare system. It addresses and provides further insight into individual patient radiation dosimetry and the global debate regarding professional and ethical practice in patient radiation safety. The guidelines framework developed is seen as an enabler for the NDoH of SA to bridge the gap with global clinical practice. It provides a potential solution on how to strengthen the justification and optimisation practices, to improve the healthcare professionals' self-reported and perceived lack of responsibility and accountability for patient radiation safety. By implementing IPRDT and subsequently including the patient as an equal partner in their own care, it is reasoned that an improved clinical decision-making process can be achieved; and this, in turn, has the potential to increase public trust and confidence in the South African healthcare system. It is rationalised that the data stored on the national patient radiation dose database/registry could potentially be utilised as a databank to further develop diagnostic reference levels (DRLs).

7.6. ORIGINAL CONTRIBUTION

The model developed in this study is grounded in the unique context of the South African healthcare system. The model, being the first of its kind, was developed from a local perspective as a pathway for relevant stakeholders to implement IPRDT. It aims

to build on and improve adherence to current patient radiation safety practices, which can be directly transferred to clinical practice through a collaborative approach to create an improved and radiation-conscious environment.

7.7. PERSONAL REFLECTIONS

I have grown substantially throughout my doctoral journey: as a person, a qualified diagnostic radiographer, an educator, and a researcher. Staying true to my personality type as identified in Chapter One (1.12.1), I feel immensely proud of the contribution I have made. Although it may be small, and whilst acknowledging that this is only the beginning of IPRDT for SA, I am happy to have contributed. As an educator, I can use my newly gained understanding of individual patient radiation dosimetry in my learning and teaching practices, emphasising the importance of IPRDT. As a researcher, I have learnt the power and impact of interprofessional collaborative practice in creating new knowledge, especially in complex and multifaceted research topics such as IPRDT. What I have come to realise is that changes in our opinions and practices about patient radiation safety are inevitable; and so we need to be proactive, be brave, and base our conclusions on evidence-based practice findings.

7.8. CONCLUSION

To conclude this thesis, I consider that the study has fulfilled its aim of exploring how IPRDT could be achieved from the perspectives of radiographers, radiologists, and medical physicists in the Western Cape Province of SA. Based on this understanding, a model has been developed to guide the implementation of IPRDT within the South African healthcare system. This was done to strengthen the current justification and optimisation practices associated with patient radiation safety and to decrease the presumed cumulative lifetime risk of individual patients developing radiation-induced injuries and cancers. The model is considered a novel contribution to the body of knowledge in the field. With that being said, and upon further reflection, I cannot help but wonder about the future role of artificial intelligence in patient radiation safety and the implementation of IPRDT.

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APPENDIX A: PERMISSION TO USE THEORETICAL FRAMEWORK FIGURE

Outlook

Re: Request to use figure in doctoral thesis

From Maria Santana <mjsantan@ucalgary.ca>
Date Thu 10/31/2024 1:39 AM
To Gerhardus Koch <KOCHG@cput.ac.za>

Hi Gerhardus,

Thanks for your message.
You do have my permission to include Fig #1 from the HEX paper in your manuscript with the appropriate reference, eg, Santana et al 2017.

Best wishes,
Maria

Maria Jose Santana, MPharm, PhD

Professor

Patient and Family-centred care Scientist
Child Health & Wellness Researcher
Departments of Paediatrics and Community Health Sciences

Director of the Person-centred Care Research Team, https://cumming.ucalgary.ca/research/person-centred-care
Academic Director, Patient and Community Engagement Research, PaCER, https://www.ucalgary.ca/patient-community-engagement-research

Cumming School of Medicine
Alberta Children Hospital Research Institute
University of Calgary

Provincial Lead, Patient Engagement, Alberta SPOR

Online connection site: Albertans4HealthResearch.ca || Web: www.absporu.ca

APPENDIX B: INTERVIEW GUIDE

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES
FACULTY OF HEALTH SCIENCES

INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

Dear participant,

Thank you for taking the time to consider participation in this research study. The interviews will be conducted in the following two methods: 1) a face-to-face interview or 2) a virtual interview using online platforms such as Microsoft Teams, Zoom, etc. The interview method will be decided upon by the participant. No written responses from the participants will be included for data analysis.

