FACTORS AFFECTING THE ACCEPTANCE AND MEANINGFUL USE OF PICTURE ARCHIVE AND COMMUNICATION SYSTEMS BY REFERRING CLINICIANS IN PRIVATE PRACTICE

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Factors Affecting the Acceptance and Meaningful Use of Picture Archive and Communication Systems by Referring Clinicians in Private Practice

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DECLARATION

I, Gustav André d'Assonville (student number: 20312464), hereby declare that the dissertation for Master of Technology in Information Technology to be awarded, is my own work and that it has not been submitted for assessment or completion of any postgraduate qualification to another University, or for another qualification.

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ABSTRACT

A Picture Archive and Communication System (PACS) is a health information technology that facilitates the electronic storage, transmission, presentation and processing of digital medical-imaging datasets. The benefits of PACS have been well-documented. It provides a means to replace traditional film-based workflows and their inherent limitations. Referring clinicians' acceptance is a critical factor in the overall success of a PACS implementation; and given the financial implications of project failure, research into physician acceptance and meaningful use is crucial. Very few PACS acceptance studies have focused on the referring clinicians, and even less in the context of the private sector. Therefore, the problem that this research aims to address is: There is a lack of understanding on which factors influence PACS acceptance and the meaningful use thereof by referring clinicians in private practice.

This explorative study follows an embedded mixed methodology approach in order to meet the research objectives, favouring a qualitative method of inquiry with the support of a quantitative strand. Electronic questionnaires were distributed to private practice referring clinicians to probe the aspects related to PACS acceptance and its meaningful use. The conceptual framework, as devised by Paré and Trudel (2007), was used as a theoretical lens to categorize and discuss the research results in terms of Project, Technological, Organizational and Behavioural factors that affect PACS acceptance and its meaningful use.

The findings showed good acceptance rates, which is in line with other research conducted in this field, including research done in the public sector. Technical and Organizational factors were the most prevalent. An extension of the above-mentioned theoretical framework was proposed to assist in maintaining positive results after the project Implementation phase has been completed.

This research expands the Information Technology PACS body of knowledge – by identifying both the technical and the non-technical factors that are crucial in private practice referring doctor acceptance and meaningful use. By addressing these factors, institutions can improve the likelihood of PACS project success in

private practice settings. Maximising referring doctor acceptance and meaningful use could also give private practices a competitive advantage over their competitors.

KEYWORDS

- Picture archive and communication system acceptance and meaningful use
- Radiology
- Private practice
- Referring doctors

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ACRONYMS

- o CD: Compact Disc
- o CIS: Clinical Information System
- o CR: Computed Radiography
- o CT: Computed Tomography (also known as CAT Scan)
- o DICOM: Digital Imaging and Communication in Medicine
- o EMR: Electronic Medical Record
- o EPR: Electronic Patient Record
- o FDA: Food and Drug Administration
- o GP: General Practitioner
- o HIT: Health Information Technology
- o LAN: Local Area Network
- o MIP: Maximum Intensity Projection
- o MPR: Multi-planar Reconstruction
- o MRI: Magnetic Resonance Imaging
- o PACS: Picture Archiving and Communication System
- o PC: Personal Computer
- o UPS: Uninterruptable Power Supply
- o US: Ultrasound
- o WAN: Wide-Area Network

1 INTRODUCTION

The introductory chapter of this research dissertation begins by exploring Picture Archive and Communication Systems (PACS), as a healthcare technology, by focusing on its role and importance. The concepts of acceptance and meaningful use, which are central to this study, are defined here. The problem statement that this research aims to address is discussed. Thereafter, the research questions and objectives are formulated. The research methodology is briefly discussed in terms of its process and design. The study delineation, ethical considerations and a brief chapter outline conclude Chapter 1.

1.1 BACKGROUND

1.1.1 PACS Background

A Picture Archive and Communication System (PACS) is a health information technology (HIT) that facilitates the electronic storage, transmission, presentation and processing of digital medical imaging datasets (Hurlen, Østbye, Borthne, & Gulbrandsen, 2010; Weatherburn, Bryan, Nicholas, & Cocks, 2000). A typical PACS system may include image acquisition devices, data management systems, image storage devices, data networks, display workstations, as well as devices to produce laser film or CD (compact disc) hard copies (Choplin, Boehme II, & Maynard, 1992).

