Cape Peninsula University of Technology

Diagnostic radiography requests in Zimbabwe's public Hospital complex: completeness, accuracy and justification

by

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DECLARATION

I, LidionSibanda, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

September 2012

Signed **Date**

Abstract

Background

Complete, accurate and justified radiological examination requests are prerequisite to radiological exposures. However, global research shows evidence of high numbers of incomplete and inaccurate requests as well as that up to 77% radiological exposures are unjustified. Plain lumbar spine and plain skull radiology examinations are reported as being procedures that generate high dose and a low diagnostic yield. This study was designed to objectively measure the completeness, accuracy and justification of these two examinations in an effort to make inferences that will contribute to an improved radiology service. This research could therefore have positive effects on optimisation of radiation protection in Zimbabwe.

Methodology

A non participatory prospective descriptive analytical document review of quota sampled radiological request forms for 200 plain skull and 200 plain lumbar spine examinations was employed. Data was captured using structured data collection instruments designed and tested by the researcher for this study. The instrument was designed using the IAEA-HHS4 (2010) minimum prescribed request data as a framework and adding additional form fields found to be relevant through a review of all identified radiological request template forms in use at the research site. Data analysis involved central tendency measures and inferential statistics.

Results: The central tendency demonstrated for the two examinations was that generally referrers for plain lumbar spine and for plain skull radiology would respectively provide 38.9 +/- 0.6% and 40.2+/-0.5% overall examination request information. This information was significantly below expectation. There was however no significant difference between the samples' means for the two examinations. The tendency demonstrated in patient information for lumbar spine and skull requests was that generally referrers would respectively provide 48.4 +/- 0.8% and 49.5+/- 0.8% patient information. These values were inclusive of each other and they were significantly (p=0.00 Sig.) below expectation. There was however no significant difference between the two examinations' data. The tendency demonstrated for examination information was that referrers for the research site would generally provide 29.8+/-0.8% (lumbar) and 32.6+/-0.8% (Skull) examination information. These values were significantly (p=0.000 Sig.) below expectation and demonstrated a significant difference between the sample means for the two examinations. With respect to referrer information, the tendency demonstrated was that generally referrers for plain lumbar spine and for plain skull examinations would respectively provide 38+/- 1% and 38.5 +/- 0.8% referrer identification information. These were significantly below expectation (p= 0.000 Sig.) but there was no significant difference between the samples' means with respect to referrer information. With respect to accuracy of request data, it was observed that 5% plain lumbar spine and 3% plain skull requests were specific in so far as information documented on request forms could unambiguously identify the area to be imaged. It was also observed that 22.5% (lumbar spine) and 12% (skull) examination requests were indicated and therefore justified. All requests forms were found to be legible.

Conclusions: Generally, referrers to this research site tend to provide incomplete, inaccurate and unjustified radiological request data. The observed levels of completeness, accuracy and justification of requests were generally consistent between the two examinations relative to expectation. These levels had medico-legal implications and negative effects on optimisation of radiation protection to patients. Further research to establish causes of this variance in referral behaviour is recommended. The researcher also recommends further research to establish whether there is an association between requested examination and completeness, accuracy and justification of diagnostic radiology examination requests.

Keywords: Radiation protection, radiological request**,** complete request, accurate request, justified request, plain skull imaging, plain lumbar spine imaging.

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May this success I find myself bewildered with not be a gratification to me alone but for all of you as well. To this end may your assistance to me bring you all the blessings your individual hearts would wish for?

DEDICATION

This thesis is dedicated to my mother, Olita, and to my mother in-law Selina who after inspiring me to undertake professional studies in radiography both never lived to see me through this study. May their souls rest in eternal peace with assurance that the knowledge gained in this study will be used in radiography profession to ensure that precision and perfection are not a dispensable luxury, but a simple necessity.

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THE PROBLEM AND ITS SETTING

> The Zimbabwe Ministry of Health and Child Welfare (ZMHCW) wrote in Zimbabwe's National Health Strategy, 2009 – 2013: Equity and Quality in Health-A People's Right that, "…the various studies and surveys carried out in Zimbabwe over the last three years point towards inadequacies in the six health system building blocks that are prerequisites for a functional health delivery system …" (ZMHCW, 2009: 8).

1.1 Introduction

This chapter begins by a discussion of a referral for radiology. The concept of complete, accurate and justified radiological requests is explained as part of referral for radiology. This is supported by the discussion of the rationale for doing this study. In this same chapter a description of the Zimbabwean context with respect to referral for radiology and the research problem is presented. This is followed by the research purpose, objectives, delimitation and research site. The chapter ends with a discussion of the research methodology, explaining the assumptions and the thesis outline.

1.1.1 Referral for radiology

A referral for radiology is generally regarded as a request by a referrer for a specialist opinion on the patient's clinical diagnosis (ECRP, 2008:15). According to the Statutory Instrument number 5 of 2004 (Zimbabwe), a referrer for radiology is a health professional (ZMHCW, 2004). The term health professional means an individual who has been accredited through appropriate national procedures to practice a profession related to health (ZMHCW, 2004). A referral for radiology, generally known as a radiology request, is normally made on a radiological request form a sample of which is shown in Appendix A. Radiological Request Forms (RRFs) are template forms whose form fields define minimum radiology request information required by a radiology department to review the justification of the request, decide on examination protocol and to verify radiology request information before exposing the patient (ECRP, 2000:11; IAEA, 2008:13). They are medico-legal documents and form the framework for requesting radiology examinations (Adebayo *et al.,* 2009; Oswal *et al.,* 2009; Longrigg & Channon, 2006; Jumah *et al.,* 1995). The content of radiological request forms must therefore be complete and accurate in order to facilitate justification of exposures (IAEA, 2008: 9 and Pelletier *et al*, 2005). This ensures that should medical malpractice be alleged, information documented on the request form should withstand scrutiny in court (Spurgeon *et al.,* 2011). Furthermore, the information contained in a request form that is completely and accurately filled in forms an integral part of note-keeping in radiology and therefore allows the radiology department to provide informed and justified care (Adebayo *et al.,* 2009; Oswal *et al.,* 2009; Longrigg & Channon, 2006; Jumah *et al.,* 1995). In this regard complete, accurate and justified radiological examination requests comprise three essential components of radiology practice which are prerequisite to a functional radiology referral system (Rehani, 2010; Oswal *et al.,* 2009; IAEA, 2008: 9; Remedios & McCoubrie, 2007).

The Radiation Protection of Patients Unit (RPoP) of the International Atomic Energy Agency (IAEA) conducted consultations in the area of diagnostic radiology and established that there was a significant level of inappropriate usage of diagnostic radiology (IAEA, 2008: 1). In its conclusions, the IAEA (2008: 1) stresses that there is need for improved communication of request data and it emphasises that, in this way, justification of diagnostic radiological exposures would be facilitated. Therefore, the design of radiological request forms and the compliance of referrers in completing these forms are essential for effective justification of radiological exposures (Oswal *et al.,* 2009; IAEA, 2008: 1).

Many researchers have investigated completeness, accuracy and justification of radiological requests (Akinola *et al.,* 2010; Oswa l*et al.,* 2009; Ya'ish *et al.,* 2007; Adebayo *et al.,* 2005; Triantopoulou *et al.*, 2005; Eccles *et al.,* 2001; Jumah *et al.,* 1995; McNally *et al.,* 1995: 640-642; Oakeshott *et al.*, 1994:197-200; Maclaren *et al.*, 1993:138-144; Scally, 1993 and Cook *et al*., 2003). This is consistent with IAEA (2008). However, none of these researches pertains to completeness, accuracy and justification of radiological requests for Zimbabwe.

1.1.2 Prescribed criteria for completeness of radiological request forms

Completeness of radiological request information is underpinned in the design of radiological request template forms which in turn form a framework for requesting a radiological examination. The use of radiological request forms in radiology attempts to provide standard radiological request information across the board for all patients in an effort to provide standardised care (Spurgeon *et al.*, 2011; IAEA HHS4, 2010; Pelletier *et al.,* 2005). Referrers are expected to fully complete the form fields in the template form (IAEA HHS4, 2010). The IAEA (2008: 26) reported the essential data for a good radiological request (Table 1.1):

Table1.1: Essential content of radiological request forms (IAEA, 2008)

Patient Information	Examination information	Referrer information
Patient's name	Clinical timeliness requested	Referring practitioner's name
Unique patient identifier	Ambulatory status	Contact details
Weight	Previous examinations with date(s)	
Height	Infectious status	
Sex	Medical device status	
Age	Medication status	
Date of birth	Renal function status	
Address	Allergy status	
Contact details, such as hospital ward or phone number	Imaging modality requested	
Pregnancy status	Body region to be examined	
	Clinical question	
	Supportive appropriate clinical information	
	Date of request	

Completing a request form with so many form fields would require a lot of time. It is not surprising therefore that this "essential content" was later summarised by IAEA-HHS4 (2010: 29) into minimum content of radiological request forms (Table 1.2):

Table 1.2: Minimum content of radiological request forms (IAEA HHS4, 2010)

Patient Information	Examination information	Referrer information
Patient's name	Study requested	Referring practitioner's signature
Date of birth	Clinical indication	Printed name and
Address	Date of request	Contact details
Contact details, such as hospital ward or phone number		
Pregnancy status		

According to IAEA-HHS4 (2010: 29), a radiological request form that has this prescribed information completely and accurately filled in meets minimum prescribed radiological request information**.** In this review**,** a radiology department would identify the diagnosis, ascertain the risk benefit associated with the request, determine if the requested examination may be substituted with non ionising radiation examination and also determine the examination protocol (IAEA, 2008: 26). Additionally, the radiology department would be able to identify patient specific factors (e.g. pacemakers and dementia) that would otherwise affect the conduct of the examination (IAEA, 2008: 26)

1.1.3 Prescribed criteria for accuracy of examination information

Radiological examinations have cost, legal and ionising radiation risks implications (Spurgeon *et al.,* 2011, Pelletier *et al*, 2005, IAEA, 2008: 26) and therefore the importance of accurate radiological requests can never be over emphasised. The referrer is expected to fully specify, without ambiguity, the region to be investigated in order to avoid repeat exposures for example (IAEA-HHS4, 2010; IAEA, 2008: 26). The request must be supported by evidence captured in the clinical history of the patient (IAEA, 2008:26). Therefore for a radiological request form to be deemed accurate with respect to the requested examination the study requested must be explicitly defined without ambiguity.

1.1.4 Prescribed criteria for the justification of Radiological Requests

The radiation protection of Patients Unit (RPoP) of the IAEA has expressed concern about the effectiveness of justification of diagnostic radiology exposures (IAEA, 2008). The concern stems from significant levels of inappropriate usage of diagnostic radiology coupled with poor level of awareness of dose and risks among both referrers and radiology staff (IAEA, 2008). For this reason justification of ionising radiation exposures has been described as an important part of ionising radiation protection (Rehani, 2010; Emanuel & Fuchs, 2008; IAEA, 2008; ACR, 2009; RCR, 2007; ESR, 2004; Levin & Rao, 2004). In this endeavour justification of a radiological request has been defined as patient specific and informed by clinical assessment of the patient, referral guidelines and examination availability (IAEA-HHS4, 2010: 28-30; Rehani, 2010; IAEA, 2008; RCR, 2007). As a fundamental principle in radiology, justification requires that the diagnostic benefits of the examination outweigh the risks for the patient (IAEA, 2008). This is particularly important if the patient is pregnant or potentially pregnant, breastfeeding or paediatric (IAEA-HHS4, 2010: 28-30). Intuitively, justification information is inherent in examination request information (IAEA, 2009; IAEA, 2008; ICRP-103, 2007, ECRP, 2000). Therefore requested examination information which essentially comprises clinical history, diagnosis and indication define three important aspects that are required for the review of justification of exposures. In this study, the measure for justification will be restricted to whether the clinical indication for the examination is one of those which can be found on the criteria for requesting a plain skull x-ray or plain lumbar spine x-ray (refer to tables 2.1: 19, 2.2: 22 and 2.3: 24).

1.2 Rationale

In this study the researcher investigated whether radiology request forms (RRF'S) are complete, accurate and justified. The importance of complete, accurate and justified requests can never be overemphasised. IAEA (2008: 9) explains that where there is incomplete and inaccurate radiological request information communication between the referrer and the radiology department is incomplete, and/or unsuccessful. Implications of an inadequate communication pathway include inadequate documented dialogue on balancing benefits with the risks to patients and this may have lethal effects (IAEA, 2008: 9; Pelletier et al., 2005).

Furthermore, plain skull and plain lumbar spine radiology requests were common at this research site. These examinations have been described as having low diagnostic yield, a high radiation dose and are mostly unjustified (Bosch *et al*, 2003; Khoo *et al.*, 2003; Kerry *et al*, 2000). A research that will determine whether these examination requests were actually indicated in light of this background information was of great value in furthering radiation protection of patients.

The researcher was therefore motivated by:

- High global number (up to 77%) of unjustified radiological examinations reported by IAEA (2008:9).
- Inadequacies of radiation protection services by the Radiation Protection Authority of Zimbabwe that are reported by Ministry of Health (ZMHCW, 2009: 95). This was viewed in respect to the report by IAEA (2008:1) that justification may be a significant factor in preventing radiation induced cancer (IAEA, 2008:1).
- Documented evidence that information contained in a request form that is completely and accurately filled is an integral part of clinical documentation in radiology and that this information allows the radiology department to provide informed and justified care (Oswal *et al.,* 2009).
- Report by IAEA (2008: 9) that complete, accurate and justified radiological examination requests comprise three essential components of radiology practice and are prerequisite for a functional radiology referral system.
- Global research that plain lumbar spine and plain skull radiology in most cases have little benefit to the patient (IAEA, 2009; Bosch *et al*, 2003; Khoo *et al.*, 2003; Kerry *et al*, 2000).

1.3 Background

Diagnostic radiology services in Zimbabwe are to a large extent provided by the government through its public health sector. The public health sector has a well established medical imaging system in all district, provincial and central hospitals (ZMHCW, 2009: 94). The referral system for the country requires that the patient be referred from primary to secondary and then a tertiary hospital as may be necessary. It is understood that referral to the radiology department is generally a request for a specialist opinion that is documented on a request form as shown in a sample request form (Appendix A).

The Zimbabwe Ministry of Health and Child welfare (ZMHCW, 2009) report that the activities of its Radiation Protection Authority: "…authorization, review and assessment, inspection and enforcement, development of regulations and guides, radioactive waste management and personnel monitoring..." have not been successfully implemented thereby compromising radiation protection and safety. In Zimbabwe, all sites using ionising radiation fall under the regulatory authority of the Radiation Protection Authority of Zimbabwe (RPAZ) which is empowered by the Statutory Instrument Number 5 of 2004 to regulate ionising radiation exposures (ZMHCW, 2009). The Zimbabwe Ministry of Health and Child Welfare is currently revising the content of this statutory instrument and is also recruiting personnel to revive full function of the Radiation Protection Authority of Zimbabwe (ZMHCW, 2009). Consistent with Triantopoulou *et al.*, (2005) the Zimbabwe Ministry of Health and Child welfare (ZMHCW, 2009) through its Radiation Protection Authority of Zimbabwe (Radiation Protection S.I. No. 5/2004) prescribes that the referrer (medical practitioner) has the legal responsibility to compile and communicate radiological examination request data to the radiology department. On its part the radiology department has the legal responsibility to review the requests for the justification of exposure before proceeding with the examination. This protocol presupposes that the radiological request forms have adequate form fields that are accurately and completely filled in (Triantopoulou *et al.*, 2005).

1.4 Research Problem

An overview of the rationale and background suggests the existence of a problem with respect to continued use of ionising radiation in an environment that has no functional radiation protection monitoring authority (ZMHCW, 2009: 95). This was compounded by background information that there was a variety of radiological request template form designs in circulation. Although ionising radiation is harmful further information exists that globally, a significant fraction (22-77%) of radiological examinations are unjustified (IAEA, 2008: 8). Therefore any effort aimed at reviewing ionising radiation exposures for the research site had possible positive effects on patient management. Furthermore, plain lumbar spine and plain skull radiology examinations have been described as having a low diagnostic yield and a high radiation dose (IAEA, 2009; Bosch *et al*, 2003; Khoo *et al.*, 2003; Kerry *et al*, 2000). Consequently, because of the harmful effects of ionising radiation a review of these requests with respect to completeness, accuracy and justification of radiological requests was of great potential benefit to the patient population and indeed to radiation protection policy makers for the hospital complex.

1.5 Research aim

In light of this research problem, a prospective descriptive analytical document review of completeness, accuracy and justification of requests for the research site was done in order to make statistical inferences about radiological request data for the hospital complex. This involved quantification of the information presented in all the blank radiological request template forms in order to develop an instrument which incorporated all aspects of the templates in circulation. These instruments [Appendix C (Skull) & Appendix D (Lumbar spine)] were then applied to a calculated sample of 200 plain skull and 200 plain lumbar spine radiological examinations, respectively, in order to determine completeness, accuracy and justification of radiological examination requests data for these two examinations. This issue was approached by reviewing documented radiological examination requests for the Bulawayo hospital complex in Zimbabwe. Inferences derived from this analysis allowed the researcher to make informed recommendations towards the provision of justified care across examinations (Pelletier *et al.,* 2011; Oswal *et al.,* 2009; Spurgeon, 2005).

1.5.1 Research question

In order to fulfil the purpose of this study, the following research question was asked:

How do the documented diagnostic radiology examination requests for plain lumbar spine and for plain skull radiology received at the Bulawayo hospital complex compare with the prescribed examination request information?

1.5.1.1 Research sub questions

In order to answer this question the following sub-questions were asked:

a. How do the radiology request for plain lumbar spine and plain skull radiology compare with the information prescribed in the respective data collection instruments? A document review of 200 plain skull and 200 plain lumbar spine radiology examination requests was conducted to identify the presence of patient information, examination information and referrer information.
b. How do the radiology request for plain skull and plain lumbar spine compare with one another? A document review of 200 plain skull and 200 plain lumbar spine requests was conducted to identify areas of consistency between the two examinations with respect to patient information, examination information and referrer information, accuracy of requests and justification of requests information.
c. How accurate are the requests in that they specify unambiguously the exact anatomical area to be imaged? A document review of 200 plain skull and 200 plain lumbar spine radiology examination requests was conducted in order to identify the

presence/absence of information that specified without ambiguity the area to be imaged.

d. Were the requests for plain skull and plain lumbar spine x-rays justified in terms of being clinically indicated (meeting at least one indication as prescribed on tables 2.2 and 2.3)? A document review of examination request information contained in 200 plain skull and 200 plain lumbar spine request forms was conducted in order to identify the presence/absence of an indication for the examination (Refer to Appendix C and Appendix D)

In order to answer sub-questions a, b, c and d, the data collection instruments (Appendix C & Appendix D) developed by the researcher from literature review and items on all the existing radiological request template forms was used as reference criteria for the review of the completeness, accuracy and justification of a calculated sample of radiological request forms. In this review the minimum prescribed criteria (IAEA-HHS4, 2010) was used as the expected score while the overall criteria derived from literature review plus the document review of existing template forms was used as the possible score.

1.6 Delimitation of the research

The site of this study was the radiology department of a referral hospital complex situated in Bulawayo. The complex has five hospitals with one radiology department which also serves as the referral centre for five provinces. There are two ways in which this thesis project was delimited:

a) The study reviewed only those radiological requests that came in the form of radiological request forms. These requests were reviewed for completeness, accuracy and justification of radiological requests against information prescribed in the data collection instrument (Appendices C & D).
b) The radiological request forms (RRFs) and radiological examination requests for plain lumbar spine and plain skull reviewed were those identified in the Bulawayo Hospital complex during the data collection between 26/04/2011 and 19/08/2011.

1.7 Research site

To appreciate this study, it is important to give a contextual overview of the research. This is important because it allows the reader to understand the environment in which the study was conducted and to appreciate how these conditions affected this study.

The study was carried out in a Bulawayo hospital complex in Zimbabwe. The hospital complex comprises a group of five hospitals located in the same campus and sharing a common radiology department. The individual hospitals within the complex are defined according to the service they provide such as Infectious Hospital, Orthopaedic Hospital and Eye Hospital. In addition, the radiology department serves as a referral centre for primary and secondary health centres from across five provinces. The patients comprise both private and public hospital referrals. This diversity of referrals is important in that it provides room to generalise results over a wider population of Zimbabwe.

The radiology department is experiencing an exponential use of diagnostic imaging which is characterised by a packed waiting area and long waiting times. The radiology department has one radiologist and four radiographers with one of the four dedicated to ultrasound imaging. The hospital complex is also a training hospital for two local medical schools. The Radiation Protection Authority of Zimbabwe (RPAZ) is empowered by Statutory Instrument No. 5 of 2004 which prescribes that ionising radiation exposures shall be regulated (ZMHCW, 2009; ZMHCW, 2004). However, the researcher did not see any such regulations or guidelines circulated by the authority to the radiology facilities that refer patients to the research site. This, as the ministry writes, may be due to human resource inadequacies (ZMHCW, 2009: 94).

1.8 Assumptions

There were two assumptions that had to be made in order to do this document review of radiological request forms. These were centred on the referral system and the ability to apply a statistical tool to the acquired data.

i. The presence of the researcher as a non-participant observer did not influence referral behaviour. This was a fair assumption because the radiology department is a service department and its location was remote from that of the referrers, some of which were more than 200km away.
ii. All categories of data formed a partition, prior probabilities for each category can be obtained from literature and all observations were independent of each other.

1.9 Overview of the research design

The schematic diagram (Figure 1.1: 10) represents the methodological steps taken to answer the research questions. The concept of this study was observing the existing radiological request template forms to capture compliance with prescribed form fields (Table 1.2: 3) and subsequent information captured by referrers on request forms with respect to completeness, accuracy and justification of radiological examination requests. This issue was approached by evaluating examination requests for plain skull and plain lumbar spine radiology in a Bulawayo hospital complex using the data collection instruments (Appendix C & Appendix D). These data collection instruments were designed by the researcher from literature as the frame work and refined based on the content of existing radiological request template forms. Plain skull and plain lumbar spine examinations were chosen for this study because they have been described as having a low diagnostic yield and a high radiation dose (IAEA, 2009; Khoo *et al.*, 2003; Bosch *et al*, 2003; Kerry *et al*, 2000).

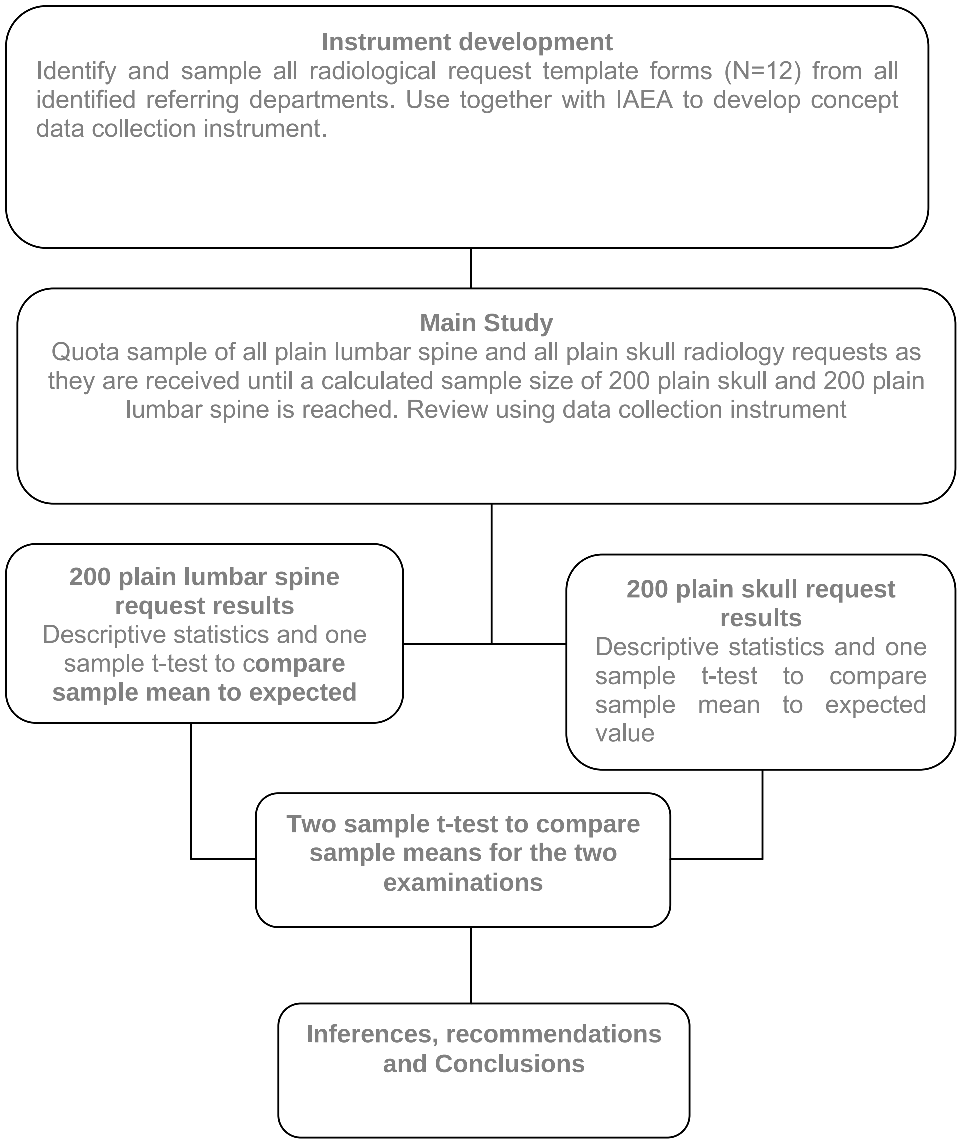

Figure 1.1: Overview of the research design

1.10 Introduction to the thesis structure

Below is an outline of the structure of the thesis.