As explained in the Research Information Letter, a set of pre-determined, open-ended questions will be used as a guide and will be asked during the individual (one-on-one) semi-structured interviews. Probing questions will also be asked by the researcher based on your answers. This will be done to get a better understanding of the information you shared. The pre-determined, open-ended questions, as informed by literature, are as follows:

1) What is your understanding of individual patient radiation dose tracking?
2) Can you provide an example of how to track an individual patient's radiation dose?
3) At which level (i.e., institutional, provincial, or national) should it be implemented?
4) Which type of patients (i.e., age groups) should be considered?
5) What resources (i.e., hardware and software) will be required?
6) What type of information (i.e., date of examination, etc.) needs to be recorded?
7) Which medical imaging examinations/modalities should be included?
8) Which unit of measurement should be used to track the individual patient's radiation dose?
9) Out of the following options, how should individual patient radiation dose tracking be recorded: a) the type and number of imaging examinations, b) the cumulative radiation dose, or c) both?

10) Who should be involved with and responsible for tracking an individual patient's radiation dose, and what should their individual roles entail?
11) How can data security, patient confidentiality, and informed consent be catered to?
12) Do you foresee any challenges with implementing individual patient radiation dose tracking, and how can these challenges be overcome?
13) Do you have any other recommendations/ suggestions/ comments?

Yours faithfully,

Gerhardus George Visser Koch
Researcher

APPENDIX C: PARTICIPANT RESEARCH INFORMATION LETTER

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES
FACULTY OF HEALTH SCIENCES

INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

Dear participant,

Thank you for taking the time to read this letter and for considering participation in this research study.

Researcher

Full names and surname	: Gerhardus George Visser Koch
Highest qualification	: MHSc: Radiography (D)

Study supervisors

1. Full names and surname : Professor Penelope Engel-Hills
   Highest qualification : DTech: Rad

2. Full names and surname : Professor Hesta Friedrich-Nel
   Highest qualification : PhD: HPE

3. Full names and surname : Professor Richard Pitcher
   Highest qualification : MBChB; Fellowship of the College of Radiologists; PhD

Brief background and rationale of the research study

Individual patient radiation dose tracking during medical imaging is receiving attention from international platforms such as the International Atomic Energy Agency and the

International Commission on Radiological Protection. This is due to growing concerns of patients in the modern era, having an increased probability of exposure to unwarranted medical radiation and their effective lifetime risk of acquiring radiation-induced injuries and cancers. According to the literature, individual patient radiation dose tracking in the modern era has been found to be both possible and beneficial. Selected countries abroad have already started the implementation thereof. In South Africa (SA), however, a paucity of literature prevails, and the need for further research exists. Therefore, the aim of this study is to explore how individual patient radiation dose tracking could be achieved according to the radiographers', radiologists', and medical physicists' perspectives. Based on this understanding, a model will be developed to facilitate the design considerations on how individual patient radiation dose tracking could be integrated within the South African healthcare system. This will be done to promote the current justification and optimisation practices associated with radiation protection and to decrease the effective lifetime risk of individual patients developing radiation-induced injuries and cancers.

Outline of the procedures

You are requested to participate in an individual (one-on-one) semi-structured interview with the researcher. A pre-defined set of questions will be used as a guide and will be asked by the researcher. The questions will be used to explore and describe how individual patient radiation dose tracking can be integrated within the South African healthcare system. The study will include participation from qualified radiographers, radiologists, and medical physicists registered with the Health Professions Council of South Africa in the Western Cape. The interviews will be audio-recorded for further data analysis and coding. A participant consent form for the interview and a participant consent form for the interview to be audio-recorded will be provided for you to sign. The researcher will share the findings (themes and subthemes) of the research study via email communication with the participants, individually, as part of member checking.

Risks or discomforts

The principle of non-maleficence will be adhered to by avoiding harm to all the study participants. No form of physical or emotional harm will, therefore, be brought upon any of the participants.

Withdrawal from the study

You may withdraw from the research study at any given time, without penalty or consequence.

Financial implications

No participant will receive any form of remuneration for participating in this study, and no participant will be liable for financial contributions towards this research study.

Confidentiality

The information provided by you will be treated as highly confidential, and the results will be reported anonymously.

Benefits

You will contribute to the development of a model relating to individual patient radiation dose tracking, a first of its kind in SA.

Persons to contact in the event of any problems or queries

Should you have any further questions or concerns about the research study, you may contact the researcher via email at kochg@cput.ac.za. Alternatively, you may contact the academic supervisor, Professor Penelope Engel-Hills, via email at engelhills@cput.ac.za. Alternatively, you can also contact the Research Ethics Committee at the Cape Peninsula University, Ms Nomathemba Seth, via email at sethn@cput.ac.za.

Yours faithfully,

Gerhardus George Visser Koch
Researcher

APPENDIX D: PARTICIPANT RESEARCH CONSENT FORM

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES
FACULTY OF HEALTH SCIENCES

INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

Please initial each box below.