Medical imaging modalities are the devices that generate medical images; and they include Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Computed Radiography (CR), to name but a few. PACS is also seen as a key technology in the drive towards a fully integrated Electronic Patient Record (EPR) (Pilling, 2003). This would typically encompass a patient's radiological history, including X-rays, scans and radiological reports.

In a traditional film-based environment, the acquisition, distribution and archiving of imaging and reports can be problematic – in both private and public healthcare facilities (Schulze, Greyling, Hayes, & Andronikou, 2009). One aspect contributing to these challenges is the logistical involvement in the manual processes of developing, storing and retrieving film. Locating and retrieving images for comparative purposes can be time-consuming, not to mention the risk of misplaced or lost x-rays. Thus, it may be argued that the inherent problems associated with a film-based workflow can limit the quality of care and productivity.

PACS is a means of replacing traditional radiological film hard-copies (Strickland, 2000). Radiology practices often decide to implement PACS to increase productivity, to increase efficiency, to improve access to imaging, to reduce costs and to reduce the film-handling time and effort (Honeyman-Buck, 2003). Studies have shown that PACS can increase radiologist efficiency by more than 40%, due to the improvements in the workflow (Siegel & Reiner, 2003).

A radiologist is a medical doctor specialising in diagnostic interpretation of medical imaging. The benefits of PACS are summarized in Table 1.

Benefit	Details
1. Superior patient care	• Improved comparison • Faster clinical decision-making • Less radiation exposure • Decreased waiting times • No lost films
2. Increased productivity	• Significant decrease in repeat examinations • Less time spent performing administrative tasks • Electronic distribution of imaging • Facilitates teleradiology
3. Improved management of resources	• Referring doctors can track the progress of an examination • Savings in film processing costs • Savings in film storage and handling costs
4. Improved interpretation	• Advanced image manipulation tools • Better decision support applications available
5. Additional Benefits	• Enhanced teaching • Enhanced research

Table 1.1: Benefits of PACS (Ayal & Seidman, 2009; Paré & Trudel, 2007; Pilling, 1999; Schulze et al., 2009)

PACS is no longer just a tool for radiologists, however; and it has evolved into an important HIT across medical disciplines (Faggioni, Neri, Castellana, Caramella, & Bartolozzi, 2011). Enterprise-wide PACS solutions can incorporate imaging from radiology, cardiology and nuclear medicine, as well as

other departments. A referring doctor will typically refer a patient to the radiology department for a scan or X-ray examination, following a consultation, if deemed necessary.

Referring physicians can include General Practitioners (GPs) or specialists, such as surgeons. Note that in this study, the terms referring clinician, physician and doctor are used interchangeably; and they refer to medical doctors with direct patient contact. This excludes medical doctors that exclusively work in research environments, as well as radiologists.

In a film-based workflow, outpatients would typically have to wait for the images and radiology report, following the procedure or examination. Alternatively, the results could be delivered to the referring doctor or ward. In the above-mentioned scenarios, one or more persons are required to deliver the results, thereby introducing the possibility for the logistical problems mentioned above. This is not the case in a PACS-based workflow. Images can be viewed via a PACS web client (e.g. Figure 1.1) through Local Area Networks (LAN), or the Internet – by multiple users simultaneously.