1.10.1 Chapter 2

In this section of the thesis, cited literature is synthesised and evaluated with respect to completeness, accuracy and justification of radiological requests. This was in order to build a framework to synthesise results into a summary of what is and is not known and to identify areas of controversy in the literature.

1.10.2 Chapter 3

The purpose of this chapter is to provide the reader with an understanding of the research design and methodology employed in this study. The philosophy underpinning document review technique is also explained. Elements of the research approach explained include the techniques used to select the sample, data collection instruments, data analysis techniques, inclusion and exclusion criteria, validity and reliability. Issues pertaining to research ethics and an outline of Chapter 4 are discussed at the end of the chapter.

1.10.3 Chapter 4

In this section, the results of the study are presented according to the research questions. Descriptive analytical tests are applied to the data in order to describe the distribution of data, determine central tendency and make inferences about the data.

1.10.4 Chapter 5

In chapter 5 a discussion of the results is presented. In this discussion, a critique of the results is presented. The framework to synthesise results derived from the literature review and data analysis is used to provide answers to each research question. Recommendations and conclusions are then made in the context of the answers to the research questions.

CHAPTER 2
LITERATURE REVIEW

> It is the World Health Organisation (WHO, 1990: 9) who wrote that, "...There are so many different methods of diagnostic imaging that medical practitioners may need guidance to choose the best way through the maze of options for each clinical problem. Advice may be required for more than the first choice, because the first imaging procedure does not always give the desired answer and, depending on the results, further imaging may have to be undertaken. The alternative is to submit the patient to a barrage of imaging and hope that one type at least, provides the diagnosis. This is a quite unacceptable way to practice medicine because of the cost and the risk of radiation damage from unnecessary examinations..."

2.1 Introduction

This chapter provides an outline of the completeness, accuracy and justification of radiological examination requests in terms of the purpose and current trends with particular focus on plain skull and plain lumbar spine examinations. The chapter begins by a review of literature with respect to local, national and international trends of the radiology referral system. This is followed by a comparison of referral systems. The purpose of this is to establish a benchmark for acceptable practice with regards to radiology referrals. This will strengthen the validity and reliability of the research instrument and therefore the study. The chapter concludes with an outline of plain skull and that of plain lumbar spine radiological imaging and a summary of the literature reviewed.

2.2 Radiological Referral System

In this section a literature review of the trends and current status of Zimbabwe's referral system is presented. This is followed by the literature that defines the international perspective of referral for radiology. The section closes by drawing comparisons between the Zimbabwean radiology referral system and the international perspective.

2.2.1The context of radiology referral in Zimbabwe

The concept of the optimisation of the radiological referral system is underpinned by the strategy for accessing health services.The Government of Zimbabwe's Ministry of Health is guided by its Primary Health Care Strategy in organizing health services (ZMHCW, 2009). This strategy is designed to ensure the provision of clinical services for all through an organized array of health facilities. The concept of this strata arrangement of services is such that services function on the basis of increasing levels of sophistication (ZMHCW, 2009). In this system, patient referral up the referral chain is informed by the nature of the patient's clinical condition (ZMHCW, 2009). The referral chain itself consists of primary, secondary, tertiary and central levels. The primary level consists of small health centres (clinics) manned by nurses and community health workers while the secondary level consists of district hospitals which among other things provide the services of a doctor (ZMHCW, 2009). Therefore, patients have their first contact with a medical doctor at the secondary (district) level within this health delivery system. To complement these services, the public health sector has a medical imaging system that is offered from secondary level through to central hospitals (ZMHCW, 2009). In this system patients have their first contact with radiology services at secondary level. However, according to the ZMHCW (2009) there are no specialist personnel at secondary level. The report states that patients have their first contact with specialists at Provincial Hospitals. Therefore while referral for radiology begins at secondary level full radiology benefits are not available at this level. The highest point in the chain is Central (Quaternary) Hospitals where Provincial hospitals refer to. These include hospitals in Bulawayo (research site), Chitungwiza and Harare that provide, together with private hospitals, the more sophisticated type of services within the country. The ZMHCW (2009) acknowledges that the referral chain works best when the patients referred from the lower levels receive the benefit of specialist [radiologists] services.

Consistent with ECRP (2009), radiology is a specialist area and a referral for radiology is therefore considered as a request for a specialist opinion on the diagnosis of the patient (ZMHCW, 2009). These requests are generally made on request forms although requests written in patients' notes in clinical files are also found. There is no national standard for the radiology referral system. Consistent with the IAEA (2008), the ZMHCW through the Statutory Instrument No. 5 of 2004 prescribes that the delivery of ionizing radiation diagnostic services that are not prescribed by a health care professional is prohibited (ZMHCW, 2004). Again consistent with many reports (IAEA-HHS4, 2010; ECRP, 2009; ICRP 105, 2007; IAEA, 2008; RCR, 1998; WHO, 1990) the ZMHCW through the same instrument prescribes that the justification process of radiological request must take into account available examination options that do not use ionising radiation and that diagnostic benefit must outweigh the risks (ZMHCW, 2004). The report goes further to prescribe that any such exposure must only be made with reference to the clinical indications and full prior justification (ZMHCW, 2004). Consistent with Triantopoulou *et al.*, (2005) the ZMHCW (2004) prescribes that the referrer has the legal responsibility to compile and communicate radiological examination request data to the radiology department. On its part the radiology department has the legal responsibility to review the requests for the justification of exposure before proceeding with the examination.

2.2.2 The International context of the referral for radiology

A referral for radiology is generally regarded as a request by a referrer for a radiologist's opinion on the patient's clinical diagnosis (ECRP, 2008:15; RCR, 2000; RCR, 1998). In this regard, a referrer to radiology is defined as a registered health professional who is accredited by the legislation to refer individuals for medical exposure to a practitioner in radiology (RCR, 2000; RCR, 1998). The health professionals that are accredited as referrers include: medical doctors, dental practitioners, chiropractors, physiotherapists, osteopaths and nurses (RCR, 2000; RCR, 1998). The referrer has a responsibility to supply complete and accurate data relating to the patient's condition when making a radiology request. To comply with this expectation, the referrer must be fully informed about the clinical history related to the current condition, the presenting complaint and previous radiological examinations related to the current condition (RCR, 2000; ECRP, 2008; ICRP 103, 2007).

Globally, the use of diagnostic radiology is accepted as doing more good than harm and therefore its overall justification is accepted (IAEA-No.59, 2009: 4; ICRP 105, 2007; ICRP 103, 2007;IAEA-radprot, 2001). The underlining factors are that the radiological procedure to an individual patient must be justified prior to the exposure and this must take into account the specific objectives of the exposure and the patient specific requirements for the examination (IAEA-No.59, 2009: 5). The benefits of this approach are underpinned by the report that there is scope for enforcing radiation safety without reducing medical benefits to the patient (IAEA-radprot, 2001).

The statute of the IAEA mandates it to oversee radiation protection within the population of its member states, including Zimbabwe (Mangena, 2010**;** Severa& Chipura, 2010; ZMHCW, 2009; ZMHCW, 2004). Consistent with this regulation mechanism, in diagnostic radiology the radiation protection objective is to keep doses as low as reasonably achievable while obtaining the necessary diagnostic information (IAEA-radprot, 2001).

The concept of optimisation of radiological services is therefore underpinned by the need for judicious use of ionising radiation which is an essential component of radiation protection (IAEA-No.59, 2009; Engel-Hills, 2005; Gonzalez, 1994: 2-11). It is noted that the IAEA report of the Basic Safety Standards (BSS) for protecting people from undue exposures in practices and interventions was born out of the participation of many organisations such as the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Commission on Radiological Protection (ICRP), the International Organisation of Medical Physicists (IOMP), the International Radiation Protection Association (IRPA), the International Society for Radiation Oncology (ISRO), the International Society of Radiographers and Radiological Technologists (ISRRT), the International Society of Radiologists (ISR) and the World Federation of Nuclear Medicine and Biology (WFNMB) (IAEA-radprot, 2001; Gonzalez, 1994: 2-11).

Many organisations have designed guidelines for referral to a radiology department (ECRP, 2000: 11; IR(ME)R, 2000; RCR, 1998; WHO, 1990). There is a consensus in all these guidelines that imaging should result in a net benefit to the patient and should enforce good practice (IAEA-radprot, 2001; ECRP, 2000: 11; RCR, 1998; WHO, 1990). In fact, in developing these guidelines these organisations have worked closely and sometimes revised versions presented by one organisation to produce their own edition (ECRP, 2000).

Patient specific benefits and risks are very difficult to quantify and therefore justification decisions demand complete, accurate and unambiguously presented clinical history (ECRP, 2000; IAEA, 2001; RCR, 2000; RCR, 1998; WHO, 1990). Therefore in the absence of complete and accurate radiological request data, more specifically with respect to clinical history, it is impossible for the radiology department to review justification of the request based only on information documented on radiology request form. Guidelines are indispensable in eliminating common causes of incomplete, inaccurate and unjustified radiology requests (IAEA-radprot, 2001; ECRP, 2000; RCR, 2000; RCR, 1998; WHO, 1990). Because of this intrinsic property, referral guidelines are therefore a fundamental concept of good practice against which patient specific radiological requirements can be considered (ECRP, 2000). Consistent with the definition of accidental exposure provided in the International Basic Safety Standards (BSS) for Protection against Ionising Radiation and for the Safety of Radiation Sources (IAEA-radprot, 2001), the majority of reported unjustified exposures are due to the following (IAEA, 2008: 13; ECRP, 2000: 11):

- Repeating investigations that have already been done
- Undertaking investigations when results are unlikely to affect patient management
- Investigating too early
- Doing the wrong investigation
- Failing to provide appropriate clinical information and questions that the imaging investigation should answer
- Over investigating
- Poor knowledge of the dose levels involved.

While a referral for radiological is aimed at adding confidence to the clinician's diagnosis this report therefore demonstrates that a significant number of radiology requests do not fulfill requirements prescribed in these radiological guidelines which are prerequisite for good radiology practice (Rehani, 2010; IAEA, 2008: 8; ECRP, 2000: 11; RCR, 2000).

2.3 Complete radiology request information

Radiological Request Forms (RRF) are template forms whose form fields define minimum radiology request information required by a radiology department to review the justification of the request, decide on examination protocol and to verify radiology request information before exposing the patient (ECRP, 2009; IAEA-HHS4, 2010; Oswal *et al.,* 2009).The IAEA (2008, 26) reported the essential features of a good radiology request and went further to list the essential data to be included in a radiology request form (Table 1.1:3) which was later summarised into minimum radiological request data reported by IAEA-HHS4 (2010). It is these criteria that were used as expected scores and therefore the basis for developing the complete request form fields (refer to table 1.2: 3). Literature explains that the design of a request form plays a significant role in modelling referral behaviour and that the quality of radiological services is greatly determined by the level of information given on radiological request forms. Therefore the design of radiological request forms plays a pivotal role in the completeness of request information (Akinola *et al.,* 2010, Triantopoulou *et al.*, 2005; Scally, 1993; Oswal *et al.,* 2009; Cook *et al*., 2003). Where this communication criteria is not satisfied, important facts about the request are therefore not transmitted efficiently to those who need to know them and consequently there is no meaningful dialogue on balancing benefits with the risks to patients (IAEA, 2008:9).

Consistent with this proposition, Jumah *et al.,* (1995) did a prospective document review of radiological request forms in order to find ways of improving the transmission of radiological request information so as to facilitate better reporting by radiologists. The study was carried out in Ghana, Sierra Leone and Nigeria. They reported significant levels of incomplete request information ranging from absence of age of the patient (29%), absence of clinical information (23%) and illegible entries (15%). They also report 65 unconventional abbreviations. Since then the subject of completeness of radiological request information has continued to attract the attention of researchers (Akinola *et al.,* 2010; Oswal *et al.,* 2009; Adebayo *et al.,* 2005; Triantopoulou *et al.*, 2005)

In the study by Adebayo *et al.,* (2005) a document review of radiological request forms to assess availability of clinical information and demographic data in 600 radiological request forms in South-West Nigeria was performed. They report that clinical information, age, hospital number and referrer identification were not given in 18.5%, 20.8%, 39.9% and 8.7% respectively. They also report that information on consultant-in-charge was not given in 11.3% of the requests. These results are consistent with the findings by Jumah *et al.,* (1995) with respect to clinical information and age of the patient. However, as regards information that relates to previous radiological examinations, 84.2% showed no information on previous radiological examinations. Adebayo *et al.,* (2005) conclude that in their study, 4.8% of the forms were completely filled. However they do not elaborate on the standard for completeness other than to make reference to the referrer fully completing the existing form fields in a request form. Neither do they elaborate whether the request forms were standard across the research sites. They go on to report that these patterns were observed in all the centres and were found to be statistically significant so much that they could not be attributed to chance variation. Consistent with Jumah *et al.,* (1995) and Cook*et al*., (2003), they recommend that the radiology department must provide orientation programmes for referrers to raise awareness of the importance of complete radiology request information.

However, in the study by Oswal *et al.,* (2009) compliance was: doctor's bleep number: 42%; patient location: 21%; study requested: 17%; Doctor's name: 15%; date of referral: 11% and consultant's name: 8%. They report that these levels of incomplete information have medico-legal implications and serious consequences on overall service provided by the radiology department. One year later, after Oswal *et al.,* (2009), Akinola *et al.,* (2010) did a similar study to assess the adequacy of completion of radiological request forms in a tertiary health institution. Consistent with Scally (1993) and Cook *et al*., (2003), their study was motivated by the realisation of the importance of complete radiological request data. Akinola *et al.,* (2010) however conclude that abbreviations that are not universally accepted were observed in all radiological request forms. They report that only the surname and the examination requested was filled in all requests; addresses: 4.2%; patient's age: 90.3% and clinical history: 18.2%. The fundamental point to note in all these studies is that none of them used a standard for completeness of radiological requests but existing request forms being fully completed with respect to existing individual form fields (Akinola*et al.,* 2010; Oswal *et al.,* 2009; Adebayo *et al.,* 2005; Triantopoulou *et al.*, 2005; Jumah *et al.,* 1995; Scally, 1993; Cook *et al*., 2003). The literature demonstrates that there is general consistency with respect to clinical history information and referrer information. The authors concur with respect to the observation that the existing request forms are incompletely filled and that there is need for radiology referrers to undergo continued professional development in order to give value to the completion of request forms (Akinola *et al.,* 2010; Oswal *et al.,* 2009; Adebayo *et al.,* 2005; Triantopoulou *et al.*, 2005; Jumah *et al.,* 1995; Scally, 1993; Cook*et al*., 2003).

2.4 Accurate radiological examination request

A referral for radiology is generally regarded as a request for a specialist opinion on the patient's clinical diagnosis (IAEA, 2008). For this reason, it is therefore important that the exact anatomical area to be imaged is accurately specified without ambiguity (ECRP, 2008:15; IAEA, 2008; ZMHCW, 2004**;** RCR, 2000). The referrer has a legal responsibility to ensure the accuracy of radiological request data (IAEA, 2008; ZMHCW, 2004; RCR, 2000; WHO, 1990). Radiological request data is patient specific and the referrer must be fully informed about the clinical history related to the current condition, the presenting complaint and previous radiological examinations related to the presenting condition (IAEA, 2008; ZMHCW, 2004; RCR, 2000; WHO, 1990). In order to aid review of justification by the radiology department, the referrer must also provide any relevant physical findings that indicate the requested examination (RCR, 2000). This is important in order to avoid exposure to the wrong anatomical region or an exposure not being performed because of lack of relevant information (RCR, 2000). Intuitively therefore this responsibility must be shared with the radiology department which has the responsibility to review request data before the onset of the radiology examination (IAEA, 2008: 8). However, because problems with respect to completeness, accuracy and justification of requests occasionally occur, the radiology facility should have a written policy and procedure on the verification of request data so that only the accurate information is used to review examination requests (IAEA-HHS4, 2010: 28-30). This is important not only in terms of the cost associated with repeat examinations but also in terms of the harmful effects of ionising radiation and the amount of time taken to review examination requests.

2.5 Justification of diagnostic radiology

A justified radiological request is one that ensures that the benefits to the patient or to society outweigh the risks of the exposure (IAEA, 2008; ICRP 103, 2007;ECRP, 2000; RCR, 2000). Such a request has a net benefit when its potential diagnostic benefits to an individual and the society outweighs the risks that the exposure might cause, taking into account risks and benefits of available alternative techniques having the same objective (IAEA-HHS4, 2010: 28-30; RCR, 2000).This consideration is underpinned in radiology through judicious use of ionising radiation (IAEA, 2008:1; WHO, 1990). Therefore above all considerations, the referrer and the radiology department should ensure that a patient referred for a radiology examination really needs the examination (IAEA, 2008:1) because radiation protection in radiology is underpinned by the concept of justification. Justification itself is three fold (ECRP, 2008: 12; IAEA, 2008: 4): a). Justification of the use of diagnostic radiology as a method for investigation, b). Justification of a specified procedure with specified objectives and c). Justification of radiology for an individual patient.

Despite the hazardous effects of ionising radiation, the use of diagnostic radiology as a method for investigation is an indispensable part of medical practice (ECRP, 2008: 12; IAEA, 2008: 4). It is justified in terms of the clinical benefit to the patient which should far outweigh the radiation risk (IAEA-No.59, 2009: 8; IAEA, 2008: 4; RCR, 2000). This is because its use is accepted as doing more good than harm and therefore its overall justification is assumed. However, a specified procedure with specified objectives is defined and justified with respect to the expected effect of the result on the management of the exposed patient (IAEA, 2008: 4). As an example a skull radiograph may show a depression fracture leading to its correction. In the case of an individual patient presenting for a radiology examination, medical diagnostic radiology is a patient specific assessment. Therefore justification of radiology for an individual patient looks at specific objectives of the examination against the characteristics of the individual patient as may be detailed in the clinical history supplied in the request data (IAEA, 2008; ICRP, 2007; RCR, 2000). Consequently, to evaluate justification of a radiological request requires knowledge of (IAEA-HHS4, 2010; IAEA, 2008; ICRP, 2007; ICRP, 2007; RCR, 2000; WHO, 1990)**:**

a) Indications for available examinations;
b) Advantages and limitations of available examination options;
c) Complementary nature of other examinations;
d) Results of prior examinations;
e) Risk-benefit considerations including adverse effects and
f) Contraindications.

Based on this information justification of radiology examinations for an individual patient (ECRP, 2008: 11) can therefore be summarised into five categories (table 2.1.)

Table 2.1: Justification categories of diagnostic radiology for an individual patient

Category		**Notes**
A	Indicated	Supplied clinical history consistent with the request. Diagnostic test may direct clinical management
B	Specialised examination	Available upon prior arrangement that is consistent with locally agreed protocols.
C	Not indicated initially	Experience has shown that the clinical problem usually resolves with time. Radiology may be postponed and only performed then if symptoms continue.
D	Indicated only in specific circumstances	Non-routine studies which are only carried out if the referrer provides strong reasons or if the radiologist feels the examination provides an appropriate way of furthering the diagnosis.
E	Not indicated	Examinations in this category are those where the supposed rationale for the investigation is untenable. Clinical information is not in support of the request.

Therefore with respect to justification of radiology for an individual patient, a radiological request may be justified where there is an indication for exposure as defined in categories A-D. Category A (Table 2.1: 19) was of particular interest to this study with regards to measuring justification of requests. Many researchers and organisations have voiced concerns over the high level of unjustified requests and overuse of radiology

(Rehani, 2010; ECRP, 2009; IAEA-HHS4, 2010; IAEA, 2008; Ya'ish *et al.,* 2007; Eccles *et al.,* 2001: 1406; RCR, 2000; Wright& Wilkinson, 1996; Oakeshott *et al.*, 1994:197-200; WHO, 1990). Concerns about the most effective use of the many different methods of diagnostic radiology available for medical applications were documented by the World Health Organisation (WHO) Scientific Group on Clinical Diagnostic Imaging as early as 1988 (WHO, 1990). This was because there are many different methods of diagnostic imaging so much that referrers may need assistance to select the most appropriate imaging modality for each clinical problem (WHO, 1990: 9). The Scientific Group therefore set out to provide sequences of steps for the imaging of most clinical problems, taking into account the global position with respect to the wide range of professional skills and facilities available (WHO, 1990). The researcher did not cite any revised edition of this publication but noted that Rehani (2010) cited these guidelines in his report. The WHO (1991-2001) publication acknowledges that these guidelines have not been reviewed and they are still being distributed. In this study only those guidelines pertaining to the use of plain skull and plain lumbar spine radiology are reported because these examinations have been identified as having low diagnostic yield in many clinical conditions (UK-RC, 2007; Glaves, 2005; Khoo *et al.,* 2003; Bosch *et al.,* 2003; ECRP, 2000; WHO, 1990).

Justification of exposures has become more important upon the realisation that global research has demonstrated a high rate (20-77%) of unjustified radiological examinations and this is of concern to the Radiation Protection of Patients Unit (RPoP) of the IAEA (IAEA, 2008: 1&8). In the studies carried out by Ya'ish *et al.,* (2007) and Eccles *et al.,* (2001: 1406) they set out to assess methods of reducing general practitioner referrals in accordance with referral guidelines. Eccles *et al.,* (2001: 1406) followed an approach that involved audit and feedback, and educational reminder messages in six radiology departments. They concluded that adopting a policy of routinely attaching reminder messages about guidelines and indications to radiographs that were sent to referrers reduced the number of unjustified examination requests by 20%. They point out that any department that receives referrals from primary care centres could deliver this intervention with great success. Eccles *et al.,* (2001: 1406), Oakeshott *et al.*, (1994:197-200) and Ya'ish *et al.,* (2007) did a document review of radiological request forms in order to investigate the effect of guidelines on general practitioners' referrals to radiology department. They report that justification was enhanced by the introduction of guidelines. Ya'ish *et al.,* (2007) further reported that individual skills of referrers, patient demand and fear of litigation are major determinants of referral behaviour that results in increased numbers of unjustified requests.

Iversen and Albert, (2010) report another dimension of unjustified radiological examinations that is not discussed in other cited literature. They did a study to try and explain influences of possible financial benefits by the referrer on the referral numbers. They report that a referrer operating a more competitive market refers more because the referrer would want to keep patients in his practice; the referrer then satisfies patients' demand for referrals. These findings are consistent in part to the idea of Ya'ish *et al.,* (2007) where the GP refers to satisfy a patient but in contrast to radiation protection guidelines. Therefore in these circumstances a referrer who faces patient shortages will refer more than a referrer who has enough patients visiting the practitioner (Iversen& Albert, 2010). This they say is a direct financial benefit related force where more referrals may add to profits from future treatments.

2.5.1 Justification of plain skull radiology

The aim of justifying a specified procedure with a specified objective is to judge whether the procedure will provide new evidence on the condition of the patient that can be used to improve management of the condition of the patient (IAEA, 2008; ICRP, 2007). Plain skull radiology may do this by detecting a skull fracture or by detecting midline shift of a calcified pineal gland which may suggest imbalance of intracranial pressure (SIG, 2001; Maclaren *et al.*, 1993:139). Plain skull radiology may also show the presence of intracranial air or presence of a foreign body. It has been reported that generally many radiological examinations have no medical and no legal value (Oluwasanmi & Pinto, 2000: 83).