☐

I confirm that I have read and understand the information letter for the above study. I have had the opportunity to consider the information, ask questions, and have had these answered satisfactorily.

☐

I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐

I agree to take part in the above study and consent to adhere to the regulations defining the Protection of Personal Information Act.

Name and surname of participant	Signature of participant	Date
Name and surname of researcher	Signature of researcher	Date

APPENDIX E: PARTICIPANT CONSENT FORM FOR AUDIO RECORDINGS

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES
FACULTY OF HEALTH SCIENCES

INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

Please initial each box below.

☐

I hereby give consent for my interview, conducted as part of the above study, to be audio-recorded.

☐

I understand that my personal details and identifying data will be changed to protect my identity. The audio files used for recording my interview will be destroyed two years after publication of the research.

☐

I have read this consent letter and have been given the opportunity to ask questions.

Name and surname of participant	Signature of participant	Date
Name and surname of researcher	Signature of researcher	Date

APPENDIX F: REFLECTIVE REPORT TEMPLATE

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES
FACULTY OF HEALTH SCIENCES

INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

PARTICIPANT DESCRIPTOR:	
DATE AND TIME:	

LOGISTICS:

OBSERVATIONAL NOTES:

PERSONAL NOTES:

METHODOLOGICAL NOTES:

THEORETICAL NOTES:

APPENDIX G: SIGNED TRANSCRIBER CONFIDENTIALITY AGREEMENT

DEPARTMENT OF MEDICAL IMAGING AND THERAPEUTIC SCIENCES
FACULTY OF HEALTH SCIENCES

INDIVIDUAL PATIENT RADIATION DOSE TRACKING GUIDELINES FOR THE SOUTH AFRICAN HEALTHCARE SYSTEM

I, Elizabeth de Graaf
hereby declare that I understand and agree to the following conditions with regard to the transcription of the audio recordings.

1. I understand that the audio recordings are received for the purpose of transcribing records of interviews held with the participants of a research study.
2. I undertake to treat all audio files received as confidential content to which only I will have access. I will keep the audio files and any copied material secured (e.g., a password-protected device and/or stowed in a locked cupboard).
3. I will return all copies to the researcher on completion of the transcription.

Elizabeth de Graaf

Name and surname of transcriber

Signature of transcriber

4 March 2022

Date

APPENDIX H: ETHICAL CLEARANCE CERTIFICATE

Cape Peninsula University of Technology

HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HWS-REC)
Registration Number NHREC: REC- 230408-014

P.O. Box 1906 • Bellville 7535 South Africa
Symphony Road Bellville 7535
Tel: +27 21 959 6917
Email: sethn@cput.ac.za

31 October 2024 –
REC Approval Reference No:
CPUT/HWS-REC 2021/H3 - Renewal

Faculty of Health and Wellness Sciences

Dear Mr. Koch

Re: APPLICATION TO THE CPUT HWS-REC FOR ETHICS CLEARANCE

Approval was granted by the Health and Wellness Sciences-REC to **Mr. G Koch** for ethical clearance. This approval is for research activities related to research for **Mr. G Koch** at Cape Peninsula University of Technology.

TITLE: **Individual patient radiation dose tracking guidelines for the South African healthcare system**

Supervisors: Prof. P Engel-Hills, Prof .H Friedrich-Nel and Prof. R Pitcher

Comment:

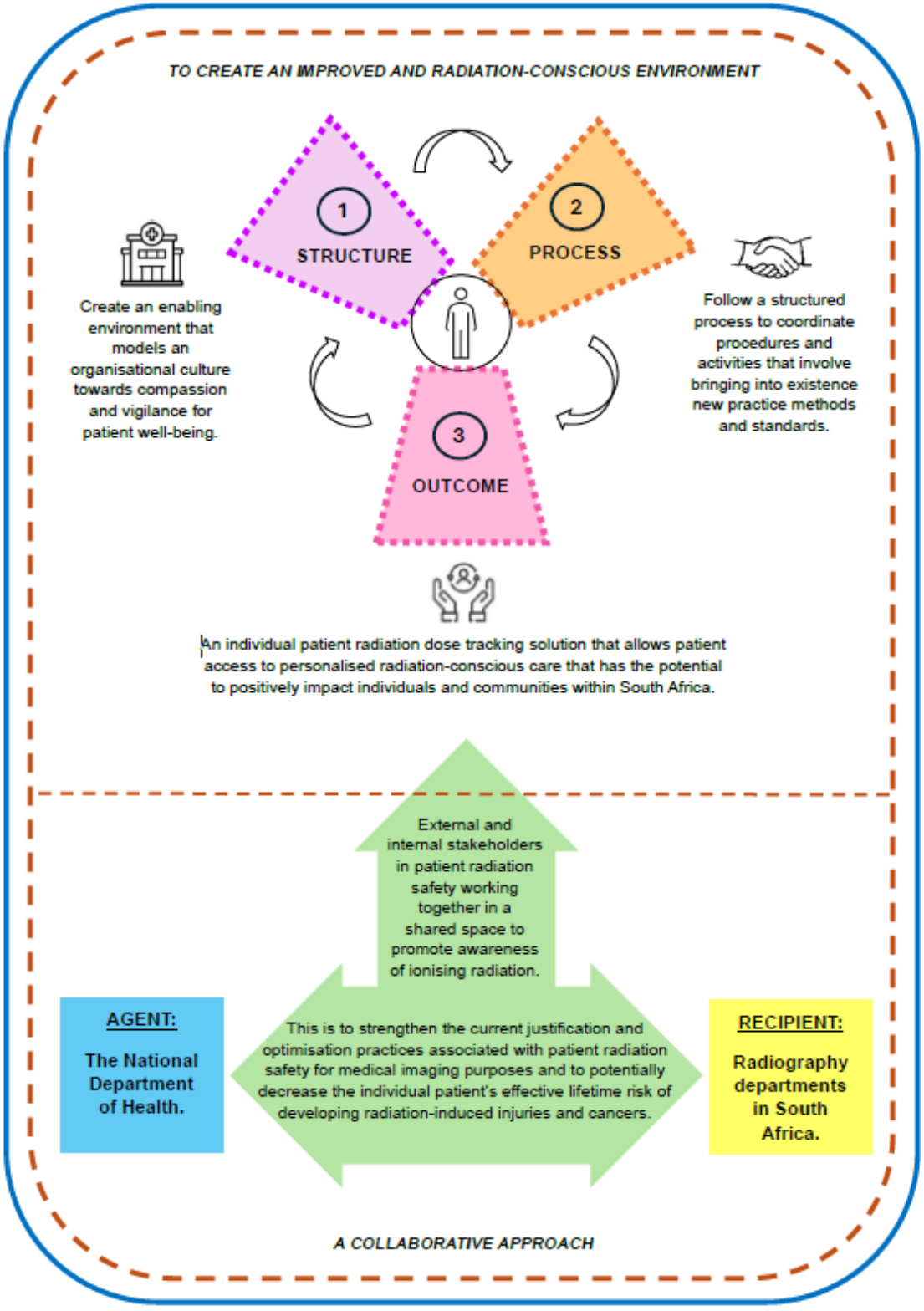
Approval will not extend beyond 01 November 2025. An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the CPUT HWS-REC in December of that particular year, for the CPUT HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

Dr. Samantha Meyer
Deputy Chairperson – Research Ethics Committee
Faculty of Health and Wellness Sciences

APPENDIX I: DRAFT MODEL TO GUIDE THE IMPLEMENTATION OF INDIVIDUAL PATIENT RADIATION DOSE TRACKING WITHIN THE SOUTH AFRICAN HEALTHCARE SYSTEM



APPENDIX J: MODEL EVALUATION FORM

A MODEL TO GUIDE THE IMPLEMENTATION OF INDIVIDUAL PATIENT RADIATION DOSE TRACKING WITHIN THE SOUTH AFRICAN HEALTHCARE SYSTEM

Dear expert panel member,

Thank you for taking the time to evaluate the above-mentioned model. The evaluation should take you approximately five minutes to complete. The questions were developed based on the criteria recommended by Chinn et al. (2022), which pertain to the clarity, simplicity, generality, accessibility, and importance of the model. In addition, kindly also indicate your years of experience in model development and select your area of expertise (profession).

Please use the link below to access and complete the evaluation form:
https://docs.google.com/forms/d/e/1FAIpQLScbcfMDxY1vb-cQiUuMVrz5p2jWRvQYP8vNBGJw_AwI7ZVAFQ/viewform?usp=header

By completing this form, you consent to your participation as an expert panel member. Participation is voluntary, and the feedback you provide will be reported on in an anonymous manner. Therefore, responses cannot be traced to the individual providing the feedback.

Should you have any questions/concerns, please feel free to reach out to me via email, kochg@cput.ac.za, or to the principal supervisor of the research study, Professor Penelope Engel-Hills (ENGELHILLSP@cput.ac.za).

Yours sincerely,
Gerhardus George Visser Koch