PACS requires a significant financial investment; therefore, the elimination of film costs, together with the increased efficiency that PACS brings, should offset a large portion of the capital expenditure over time (Paré & Trudel, 2007). It may, therefore, be argued that it is in the best interests of the patients, the radiology practice, and the referring doctors to accept and use PACS to its full potential, and to thereby minimize any reliance on physical media.
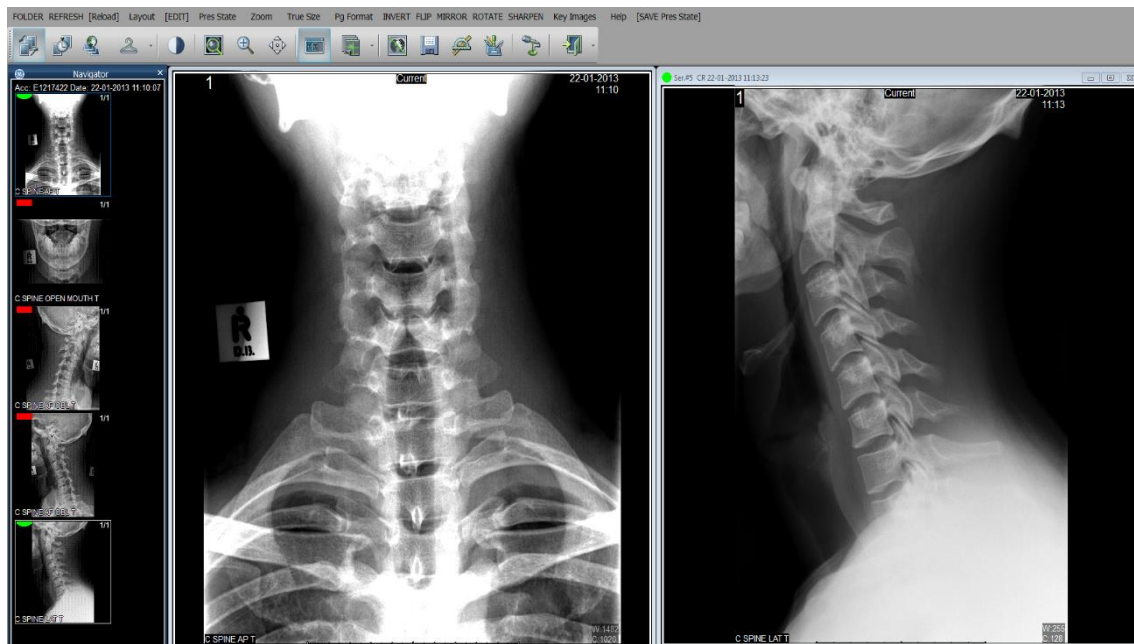
Figure 1.1: Example of a PACS Internet browser interface (GE Centricity IW version 3.7.3)

1.1.2 PACS Access

Image acquisition modalities, such as CT scanners, or CR readers, transmit the DICOM (Digital Imaging and Communication in Medicine) formatted images across the radiology local area network (LAN) to a PACS. The images can be made available to authorized users immediately, often before a radiology report is generated. If the radiology department is located within a hospital complex, the hospital LAN is often connected to radiology through a firewall, enabling secure high-speed connectivity for hospital clinical users. This could include access in theatres, doctors' suites, wards and emergency departments.

General practitioners, specialists and travelling physicians can access PACS via the Internet, provided they have access to a dependable broadband-Internet connection (Avrin, Wiggins, & Bahr, 2003). Figure 1.2 summarizes the above-mentioned access scenarios. The proliferation of smart phone and tablet computers can further enhance user accessibility; as many PACS vendors are now distributing smartphone and tablet PACS viewers. While initially limited to review purposes only, some have obtained clearance from the United States Food and Drug Administration (FDA) for diagnostic purposes (Johnson et al., 2012; Székely, Talanow, & Bágyi, 2013).
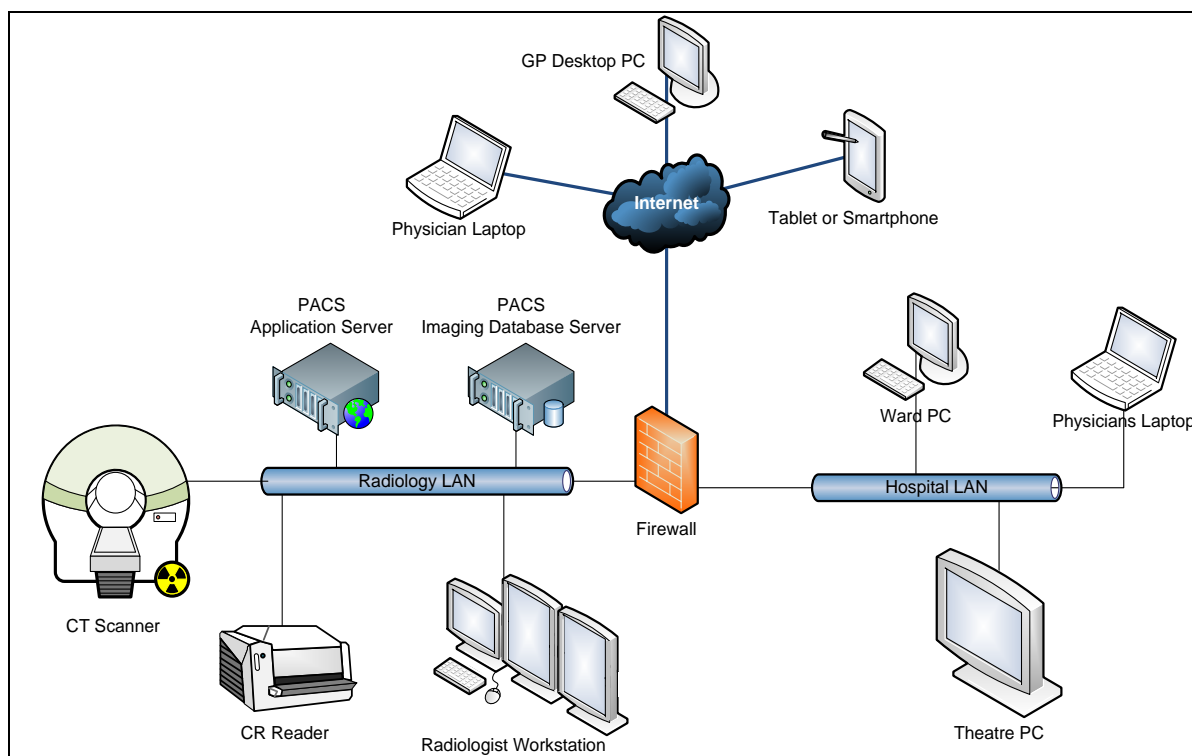
Figure 1.2: Example of PACS network