Justification of plain skull radiology has been under scrutiny dating back as far as 1971 (Maclaren *et al.*, 1993:139). This has mainly been because justification of plain skull radiology was perceived as requiring guidance (Maclaren *et al.*, 1993:139). Consequently, the Royal College of Radiologists Working Party set on a 15 year study to come up with guidelines on when to perform plain skull radiology (MacLaren *et al,* 1993: 138). Many organizations (ECRP, 2008; SIG, 2001; RCR, 1998; WHO, 1990) concur that the presence of at least one of the items listed on Table 2.2 is an indication for plain skull radiology.

Table 2.2: Indications for plain skull radiology

a) **Recent head trauma patients** • Loss of consciousness or amnesia at any one time, coagulopathy (if loss of consciousness or amnesia has been experienced) • Neurological symptoms or signs such as post-traumatic seizure and focal neurological deficit • Cerebrospinal fluid or blood from the nose or ear • Suspected penetrating injury • Any sign of basal skull fracture such as haemotympanum, 'panda' eyes, rhinorrhoea, otorrhoea or retromastoid bruising • Scalp bruising or swelling • Alcohol intoxication • Suspected foreign object penetrating skull • Difficulty in assessing the patient (e.g. the young, epilepsy).
b) Non head trauma cases ▪ Acute headache with abnormal results on clinical examination ▪ Chronic headache with abnormal results on clinical examination. Localising signs to be included in request. ▪ Chronic infection of the middle ear or mastoiditis (not for infants and children) ▪ Orbital pain or disease (without trauma)-sinus radiography ▪ Hearing loss ▪ Space occupying lesion

However, a simple scalp laceration is clearly not an indication for plain skull radiology (ECRP, 2008; SIG, 2001; RCR, 1998; WHO, 1990). In the assessment of head trauma patients when clinical features point strongly to an intracranial haematoma (e.g. the emergence of focal signs, or a deterioration in consciousness level), the patient stands to benefit more if promptly referred for both CT scanning and an emergency neurosurgical service (ECRP, 2008; SIG, 2001; RCR, 1998; WHO, 1990). Again for skull fractures in children, though significantly associated with an increased risk of intracranial injury, plain skull radiology is not as discriminating as in adults because in children with head injury, significant intracranial injury occurs more frequently in the absence of a skull fracture than is the case in adults (SIG, 2001). Furthermore, the use of plain skull radiology is therefore unjustified for children since clinical evidence which does not require ionising radiation (e.g. tense fontanel) are an equally important factor in determining the need for a CT scan to rule out intracranial injury (SIG, 2001). However, in the absence of clinical signs of intracranial injury, observation by experienced paediatric practitioner in an appropriate unit/ward is an alternative to urgent CT scan (SIG, 2001). Again, because children are more vulnerable to the harmful (stochastic) effects of ionising radiation than adults, justification of these requests must be scrutinised adequately by both the referring and the radiology departments (IAEA, 2008; SIG, 2001).

Maclaren *et al.*, (1993:138-144) used guidelines published by the Royal College of Surgeons' Working Party on when to perform plain skull radiology on a head trauma patient. However, contrary to other cited literature in which cross sectional approach or a prospective approach was followed, they did a retrospective document review of 405 radiology request forms. They conclude that dissemination of guidelines do have significant impact on the reduction of unjustified requests. Two years later, McNally *et al.,* (1995: 640-642) explored the use of posters to display guidelines encouraging the more effective use of radiology in patients with head trauma, twisted ankles, cervical spine injuries and abdominal pain. Guidelines were prepared, consistent with WHO (1990) and SIG (2005), indicating when to request a radiograph for each category of patients. The main outcome measure was the proportion of patients having radiology. Consistent with Ya'ish *et al.,* (2007); Eccles *et al.,* (2001: 1406) andOakeshott*et al.*, (1994:197-200), the findings by Maclaren *et al.*, (1993:138-144) and McNally *et al.,* (1995: 640-642) are in total agreement that dissemination of guidelines do have significant impact on the reduction of unjustified requests. McNally *et al.,* (1995: 640-642) concludes that the administration of this method reduced skull radiographs by 36%; abdominal radiographs were reduced by 24% while those for cervical spine and twisted ankle injuries did not change. These results show an association between the requested examination and justification of a request. It can also be inferred from these results that even where radiological guidelines are disseminated, completeness, accuracy and justification of exposures was not adhered to all the time and that there is always a need for a sustained program of education in order to optimise justification of radiological exposures.

2.5.2 Justification of plain lumbar spine radiology

Plain lumbar spine radiology is one other radiological procedure that has received a lot of attention with respect to justification of the examination requests (Khoo *et al.,* 2003; UK-RC, 2007; Glaves, 2005; Bosch *et al.,* 2003). This is specifically because of high radiation dose associated with plain lumbar spine radiology and its low diagnostic yield (Khoo *et al.,* 2003; UK-RC, 2007; Glaves, 2005; Bosch *et al.,* 2003). Consequently, these conditions have put pressure on diagnostic radiology to resist doing them or pursue methods of reducing unjustified requests or to limit the examination to laterals only (Khoo *et al.,* 2007; UKRC, 2007; Glaves, 2005; Bosch *et al.,* 2003). As a sequel of this emerging evidence, the Congress reports that in Glasgow, UK, for example lumbar spine plain radiographs have been abandoned for all non trauma cases (UK-RC, 2007).

The Zimbabwe Ministry of Health and Child Welfare (ZMHCW, 2004); the Ionising Radiation (Medical Exposure) Regulations (IR(ME)R, 2000), the Royal College of Radiologists (RCR, 1998) and the WHO (1990) all require justification of every medical exposure. Plain lumbar spine radiology is indicated (UK-RC, 2007; RCR, 1998; WHO, 1990) when there is:

Table 2.3: Indications for plain lumbar spine radiology

• Trauma to the spine • Back pain with sciatica, which is usually due to disc prolapse. Imaging is not indicated initially but only after conservative treatment has failed and surgery is contemplated. • Low back pain (without trauma) with abnormal results on neurological examination or persistent pain • Back pain with red flags (such as night pain, fever, neurological disturbance and weight loss) which is usually indicative of serious pathology such as osteoporotic collapse, malignancy and spondyloarthropathy. Time period from the onset of symptoms is vital because plain lumbar spine radiology is usually unhelpful in the early stages of disease. • Paraplegia (without trauma)

Therefore these indications outline that acute non-specific low back pain which resolves spontaneously and chronic back pain without sinister features do not indicate plain radiology of lumbar spine. The advent of these guidelines has introduced a new dimension in the justification of radiology procedures. Research has shown that dissemination of radiology guidelines unsupported by other initiatives such as feedback has remained ineffective in modelling the referral behaviour (Eccles *et al.,* 2001). However, the use of guidelines coupled with interventions directed at high users has shown reductions as high as 31.6% in plain lumbar spine radiology (Glaves, 2005). Glaves (2005) further explains that specially designed request forms (specifying indications for spinal radiology) reduced unjustified plain spinal radiology by as much as 47%. Contrary to the approach by Eccles *et al.,* (2001: 1406), Oakeshott *et al.*, (1994:197-200) and Ya'ish *et al.,* (2007), the work by Cooke *et al.,* (2003) involved investigation of the potential for patients to be assessed and discharged directly from the accident and emergency department. They collected retrospective electronic data from four different emergency departments. Their conclusion was that there is great potential for a large number to be discharged within minutes of arrival if appropriate assessment skills are available at first contact. This is consistent with Glaves (2002) who demonstrated that when indications for an examination are availed to the referrer this had the effect of significantly reducing the number of unjustified requests.

2.6 Summary of literature reviewed

This section brings together main points derived from the literature review chapter. The literature review was centred on referral for radiology and within this system, gave particular attention to radiological requests data. Guidelines and previous research were reviewed with respect to completeness, accuracy and justification of requests. In this review three important points emerged:

- Criteria for minimum radiological request data developed by the IAEA (2010) that defined the expected score for observed radiological request data.

- Criteria for accuracy of radiological request data defined with respect to accurate identification of the anatomical area to be imaged (IAEA, 2008, ECRP, 2000; RCR, 2000; RCR, 1998; WHO, 1990)
- Criteria for justification of radiological requests (category A refer to table 2.1:19) with respect to indications for plain skull examinations (Table 2.2: 22) and for plain lumbar spine examinations (Table 2.3:24).

The following chapter (Chapter 3) sought to develop data collection instruments that would measure completeness and accuracy of plain skull and that for plain lumbar spine examinations' request data. Furthermore, the same instruments were to measure justification of these requests with respect to the examinations being indicated (Tables 2.1: 19, 2.2: 22, and 2.3: 24).

CHAPTER THREE
RESEARCH METHODOLOGY

> The question of reliability has to do with the consistency of observations: whether a research instrument yields the same results every time it is applied. If it does yield the same results time after time then it can be said that the instrument is dependable for the purpose at hand.
> **(Lindlof &Taylor, 2002: 238).**

3.1 Introduction

This chapter begins by explaining the positivist methodological paradigm that define the way investigations were carried out in order to answer research questions for this study (Saunders, Lewis & Thornhill, 2007; Welman & Kruger, 2001; Haralambos & Holborn, 2000; Gill & Johnson, 1991). Philosophies upon which the observational descriptive analytical research design and data analysis were based are briefly explained (Hopkins, 2008**;** Grimes & Schulz, 2002; Hulley *et al.,*2001; Haralambos & Holborn, 2000; Howard & Borland, 1999). Furthermore, there is a description of the document review method as applied to the practices and techniques used to sample, process and analyse data for this study. Issues that relate to validity and reliability are also discussed (Bowling, 2009: 158; Hopkins, 2008; Eng, 2003; Hulley *et al.,*2001; Welman & Kruger, 2001**)**. The chapter concludes by a discussion of issues pertaining to research ethics and an outline of Chapter 4.

3.2 Research question

The research question for this study was:

How do the documented diagnostic radiology examinations requests for plain lumbar spine and for plain skull radiology received at the Bulawayo hospital complex, compare with the prescribed examination request information?

In order to answer this question the following sub-questions were answered:

a. How do the radiology request for plain lumbar spine and plain skull radiology compare with the information prescribed in the respective data collection instruments?
b. How do the radiology request for plain skull and plain lumbar spine compare with one another?
c. How accurate are the requests in that they specify unambiguously the exact anatomical area to be imaged
d. Were the requests for plain skull and plain lumbar spine x-rays justified in terms of being clinically indicated (meeting at least one indication as prescribed on tables 2.2 and 2.3)?

3.3 Research philosophy

The discussion of the research philosophy that underpins this study was hinged upon the approach considered appropriate to answer the research questions for this study. Because the key idea was that the observations made were not inferred subjectively through sensation, reflection or intuition but through objective measurements, the research philosophy adopted was therefore positivist (Ritchie & Lewis, 2003; Haralambos & Holborn, 2000; Smith & Hunt, 1997: 25).Consistent with approach adopted for this study, this required that the methodology be highly structured and the instruments reliable and valid (Burton & Mazerolle, 2011; Gill and Johnson, 1997).

3.4 Research design

The research design was a prospective, non participatory descriptive analytical study using a document review method (Hopkins, 2008**;** Creswell, 2003; Grimes & Schulz, 2002; Hulley *et al.,* 2001; Howard & Borland, 1999) for collecting data from radiological request forms at a referral radiology department in Zimbabwe. The design was in two phases**:** instrument development and the main study**.** A self designed data collection instrument was used to review the request forms for completeness, accuracy and justification with respect to whether the examination requested was clinically indicated.

3.4.1 Document review method

The advantages of the document review approach were that the data sources were available at one place and thus inexpensive, convenient and efficient to use (Bowling, 2009; Grimes & Schulz, 2002). Radiological request forms form an integral part of medical records in radiology practice and were kept together with the radiological images for future reference at the research site. It was therefore possible for the researcher to verify collected data where there was the need. The reliability of information and subsequent conclusions were therefore greatly enhanced (Bowling, 2009: 449). Document review of radiological request forms had an added advantage of non reactivity with the investigator (Bowling, 2009: 449). Furthermore, the data collection process did not interrupt the routine organisational process of the research site as the researcher operated as a non participant observer (Bowling, 2009: 449; Weisberg *et al*, 1996:105).

3.4.2 Completeness of requests

In this study completeness of examination requests was assessed using three categories which are completeness of patient information, examination information and referrer information. Many researchers and organisations have used these categories to define completeness of radiological request information (Akinola *et al.,* 2010; IAEA-HHS4, 2010; Oswal *et al.,* 2009; IAEA, 2008; Adebayo *et al.,* 2009; Ya'ish *et al.,* 2007; Longrigg & Chanon, 2006; Triantopoulou *et al.*, 2005; Cook *et al.*, 2003; Eccles *et al.,* 2001; Jumah *et al.,* 1995; McNally *et al.,*1995: 640-642; Oakeshott *et al.*, 1994:197-200 and Maclaren *et al.*, 1993:138-144). These three categories have also been used to design the framework (radiological request forms) for requesting radiological examinations (Scally, 1993). Consistent with this observation, the IAEA-HHS4, (2010) defined the minimum variables for each of these three categories of measurement (Table 1.2: 3). However to ensure clarity in the allocation of scores, referrer name and patient name were split into "Name" and 'Surname" form fields. Furthermore, because clinical indication and therefore diagnosis are inherent in presenting clinical history and are important considerations in the justification process, the researcher made a decision to include these two form fields. These modifications were consistent with form fields observed in identified request forms. Because theory derived criteria (IAEA-HHS4, 2010) define the minimum request data that referrers must fulfil on radiological request forms the researcher made a decision to use this information to define the expected completeness values. Table 3.1 illustrates these form fields in which those in italic were derived from identified radiological request template forms for the research site.

Table 3.1: Determination of expected frequencies

Patient information	Examination information	Referrer information
• Name • Surname • Age/ Date of birth • Contact details • Address • LMP/Pregnancy status ➢ *Sex* ➢ *Allergies*	• Study requested • Clinical history • Indication • Diagnosis • Date ➢ *X-ray no.* ➢ *No. of films taken* ➢ *Previous x-rays* ➢ *Surgical operations* ➢ *Walking/stretcher*	• Name • Surname • Contact • Signature
Minimum expected score =6/8 = 75%	Minimum expected score =5/10 =50%	Minimum expected score = 4/4 =100%
• Overall expected request form data indicating completeness of request form= [6+5+4]/22 =68%		

3.4.3 Accuracy of requests

In this study accurate requests were those in which the exact anatomical area to be imaged was specified without ambiguity (IAEA, 2008; ZMHCW, 2004**;** RCR, 2000). For example, an accurate plain skull request following trauma to the skull would specify that the referrer is suspecting a depression fracture on the frontal bone. This would then enable the radiology department to offer a patient specific radiology technique. This information was derived from the documented patient's examination information (IAEA, 2008; ZMHCW, 2004; RCR, 2000; WHO, 1990). The researcher therefore decided to use expected score of 50% with respect to accuracy of requests, which was the same as that for examination information.

3.4.4 Justification of requests

Many organisations have defined justification of a radiological request as patient specific and determined by specific objectives of the examination against the characteristics of the individual detailed in the clinical history supplied in the request data (IAEA, 2008; ICRP, 2007; RCR, 2000). The attributes are indication for the examination, risk-benefit consideration, limitations of requested examination and results of prior examination (IAEA-HHS4, 2010; IAEA, 2008; ICRP, 2007; ICRP, 2007; RCR, 2000; WHO, 1990). In this study focus was on justification of radiology for an individual patient with respect to the examination being indicated for the patient's presenting condition. Because IAEA (2008) reports that up to 77% of requests are unjustified, the researcher made a decision that expected justified request was therefore 23%.

3.5 Instrument development

The design of data collection instruments was fundamental to valid and reliable results (Burton & Mazerolle, 2011; Hopkins, 2008; Hope *et al.*, 2003)**.** These instruments were intended to be objective, structured and valid. To be able to do this the design of the data collection instruments was a process hinged upon the research questions, the literature review and the background information for the research site. Therefore the instrument development process was intended to objectively answer the questions:

a. What are the minimum prescribed criteria for a radiology request from?

b. How many template radiology request forms are in circulation at the research site?

c. What information is on these request forms?

d. How does the information on these request forms compare with the minimum prescribed radiology template form information?

Initially the minimum prescribed criteria determined from a literature search (Table 1.2: 3) answered sub-question "a." and was therefore used as a baseline. The literature review demonstrated the concepts of measuring completeness, accuracy and justification of radiological requests (IAEA-HHS4, 2010; IAEA, 2008; ICRP, 2007; ZMHCW, 2004; RCR, 2000; WHO, 1990). Previous research findings provided fundamental guidance in applying these concepts in a practical situation (Akinola *et al.,* 2010; IAEA-HHS4, 2010; Oswal *et al.,* 2009; IAEA, 2008; Adebayo *et al.,* 2009; Ya'ish *et al.,* 2007; Longrigg & Chanon, 2006; Triantopoulou *et al.*, 2005; Cook *et al*., 2003; Eccles *et al.,* 2001; Jumah *et al.,* 1995; McNally *et al.,*1995: 640-642; Oakeshott *et al.*, 1994:197-200 and Maclaren *et al.*, 1993:138-144). This enabled the researcher to develop a working data collection instrument.

A study was conducted to identify radiological template forms that were in use at the research site. A total of 12 template forms representing all the current radiological template forms in circulation were identified and collected. These templates were reviewed using the working data collection instrument to see if any additional information with respect to patient, examination and referrer information emerged. The purpose of this process was to develop a concept data collection instrument which incorporated minimum criteria as well as information on the current templates in use at the research site. In the concept data collection instrument, form fields developed from the IAEA-HHS4 (2010) criteria were listed together with form fields developed from the document review. However, those form fields developed from the document review process were written in italics in order to discriminate them from the minimum criteria.

3.5.1 Results for the instrument development process

A total of twelve radiological template forms were identified. These request forms had varied design and content. The form fields were significantly different (p=0.00 (Sig.)) from expectation. The researcher noted that form fields derived from IAEA-HHS4 (2010) were generally not presented with precision that the researcher expected. However some identified request forms had form fields that demonstrated the precision that the researcher expected. As an example, with respect to referrer information it was easier to allocate scores where the referrer identification was split into name and surname. To add precision in the collected data, the researcher made a decision to include a list of form fields identified in the essential content and in the review of all identified radiological request template forms in use at the research site. Table 3.2 illustrates these changes.

Table 3.2: Completeness and accuracy of requests' form fields

	Final instrument form fields	**Minimum criteria (Table 1.2 :3)**
Patient information	1. i. Name	Patient's name
	ii. Surname	
	2. Age	Date of birth
	3. i. Contact e.g Hosp. No.	Contact details such as hospital ward or phone number
	ii. Address	Address
	4. i. Pregnancy status/ LMP	Pregnancy status
	ii. Sex	
	5. Allergies	Not listed
Examination information provided on request form.	6. i. Study requested	Study requested
	ii. Accuracy	Not listed
	7. i. Clinical history	Not listed
	ii. Clinical indication	Clinical indication
	iii. Clinical diagnosis	Not listed
	8. Date of request	Date of request
	9. X ray number	Not listed
	10.Number of Films taken	Not listed
	11. Previous x-rays	Not listed
	12. Surgical operations	Not listed
	13. Walking/stretcher/ chair	Not listed
Referrer identification provided on request form	14. i. Name	Printed name
	ii. Surname	
	15. Contact/ bleep no.	Contact details
	16. Signature	Signature
	17. Legibility	Not listed

The list was further refined to include a score for legibility with respect to whether the researcher was able to read request information in its totality and that for accuracy with respect to unambiguous identification of the area to be imaged.

Justification criteria set by WHO (1990) with respect to indications for plain lumbar spine and plain skull radiology examinations were then appended at the end of this list of form fields to come up with instruments that measured completeness, accuracy and justification of plain lumbar spine and plain skull requests. The form fields specifying indications for plain skull radiology in the final tool are listed against indications for plain skull radiology in table 3.3.

Table 3.3: Form fields and indications for plain skull radiology

	Form field on final instrument	**Literature form field (Table 2.2: 22)**
Skull trauma patients	Loss of consciousness	Loss of consciousness
	Neurological symptoms	Amnesia, coagulopathy, neurological seizure
	Fluid through nose/ ear	Cerebrospinal fluid through nose or ear
	Penetrating injury	Suspected penetrating foreign body or injury
	Alcohol intoxicated	Alcohol intoxication
	Patient vomited	Neurological symptoms such as focal neurological deficit
	Difficult patient	Difficulty in assessing the patient
	Blood through ear/nose	rhinorrhoea, otorrhoea or retromastoid bruising
Justification of examination request (Skull -non trauma cases)	Chronic headache with abnormal results on clinical examination	Chronic headache with abnormal results on clinical examination
	Hearing loss	Hearing loss
	Suspected space occupying lesion	Space occupying lesion
	Paranasal Sinusitis >3yrs	Orbital pain or disease (without trauma)
	Police investigations	Not listed
	Notes- Other: to include any observed justification criterion that was not included in listed criterion	Acute headache with abnormal results on clinical examination
		Chronic infection of the middle ear or mastoiditis (not for infants and children)

In cases where litigation issues are involved, radiological examinations were requested to further police investigations on the patient. The researcher therefore decided to include this form field in the final instrument because it was an accepted protocol for the research site. The form fields specifying indications for plain lumbar spine radiology in the final tool are listed against indications derived from literature, in table 3.4.

Table 3.4: Form fields and indications for plain lumbar spine radiology

Form fields in final instrument	Indications from literature (Table 2.3: 24)
a). Trauma	Trauma to the spine
b). Pre-orthopaedic surgery	Back pain with sciatica, which is usually due to disc prolapse. Imaging is not indicated initially but only after conservative treatment has failed and surgery is contemplated.
c). Post-orthopaedic surgery (review)	Not listed
d). Low back pain (Persistent)	Back pain with red flags (such as night pain, fever, neurological disturbance and weight loss) which is usually indicative of serious pathology such as osteoporotic collapse, malignancy and spondyloarthropathy. Time period from the onset of symptoms is vital because plain lumbar spine radiology is usually unhelpful in the early stages of disease.
e). Possible malignancy	
f).Persistent Hip, leg or sacroiliac pain	Back pain with sciatica, which is usually due to disc prolapse. Imaging is not indicated initially but only after conservative treatment has failed and surgery is contemplated.
g). Unresolved Inflammatory conditions	Back pain with red flags (such as night pain, fever, neurological disturbance and weight loss) which is usually indicative of serious pathology such as osteoporotic collapse, malignancy and spondyloarthropathy.
h).Persistent Neurological symptoms	Low back pain (without trauma) with abnormal results on neurological examination or persistent pain
i).Non-traumatic paraplegia (Clinical localisation of the affected level of spinal cord must precede imaging)	Paraplegia (without trauma)
j).Other: Specified overleaf	Not applicable

The form field for "other" was included to accommodate incidental additional indications identified during the data collection period. The researcher decided to include post orthopaedic surgery form field because it was the protocol of the research site to image patients just before and immediately after the orthopaedic examination. Therefore the final data collection instruments consisted of five parts that essentially defined the framework for complete, accurate and justified examination requests for plain skull (Appendix C) and for plain lumbar spine examinations (Appendix D). The first part was a list of form fields about the demographic information of the patient. The second part was examination information which included a form field for accuracy of examination request with respect to specificity of the area to be imaged. The third part was a list of form fields that defined required referrer information. The fourth part was a list of indications for the examination (ECRP 2008; ESR, 2004; RCR, 1998; WHO, 1990). The fifth part was a list of incidental findings, request form identification and comments by the researcher on the observations. The instrument was designed in a way that allowed the researcher to identify the presence (or absence) of information defined in each form field and register it into categories. The categories were labelled as: √= information present and X= information absent. Measurements were captured as shown in appendix E.

3.6 Main study

3.6.1 Introduction

The purpose of the study was to describe and analyse the completeness, accuracy and justification of examination requests for plain skull and plain lumbar spine radiology requests against the criteria defined in the data collection instruments (Appendices C & D). This section of the thesis therefore begins by revisiting the research questions following which a description of the research site is given. The population, the sample, inclusion and exclusion criteria are subsequently discussed. The discussion of data capturing, data analysis, reliability and validity of the study and ethics consideration are presented following which chapter conclusion is presented as the last item of the chapter.

3.7 Research question

The research question for this study was:

How do the documented diagnostic radiology examination requests for plain lumbar spine and for plain skull radiology received at the Bulawayo hospital complex compare with the prescribed examination request information?

The research sub-questions were:

a. How do the radiology request for plain lumbar spine and plain skull radiology compare with the information prescribed in the respective data collection instruments?
b. How do the radiology request for plain skull and plain lumbar spine compare with one another?
c. How accurate are the requests in that they specify unambiguously the exact anatomical area to be imaged
d. Were the requests for plain skull and plain lumbar spine x-rays justified in terms of being clinically indicated (meeting at least one indication as prescribed on tables 2.2: 22 and 2.3: 24)?

These were answered through a document review of 200 plain skull and 200 plain lumbar spine radiology requests using the data collection instruments designed by the researcher.

3.8 The research site

A non-probability type of sampling was used for research site selection. The radiological site was purposively sampled (Babbie & Mouton 2001; Haralombos & Holborn, 2000) because it was a central referral department which had a high patient turnover. The researcher had an appreciation of the departmental environment and reporting protocols. This was important because such understanding allowed the researcher to efficiently make arrangements for any verification of the data.

The research site was located in a referral hospital whose services were defined in the national health strategy (ZMHCW, 2009). This strategy was designed to ensure the provision of clinical services through an array of health facilities organized according to the sophistication of the services they provide. In this system, therefore, patient referral up the referral chain was informed by the severity of the patient’s clinical condition (ZMHCW, 2009). The referral chain itself consisted of primary, secondary, tertiary and central levels.

The primary level consisted of small health centres (clinics) that provided nursing care while the secondary level consisted of district hospitals which among other things provided doctor services (ZMHCW, 2009). The highest point in the chain was the central hospitals also called Quaternary Hospitals (research site level) where Provincial hospitals refer to. Secondary and Quaternary hospitals were clinical training centres for doctors, nurses and radiographers.

The public health sector of Zimbabwe had a well established medical imaging system that was offered from secondary level through to central hospitals (ZMHCW, 2009). However, according to the ZMHCW (2009) there were no specialist personnel at secondary level. The report states that patients have their first contact with a specialist at Provincial Hospitals (tertiary care facilities). Therefore although referral for radiology begins at secondary level full radiology benefits were not available at this level.

The research site was located in the metropolitan province of Bulawayo. In this province there were 34 primary centres and 7 quaternary level centres making a total of 41 health centres (ZMHCW, 2009). Contrary to the general structure of the national health strategy, this means that there were no intermediate referral centres between the research site and the primary centres in this province. The radiology department served as a referral centre for both government and private sector patients and therefore the population of requests received in this department represented a wide view of radiological requests which was an important consideration for generalisation of the results.

Statistics in the use of diagnostic radiology for the research site that was extracted from the radiology department patients' log book is presented in Table 3.5.

Table 3.5: Diagnostic radiology examination requests statistics (Research site)

Year	Total number of patients	Year on year increase	Increase from year 2007
2007	7 697		
2008	8 206	509	509
2009	10 086	1880	2389
2010	15 986	5900	8289
Up to June 2011	6 060		

These statistics refer to the total number of radiology patients. To further illustrate these results a graph, Fig. 3.1, was plotted.

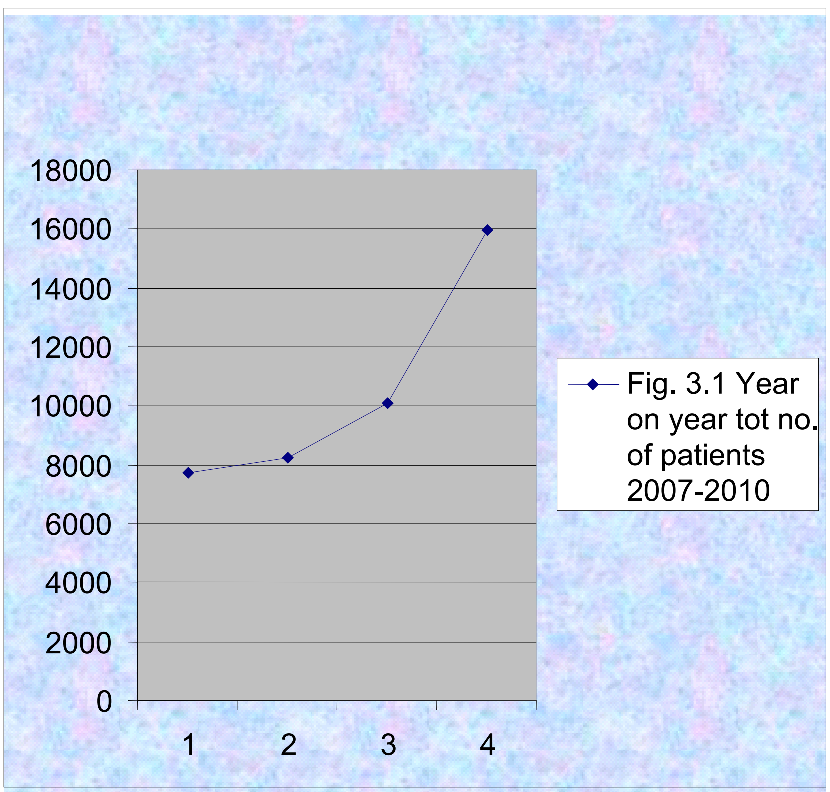

Figure 3.1: Year on year total number of patients 2007-2010

This data demonstrates that there was a growing (exponential) use of radiology at the research site thus strengthening the relevance of this study to the research site.

3.9 Study population

The population of this study comprised all plain skull and all plain lumbar spine requests documented at the research site. With respect to plain skull and plain lumbar spine examinations, an average of 6 radiology requests was received per day. Therefore not all of these request forms were practically accessible because the volume of request forms was so large as to render the process impractical (Bland, 2009; Eng, 2003; Haralambos & Holborn, 2000; Smith & Hunt, 1997; Desu & Raghavarao, 1990). Therefore the researcher decided to select (quota sample) all examination requests for plain lumbar spine and those for plain skull received during the 4 month data collection period (26 April 2011 to 31 August 2011.) until the calculated sample size was reached (Bland, 2009; Eng, 2003; Haralambos & Holborn, 2000; Smith & Hunt, 1997). These were identified as they were brought in for filing. The selected examinations have been described as having a high radiation dose, low diagnostic value and are unjustified in many clinical cases (Glaves, 2005; Bosch *et al.,* 2003; Khoo *et al.,* 2003; Gillan *et al.,* 2001;SIG, 2001; Brennan & Madigan, 2000; Gutierrez, 1997; Simmons *et al.,* 1995; Halpin *et al.,* 1991; Symmons *et al.,* 1991; Liang& Komaroff, 1982). It was for this reason that the researcher decided to compare data for these two examinations in order to determine to what extent the completeness, accuracy and justification of these two examinations were consistent with each other.

3.9.1 The sample

Success of this study was hinged on a representative sample which also added reliability and objectivity to the study (Olsen & George, 2004; Eng, 2003). Such a sample is defined as a representative subgroup of the population (Davidson, 2006). To get the representative sample for this study, quota sampling of request forms was employed in that all plain skull and all plain lumbar spine request forms in the data collection period were captured for analysis until the calculated sample size (200) was reached per examination (Eng, 2003; Robson, 2003; Haralambos & Holborn, 2000). Quota sampling enabled the researcher to obtain a sample of request forms for plain skull and for plain lumbar spine that had different referrers represented proportionately in each sample (Decoursey, 2003; Haralambos & Holborn, 2000; Cohen & Manion, 1991). Bowling (2009: 205) concurs with Haralambos & Holborn (2000: 724-5) that proportionate representation in a sample ensures that the observations drawn from such a sample accurately and precisely represents the true attributes of the population.

3.9.2 Sample size calculation

Sample size for this study was pre-determined (David, 2005; Eng, 2003; Kirby *et al.,* 2002; Lenth, 2001; Odeh & Fox, 1991) in consultation with the CPUT consultant statistician. The sample size calculation was hinged on the research questions for this study and the intended statistical analysis methods (Bland, 2009; David, 2005; Eng, 2003; Lenth, 2001; Odeh & Fox, 1991). There were two distinctly different statistical analysis methods used in this study both of which required different sample sizes (Eng, 2003). These were the one sample t-test and the two sample t-test. The one sample t-test involved comparing the sample mean to the expected value while the two sample t-test involved comparing data for the two samples (MedCalc, 2012; Kirby, *et al.,* 2002; Decoursey, 2003; Richard, 2000) denoted as n_1 Lumbar spine and n_2 skull requests.

In calculating sample sizes (Equation 3.2) there were six specified parameters. In the case of a two sample t-test, the sample size "N" denotes the total sample size. This is the sum ($n_1 + n_2$=N) of the samples for both examinations (Bland, 2009; Eng, 2003, Hulley, 2001). In this study $n_1 = n_2$ =n and therefore N=2n. The z_{crit} value defines the cutoff point along the baseline of a standard normal probability distribution that demarcates probabilities matching the specified significance criterion (Bland, 2009; Peck*et al.*, 2008; David, 2005; Decoursey, 2003; Eng, 2003; Hulley, 2001; Petrie& Watson, 1999). The z_{pwr} value defines the cutoff point along the baseline of a standard normal probability distribution that demarcates probabilities matching the specified statistical power (Bland, 2009; David, 2005; Decoursey, 2003; Eng, 2003; Petrie & Watson, 1999). The z_{crit} value was determined from literature for the desired 0.05 significance criterion thus giving z_{crit} value of 1.960 (Eng, 2003). The z_{pwr} value was also read from literature for the desired statistical power (90%) giving z_{pwr} value of 1.282 (Eng, 2003).

In order to determine the standard deviation required for sample size calculation the main study instrument was administered by the researcher to the first 20 observed request forms. This test was also important in testing general item analysis for the study. The calculation of the standard deviation was done using SPSS version 19 (Table 3.6).

Table 3.6: Statistics for the estimation of standard deviation for the population

	N	Mean	Std. Deviation	Std. Error Mean
Patient_infor	20	51.8600	8.36549	1.87058

The standard deviation for the sample was therefore 8.365 and this value was important in the calculation of sample size for the main study. The minimum expected difference between the two means (=13%) was symbolized as D and was determined from literature (Bland, 2009; IAEA, 2008; Kerry *et al.,* 1999). The International Atomic Energy Agency (2008: 15) reports that global research has shown that up to 77% of radiological requests are unjustified. Because the Zimbabwe Ministry of Health and Child Welfare had begun the process of monitoring radiological exposures (ZMHCW, 2004) this would have the effect of reducing unjustified requests (IAEA, 2008). Based on this background information the pre-study estimates for the first proportion was **p_1=77%.** The minimum expected difference (**D=13%)** gave reduced estimated expected count of unjustified requests such that the second proportion was therefore **p_2=64% (77-13).**Substituting into equation 3.1 and 3.2 gave sample sizes for one sample t-test and for the two sample t-test respectively.

Therefore, with D=0.13, p_1=0.77, p_2= 0.67**,** α =8.365, z_{crit}= 1.960 and z_{pwr} = 1.282

$$N= \frac{4\alpha^2(z_{crt} + z_{pwr})^2}{D^2}$$ ……………………… Eqn 3.1 (Eng, 2003)

Substituting numerical values for the parameters in equation 3.1 gave an output of 29.42. The calculated sample size for the one sample t –test was therefore 30 radiological request forms. This sample size is consistent with that proposed by Eng (2003: 311) who prescribed a sample size of 35 in a similar study.

In order to determine whether referrers were consistent between the two examinations, a two sample t-test was applied. The test compared the means for plain lumbar spine and that for plain skull request data. Equation 3.2 defines the calculation for the sample size

$$N= \frac{2^*\{z_{crit}[2p_m(1-p_m)]^{1/2} + z_{pwr}[p_1(1-p_1) + p_2(1-p_2)]^{1/2}\}^2}{D^2}$$ …Eqn 3.2 (Eng, 2003).

Where p_m=mean p= (p_1 +p_2)/2

Substituting for numerical values in equation 3.2 gives N=340. Because by definition of N (Bland, 2009; Eng, 2003):

N= n_1 + n_2= Sample size for lumbar spine + sample size for skull

=2n

=340

Therefore sample size for each examination for a two sample t-test was 170 (rounded to 200) examination requests.

This sample size is consistent with that used by Oswal *et al.,* (2009) in a similar study and that proposed by Eng (2003: 311).

3.9.3 Inclusion and exclusion criteria

The inclusion and exclusion criteria for this study were an important consideration because it enabled the researcher to enhance the validity of the study. The radiological requests that were finally included in this study were all plain skull and all plain lumbar spine examination requests that were received at the research site during the data collection period (26 April 2011 to 31 August 2011). This was on condition that the radiological requests fulfilled the two additional inclusion criteria:

a) Inclusion criteria

- The examination requests were documented on one of the twelve identified radiological request forms and
- The documented examination request had gone through the internal departmental verification process.

These inclusion criteria were chosen because:

- The policy of the research site was that requests were reviewed upon registration in the radiology department prior to the radiology examination. It is here that x-ray numbers which actually denoted file number for the patient were allocated. The radiographer would also review the request prior to the exposure. Radiological requests that had gone through this verification process had been approved by the department and had been prepared for filing. This was important in that it enhanced the validity and reliability of the conclusions through verifiable data.
- Examination requests that were documented in request forms could be consistently and reliably measured using the data collection instrument.
- Examination requests that were documented in request forms represented the framework of requesting radiological examinations typical for the research site

b) Exclusion criteria

Radiological examination requests were excluded from the study if they showed the following characteristics:

- All radiological requests for theatre radiography. The instrument development phase had established that these requests are sometimes made telephonically. Therefore using the criteria for this study, such request would be incomplete, inaccurate and unjustified due to these factors. The researcher determined that taking these request to be representative of the referral behaviour would introduce distortions in the observed behaviour of referrers under normal conditions.
- All radiological requests for intensive care unit (I.C.U.). Similar reason as for theatre radiology was considered for this category of requests.

3.10 Data capturing

The presence of the researcher at the research site was solely to collect research data presented in radiological request forms. Data was collected through a non participatory document review process. The purpose was to observe the practice without intervening and capture completeness, accuracy and justification data as would otherwise appear if the researcher was not there.

The researcher was stationed in the filing room, where the images and request forms were kept, from Monday to Friday. The purpose was to capture radiological request forms after the radiology procedure had been done and the documents were ready for filing. This station was convenient in that the presence of the researcher did not interfere with the general flow of patients in the department. The radiographers were not constantly aware of the researcher and this had the effect of reducing the impact of his presence. It also ensured at the time that the request form was reviewed by the researcher, the radiographers would have had an opportunity to review the request form for justification.

Data was captured onto the data collection instruments Appendix C for plain skull and Appendix D for plain lumbar spine requests. Appendix E, entry number 28 illustrates data captured from one request form (Appendix A) that was randomly picked from the sample in order to clarify how data was captured. After data collection each radiological request form was immediately returned to the envelope ready for filing. A master link code was in-turn generated by the researcher and recorded in the RRF ID code column (Appendix C & Appendix D).

3.11 Preparatory procedures for statistical analysis

The data collection instruments designed by the researcher for this study had assessment categories for completeness, accuracy and justification of radiological requests. Each category had a predefined possible count based on the total number of form fields in that category. The organisation of the data involved frequencies per category per radiological request form. Each frequency data so generated was converted to a percentage as a normalisation process. In the case of two sample test, this was followed by data coding of the raw data. Plain skull data was coded “1” while plain lumbar spine data was coded “2”.Data was tabulated into a spread sheet in preparation for statistical analysis. The expected values for patient information, referrer information, examination information and overall request form data were 75%, 50%, 100% and 75% respectively (Table 3.1: 28). The expected values for accurate identification of the area to be imaged (Section 3.4.3: 28) and justification of requests (Section 3.4.4: 29) were 50% and 23% respectively.

3.12 Data analysis

Descriptive analysis and inferential analysis statistical tools were applied to the collected data using the Statistical Package for Social Science (SPSS) version 19. All observed data were included into the spread sheet. Descriptive analysis involved frequencies, percentages, distribution of request form data and central tendency measures. Inferential analysis involved one sample t-test.and a two sample t-test. The significance level used for the inferential statistics was 0.05. Descriptive statistics was used to describe data for the two examinations in terms of central tendency measures. Inferential statistics was used to compare data for the two examinations to expected values as well as between the examinations. This was in order to add confidence in the conclusions drawn from observed data (MedCalc, 2012; Peck *et al.,* 2008; Decoursey, 2003; Eng, 2003; Petrie & Watson, 1999). Data from the two examinations were compared in order to draw conclusions whether there were any consistencies in referral behaviour between the two examinations which could be attributed to their percieved high rate of unjustified requests. Table 3.7 shows research questions and data analysis tests used to answer the questions.

Table 3.7: Research questions and associated data analysis tests

Research question	Statistical tests
a. How do the radiology request for plain lumbar spine and plain skull radiology compare with the information prescribed in the respective data collection instruments?	Descriptive: Frequencies Analytical: Two tail one sample t-test for patient and examination information. One tail one sample t-test for referrer information.
b. How do the radiology request for plain skull and plain lumbar spine compare with one another?	Descriptive: Frequencies Analytical: two tail two sample t-test for the analysis between examinations.
c. How accurate are the requests in that they specify unambiguously the exact anatomical area to be imaged?	Descriptive: Frequencies
d. Were the requests for plain skull and plain lumbar spine x-rays justified in terms of being clinically indicated (meeting at least one indication as prescribed on tables 2.2 and 2.3)?	Descriptive: frequencies

3.12.1 Statistical analysis

The sequence of computational instructions on the spread sheet with respect to the t-tests and descriptive statistics respectively (Peck *et al.,* 2008; MedCalc, 2012; Decoursey, 2003; Eng, 2003; Richard, 2000) was:

Analyse → Compare Means → One-sample t-test
Analyse→ Descriptive statistics→ Frequencies

With respect to a two sample t-test the computational instructions were:

Analyze → Compare Means → independent Samples t-Test

In this case there were two different groups (plain lumbar spine and plain skull radiological requests) whose means were compared with respect to completeness, accuracy and justification of radiological requests using a two sample (independent) t-test (MedCalc, 2012; Peck *et al.,* 2008; Creswell, 2003; Eng, 2003; Decoursey, 2003; Grimes & Schulz, 2002).

According to Pacitti (1998) quantitative data analysis generally consists of raw data assessment; data processing; communicating findings and data interpretation. In this study, raw data assessment involved examining the raw data to search for trends and, in order to add confidence in the results; a statistical tool was applied (William, 2006; Decoursey, 2003; Welman & Kruger, 2001: 184; Pacitti, 1998). The statistical tool enabled the researcher to describe the distribution of the data and to make inferences about the observed data with respect to the measures of central tendency. Skewness was used as a preliminary indicator of asymmetry and deviation from a normal distribution while kurtosis was used as a preliminary indicator for peakedness of the distribution for the data (Decoursey, 2003).Interpretation of skewness (MedCalc, 2012; Sheskin, 2011; SPUNE, 2000; Intercapital Invest, 1995) was:

- Skewness> 0: This demonstrated a right skewed distribution of data such that most values were concentrated on left of the sample mean, with extreme values to the right.
- Skewness< 0: This demonstrated a left skewed distribution in which most values were concentrated on the right of the sample mean, with extreme values to the left.
- Skewness = 0: In this class of data, the mean was equal to the median and therefore the distribution was symmetrical around the mean.

The kurtosis statistical indicator was used to determine the flattening (peakedness) of the distribution for the data. The interpretation for kurtosis (MedCalc, 2012; Sheskin, 2011; SPUNE, 2000; Intercapital Invest, 1995) was:

- Kurtosis >0: This demonstrated a leptokurtic distribution in which the peak was sharper than in a normal distribution. Values were concentrated around the mean and distribution tail was thicker than for normal distribution. This implied a high probability for extreme values.

- Kurtosis < 0: This demonstrated a platykurtic distribution in which the distribution was flatter than a normal distribution with a wider peak. In this case, the probability for extreme values was less than for a normal distribution and the values were wider spread around the mean.
- Kurtosis = 0: This demonstrated a mesokurtic distribution in which data was normally distributed.

To test the skewness and kurtosis for significance, the numerical values for skewness and those of kurtosis were compared with twice the standard error of skewness and kurtosis respectively (MedCalc, 2012; Sheskin, 2011; SPUNE, 2000). For values of skewness and kurtosis that fell within this range the skewness and kurtosis were considered insignificant (MedCalc, 2012; Sheskin, 2011; SPUNE, 2000).

In order to make inferences from the observed data a positive t-value showed that the mean for the sample data was larger than the test value while a negative t-value showed that the mean for the sample data was smaller (William, 2006; Jackson *et al.,* 2005; Creswell, 2003; Eng, 2003; Decoursey, 2003; Grimes & Schulz, 2002). To test the significance, the risk level (also called the alpha level) was preset at 0.05. The meaning of this value was that five times out of a hundred the researcher would, by chance; find a statistically significant difference between the mean values even if there was none (Jackson *et al.,* 2005; Creswell, 2003; Eng, 2003; Decoursey, 2003; Grimes & Schulz, 2002). To make use of this value in descriptive statistics the degrees of freedom (df) for the test were calculated (automatic in SPSS 19) such that the degrees of freedom equals n_1+n_2-2, where $n_1= n_2=200$ are the sample sizes for both examination in this case(MedCalc, 2012; Decoursey, 2003; Eng, 2003; Richard, 2000).

The criterion for a statistical significance was a “two tailed significance” less than 0.5 and a “one tailed significance” less than 0,025 (MedCalc, 2012; William, 2006; Decoursey, 2003; Eng, 2003; Richard, 2000). This was considered together with the relationship between the “95% Confidence Interval of the Difference” and the test value. Interpretation of the Levene's Test for Equality of Variances was that a p-value that was less than 0.05 indicated that the variances were heterogeneous and this violates a key assumption of a t-test (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

3.13 Reliability and validity of the study

To ensure validity of the data collection instruments three steps were taken (Neuman, 2007:167; Davidson, 2006; Babbie & Mouton, 2001:123; Du Plooy, 2001; Weisberg, Krosnick & Bowen 1996:95). These steps allowed the researcher to determine the extent to which the measure reflected the real meaning of the concept of completeness, accuracy and justification of radiological requests. Firstly, a review of literature that defined local and literature standards for completeness, accuracy and justification of radiological requests was made. Secondly, previous studies were reviewed with respect to proven methods for measuring completeness, accuracy and justification of radiological requests. These review steps allowed the researcher to spell out what was and what was not measured. Therefore these reviews determined how much the measures covered the range of meanings included within the concept of complete, accurate and justified radiological requests thus providing the basis for content validity (internal validity) of the observations (Babbie & Mouton, 2001:123; Weisberg, Krosnick & Bowen, 1996:95).

Thirdly, a document review of all identifiable radiological request forms for the research site was conducted using predefined set of rules against these standards. This was in order to determine how well observations meshed with the concept being measured (compliance with defined criterion) thus giving a measure for face validity of the measurements (Neuman, 2007:167).The use of pre defined set of rules that spelt out the sequence of events to be conducted ensured that the study was systematic and logical such that conclusions drawn were free from guessing and intuition (Burton & Mazerolle, 2011; Awoniyi & Alege, 2007: 25; Neuman, 2007; Du Plooy, 2001; Haralambos & Holborn, 2000; Murphy *et al.,* 1998; Remenyi *et al.,* 1998).The use of a document review process that allowed research results to be verifiable and analysed using inferential statistics provided further basis for external validity of the results (Burton & Mazerolle, 2011; Bowling, 2009; Gill and Johnson, 1991). External validity was further enhenced by the fact that a real situation for the research site was observed (Burton & Mazerolle, 2011; Bowling, 2009).

3.14 Ethical issues

This section of the thesis deals only with ground rules with regard to ethical guidelines that governed this study. This was an important consideration because research ethics is essentially a guiding factor in defining morality in health research and in protecting participants from harm that can be directly attributed to their participation in research (Babbie & Mouton, 2001:520).

The ZMHCW, (2009) explains that their networks of health institutions from secondary level through to quaternary hospitals are academic hospitals. Consistent with literature

(Hope, Savulescu & Hendrick, 2003), as an academic hospital, the research site had a culture of filing documents written by those patient not consenting to have their data used for academic purposes together with the radiological image. In this study request forms were collected after the radiological procedure had been done and the request form together with other radiology data was ready for filing. No request form had any message attached to them indicating that the data was not available for academic purposes. Based on these observations the researcher was therefore satisfied that the liberitarian approach (Hope, Savulescu & Hendrick, 2003) had been fulfilled and therefore all the sampled request forms could be reviewed.

In this study, data collection did not involve recording biographic details of patients and the researcher did not have any direct patient contact. The method (non participatory observational document review) did not interfere with the medical management of patients nor did it interfere with the day to day running of the department (Bowling, 2009). The researcher maintained confidentiality of source documents throughout the study by coding the data and recoding the code in the pass worded master link list. In so doing once the request form had been filed it was not possible to identify it with the research data but only by use of the pass worded master link list. This master link list was generated for the purpose of data verification in the event of this being needed.