1.1.3 PACS Acceptance and Meaningful use

Systems, such as PACS, EPR and clinical support systems belong to the Clinical Information Systems (CIS) category; and their acceptance and use by physicians has a profound impact on patient care (Pynoo et al., 2012). Medical imaging plays a vital role in disease diagnosis, as well as ongoing disease management in patients (Flanders, 2010). Hence, one can argue that acceptance and meaningful use of any system facilitating this would be of the utmost importance. For the purposes of this research, referring physicians' PACS acceptance and meaningful use will be defined as capable, consistent use, and positive acceptance by the end-user (Crivianu-Gaita, Babyn, Gilday, O'Brien, & Charkot, 2000). In other words, an agreement to incorporate the system in the day-to-day clinical management of patients, as and when required, with limited reliance on physical media, such as CDs and film. Examples of the capable use of a PACS would include the digital manipulation of brightness and contrast, in order to highlight any pathology in a CT image – or zooming to identify a hairline fracture on an X-ray image.

Referring clinician acceptance is a critical factor in the overall success of a PACS implementation (Aldosari, 2012). Duyck et al. (2010) found that during implementation, initially some physicians resisted PACS; but they became more accepting of the technology with use. A significant concern with PACS is the potential that limited computer skills may negatively affect the user experience of medical staff (Strickland, 2000). Based on a literature survey conducted by Paré and Trudel (2007), the authors concluded that information technology resistance by physicians in general is a big problem. Bosmans et al. argue that even though PACS is widely available, referring clinicians often lack the necessary expertise for advanced imaging analysis and interpretation (Bosmans, Weyler, De Schepper, & Parizel, 2011).

Given the important role that PACS plays in a modern clinical setting, it is surprising to note that very few studies specifically investigate referring physicians' acceptance (Pynoo et al., 2012). Pynoo et al. further state that most PACS acceptance studies are conducted in university and public hospitals; thus, it is important to conduct further research in the private sector. Further research could assist private radiology practices in referring physician PACS acceptance; and once the system is in place, maximize its use (Pynoo et al., 2012) and take full advantage of its tangible and intangible benefits (Aldosari, 2012).

1.2 PROBLEM STATEMENT

A number of studies have indicated that physician acceptance of Picture Archiving and Communication Systems is generally high (Aldosari, 2012; Duyck et al., 2010; Prasad & Wright, 2003; Pynoo et al., 2012); but these studies have mainly focused on public sector and university hospitals. Based on an initial literature survey conducted by the researcher, there are very few PACS acceptance studies focusing on referring clinicians, and even less in the context of the private sector. This is supported by Pynoo et al. (2012) and Top (2012), both of whom maintained that more research is needed in the private sector.