Because this study was conducted by the researcher for academic purposes as a student at the Cape Peninsula University of Technology in Cape Town, South Africa an application for approval was made to the university. The approval was granted by the Health and Wellness Sciences Research Ethics Committee (CPUT/HW-REC 2011/H07) on the 13 of April 2011(Appendix G). Permission to collect data for the study was obtained from the radiology department (Appendix H).In making this application an undertaking was made by the researcher to the radiology department that a report will be made available to them upon completion of the study.

3.15 Chapter conclusion

A reflection on chapter 3 shows the steps taken to answer the research questions. In this chapter, the researcher goes through the research questions, research philosophy, research design and the study population. This is followed by data capturing, data analysis and validity of the study. The chapter closes with a discussion on the ethical consideration and chapter conclusion.

The following chapter (Chapter 4) provides results of the study presented with respect to research questions. The description of the results was hinged upon measures of central tendency while inferences were hinged upon 0.05 statistical significance.

CHAPTER FOUR
RESULTS

> It is Rehani (2010) who wrote that, "…would I prescribe this procedure if the patient was my own child? In the absence of a better term, we can call it decision making based on moral considerations, although some would put this in the category of ethics, which strictly does not cover the moral issue involved."

4.1 Introduction

In this chapter results of the completeness, accuracy and justification of radiological requests are presented. The chapter begins by a description of the distribution of template forms in the reviewed sample and general observations. This is followed by descriptive analysis and inferential analysis of the results both organized according to research sub-questions in order to permit conclusion drawing and to provide explicit answerer to the research questions:

a. How do the radiology request for plain lumbar spine and plain skull radiology compare with the information prescribed in the respective data collection instruments?
b. How do the radiology request for plain skull and plain lumbar spine compare with one another?
c. How accurate are the requests in that they specify unambiguously the exact anatomical area to be imaged
d. Were the requests for plain skull and plain lumbar spine x-rays justified in terms of being clinically indicated (meeting at least one indication as prescribed on tables 2.2 and 2.3)?

Description of the results was based on the distribution of observed frequency data, observed measures of central tendency and kurtosis and skewness of the distribution. All three measures of central tendency (mean, median and the mode) were calculated although the mean was used as the basis for describing the central tendency for the research site. Measures of variation described the range of the distribution of each attribute relative to the measures of central tendency. This presentation format enabled the researcher to make informed statistical inferences based on the analysis of what the data demonstrates for the research site. The chapter closes by a summary of the results and an outline of chapter 5.

4.2 Frequency counts of radiology template forms in the reviewed sample

A total of 200 radiology requests for plain skull and 200 radiology requests for plain lumbar spine were reviewed for completeness, accuracy and justification as prescribed in the main study data collection instrument (Appendices C & D). The most frequently (mode) used request form in the sample for the two examinations taken individually was template form number 3 (Appendix A) which accounted for 85% of the reviewed radiology requests. This request form appeared 171 times out of 200 requests in the plain skull requests and 169 times in plain lumbar spine requests. Table 4.1illustrates these observations.

Table 4.1: Event rates for the individual template forms in the sample

	Request (template) form ID number											
	1	2	3	4	5	6	7	8	9	10	11	12
Number of individual request forms inplain skull sample (N=200)	3	2	171	2	11	1	2	2	2	1	2	1
Number of individual request forms in plain lumbar spine sample (N=200)	2	3	169	4	13	3	1	2	0	2	1	0
Number of individual request forms in the overall sample (N=400)	5	5	340	6	24	4	3	4	2	3	3	1

It was observed that on average 85% of referrers for this research site tend to use request form number 3 followed by 6% that use request form number 5. Request form number 5 and 3 had almost equivalent form fields.

4.3 General observations

The results presented in table 4.2 demonstrate average compliance values in the observed radiological request forms categorised according to form fields that were verbatim printed from the data collection instruments (Appendices C&.D).

Table 4.2: Average compliance per form field

Measurement category	Form field	Form field score		
		Plain skull N=200	Plain Lumbar spine N=200	
Patient & exam information provided on request form.	1. i. Name	**98.5**	**98.0**	
	ii. Surname	**98.5**	**99.0**	
	2. Age	**82.0**	**80.0**	
	3. i. Contacte.g Hosp. No.	**33.5**	**30.0**	
	ii. Address	**0.5**	**0.0**	
	4. i. Pregnancy status/ LMP	**0.5**	**0.0**	
	ii. Sex	**84.0**	**78.5**	
	5. Allergies	**0.0**	**0.0**	
	6. i. Study requested	**99.0**	**97.0**	
	ii. Accuracy	**3.5**	**5.0**	
	7. i. Clinical history	**46.0**	**32.0**	
	ii. Clinical indication	**11.5**	**22.5**	
	iii. Clinical diagnosis	**39.5**	**26.5**	
	8. Date of request	**90.5**	**90.0**	
	9. X ray number	**50.0**	**52.0**	
	10.Number of Films taken	**0.0**	**0.0**	
	11. Previous x-rays	**1.5**	**0.0**	
	12. Surgical operations	**0.0**	**0.0**	
	13. Walking/stretcher/chair	**15.5**	**5.5**	
Referrer identification provided on request form	14. i. Name	**3.5**	**6.5**	
	ii. Surname	**4.0**	**10.0**	
	15. Contact/ bleep no.	**1.0**	**3.5**	
	16. Signature	**81.5**	**88.0**	
	17. Legibility	**96.5**	**93.0**	
Justification of request	18. Examination justified	**12.0**	**22.5**	

None of the radiological requests (refer to Table 4.2), between the two examinations, demonstrated 100% complete data with respect to data prescribed in the data collection instruments. Other observations made in this study include use of unconventional abbreviations in 11% examination requests. In all, twelve unconventional abbreviations were identified (Appendix F).Seventy five percent of these abbreviations were cleared with the radiology clinicians. These acronyms and their meanings are listed in Appendix F. However, 25% unconventional abbreviations could not be cleared with the radiology clinicians.

4.3 a. How do the radiology request for plain lumbar spine and plain skull radiology compare with the information prescribed in the respective data collection instruments?
b. How do the radiology request for plain skull and plain lumbar spine compare with one another?

In this section, a descriptive and analytical review of data for the completeness of plain lumbar spine and plain skull radiology examination requests is given. Data obtained with respect to research sub-questions a. & b. are reported together in order to provide clear answers in the categories of patient information, examination information and referrer information. Descriptive statistics was used to identify the central tendency for each examination. A one sample t-test was used to compare the sample mean with a test value (Hypothesised value) while a two sample t-test was used to compare the two sample means. With this inferential statistical test the researcher was able to make judgements of the probability that an observed difference between the mean and the test value and also the observed difference between two sample means was a dependable one or one that might have happened by chance.

4.3.1 Descriptive and analytical review of request forms: observed patient information

In this sub-section a report is given on the existence of patient's name, surname, age/date of birth, address, contact details, sex, allergies and pregnancy status (Table 3.1: 28) information. The possible score was 8/8 (100%) while the expected score was 6/8 (75%). Table 4.3 gives measures of central tendency derived from the data for plain skull and for plain lumbar spine requests with respect to patient information. The statistics demonstrate that all 200 examination requests for each examination were included in the calculation of central tendency for the research site. The maximum and minimum scores for plain lumbar spine data was 62.50% and 25.00% thus giving a range of 37.50%. Extreme values (0.00% and 75.00%) were observed for plain skull data.

The mean for plain lumbar spine and that for plain skull were respectively 48.4+/- 0.8% and 49.5 +/- 0.8%. The mode and the median (Equal to 50.0% for both examinations) were within the error margins of the mean for skull data but outside that of lumbar spine data. The skewness for the distribution of lumbar spine and skull data was -0.807 and -1.180 respectively. This negative sign means that the distribution of this data was right skewed. Because the mode and the median values were identical (50.0%) in each of the two examinations, the observed extreme values were therefore responsible for the relatively higher skewness for the skull data relative to that of lumbar spine data. In both cases, most of the values were concentrated on the right of the mean with extreme values to the left. Similarly in both cases, the standard error of skewness was 0.172 and the magnitude of this skewness was greater than two times the standard error of skewness meaning that skewness was statistically significant.

Table 4.3: Central tendency measures- completeness of patient information

		Patient information- Plain lumbar spine requests	Patient information- plain skull requests
N	Valid	200	200
	Missing	0	0
Mean		48.4375	49.5000
Std. Error of Mean		.78227	.81135
Median		50.0000	50.0000
Mode		50.00	50.00
Std. Deviation		11.06297	11.47424
Variance		122.389	131.658
Skewness		-.807	-1.180
Std. Error of Skewness		.172	.172
Kurtosis		.139	3.035
Std. Error of Kurtosis		.342	.342
Range		37.50	75.00
Minimum		25.00	.00
Maximum		62.50	75.00

The kurtosis for the distribution of lumbar spine and skull data was 0.139 (Leptokurtic distribution) and 3.035 (Leptokurtic distribution) respectively. The standard error of kurtosis was 0.342 in both cases. These values demonstrate that the distribution of data in the two examinations was more concentrated around the mean than in a normal distribution resulting in a sharper than normal distribution. The magnitude of kurtosis for lumbar spine data was less than two times the standard error of kurtosis and was not statistically significant. The spread of the data was therefore close to that of a normal distribution. The magnitude of kurtosis for plain skull data was statistically significant.

Table 4.4: Frequency statistics for plain lumbar spine patient information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25.00	24	12.0	12.0	12.0
	37.50	20	10.0	10.0	22.0
	50.00	113	56.5	56.5	78.5
	62.50	43	21.5	21.5	100.0
	Total	200	100.0	100.0	

Table 4.5: Frequency statistics for plain skull radiology patient information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	2	1.0	1.0	1.0
	25.00	15	7.5	7.5	8.5
	37.50	20	10.0	10.0	18.5
	50.00	116	58.0	58.0	76.5
	62.50	44	22.0	22.0	98.5
	75.00	3	1.5	1.5	100.0
	Total	200	100.0	100.0	

Tables 4.4 and 4.5 demonstrate frequency statistics for the two examinations with respect to patient information. The mode score which was also equal to the median score was the same for the two examinations and was 50.00%. This mode score appeared 56.5% of the requests for lumbar spine and 58.0% for skull requests. One percent observations had no patient information for skull requests. Lumbar spine data had a minimum score of 25%. Both examinations' data demonstrated unimodal distribution. The tendency demonstrated in patient information for lumbar spine and skull requests was that generally referrers would respectively provide 48.4 +/- 0.8% and 49.5+/- 0.8% patient information. These values were inclusive of each other in that they were within the error margins of each other. In the total sample for the two examinations, 99.8% of the reviewed examination requests did not have pregnancy status of the patients yet 24% of these requests were for female patients of child bearing age. This means that 98.9% child bearing age patients did not have pregnancy status indicated on the request forms that were assessed after the examination had been performed.

The test value (expected frequency) for the completeness of patient information (75%) was shown in table 3.1: 28.

Table 4.6: One-Sample Statistics- Completeness of patient information

...	N	Mean	Std. Deviation	Std. Error Mean
Patient_infor_lumbar	200	48.4375	11.06297	.78227
Patient_infor_skull	200	49.5000	11.47424	.81135

Table 4.7: One-Sample Test- Completeness of patient information

...	Test Value = 75			
	T	Df	Sig. (2-tailed)	Mean Difference
Patient_infor_lumbar	-33.956	199	.000	-26.56250
Patient_infor_skull	-31.429	199	.000	-25.50000

Table 4.8: One-Sample Test (continued)- Completeness of patient information

...	Test Value = 75	
	95% Confidence Interval of the Difference	
	Lower	Upper
Patient_infor_lumbar	-28.1051	-25.0199
Patient_infor_skull	-27.1000	-23.9000

The one sample t-test statistic was -33.956 (lumbar) and -31.429 (Skull). The negative t-scores show that the means for the samples 48.4+/-0.8% (lumbar) and 49.5+/-0.8% (Skull) are less than the expected hypothesised population mean (75.00). The *p*-value means that the probability of collecting a sample with the mean value of 48.4+/-0.8% (lumbar) and that of collecting a sample with a mean 49.5+/-0.8 (Skull) given that the true population mean is 75.0% is 0.00 (Sig.) for both examinations. This *p*-value (0.00) for the two examinations was less than 0.05. This was significant at both alpha =0.05 and alpha =0.01 alpha levels. Again the expected value falls outside the 95%Confidence Interval of the difference and was also outside the error margins of the means for the two examinations. Such a difference indicates that there was a significant difference between the observed sample means and the hypothesised population mean. Therefore, there was sufficient evidence to conclude that the observed completeness values of patient information were significantly below the expected completeness level.

In order to determine whether referrers for this research site were consistent in providing request information between plain skull and plain lumbar spine examinations with respect to patient information, patient information data for plain lumbar spine and for plain skull were statistically analysed using a two tailed (independent sample) two sample t-test. The grouping coding (maintained throughout the study) for plain skull was 1.00 while plain lumbar spine was 2.00. There were a total of 200 independent radiological request forms considered for each of the two examinations and there were no missing values. Therefore the total sample size for the group was N=400 requests and the grouping code enabled the two examinations to be distinguished from each other in the total sample.

Table. 4.9: Group Statistics- Significance test for completeness of patient information

..	Grouping	N	Mean	Std. Deviation	Std. Error Mean
pattient_inf or	1.00	200	49.5000	11.47424	.81135
	2.00	200	48.4375	11.06297	.78227

Mean completeness for the two examination requests per category of measurement, standard deviation and standard error in the mean per category of measurement are shown in table 4.9.

Table 4.10: Patient information –Test for equality of variances

..		Levene's Test for Equality of Variances	
		F	Sig.
pattient_inf or	Equal variances assumed	.784	.376
	Equal variances not assumed		

Results for the "Levene's Test for Equality of Variances" are shown in table 4.10. The test results gave the researcher insight into the homogeneity of variance assumption with respect to the results of this study. The results demonstrate that the *P*-value (0.376 Sig.) was greater than 0.05 and hence equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

Table 4.11: Independent Samples Test -Significance test for completeness of Lumbar against Skull examination requests

..		t-test for Equality of Means			
		T	Df	Sig. (2-tailed)	Mean Difference
pattient_inf or	Equal variances assumed	.943	398	.346	1.06250
	Equal variances not assumed	.943	397.471	.346	1.06250

The t-values, degrees of freedom (df), sig-value and the "Mean Difference" statistic which indicates the magnitude of the difference between the means for the two samples are shown in table 4.11.

Table 4.12: Significance test for completeness (Continued):patient information

..		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
pattient_infor	Equal variances assumed	1.12705	-1.15321	3.27821
	Equal variances not assumed	1.12705	-1.15322	3.27822

Results of the t-test are shown in tables 4.11-12 in two formats -format for "Equal" variances and format for “Unequal” variances (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).The 0.346 probability demonstrated in table 4.10 (0.346 Sig.) for patient information is greater than 0.05 so the difference in the sample means was not statistically significant. Again the sample means (49.5+/-0.8 Skull and 48.4+/-0.8 Lumbar) for the two examinations were within the error margins of each other. Furthermore, the population means fall within the 95% Confidence Interval of the difference. This means that the variation in the provision of patient information in the request forms was not significant between the two examinations.

4.3.2 Descriptive and analytical review of request forms: observed examination information

In this sub-section a report on the existence of study requested, clinical history, indication for the examination, diagnosis, date of request, *X-ray number, number of films taken, previous x-rays, surgical operations and Walking/stretcher* information (Table 3.2: 30) is given. The possible score was 10/10 (100%) while the expected score was 5/10 (50%).

Central tendency measures derived from the data for plain lumbar spine and for plain skull requests with respect to examination information are shown in Table 4.12. The statistics demonstrate that all 200 examination requests for each examination were included in the calculation of central tendency for the research site. The maximum and minimum scores for plain lumbar spine data was 63.64% and 0.00 thus giving a range of 63.64%. For plain skull requests the range was 63.64% with the lowest value being 9.09% and the highest being 72.73%. The mode values were identical for the two examinations. While the mode and the median values were identical for plain lumbar spine data and were falling within the error margins of the mean, plain skull data demonstrated different mean, mode and median values. However the median was within the error margins of the mean. By virtue of being equal, the mean, mode and median for lumbar spine therefore defined normally distributed data. The skewness as well as kurtosis was relatively higher for skull data compared to that of lumbar spine data. The skewness for the distribution of lumbar spine and skull data was 0.493 and 0.528 respectively. The standard error of skewness was 0.172 in both cases. This positive sign in skewness values means that the distribution of this data was left skewed. In both cases, the magnitude of this skewness was greater than two times the standard error of skewness and therefore was statistically significant. Therefore with respect to skewness the data was not symmetrically distributed on both sides of the mean.

Table 4.13: Measures of central tendency- examination information

		Examination information for plain lumbar spine requests	Examination information for plain skull requests
N	Valid	200	200
	Missing	0	0
Mean		29.8159	32.5933
Std. Error of Mean		.84804	.77155
Median		27.2700	31.8150
Mode		27.27	27.27
Std. Deviation		11.99307	10.91135
Variance		143.834	119.058
Skewness		.493	.528
Std. Error of Skewness		.172	.172
Kurtosis		.458	.623
Std. Error of Kurtosis		.342	.342
Range		63.64	63.64
Minimum		.00	9.09
Maximum		63.64	72.73

The kurtosis for the distribution of lumbar spine and skull data was 0.458 (Leptokurtic distribution) and 0.628 (Leptokurtic distribution) respectively. The standard error of kurtosis was 0.342 in both cases. These values demonstrate that the distribution of plain lumbar spine data and that of plain skull data was concentrated around the mean. However, the magnitude of kurtosis for both lumbar spine data and plain skull data was less than two times the standard error of kurtosis and therefore was not statistically significant. The spread of the data was therefore close enough to that of a normal distribution.

Table 4.14: Frequency statistics for plain lumbar spine examination information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	2	1.0	1.0	1.0
	9.09	10	5.0	5.0	6.0
	18.18	41	20.5	20.5	26.5
	27.27	73	36.5	36.5	63.0
	36.36	42	21.0	21.0	84.0
	45.45	19	9.5	9.5	93.5
	54.55	9	4.5	4.5	98.0
	63.64	4	2.0	2.0	100.0
	Total	200	100.0	100.0	

Table 4.15: Frequency statistics for plain skull examination information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	9.09	4	2.0	2.0	2.0
	18.18	30	15.0	15.0	17.0
	27.27	66	33.0	33.0	50.0
	36.36	61	30.5	30.5	80.5
	37.36	1	.5	.5	81.0
	45.45	25	12.5	12.5	93.5
	54.55	10	5.0	5.0	98.5
	63.64	2	1.0	1.0	99.5
	72.73	1	.5	.5	100.0
	Total	200	100.0	100.0	

Frequency statistics for the two examinations with respect to examination information are demonstrated in Tables 4.14 and 4.15. The mode which was also equal to the median for plain lumbar spine data was 27.27%. This appeared in 36.5% of the requests for lumbar spine and while that for skull appeared in 33.0% requests. It was observed that one percent of plain lumbar spine requests had no examination information documented on request forms. Both plain skull and plain lumbar spine data sets were unimodal. The tendency demonstrated in these two examinations was that generally referrers for plain lumbar spine and plain skull would respectively provide 29.8+/-0.8% and 32.6+/- 0.8% examination information.

The test value (expected frequency) for the completeness of examination information was 50% (refer to table 3.1:28). Application of a one sample t-test on the data produced the following results.

Table 4.16: One-Sample Statistics- Completeness of examination information

	N	Mean	Std. Deviation	Std. Error Mean
Exam_info_lumbar	200	29.8159	11.99307	.84804
Exam_info_skull	200	32.5933	10.91135	.77155

Table 4.17: One-Sample Test- Completeness of examination information

	Test Value = 50			
	T	Df	Sig. (2-tailed)	Mean Difference
Exam_info_lumbar	-23.801	199	.000	-20.18415
Exam_info_skull	-22.561	199	.000	-17.40670

Table 4.18: One-Sample Test- (continued) - Completeness of examination information.

	Test Value = 50	
	95% Confidence Interval of the Difference	
	Lower	Upper
Exam_info_lumbar	-21.8564	-18.5119
Exam_info_skull	-18.9282	-15.8852

The one sample t-test statistic was -23.801 (lumbar) and -22.561 (Skull). The negative t-scores shows that the means for the samples 29.8+/-0.8% (lumbar) and 32.6+/-0.8% (Skull) were less than the expected hypothesised population mean (50.0%). This p-value means that the probability of collecting a sample with the mean value of 29.8+/-0.8% (lumbar) and that of collecting a sample with a mean 32.6+/-0.8% (Skull) given that the true population mean is 50.00% was 0.00 (Sig.) for both examinations. This p-values (0.00) for the two examinations was less than 0.05. This was significant at both alpha =0.05 and alpha =0.01 alpha levels. Again the expected population mean was outside the 95%Confidence Interval of the difference and was also outside the error margins of the means. Such a difference indicates that there was a significant difference between the observed sample means and the hypothesised population mean. Therefore, there was sufficient statistical evidence to conclude that the observed completeness values of examination information were significantly below the expected level.

In order to determine whether referrers for this research site were consistent in providing request information between plain skull and plain lumbar spine examination information, examination information data for plain lumbar spine and for plain skull were statistically analysed using a two tailed (independent sample) two sample t-test. Levene's Test for Equality of Variances was also applied in order to ensure that the conditions for the application of the t-test were fulfilled.

Table. 4.19: Significance test: Completeness of examination information

..	Grouping	N	Mean	Std. Deviation	Std. Error Mean
Exam_infor	1.00	200	32.5933	10.91135	.77155
	2.00	200	29.8159	11.99307	.84804

In this test the sample size was 200 per examination (Refer to Table 4.19). Mean completeness for the two examination requests, standard deviation and standard error in the mean are also listed in this table.

Table 4.20: Levene's Test for Equality of Variances: completeness of examination information

..		Levene's Test for Equality of Variances	
		F	Sig.
Exam_infor	Equal variances assumed	.550	.459
	Equal variances not assumed		

Results for the "Levene's Test for Equality of Variances" are demonstrated in Table 4.20. These test results gave the researcher an insight into the homogeneity of variance assumption with respect to the results of this study. In this test, the *P*-value was greater than 0.05 and hence equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

Table 4.21: Significance test for completeness of examination information

..		t-test for Equality of Means			
		T	Df	Sig. (2-tailed)	Mean Difference
Exam_infor	Equal variances assumed	2.423	398	.016	2.77745
	Equal variances not assumed	2.423	394.496	.016	2.77745

In table 4.21, the t-values, degrees of freedom (df), sig-value and the "Mean Difference" statistic which indicates the magnitude of the difference between the means for the two samples are shown.

Table 4.22: Significance test for completeness of examination information (continued)

..		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Exam_infor	Equal variances assumed	1.14650	.52350	5.03140
	Equal variances not assumed	1.14650	.52344	5.03146

The actual t-test results in two formats -format for "Equal" variances and format for “Unequal” variances are shown in table 4.22. The two demonstrated equal values. The criterion for statistical significance was a "2-tailed significance" less than 0.05 and equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

The 0.016 probability demonstrated in table 4.21 for examination information was less than 0.05 so the difference in the sample means was statistically significant. The means (32.6+/-0.8% Skull and 29.8+/-0.8% Lumbar) for the two examinations were outside the error margins of each other. Furthermore, the sample means fell outside the 95%Confidence Interval of the difference. This means that the provision of examination information in the request forms varied significantly between the examinations and meaning that referrers were not consistent in providing examination information between the two examinations. What this test result means in essence is that unlike for patient information, there was an association between the supplied examination information and the requested examination.

4.3.3 Descriptive and analytical review of request forms: observed referrer information

In this sub-section a report is given on the existence of referrer name, surname, contact and signature (Table 3.1: 28). The possible score was 4/4 (100%) and the expected score was also 100%.

Measures of central tendency derived from the data for plain lumbar spine and that for plain skull requests with respect to referrer information are shown in table 4.23. The statistics demonstrate that all 200 examination requests for each examination were included in the calculation of central tendency for the research site. The maximum and minimum scores for both plain lumbar spine data and plain skull data were 100.00% and 0.00% thus giving a range of 100.00%. The mode and the median values were both 40.00% and were identical for the two examinations. The means for plain lumbar spine and plain skull requests were 38+/- 1% and 38.5 +/- 0.8% respectively and the median and the mode were not included in the error margins of the mean which is contrary to values for normally distributed data. This was a reflection of the presence of extreme maximum and minimum values. The skewness for the distribution of lumbar spine and skull data was 0.644 and 0.477 respectively. The skewness as well as kurtosis was relatively higher for skull data as compared to that of lumbar spine data. The standard error of skewness was 0.172 in both cases. This positive sign in skewness values means that the distribution of this data was right skewed. Most of the values were concentrated on the left of the mean with extreme values to the right of the mean. In both cases, the magnitude of this skewness was greater than two times the standard error of skewness and therefore was statistically significant.

Table 4.23: Central tendency measures for referrer information

		Referrer information plain lumbar spine	Referrer information plain skull
N	Valid	200	200
	Missing	0	0
Mean		38.4000	38.5000
Std. Error of Mean		1.05488	.81367
Median		40.0000	40.0000
Mode		40.00	40.00
Std. Deviation		14.91820	11.50704
Variance		222.553	132.412
Skewness		.644	.477
Std. Error of Skewness		.172	.172
Kurtosis		5.664	11.045
Std. Error of Kurtosis		.342	.342
Range		100.00	100.00
Minimum		.00	.00
Maximum		100.00	100.00

The kurtosis for the distribution of lumbar spine and skull data was 5.664 (Leptokurtic distribution) and 11.045 (Leptokurtic distribution) respectively. The standard error of kurtosis was 0.342 in both cases. These values demonstrated a sharper than normal distribution. This demonstrated high probability for extreme values. This was consistent with observed maximum and minimum values. The magnitudes of kurtosis for both examinations were more than two times the standard error of kurtosis and therefore were statistically significant. The spread of the referrer information therefore demonstrated a departure from a normal distribution.

Table 4.24: Frequency statistics for plain lumbar spine referrer information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	10	5.0	5.0	5.0
	20.00	20	10.0	10.0	15.0
	40.00	157	78.5	78.5	93.5
	60.00	5	2.5	2.5	96.0
	80.00	5	2.5	2.5	98.5
	100.00	3	1.5	1.5	100.0
	Total	200	100.0	100.0	

Table 4.25: Frequency statistics for plain skull referrer information

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	6	3.0	3.0	3.0
	20.00	16	8.0	8.0	11.0
	40.00	170	85.0	85.0	96.0
	60.00	5	2.5	2.5	98.5
	80.00	1	.5	.5	99.0
	100.00	2	1.0	1.0	100.0
	Total	200	100.0	100.0	

Frequency statistics for the two examinations with respect to referrer information are demonstrated in tables 4.24 (plain lumbar spine) and table 4.25 (plain skull). The mode which was also equal to the median for both examinations was 40.00%. This appeared 157 times (78.5% of the requests) for lumbar spine and 170 times (85.0% of the requests) for skull requests. There were 10 observations (5.0%) and 6 observations (3.0%) that had no referrer information for plain lumbar spine and plain skull requests respectively. There were also 3 observations (1.5%) and 2 observations (1.0%) that had complete referrer information for plain lumbar spine and plain skull requests respectively. The two sets of data were unimodal. Therefore the tendency demonstrated in these two examinations was that generally referrers for plain lumbar spine and for plain skull would respectively provide 38+/- 1% and 38.5 +/- 0.8% referrer identification information.

There were 126 out 200 lumbar spine requests that had the referrer signature as the only means to identify the referrer. A total of eight (8) examination requests out of a total of 400 sampled requests had referring practitioners contact details. This represented 2% of the total number of the requests.

A one sample t-test was applied in order to compare the sample means with the expected frequency (Hypothesised population mean). The test value (expected frequency) for the completeness of referrer information was 100% (refer to table 3.1: 28). Application of a one sample t-test on the data produced the following results.

Table 4.26: One-Sample Statistics- Completeness of referrer information

	N	Mean	Std. Deviation	Std. Error Mean
Referrer_info_lumbar	200	38.4000	14.91820	1.05488
Referrer_info_skull	200	38.5000	11.50704	.81367

Table 4.27: One-Sample Test- Completeness of referrer information

	Test Value = 100			
	T	df	Sig. (2-tailed)	Mean Difference
Referrer_info_lumbar	-58.395	199	.000	-61.60000
Referrer_info_skull	-75.583	199	.000	-61.50000

Table 4.28: One-Sample Test (continued)- Completeness of referrer information

	Test Value = 100	
	95% Confidence Interval of the Difference	
	Lower	Upper
Referrer_info_lumbar	-63.6802	-59.5198
Referrer_info_skull	-63.1045	-59.8955

From table 4.27, the one sample t-test statistic was -58.395 (lumbar) and -75.583 (Skull). The negative t-scores shows that the means (Table 4.26) for the samples 38+/-1% (lumbar) and 38.5+/-0.8 (Skull) were less than the expected hypothesised population mean (100.0%). The p-value (0.00) means that the probability of collecting a sample with the mean value of 38+/-1% (lumbar) and that of collecting a sample with a mean 38.5+/-0.8% (Skull) given that the true population mean is 100.00% was 0.00 (Sig.) for both examinations. Furthermore, the calculated *p*-values (0.00) for the two examinations were less than 0.05. This was significant at both alpha =0.05 and alpha =0.01 alpha levels. Again the expected value falls outside the 95%Confidence Interval of the difference and is also outside the error margins of the mean. Such a difference indicates that there is a significant difference between the observed sample means and the hypothesised population mean. Therefore, there is sufficient evidence to conclude that for both examinations the observed completeness values of referrer information were significantly below the expected level.

In order to determine whether referrers for this research site were consistent in providing referrer information between plain skull and plain lumbar spine examinations, referrer information data for plain lumbar spine and plain skull were statistically compared using a two tailed (independent sample) two sample t-test.

Table. 4.29: Significance test for completeness of requests: referrer information

..	Grouping	N	Mean	Std. Deviation	Std. Error Mean
Referrer_infor	1.00	200	38.5000	11.50704	.81367
	2.00	200	38.4000	14.91820	1.05488

The sample size was 200 per examination (Table 4.29). Mean completeness for the two examination requests, standard deviation and standard error in the mean are also listed in this table.

Table 4.30: Levene's Test for Equality of Variances: Referrer information

..		Levene's Test for Equality of Variances	
		F	Sig.
Referrer_infor	Equal variances assumed	3.747	.054
	Equal variances not assumed		

Results for the "Levene's Test for Equality of Variances" are shown in table 4.30. The test results gave the researcher an insight into the homogeneity of variance assumption with respect to the results of this study. From table 4.30, the *P*-value was greater than 0.05 and hence equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

Table 4.31: Significance test for completeness of requests: referrer information

..		t-test for Equality of Means			
		T	Df	Sig. (2-tailed)	Mean Difference
Referrer_infor	Equal variances assumed	.075	398	.940	.10000
	Equal variances not assumed	.075	373.889	.940	.10000

The t-values, degrees of freedom (df), sig-value and the "Mean Difference" statistic which indicates the magnitude of the difference between the means for the two samples are shown in table 4.31.

Table 4.32: Significance test for completeness (continued): referrer information

..		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Referrer_infor	Equal variances assumed	1.33223	-2.51908	2.71908
	Equal variances not assumed	1.33223	-2.51959	2.71959

The criterion for statistical significance was a "2-tailed significance" less than 0.05 and equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).The 0.940 probability demonstrated in table 4.32 for referrer information was greater than 0.05 so the difference in the sample means was statistically insignificant. The sample means (38.5+/-0.8% Skull and 38+/-1% Lumbar) were also within the error margins of each other. Furthermore, the population means fell within the 95% Confidence Interval of the difference. This demonstrates that the variation in the provision of referrer information in the request forms did not vary significantly between the examinations meaning that referrers were consistent in providing referrer information between the examinations. What these test results mean in essence is that similar to patient information, for referrer information there was no significant difference between that which is supplied for plain lumbar spine radiology and that supplied for plain skull radiology. Therefore there was no association between the observed referrer identification information and the requested radiological examination.

4.3.4 Descriptive analytical review of request forms: overall radiological request data

In this sub-section a report is given on the existence of patient information, examination information and referrer information (Table 3.2: 31). The possible score was 22/22 (100%) and the expected score was 15/22 (68%)

The statistics derived from the data for the plain skull and that for plain lumbar spine requests with respect to total information contained in each radiological request form are given in table 4.33. There were no missing values for both examinations in the calculation of central tendency for the research site. The maximum and minimum scores for plain lumbar spine data were 65.68% and 11.36% thus giving a range of 54.32%. However for plain skull requests the range was 57.96% while the lowest entry was 23.71% and the highest entry was 57.50%. The mode, median and the mean for plain lumbar spine data were 39.09%, 39.09% and 38.9 +/- 0.6% respectively. These values show that the median and the mode fell within the error margins of the mean thus giving measures for central tendency that satisfied the criterion for normally distributed data. The mode, median and the mean for plain skull request data were 42.12%, 40.23% and 40.2+/- 0.5% respectively which demonstrates that the mode falls outside the error margins of the mean. The skewness for the distribution of lumbar spine and skull data was -0.173 and 0.223 respectively. The standard error of skewness was 0.172 in both cases. This positive sign of the skewness for skull data means that the distribution of this data was right skewed. Most of the values were concentrated on the left of the mean with extreme values to the right. In both cases, the magnitude of this skewness was less than two times the standard error of skewness and therefore was not statistically significant. With respect to skewness, the data was therefore normally distributed.

Table 4.33 Frequency statistics for completeness of overall request information

	Requestinformation plain lumbar spine	Requestinformation plain skull
Valid	200	200
Missing	0	0
Mean	38.8845	40.1978
Std. Error of Mean	.56781	.50910
Median	39.0900	40.2267
Mode	39.09	42.12
Std. Deviation	8.03001	7.19977
Variance	64.481	51.837
Skewness	.173	.223
Std. Error of Skewness	.172	.172
Kurtosis	1.475	4.085
Std. Error of Kurtosis	.342	.342
Range	54.32	57.96
Minimum	11.36	17.42
Maximum	65.68	75.38

The kurtosis for the distribution of lumbar spine and skull data was 1.475 (leptokurtic distribution) and 4.085 (Leptokurtic distribution) respectively. The standard error of kurtosis was 0.342 in both cases. Kurtosis values for both examinations demonstrate that the distribution graph for the data was sharper than in a normal distribution. This demonstrated high probability for extreme values. This was consistent with observed maximum and minimum values for plain skull data. The magnitudes of kurtosis for both examinations were more than two times the standard error of kurtosis and were therefore statistically significant. The spread of the radiology request information therefore demonstrated a departure from that of normal distributed data. Fig. 4.1 and 4.2 demonstrate these results graphically. The graphs demonstrate that the two sets of data were unimodal. The central tendency demonstrated in these two examinations was that generally referrers for plain lumbar spine and for plain skull would respectively provide 38.9 +/- 0.6% and 40.2+/-0.5% overall examination request information.

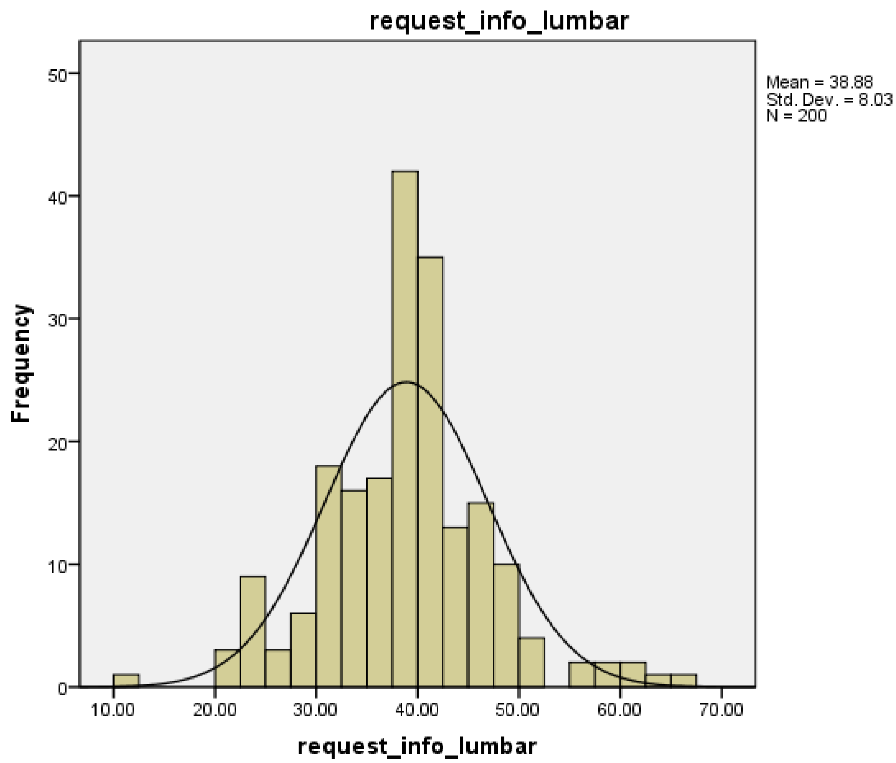

Figure 4.1: Histogram with normal curve fit for plain lumbar spine overall request information

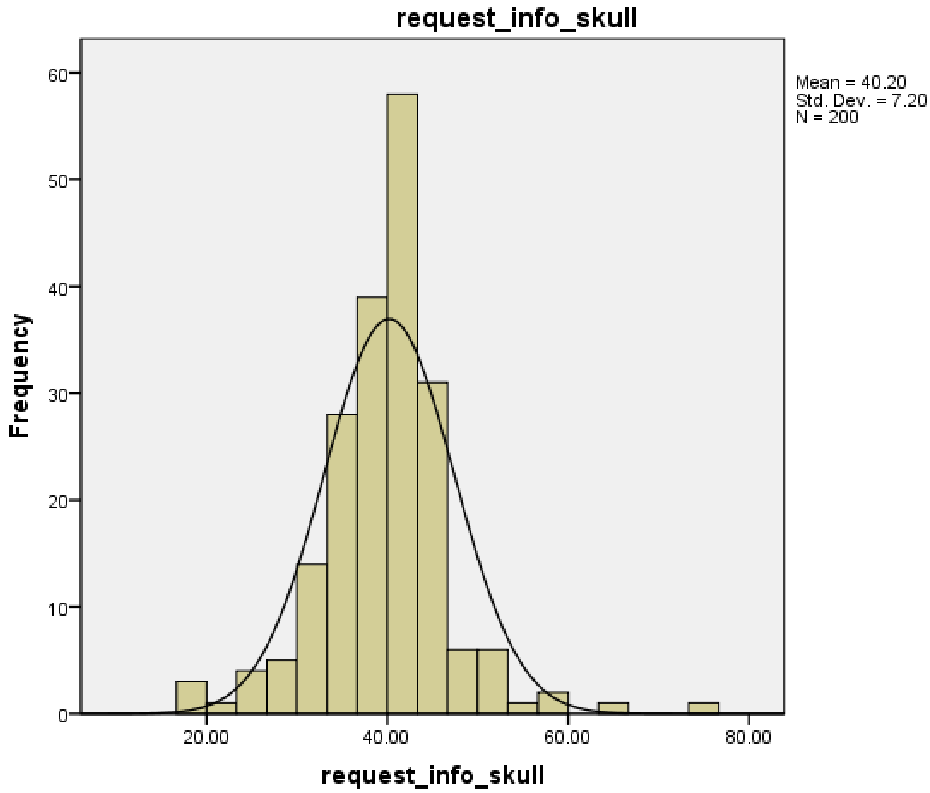

Figure 4.2: Histogram with normal curve fit for plain skull request information

The test value for the completeness of examination information was 68% (refer to table 3.2:31).

Table 4.34: One-Sample Statistics- Completeness of overall examination request information

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
request_info_lumbar	200	38.8845	8.03001	.56781
request_info_skull	200	40.1978	7.19977	.50910

Table 4.35: One-Sample Test- Completeness of overall examination request information

	Test Value = 68			
	T	df	Sig. (2-tailed)	Mean Difference
request_info_lumbar	-51.277	199	.000	-29.11555
request_info_skull	-54.610	199	.000	-27.80223

Table 4.36: One-Sample Test (continued)-completeness of overall examination request information

	Test Value = 68	
	95% Confidence Interval of the Difference	
	Lower	Upper
request_info_lumbar	-30.2352	-27.9959
request_info_skull	-28.8062	-26.7983

The one sample t-test statistic was -51.28 (lumbar) and -54.61 (Skull). The negative t-scores shows that the means for the samples 38.9+/-0.6% (lumbar) and 40.2+/-0.5% (Skull) were less than the expected hypothesised population mean (68.00%). The p-value (0.00) means that the probability of collecting a sample with the mean value of 38.9+/-0.6% (lumbar) and that of collecting a sample with a mean 40.2+/-0.5% (Skull) given that the true population mean was 68% was 0.00 (Sig.) for both examinations. This p-value (0.00) was less than 0.05 for both examinations. This was significant at both alpha =0.05 and alpha =0.01 alpha levels. Again the expected value falls outside the 95% Confidence Interval of the difference and also outside the error margins of the two means. Such a difference indicates that there is a significant difference between the observed sample means and the hypothesised population mean. Therefore, there was sufficient statistical evidence to conclude that the observed completeness values of overall examination request information for both examinations were significantly below the expected hypothetical value.

In order to determine whether referrers for this research site were consistent in providing overall request information between plain skull and plain lumbar spine examinations, overall request data for plain lumbar spine and for plain skull were statistically compared using a two tailed (independent sample) two sample t-test.

Table. 4.37:Significance test for completeness of request data: Overall request data

..	Grouping	N	Mean	Std. Deviation	Std. Error Mean
Request_infor	1.00	200	40.1978	7.19977	.50910
	2.00	200	38.8843	8.03058	.56785

Mean completeness for the two examination requests per category of measurement, standard deviation and standard error in the mean are listed in table 4.37.

Table 4.38: Significance test for completeness of request data: Levene's Test for Equality of Variances

..		Levene's Test for Equality of Variances	
		F	Sig.
Request_infor	Equal variances assumed	1.832	.177
	Equal variances not assumed		

Results for the "Levene's Test for Equality of Variances” are shown in table 4.38. The test results gave the researcher an insight into the homogeneity of variance assumption which was the key assumption for the application of the t-test. The *P*-value was greater than 0.05 and hence equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

Table 4.39: Significance test for completeness of overall request data

..		t-test for Equality of Means			
		T	Df	Sig. (2-tailed)	Mean Difference
Request_infor	Equal variances assumed	1.722	398	.086	1.31347
	Equal variances not assumed	1.722	393.346	.086	1.31347

The t-values, degrees of freedom (df), sig-value and the "Mean Difference" statistic which indicates the magnitude of the difference between the means for the two samples are shown in table 4.39.

Table 4.40: Significance test for completeness overall request data (continued)

..		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
Request_infor	Equal variances assumed	.76265	-.18586	2.81279
	Equal variances not assumed	.76265	-.18591	2.81285

The criterion for statistical significance was a "2-tailed significance" less than 0.05 and equal variances were assumed (MedCalc, 2012; Perk *et al.,* 2008; Decoursey, 2003; Eng, 2003; Richard, 2000).

The 0.086 probability for supplied radiological request information was greater than 0.05 so the difference in the sample means was not statistically significant. The means for the two examinations (40.2+/- 0.5% for skull and 38.9+/- 0.6% for lumbar) were also within the error margins of each other. Furthermore, the expected population means fell within the 95%Confidence Interval of the difference. This means that the provision of overall radiology request information in request forms did not vary significantly between the two examinations. What this test result means in essence is that for overall radiological request information there was no significant difference with respect to completeness between that which was supplied for plain lumbar spine radiology and that supplied for plain skull radiology. Therefore referrers for this research site were consistent in providing overall radiology request information between plain skull and plain lumbar spine examinations.

4.4 How accurate are the requests in that they specify unambiguously the exact anatomical area to be imaged?

In this subsection, frequency counts of those radiological requests that had the exact anatomical area to be imaged specified without ambiguity were reported as accurate requests. As an example, a plain skull request specifying that the referrer is suspecting a depression fracture on the frontal bone was counted positive. There was therefore a possible count of 200 per examination and the expected score was 50% (Ref. Sub-section 3.4.3: 28).

There were no missing values for both examinations in the calculation of central tendency for each examination. It was observed that 5% plain lumbar spine and 3% plain skull requests were accurate in so far as information documented on request forms could show. On average, 4% requests had the area to be imaged accurate identified. With respect to legibility, the requests were found to be generally readable although it was observed that generally radiographers did not correct requests data on the request forms.

4.5 Were the requests for plain skull and plain lumbar spine x-rays justified in terms of being clinically indicated (meeting at least one indication as prescribed on tables 2.2 and 2.3)?

In this subsection, frequency counts of those radiological requests that were clinically indicated with respect to information documented on the request form were reported as justified (Ref. Sub-section 3.4.4: 29). As an example, a plain skull request specifying that the patient had focal signs following trauma to the head was counted positive. There was therefore a possible count of 200 per examination and the expected score was 23% justified (Ref. Sub-section 3.4.4: 29). Figure 4.3 is an extract from the plain skull data collection instrument that illustrates how the frequency count for justified requests was obtained.

Fig. 4.3: Justification of requests by virtue of being indicated

Justification of examination on request form (Skull trauma cases)	**Request form I.D. number**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**A1**
	18. Exam Justified	x	x	x	x	x	x	x	x	x	x	x	**Nil**
	At least one positive justifies exam												
	Loss of consciousness	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Neurological symptoms	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Fluid through nose/ ear	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Penetrating injury	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Alcohol intoxicated	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Patient vomited	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Difficult patient	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Blood through ear/nose	X	X	X	X	X	X	X	X	X	X	X	**Nil**
Justification of examination on request form (Skull -non trauma cases)	Chronic headache with abnormal results on clinical examination	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Hearing loss	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Suspected SOL	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Paranasal Sinusitis >3yrs	X	X	X	X	X	X	X	X	X	X	X	**Nil**
	Police investigations	X	X	X	X	X	X	X	X	X	X	X	**Nil**

In this illustration (Fig. 4.3, column labelled 4), for request form number 4 for example and for each row of indications, x denotes that none of the listed indications was identified on the request form and therefore along row "18. Exam justified" the request was found to be unjustified. Column marked "A1" denotes the total count of justified requests for this particular data collection sheet (page). The proportion of justified requests was therefore the sum of all requests that were indicated and therefore justified as a fraction of the total sample (200 requests). There were no missing values for both examinations in the calculation of central tendency for the research site. It was observed that generally referrers for this research site would tend to request 22.5% (plain lumbar spine) and 12% (plain skull) requests that were justified by virtue of being indicated.

4.6 Summary of results

This chapter set out to provide results for the completeness, accuracy and justification of plain lumbar spine and plain skull radiology requests for the research site. A descriptive analytical approach that culminated in the determination of the distribution and central tendency measures was used. This was followed by inferential analysis. A summary of the results is given in table 4.41.

Table 4.41: Summary of results for completeness, accuracy and justification of requests

1	**Completeness of information**	
1.1	**Patient information: Plain Skull 49.5+/-0.8%; Plain lumbar spine 48.4+/-0.8%**	
1.1.1	Significance: 2 sample t-test	No significant difference
1.1.2	Skull and lumbar against data collection instrument: One sample t-test	Significant difference
1.2	**Examination information: Plain skull 32.6+/-0.8%; Plain lumbar spine 29.8+/-0.8%**	
1.2.1	Significance test: 2 sample t-test	Significant difference
1.2.2	Skull and lumbar against data collection instrument: 1 sample t-test	Significant difference
1.3	**Referrer information: Plain Skull 38.5+/-0.8%; Plain lumbar spine 38+/-1%**	
1.3.1	Significance test: 2 sample t-test	Insignificant difference
1.3.2	Skull and lumbar against data collection instrument: 1 sample t-test	Significant difference
1.4	**Examination request information: Plain Skull 40.20%; Plain Lumbar spine 38.88%**	
1.4.1	Skull against lumbar: 2 sample t-test	Insignificant difference
1.4.2	Skull and lumbar against data collection instrument: 1 sample t-test	Significant difference
1.5	**Accuracy of requests:** Plain skull 3%; Plain Lumbar spine 5%	
1.6	**Justification of requests:** Plain skull 12%; Plain lumbar spine 22%	

4.7 Outline of chapter 5

The following chapter (Chapter 5) focuses on the discussion, conclusion and recommendations drawn from the results of this study. The focus of the discussion is to develop recommendations on the completeness, accuracy and justification of radiological requests that would have possible positive outcome for the research site.

CHAPTER 5
DISCUSSIONS

> It is ECRP (2009: 18) who wrote that, "…It should be understood that good practice is not a permanent concept but should evolve with the general development of evidence based medicine, medical RADIOLOGICAL equipment and techniques. Agreed good practices should be considered from time to time and modified, when there are evidence based reasons to change. Such modifications can become necessary when new data or experience is gained through research…or due to development of new technique or equipment which can provide better tools to achieve desired objectives of a certain procedure"

5.1 Introduction

In this final chapter of the thesis, focus is put on the discussion, conclusion and recommendations on the completeness, accuracy and justification of radiology requests for the research site. The sequencing of discussion topics was based on research sub-questions. The ultimate purpose was to provide clear answers to the research questions and therefore provide clear recommendations on the development of a framework for requesting radiology examinations that would have possible positive outcome on radiology patient care.

5.2 Descriptive and analytical review of the framework for requesting radiology examinations

On average, 56% overall compliance with respect to the prescribed criteria was observed in the sample of 12 identified radiological template forms. Notably, 8% and 50% compliance was observed with respect to form fields for referrer contact and pregnancy status respectively. These observations have medico-legal implications and affect the quality of overall service provided by the radiology department (Triantopoulou *et al*., 2005; Cook *et al*., 2003).

Observed form field data for the research site's template forms demonstrated that these request forms had varied form field content. Because radiological request forms are the main medium of communicating examination request information, this observation demonstrated that they promoted incomplete transmission of examination request information. In such a situation important facts about the request are not transmitted in an effective way to those who need to know them thus leading to no meaningful documented dialogue on balancing benefits with the risks to patients (IAEA, 2008: 9; Triantopoulou *et al*., 2005; Scally, 1993; Cook *et al*., 2003). The researcher therefore recommends that such request forms were not suitable to be used for such important purposes and should be withdrawn from circulation.

5.3 Descriptive and analytical review of plain skull and plain lumbar spine request data

In this sub-section, descriptive and analytical report on plain skull and plain lumbar spine request data is given with respect to patient, examination, referrer, accuracy and justification information.

5.3.1 Descriptive and analytical review of patient information

It was observed that there was general consistency between the patient information submitted for plain lumbar spine requests and that for plain skull radiology requests. The statistical test [two tailed (independent sample) 2 sample t-test] demonstrated no significant difference between the means of the two data sets. Therefore, in so far as patient information was concerned, the trends observed were consistent between the examinations. However, the means for the two data sets were each significantly below expectation. What this means is that the patient information received in this research site for these two examinations generally fell short of prescribed information required to identify the patients fully. This was consistent with Basulaiman (1996) who demonstrated that referrers for their research site were 20.4% compliant with respect to patient information.

It was also observed that for both plain skull and plain lumbar spine requests there was 100% none compliance with the form field for allergies. Lumbar spine requests were observed to be 100% noncompliant with the form field for patient's address while plain skull requests demonstrated 0.05% compliance with the form field for patient's address. Radiological examination requests for female child bearing age patients that did not have pregnancy status information were observed. Holmes and White (2010) and the IAEA (2008: 10) explain that the fetus is very vulnerable to ionising radiation exposure in pregnant women. This is important because radiation-induced malformations during pregnancy are important illustrations of radiation induced deterministic effect (IAEA, 2008: 10; Holmes & White, 2010).

Therefore the absence of pregnancy or last menstrual period information on 98% of the request forms that were for female child bearing age patients demonstrates a systematic problem in the referral system for this research site. Depasquale and Crockford (2005) reported in their study that only 4% of examination requests' information was complete in their study. However, none of the radiological examination requests in this study were fully completed nor did they present the minimum prescribed request data. In the study by Depasquale and Crockford (2005), for patient information, all the names and surnames were filled in as opposed to this study in which 99% were filled in. Depasquale and Crockford (2005) report 77% compliance with the address form field as opposed to average 0.3% in this study. The researcher therefore concludes that these margins of incompleteness point towards a problem that needs urgent remedy.

5.3.2 Descriptive and analytical review of examination information

Both the skull and the lumbar spine requests demonstrated significant differences with the hypothesised null value with respect to examination information. Therefore the examination information provided in the request forms fell short of meeting the prescribed request information. The results of a two tailed (independent sample) 2-sample t-test demonstrated that there was a significant difference between the sample mean for lumbar spine and the sample mean for skull request data with respect to examination information. Importantly, the referrers for plain lumbar spine and plain skull radiology were from the same referring hospitals. The difference was therefore the requested examination. It was observed that plain skull requests demonstrated relatively higher scores with respect to clinical history, diagnosis and mobility status of the patient and hence the significant difference between the samples' means. What the data for this study could not answer, although not part of this study, was why then the difference in compliance rates for the two examinations. Further research to establish whether there was an association between the requested examination and completeness of examination information is therefore recommended.

Radiological request forms form the framework for requesting radiology examinations and inadequate form fields in the existing template forms may therefore be considered as one factor in modelling compliance level for request information (Akinola *et al.,* 2010; Adebayo *et al.,* 2009). If this proposition is acceptable then the observations made in this study that form fields content of existing template forms were not significantly different with respect to the number of prescribed form fields present, then completeness of request data was not modelled by the proportions of individual existing request forms used in the sample. This was supported by the observations that while using the same request template forms, plain skull and plain lumbar spine requests demonstrated a significant difference in their examination information data. This may suggest another factor coming into effect. Oswal *et al*., (2009) report that many radiology departments have generally accepted this problem of inadequate request information as an integral part of their practice.

Unlike Cohen *et al.,* (2006), who reported clinical indication in 71% of the request forms, this study revealed that, on average, it was given in 17.0% cases. Again while Cohen *et al.,* (2006) report that the clinical diagnosis was given in 1.4% cases, in this study it was given in 33% cases averaged for the two examinations. Cohen *et al.,* (2006), report ninety seven percent compliance with consultant in charge form field. Many radiographers and radiologists acknowledge the existence of the problem of incomplete transmission of examination request information (Oswal *et al*., 2009). In a consultative meeting with radiographers it was generally accepted that this problem is widespread and that the department had resorted to increased communication with the patients in order to get basic clinical information to conduct radiological examinations. It is not surprising therefore that, Oswal *et al*., (2009) report that many radiological departments have generally accepted this problem of inadequate request information as an integral part of their practice. Consistent with this observation, while statistical results for this study show that the examinations' request information for this research site was significantly below the prescribed minimum information, the examinations were none the less performed thus pointing towards acceptance of this problem and therefore the observed tendency to perform requests with no documented justification information.

5.3.3 Descriptive and analytical review of referrer information

A two tailed (Independent samples) two sample t-test was applied to the data for referrer identification to determine whether there was any significant difference between the sample means for the two examinations. The test demonstrated that there was no significant difference between the two data sets. This meant that the referrers for this research site tend to give consistent referrer information between the two examinations. However when a two tailed one-sample t-test was applied to the data, the two examinations' data sets demonstrated a significant difference from the expected compliance values for referrer information. Notably, the referrer contact was given in 2.3% cases out of 400 cases and the referrer name was given on average 5% cases out of 400 cases.

It was observed that a total of 8 (2.3%) examination requests out of a total of 400 reviewed examination requests had referring practitioners contact details. Absence of this information may pose a problem when subsequent questions arise in connection with the request. This observation may well be compounded by the observation that 91% of identified template forms did not have referring practitioners contact form field which translates to 9% those that had the form field. Notably, the mode request form (~85% cases) in the two samples had the form field for referring practitioner contact. These results suggest a problem in the framework of requesting radiology examinations. Possible positive gains may be realised if the radiology department were to emphasise to the referrers that this information is necessary to seek clarification about clinical details, to discuss the justification of the examination and to discuss any significant findings before a formal radiological report is written. Research has shown that such communication can have significant impact on patient management and that the absence of this form field may be due to lack of education on the importance of such information (Oswal *et al.,* 2009; Cook *et al.,* 2003).

This study also showed that in 70.5% of the reviewed radiological request forms, the referrer signature serves as the only means of referrer identification. Because very few referrers, if any, can be identified by their signatures and because request forms are medico-legal documents that form an integral part of note keeping in medical practice, the signature may not serve the purpose of referrer identification in the event of litigation issues against the request (Pelletier *et al.,* 2005). This observation is fundamental in requesting radiology examinations. This information is also important for medical statistics. For these reasons, incomplete referrer information demonstrated in this study renders examination request documents to be of little value in medical practice (IAEA-HHS4, 2010).

5.4 Accuracy of request

The results of this study demonstrate low scores relative to expected score for accurate requests for both plain lumbar spine data and for plain skull data with respect to accurate identification of the area to be imaged. These results demonstrate the same trend in the identification of the area to be imaged between the two examinations. On average, between the two examinations, 4% of the requests were accurate in so far as specificity of the area to be imaged was concerned. This was well below the results of 20% reported by Depasquale & Crockford (2005) and Basulaiman (1996). In Depasquale and Crockford (2005) study 41% asked specific questions to be addressed by the radiological examination which in turn resulted in the examination being able to give a conclusive answer to the questions asked. However, although documented information at the research site suggests that all reviewed examination requests were performed, observed data does not show whether these were performed after soliciting more information to complement the inaccurate information presented on the radiological request forms. This is underpinned by the fact that any radiological examination is patient specific and therefore the positioning and the exposure factors are specific to what imaging intends to demonstrate.

5.5 Justification of requests

The results of this study demonstrate low scores (22.5% and 12% respectively) relative to expected score for justified requests for both plain lumbar spine and plain skull with respect to indicated examinations. These results were consistent with documented examination information for the two examinations. In Zimbabwe, as far as the radiological examinations are concerned, justification is imposed by the Radiation Protection S.I. No. 5 of 2004. Consistent with literature review (IAEA, 2008), observations showed that generally the justification principle for radiological examinations was not always applied in this research site.

The role of the radiology department in this regard was to exercise its legal responsibility to review justification of requested examinations from request data. The radiology department however relies on the information provided by the referrers. Results of this study demonstrate that examination request information was generally incomplete and referrer contact was given in 1% and 3.5% cases for plain skull and plain lumbar spine requests respectively. Certainly, with these observations problems were liable to arise in trying to verify request data from the referrers before the examination could be conducted. If the radiology department were to enforce its legal responsibility, such an event would amount to a request denial which in turn would entail a big delay especially for outpatients. If the proposition by the researcher that the radiology department ought to use its discretion in this regard is accepted, denial of a radiology request should be observed only in special occasions, where the referrer’s omissions or errors are serious and any effort to verify the request data with the referrer or with the patient has failed. However, the fundamental point is that verification must take place before any exposure is made in order to optimise diagnostic yield and minimise dose to the patient. Ionizing radiation must be used judiciously keeping radiation dose as low as reasonably achievable (Holmes & White, 2010, IAEA-HHS4, 2010; RCR, 2000; IAEA, 2008; WHO, 1990).

Jumah *et al.,* (1995) report that many researchers have reported similar problems elsewhere and they further report that the more examination request information radiologists get, the better is the report. Therefore, consistent with Jumah *et al.,* (1995), the researcher prescribes that the radiology department should have access to previous radiographs and reports as part of radiological request information. This was generally not the case in this research site where in 1% of the reviewed examination requests, reference was made to previous radiographs. It is important to note that previous radiographs can help reduce the number of unjustified radiological exposures by ensuring that examinations that have been done elsewhere are not repeated and also by ensuring that review examinations are not performed before the condition of the patient could resolve from the previous state (ECRP, 2007; WHO, 1990). This is important for this research site mainly for three reasons. It is important economically because this study observed an exponential use of radiology in this research site and no health care system can sustain an exponential use of imaging facilities (ECRP, 2009). Secondly, it is important clinically because of the manpower implications which include increasing demands to continuously increase radiology staff and thirdly because exponential use of radiology has negative effects in terms of population dose, individual dose and occupational dose (ECRP, 2009).

5.6 Overall examination request information

Overall radiological request data for plain lumbar spine and plain skull demonstrated that there was no significant difference between the sample mean for skull and the sample mean for lumbar spine examination request data. This means that observed trends were consistent between the two examinations although the two examinations demonstrated a statistically significant difference with respect to examination information. The skull data demonstrated average 40.2% compliance while lumbar spine data demonstrated 38.9% compliance. The expected population mean fell outside the 95% Confidence Interval of the Difference for both examinations. The t-values were negative symbolizing that both sample means were less than the expected population means. Therefore there was sufficient statistical evidence to conclude that the documented diagnostic radiology examination requests for lumbar spine and skull examinations received at the Bulawayo hospital complex were significantly different from the request information prescribed in the data collection instrument. Based on the central tendency, overall (between the two examinations) examination requests information for the research site were 39.6+/-6% complete, 4% accurate and 17% justified.

5.7 Plain lumbar spine radiology

Lumbar spine radiography is still frequently requested by referrers to the Bulawayo hospital complex in the initial assessment of patients with low back pain. In this study 22% of lumbar spine requests were related to initial assessment of patients with low back pain. This is despite evidence recommending limitation of its usage (RCR, 1998; Khoo *et al.,* 2003). Bosch *et al.,* (2003) revealed that whilst radiological examination of the lumbar spine appears innocuous, its radiation burden was calculated to lead to 19 additional deaths per annum. The observation made in this study was that the policy for the research site was to perform both anterio-posterior (AP) projection and the lateral projection for lumbar spine requests. Again lumbar spine exposures were observed to be lumbar- sacral spine radiology. Therefore the benefits of dose reduction from a review of the use of these examination requests can be achieved by limiting to laterals only unless special justification is made for the AP- projection (Bosch *et al.,* 2003; Brennan and Madigan, 2000; Halpin *et al.,* 1991; Symmons *et al.,* 1991; and Kelsey & White, 1980).

Literature has also shown that most of the patients with low back pain have normal radiographs or present with age-related degenerative changes (Brennan and Madigan, 2000; Halpin *et al.,* 1991; Symmons *et al.,* 1991; and Kelsey & White, 1980). Furthermore, lumbar spine radiology is often performed in requests where the probability of serious disease is very low and where radiological findings have untenable relevance (Bosch *et al.,* 2003; Brennan and Madigan, 2000; Halpin *et al.,* 1991; Symmons *et al.,* 1991; Kelsey & White, 1980). With this evidence in mind, regardless of the arguments used to justify lumbar spine radiology, lumbar spine radiology adds considerably to the radiation burden of the individual (Bosch *et al.,* 2003 Khoo *et al*., 2003; Liang & Komaroff, 1982).

However, results of this study indicate that a great proportion of referrals for plain radiology of the lumbar spine received in this research site do not conform to cited literature findings in that lumbar spine radiology was performed in requests where the probability of serious disease is very low and where radiological findings have untenable relevance (Bosch *et al.,* 2003; Khoo *et al*., 2003; Brennan & Madigan, 2000; RCR, 1998; Halpin *et al.,* 1991; Symmons *et al.,* 1991; WHO, 1990; Deyo, 1986; Liang & Komaroff, 1982 and Kelsey & White, 1980). Furthermore, literature has demonstrated that even if degenerative changes are diagnosed, the consequences for clinical or therapeutic management are low and therefore some researchers have used these reasons to suggest that use of lumbar spine imaging can only be justified in the investigation of more serious disease (Khoo *et al*., 2003; Liang & Komaroff, 1982). Consistent with these researchers, Bosch *et al.,* (2003), Deyo (1986) and Liang & Komaroff (1982) concur that plain lumbar spine radiology is justifiable in patients with a history of previous cancer and that there is low probability of encountering disease requiring specific therapy in patients with low back pain using radiology. However, results of this study demonstrate that over 20% of these patients were over 40 years and the trend in the request forms demonstrated inadequate clinical details to justify the requests. Further to this in the majority of these requests the clinical question was “tumour?” or “infection?” With no clinical history or evidence suggesting history of previous cancer, in keeping with existing evidence, the researcher therefore believes that these radiological examination requests were to a greater extent unjustified (Bosch *et al.,* 2003; Khoo *et al*., 2003; Brennan & Madigan, 2000; RCR, 1998; Halpin *et al.,* 1991; Symmons *et al.,* 1991; WHO, 1990; Deyo, 1986; Liang & Komaroff, 1982 and Kelsey & White, 1980). The study revealed that for this research site the majority of the requests were centered on low back pain which is contrary to the recommendations based on findings by Bosch *et al.,* (2003) and Deyo (1986). This was also contrary to the guidelines for lumbar spine radiology prescribed by ECRP, (2000); RCR, (1998) and WHO (1990).

The study also demonstrated plain lumbar spine requests for children under the age of two years, the youngest being 3 days old. There was no adequate clinical information to support these requests which were none the less performed. Because these requests did not have adequate referrer details, the researcher recommends that such conditions be handled by specialist- paediatricians and that the hospital complex develop a referral protocol that should act as a framework for requesting such radiology examinations. This should be based on policy documents that encourage interaction between professionals in the interest of optimised patient care. In the case of lumbar spine for example, physiotherapy/occupational therapy and neurology departments are invaluable in the initial management of these patients (WHO, 1990). Their contribution should be viewed as a necessity not an option. The results of this study therefore suggest that the current use of lumbar spine radiology for this site probably contributed substantially towards increased imaging cost and increased radiation hazards in patients who had no serious lesions. This means that 77.5% of these requests had no contribution towards future management of the patients and therefore were unjustified.

5.8 Plain Skull radiology

In the case of skull radiography, literature is very clear on indications for skull radiography (ECRP, 2000; RCR, 1998; WHO, 1990). These indications show that when clinical features, such as the emergence of focal signs or a deterioration in consciousness level, point strongly to an intracranial pressure in the form of haematoma for example, the patient stands to benefit more from a prompt transfer to a location which has both CT scanning facilities and an emergency neurosurgical service. It therefore goes without saying that the management of these patients depends, to a large extent, on the extent of involvement of neurosurgical services (SIG, 2005; ECRP, 2000; RCR, 1998; WHO, 1990). This study demonstrated that, consistent with findings made in the lumbar spine analysis, general lack of adequate clinical information accompanying these requests made it difficult to justify the requests based on request data. This is despite the fact that in some cases patients indeed showed evidence of indications for skull radiography but these were invariably not captured by referrers when completing examination request forms.

Skull fractures in children are significantly associated with an increased risk of intracranial injury but these are not as discriminating as in adults (SIG, 2005). Because bones in children are more prone to green stick fracturing, in children with a head injury significant intracranial injury occurs more frequently in the absence of a skull fracture than is the case in adults (SIG, 2005; RCR, 1998; WHO, 1990). For these reasons the use of plain skull radiology is therefore unjustified for children since clinical features such as a tense fontanel for example, can be used to determine the need for a CT scan to rule out intracranial injury (SIG, 2005). Therefore in the absence of clinical signs of intracranial injury, observation by paediatric medical practitioner is an alternative to urgent CT scan (SIG, 2005)

Observations made in this study show that there was indeed plain skull radiography of children in this research site. The lowest age reported was one month in which the referrer was querying intracranial pressure following a perceived space occupying lesion penetrating the skull. Because ultrasound imaging is more easily available in this department the researcher believes that ultrasound together with clinical assessment of the fontanels was the modality of choice in this case. The results further demonstrate that in all these requests, there was no clinical evidence captured by the referrers on the request forms to suggested consistency with prescribed assessment guidelines. This had major disadvantages for patient care and also had medico legal implications.

Radiological guidelines are not designed to be a restrictive measure in medical practice but to promote good practice. The research site was a referral hospital that also received patients from rural settings. In remote communities other factors must be taken into account when considering the justification of plain skull films as a triage tool. These considerations should, as an example, consider skill mix and available equipment. While this observation could have influenced the results, the study was not able to quantify how many of these requests came from rural centres because referrers did not provide complete details on request forms to enable this discrimination to be made.

5.9 Unconventional Abbreviations

Observed level of usage of abbreviations (Appendix F) in radiological requests presented another observed problem in patient care. This was an important observation because some of these abbreviations could not be resolved by radiology staff and this meant that examination request information communication was affected negatively by the use of unconventional abbreviations. Implications of this include failure to communicate specific information that was crucial for the justification of exposures. This had medico-legal implications. In the absence of referrer contact information to facilitate verification of request data, the researcher considered this observation as a major problem in patient care that needed an urgent solution.

5.10 Limitations of the study

The researcher captured information from request forms that had been prepared for filing after the requested examination. There was a chance that by this time some of the form fields left blank by the referrers could have been completed by the radiographers during the verification process. In this regard the frequency counts may represent an over estimate of referrer completed form fields.

The data collection instrument had a form field for allergies and pregnancy status. These were not applicable for all cases. These were however included in the overall count. The researcher decided that in such cases the referrer would indicate “inapplicable” to show that the referrer saw this form field. It is possible that some referrers left it blank where they thought it was not applicable thus increasing noncompliance count. Furthermore, inferential statistics were used to make inferences from the observed data to more general conditions. The theoretical requirements for the application of the t-tests include a representative sample and the distribution of the variables that approximates a normal distribution (Decoursey, 2003). These conditions are generally not completely met practically (Decoursey, 2003). While a representative sample size was achieved in this study, some data was not truly normally distributed as witnessed by the observed skewness and kurtosis values. Because of this discrepancy, literature explains that practically the confidence interval may be reduced by about 2 percentage points (Decoursey, 2003).

The inherent characteristic of secondary data sources was also a limitation. The radiological request forms were a convenient, efficient and economic source for radiological request information but because in100% of the forms some vital information that could have enabled more statistical analysis was missing this imposed a limitation on the study. As an example, the researcher could not discriminate request forms based on demographic location of the referrer because address and contact were generally not provided on the request forms.

Furthermore, because the study was limited to data collected from request forms, it was not possible for the researcher to solicit missing data from the patients or to verify whether the identification of the anatomical region and the patient identification information on the request forms was correct for the individual patients. This was particularly tempting for request forms that had no patient name on them.

5.11 Recommendations

In this section recommendations derived from this study are presented. These recommendations are intended for the research site, the referrers and the Ministry of Health. Included also in this section are recommendations for further research. Because the foundations of these recommendations are interrelated, the recommendations are therefore presented in an integrated format.

5.11.1 Significance of the results

The results for this study are important for the research site in that they provide the baseline values for completeness, accuracy and justification of requests which are invaluable in quality control and clinical audits. The results are also important economically in that they provide evidence with respect to inappropriate use of radiology which has direct implications on human resource budget, recurrent financial expenditure and medico legal implications. The results of this study showed a significant difference between the skull and the lumbar spine radiology requests with respect to examination information. These results can therefore be taken as a pilot study for a bigger multi-centre study that could be generalised over all examinations and the whole country. This recommended study should be designed to identify factors that lead to this variation in the completeness, accuracy and justification of examination requests.

The results of this study also demonstrated that there is no standard radiology request form for the research site and that the form field content of the existing template forms were significantly below expectation. It is recommended that, over and above the minimum prescribed information, a foot note or header note stipulating special radiation protection measures to be taken by referrers for children and the foetuses is mandatory for all request forms (Holmes & White, 2010). To this end, a statutory instrument and/or regulatory authority clause in this regard may go a long way in protecting these vulnerable groups from unjustified ionising radiation exposures such as has been done in many countries including Zimbabwe in respect of smoking and alcohol intake for example. In Zimbabwe, the host nation, the Ministry of Health and Child Welfare (MOHCW) has already enacted the Radiation Protection Authority of Zimbabwe (RPAZ) which was initially formed through S.I. No. 5 of 2004*.* However, the practical benefits of this body are yet to be seen (ZMHCW, 2009).The researcher has designed a template request form that is offered as a framework that meets the specific requirements of the research site (Fig 5.1.). The offered form meets the minimum criteria (IAEA-HHS4, 2010) plus the prescribed criteria for the research site. It is ergonomically superior to the full range of identified template forms which demonstrate inadequate form fields and is designed to increase completeness, accuracy and justification of requests while fulfilling an educative function by requiring identification of patient specific conditions by both the referrer and the radiology practitioner. It is also recommended that implementation of this request form be accompanied by dissemination of clinical indications for radiology requests. Consequently, further study into the changes that this approach will have on the levels of completeness, accuracy and justification of radiological exposures is recommended to provide the much needed feedback information on the effectiveness of the changes.

There was no observed contra indications to the use of radiology other than that alternative form of pursuing diagnosis was preferred or that radiological imaging was considered unjustified in some cases where the researcher deemed that treatment would not be affected by the result of the examination. The Royal College of Radiologist, (1998) explains that contra indications to the use of ionizing radiation include the use of imaging in order to reduce the possibility of medico legal litigation and for psychological reassurance of patients. This was not investigated in this study, but, because there was a general lack of complete request data to rule out this possibility, the researcher recommends that this is an area for future investigation at the research site.

In light of these observations, the credibility of the referral for radiology in this research site will be enhanced if compliant request forms are used. This will eliminate systematic errors in the evaluation of justification, completeness and accuracy of examination requests by ensuring that fundamentals of radiology particularly correct identification of the patient, performing the correct examination and that the correct anatomical area is exposed are upheld (IAEA, 2010: 31).

With respect to lumbar spine examinations, if the argument that lumbar spine radiology has low diagnostic yield and high radiation dose is accepted, then every effort must be put in place to ensure that lumbar spine exposures are justified (Bosch *et al.,* 2003; Khoo *et al*., 2003; Brennan & Madigan, 2000; RCR, 1998; Halpin *et al.,* 1991; Symmons *et al.,* 1991; WHO, 1990; Deyo, 1986; Liang & Komaroff, 1982 and Kelsey & White, 1980). It is also equally important therefore that the observed exponential use of diagnostic radiology for this research site be understood as one factor pointing towards the need for a broader understanding of the implications of these observations. This is because the risk of developing adverse effects, though small, is significant when the exposure is unjustified (Bosch *et al.,* 2003; Khoo *et al*., 2003; Brennan & Madigan, 2000; RCR, 1998; Halpin *et al.,* 1991; Symmons *et al.,* 1991; WHO, 1990; Deyo, 1986; Liang & Komaroff, 1982 and Kelsey & White, 1980). To appreciate justification one must know the risks associated with ionising radiation (IAEA, 2008). Therefore a referrer who knows the risks will appreciate the importance of complete, accurate and justified request forms.

5.12 Conclusions

The researcher was able to answer the research question from the data collected in this study. There were a total of 12 template radiological request forms identified at the research site and these forms had varied content and nomenclature. The form fields' content was significantly below expectation. There was sufficient statistical evidence to conclude that the documented diagnostic radiology examination requests information for plain lumbar spine and plain skull received at the Bulawayo hospital complex (the research site) were significantly below expectation. There was general consistency in the plain lumbar spine data and plain skull data with respect to patient, referrer and accuracy information. This consistency between the two examination requests may, for this research site, hold clues to the perceived low diagnostic yield for these two examinations reported by some researchers.

A number of inadequacies were observed in the samples of radiological requests. These inadequacies have medico-legal implications and impact on the quality of overall service provided by the radiology department at the research site. The study demonstrated that all observed request forms had inadequate form fields and therefore promote incomplete transmission of examination request information. This means that important facts about the requests were not effectively and efficiently transmitted to the radiology department partly due to the inadequacy of radiological request forms and partly due to non compliance by referrers. These template forms must therefore be withdrawn from circulation and replaced by request forms that include minimum prescribed radiological request form fields.

The study also revealed that all observed examination requests demonstrated inadequate request information therefore compromising justification of requests. Generally, there was practically no meaningful documented dialogue on balancing benefits with the risks to patients in this research site (IAEA, 2008: 9). It was observed that generally, all request forms were legible.

To avoid continued problems with respect to the quality of radiological patient care continued professional development with respect to completeness, accuracy and justification of radiology requests it is recommended. A template request form designed by the researcher is also proposed (Figure 5.1). The recommended template form is more robust than the existing template forms (Appendix A) in that it plays a more provocative role in ensuring accountability on the part of clinicians while promoting patient specific justification of requests. Furthermore, this template form is suitable in that it embraces the concept of radiation protection and awareness of exposure risks among clinicians while constantly reminding clinicians that radiological request forms are medico-legal documents that are an integral part of note keeping in radiology practice. This template form will help the referrer to communicate request data that can withstand legal scrutiny should any mal practice related to the request be alleged. For this reason this recommended template form (Fig 5.1) would play a more educative role than identified existing radiology template forms.

Fig 5.1: Recommended radiological request template form

UNITED BULAWAYO HOSPITALS' RADIOLOGY REQUEST FORM

IMPORTANT

1. X-ray exposures are regulated and therefore justification of radiological examination requests is prerequisite to any x-ray exposure.

2. Radiological request forms are medico-legal documents which are an integral part of note keeping in radiology and must always be completed accurately, legibly and in full.

X-ray number	Radiographer's Printed Name	Signature

REFERRER INFORMATION		PATIENT INFORMATION	
Initials	....	Printed Name	....
Printed surname	....	Printed Surname	....
Contact/Bleep No.	....	Contact e.g. Hosp. No.	....
Signature	....	Sex	....
		Age	....
Date	....	LMP/Preg. status	....

EXAMINATION SPECIFICATION INFORMATION

Exam requested	....
Date of request	....
Clinical Diagnosis	....
Clinical indication	....
Prev. X-ray date	....

Previous x-rays provided?	Yes ...... / No ....
Number of images taken	....

Clinical History

....

....

....

....

....

The patient is ambulant	Y	N ....
Condition is infectious	Y	N....

RADIOLOGICAL REPORT
(To be completed for every radiology examination)

....

....

....

....

....

....

....

....

RADIOLOGY CONSULTANT'S INFORMATION

Radiologist's printed initial	....
Radiologist's printed Surname	....
Radiologists Signature & date	....

The results of this study demonstrate that the use of plain skull and plain lumbar spine radiology is wide spread in this research site. Radiology examinations requested without clinical history, indication/diagnosis and referrer identification were observed. This had medico legal implications. The researcher however believes that with the development of the Radiation Protection Authority of Zimbabwe, time has come for every radiology referrer and every radiology practitioner to review completeness, accuracy and justification of radiological exposures. With this in mind, again time has come for clinical practitioners to engage each other and debate the role of each profession in the management of medical conditions that justify plain skull and plain lumbar spine imaging. Observed absence of complete and accurate request in which a referrer ought to identify any clinical feature from the patient's condition that would make the request of value in medical practice, provoked the researcher to concur with Rehani, (2010) in recommending that the referrer must ask the question, *"…would I prescribe this procedure if the patient was my own child?"* This question therefore provokes the referrer and the radiology department to embrace decision making based on moral and ethical considerations (Rehani, 2010). Finally, these findings are intended to inform radiology practitioners, radiology referrers and the Zimbabwe Ministry of Health and Child Welfare to consider complete, accurate and justified requests as a prerequisite to a functional radiology referral system so that radiation protection and justification of exposures can be optimised.

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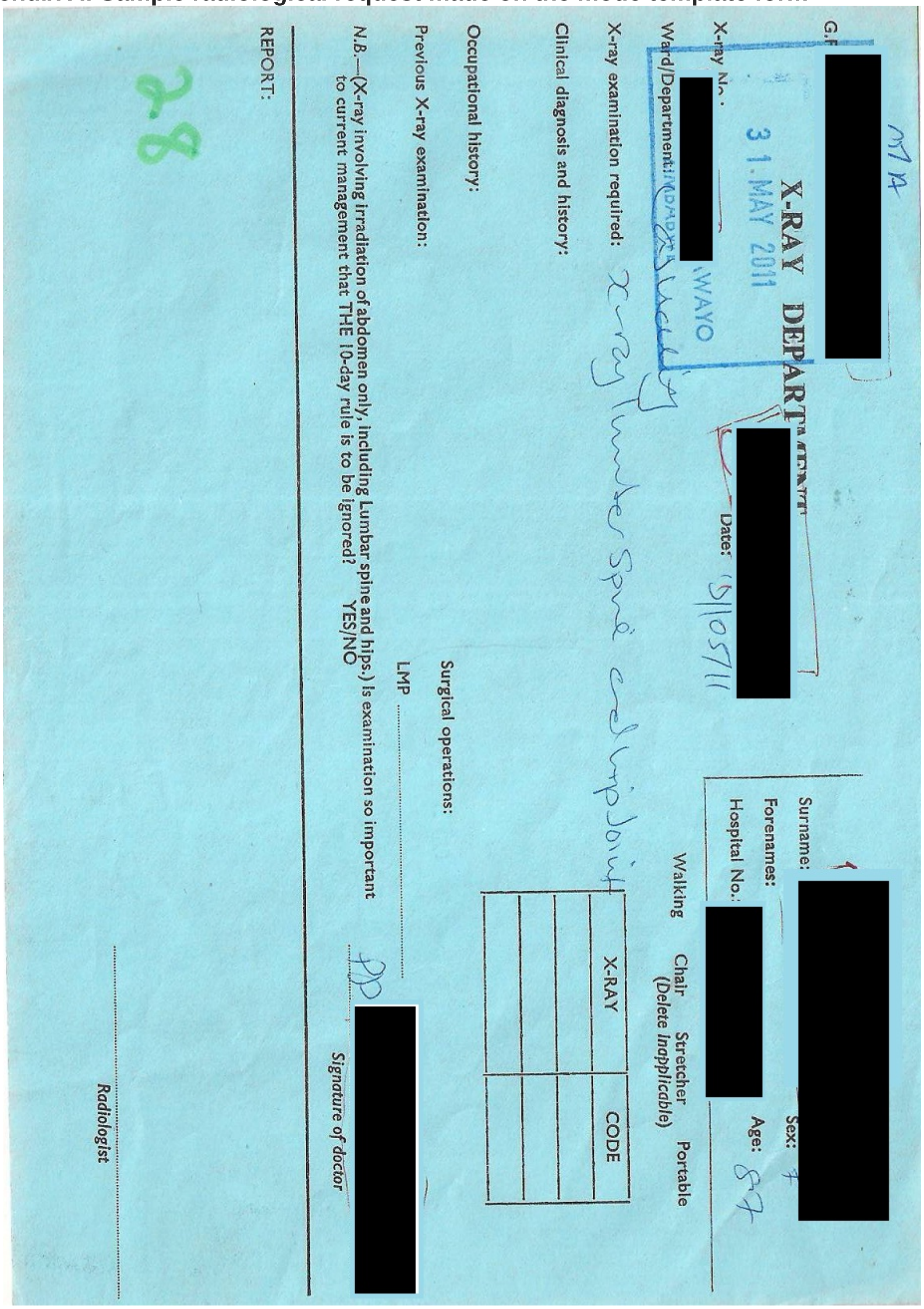
APPENDICES

Appendix A: Sample radiological request made on the mode template form



G.P. [redacted]

X-RAY DEPARTMENT

31 MAY 2011

X-ray No.: [redacted]

Ward/Department: [redacted]

Date: 13/05/11 [redacted]

Surname: [redacted] Sex: F

Forenames: [redacted]

Hospital No.: [redacted] Age: 87

Walking Chair Stretcher Portable
(*Delete inapplicable*)

X-ray examination required: x-ray lumber spine and hip Joint

Clinical diagnosis and history:

Occupational history:

Previous X-ray examination:

Surgical operations:

LMP ....

X-RAY	CODE

N.B.—(X-ray involving irradiation of abdomen only, including Lumbar spine and hips.) Is examination so important to current management that THE 10-day rule is to be ignored? YES/NO

[redacted]
Signature of doctor

REPORT:

28

....
Radiologist

Appendix B: Instrument development master link list:

RRF I.D. code	Institution	Area of influence
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Appendix C: Final data collection instrument

Good Practice Patient referral Data Sheet

Examination: Plain Skull radiography **Date** ....

Refined IAEA and WHO minimum radiological examination request information	***Researcher generated Request form ID.***												
Patient & exam information provided on request form.	1. i. Name												
	ii. Surname												
	2. Age												
	3. i. Contacte.g Hosp. No.												
	ii. Address												
	4. i. Pregnancy status/ LMP												
	ii. Sex												
	5. Allergies												
	6. i. Study requested												
	ii. Accuracy												
	7. i. Clinical history												
	ii. Clinical indication												
	iii. Clinical diagnosis												
	8. Date of request												
	9. X ray number												
	10.Number of Films taken												
	11. Previous x-rays												
	12. Surgical operations												
	13. Walking/stretcher/chair												
Referrer identification provided on request form	14. i. Name												
	ii. Surname												
	15. Contact/ bleep no.												
	16. Signature												
	17. Legibility												
Justification of examination on request form (Skull trauma cases)	**18. Exam Justified**												
	At least one positive justifies exam												
	Loss of consciousness												
	Neurological symptoms												
	Fluid through nose/ ear												
	Penetrating injury												
	Alcohol intoxicated												
	Patient vomited												
	Difficult patient												
	Blood through ear/nose												
Justification of examination on request form (Skull -non trauma cases)	Chronic headache with abnormal results on clinical examination												
	Hearing loss												
	Suspected SOL												
	Paranasal Sinusitis >3yrs												
	Police investigations												
NOTES	**Form field completed but not readable will be given zero score. Uncompleted Form field whether applicable or N/a will be given zero score.No form field and information not supplied will be given zero score. No form field but information included elsewhere will be given score of 1.**												

RRF Code	Notes Other: To include any observed justification criterion that was not included in listed criterion	Comments

Appendix D: Final data collection instrument

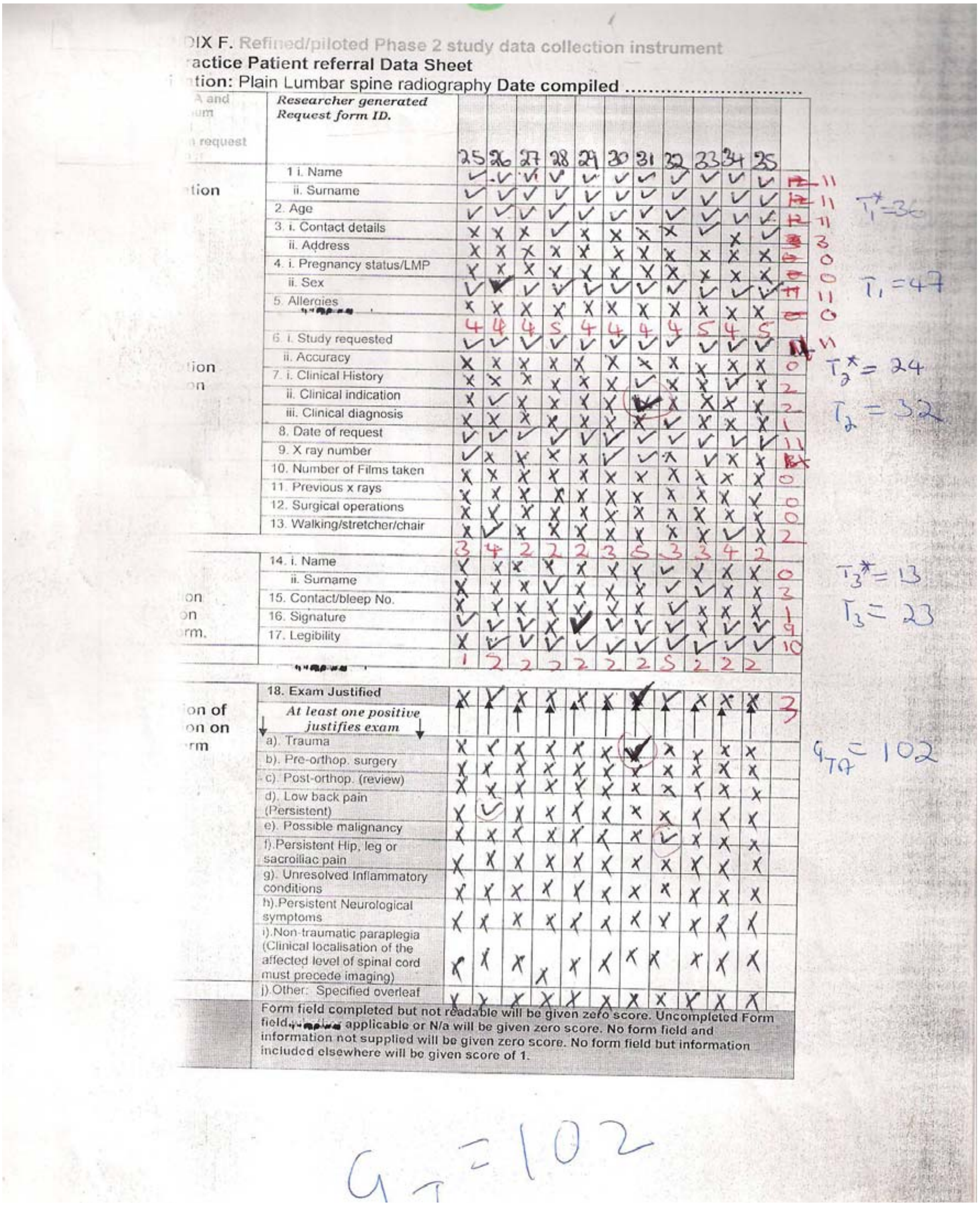
Good Practice Patient referral Data Sheet

Examination: Plain Lumbar spine radiography **Date compiled ....**

Refined IAEA and WHO minimum radiological examination request information	***Researcher generated Request form ID.***												
Patient identification	1 i. Name												
	ii. Surname												
	2. Age												
	3. i. Contact details												
	ii. Address												
	4. i. Pregnancy status/LMP												
	ii. Sex												
	5. Allergies												
Exam specification information provided	6. i. Study requested												
	ii. Accuracy												
	7. i. Clinical History												
	ii. Clinical indication												
	iii. Clinical diagnosis												
	8. Date of request												
	9. X ray number												
	10. Number of Films taken												
	11. Previous x rays												
	12. Surgical operations												
	13. Walking/stretcher/chair												
Referrer identification provided on request form.	14. i. Name												
	ii. Surname												
	15. Contact/bleep No.												
	16. Signature												
	17. Legibility												
Justification of examination on request form	**18. Exam Justified**												
	At least one positive justifies exam	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	
	a). Trauma												
	b). Pre-orthop. surgery												
	c). Post-orthop. (review)												
	d). Low back pain (Persistent)												
	e). Possible malignancy												
	f).Persistent Hip, leg or sacroiliac pain												
	g). Unresolved Inflammatory conditions												
	h).Persistent Neurological symptoms												
	i).Non-traumatic paraplegia (Clinical localisation of the affected level of spinal cord must precede imaging)												
	j).Other: Specified overleaf												
NOTES	**Form field completed but not readable will be given zero score. Uncompleted Form field whether applicable or N/a will be given zero score.No form field and information not supplied will be given zero score. No form field but information included elsewhere will be given score of 1.**												

RRF Code	Notes Other: To include any observed justification criterion that was not included in listed criterion	Comments

Appendix E: Sample Main study raw data showing data collected from sample examination request (Appendix A) under RRF code 28


DIX F. Refined/piloted Phase 2 study data collection instrument

actice Patient referral Data Sheet

tion: Plain Lumbar spine radiography Date compiled ....

Researcher generated Request form ID. 25 26 27 28 29 30 31 32 33 34 35

1 i. Name — 11

ii. Surname — 11

2. Age — 11

3. i. Contact details — 3

ii. Address — 0

4. i. Pregnancy status/LMP — 0

ii. Sex — 11

5. Allergies — 0

6. i. Study requested — 11

ii. Accuracy — 0

7. i. Clinical History — 2

ii. Clinical indication — 2

iii. Clinical diagnosis — 1

8. Date of request — 11

9. X ray number

10. Number of Films taken — 0

11. Previous x rays — 0

12. Surgical operations — 0

13. Walking/stretcher/chair — 2

14. i. Name — 0

ii. Surname — 3

15. Contact/bleep No. — 1

16. Signature — 9

17. Legibility — 10

18. Exam Justified — 3

At least one positive justifies exam

a). Trauma

b). Pre-orthop. surgery

c). Post-orthop. (review)

d). Low back pain (Persistent)

e). Possible malignancy

f). Persistent Hip, leg or sacroiliac pain

g). Unresolved Inflammatory conditions

h). Persistent Neurological symptoms

i). Non-traumatic paraplegia (Clinical localisation of the affected level of spinal cord must precede imaging)

j) Other: Specified overleaf

Form field completed but not readable will be given zero score. Uncompleted Form field, applicable or N/a will be given zero score. No form field and information not supplied will be given zero score. No form field but information included elsewhere will be given score of 1.

$T_1^* = 36$ $T_1 = 47$

$T_2^* = 24$ $T_2 = 32$

$T_3^* = 13$ $T_3 = 23$

$G_{TA} = 102$

$G_T = 102$

Appendix F: Observed unconventional abbreviations

Unconventional Abbreviations	Local (research site) Explanation	Comments
#	Fracture	
?	Query	
↑	High	
Δ	Diagnosis	This symbol was not recognised by the participants but was later defined in follow-up consultative meeting.
♀	Female	
S.I.	Two meanings were raised by the radiographers	This symbol was defined as “statutory instrument” requirement and also as soft tissue injury
RTA	Road traffic accident	
S. T. I.	Soft tissue injury	Participants were not sure what this abbreviation stood for in the context in which it was used.
R/O	Rule out	
HONK		Participants did not know what this abbreviation stood for
H.T.	Hypertension	
CHO		Participants did not know what this abbreviation stood for

Appendix G: Ethics approval certificate

Cape Peninsula
University of Technology

13 April 2011
CPUT/HW-REC 2011/H07

P.O. Box 1906 • Bellville 7535 South Africa •Tel: +27 21 442 6162 • Fax +27 21 447 2963
Symphony Road Bellville 7535

OFFICE OF THE CHAIRPERSON:
HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HW-REC)
Registration Number NHREC: REC- 230408-014

At the meeting of the Health & Wellness Sciences Research Ethics Committee on 21 February 2011 approval was granted to Lidion Sibanda pending amendments that have now been received and reviewed. This approval is for research activities related to an MTech: Radiography at this institution.

TITLE:

Diagnostic radiography examination requests in Zimbabwe's public Hospital complex.

INTERNAL SUPERVISOR:	**Mrs F Davidson**
INTERNAL CO-SUPERVISOR:	**Prof P Engel-Hills**

Comment:

Research activities are restricted to those detailed in the proposal and application submitted in January 2011.

Approval will not extend beyond 13 April 2012. An extension must be applied for should data collection for this study continue beyond this date.

Prof PENELOPE ENGEL-HILLS
CHAIR: HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE

e-mail: *engelhillsp@cput.ac.za*

Appendix H: Letter of authority from the research site

Cape Penninsula
University of Technology
Radiography department
Observatory
Cape Town, RSA

The Head of Department
United Bulawayo Hospitals
Radiology/X-ray Department
Bulawayo
Zimbabwe.

13 November 2010

Dear Madam
RE: Application to do thesis research in your department.

My name is Lidion Sibanda and I am a Zimbabwean registered radiographer studying for a Masters degree in diagnostic radiography with the Cape Peninsula University of Technology, in South Africa. I am doing research on IAEA and WHO criteria based referral system. I will specifically be evaluating the justification, completeness and accuracy of lumbar spine and skull plain radiography referrals. These examinations are perceived as having relatively high radiation dose and relatively low diagnostic yield. I believe that, because of the harmful effects of ionizing radiation, a review of their use will be of great benefit to your department's radiation protection quality control and to the patient population. You may also be aware that Zimbabwe's Ministry of Health and Child Welfare has reported that its National Radiation Protection unit is not serving its purpose due to shortage of staff (The National Health Strategy For Zimbabwe 2009 – 2013: page 95). For this reason this project may provide your department with an opportunity to know its status of radiation protection with regard to these examinations.

Purpose of the research
This study will focus on the evaluation of the justification, completeness and accuracy of skull and lumbar spine examination requests in order to make recommendations to your department on the status of these referrals with respect to IAEA and WHO referral criteria.

Type of research
This research will involve a documentation (requests forms) review. The research will not interfere with routine management of your patients.

Site selection
Your department has been purposively selected for the study because it is conveniently available to me. I enjoy a professional relationship with your department and I have an appreciation of your departmental environment. This is important to me because such understanding will help me to make sense of the data and to make meaningful recommendations.

UNITED BULAWAYO HOSPITALS
CHIEF RADIOGRAPHER
12 JAN 2011
PO BOX 958, BULAWAYO
ZIMBABWE

Procedures

The study will involve a quantitative criteria based documentation (request forms) review in order to examine compliance with IAEA and WHO referral criteria. The main outcome measure will be the proportion of justified, accurate and the proportion of complete radiological requests.

Duration of the study

The data collection will commence in March 2011. During this time I will collect data in your department until the target sample size is reached.

Risks

A risk that is normally associated with documentation review is sharing of confidential information. I do not wish this to happen. I will be ready to sign confidentiality statement of your department and further to this the research design is such that the data coding will not identify the data with the patient and neither will it identify it with the source documents. A pass worded master link list will only be used by me (the researcher) for the duration of data analysis period after which I will destroy it.

Benefits

Upon completion of this project, your department stands to gain information about the level of justification, completeness and accuracy of these radiological referrals to your department.

Reimbursements

Your department will not be provided with any incentives to take part in this research.

Who to contact

If you have any questions you may contact me on: lidionsibanda@gmail.com. 0027728666187 or 00263772345775. This project has been reviewed and approved by the Cape Peninsula University of Technology (CPUT) Health and Wellness Sciences (HWS) Research Ethics committee (REC) which is the committee whose task is to make sure that research participants are protected from harm. If you want to find more about HWS-REC please contact:

The Secretary-REC
Health and Wellness Faculty
Belville Campus
CPUT
RSA

Yours faithfully,

……………………

L. Sibanda (Mr.)
Radiographer

Your application has been approved.
Our department will be happy to assist you in undertaking your research.

Candice Mbaita (Chief Radiographer)

UNITED BULAWAYO HOSPITALS
CHIEF RADIOGRAPHER
12 JAN 2011
PO BOX 958, BULAWAYO
ZIMBABWE