Furthermore, the literature survey has also indicated that very few studies have been conducted in South Africa. Van de Wetering and Batenburg (2014) postulate that, given the financial investment associated with PACS, more

information is needed to evaluate the performance of PACS, aiding in the improvement of future PACS implementations.

In the private healthcare sector, the radiology department is typically a separate business entity, or private practice; and it is responsible for the procurement and implementation of PACS. In comparison, radiology departments in public sector hospitals are under the management of the hospital. Pynoo et al. (2012) argue that the motives for the acceptance and use of PACS may differ, when comparing private and public-hospital settings.

Thus, the problem that this research aims to address is: **There is a lack of understanding on which factors influence Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice**.

1.3   RESEARCH QUESTION

The primary question that this research will attempt to answer is: **Which factors influence the acceptance and meaningful use of Picture Archiving and Communication Systems amongst referring clinicians in private practice**? The following sub-questions will also be addressed, as part of the proposed research:

- What is the state of Picture Archiving and Communication Systems acceptance and meaningful use in healthcare provision?
- Which factors affect referring clinicians' acceptance and meaningful use of Picture Archiving and Communication Systems in private practice?
- How can the identified factors be theorised, to obtain a broader understanding of Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice?

1.4   RESEARCH OBJECTIVES

The primary research objective of this dissertation is to: **Identify factors for referring clinician acceptance and meaningful use of Picture Archiving and Communication Systems in private practice**. Furthermore, the following sub-objectives need to be met in order to address the research questions:

- Investigate the state of Picture Archiving and Communication Systems acceptance and meaningful use in healthcare provision.

- Identify which factors affect the acceptance and meaningful use of Picture Archiving and Communication Systems amongst private practice referring clinicians.

- Theorise the identified factors, to obtain a broader understanding of Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice.

1.5 RESEARCH METHODOLOGY

It is important to follow a structured process and methodology to meet the objectives of this research. An overview of the research design, the research process and the data-collection recruitment strategy is subsequently provided. Chapter 2 provides detailed information on the research methodological aspects of this research.

1.5.1 Research Design

A mixed method design was followed, where both qualitative and quantitative data were collected by using a questionnaire. The respondents were given ample opportunity to elaborate further where qualitative responses were required.

There are six primary mixed method designs; and researchers should choose a design that best reflects the level of interaction, priority, timing and mixture of the qualitative and quantitative methods (Creswell & Plano Clark, 2010). The six mixed method designs are: convergent parallel design; explanatory sequential design; exploratory sequential design; embedded design; transformative design; and lastly, the multiphase design.

The design chosen for this research project is the embedded design. An embedded design includes both a qualitative and quantitative strand of data, with one strand taking precedence over the other. The secondary strand is used to supplement the primary strand. Chapter 2 elaborates further on the design choice and motive.

Qualitative content analysis was used to analyse the qualitative results. This data-analysis method represents a systematic and objective method to analyse and interpret qualitative data (Schreier, 2012). The quantitative results will be analysed by using descriptive statistics, which can be defined as the numerical and/or graphical techniques used to describe the attributes or factors of a chosen sample (Fisher & Marshall, 2009).

The findings from the empirical data were analysed and compared with the secondary data obtained from the literature review, by utilizing qualitative content analysis. By following this process, methodological triangulation was applied. This is in line with the definition of Morse (1991) for methodological triangulation: The use of two or more methods, preferably quantitative and qualitative, to answer the same research question.

1.5.2 Research Process

Following the embedded research design, both qualitative and quantitative strands ran concurrently, the latter playing a supplementary role in the analysis and presentation of the identified factors. Firstly, a literature survey was conducted to investigate the current state of factors affecting PACS acceptance and meaningful use. A data-collection instrument was drafted; and a pilot study was used to test and refine it.

The questionnaire was then finalized and distributed to the study participants. The data was analysed using qualitative content analysis, descriptive statistics and logical argumentation. The results were theorised, using the theoretical framework of Paré and Trudel (2007). The research process is further explored in Chapter 2, section 2.2.

1.5.3 Data Collection Recruitment Strategy

The study participants were recruited from the referring doctor base of a private radiology practice based in the Eastern Cape, South Africa. The practice consists of multiple branches with a large number of active referring clinicians, including GPs and specialists, who are based primarily in the Nelson Mandela Metropolitan area and surrounding towns. Patients may also be referred by doctors based in other cities and towns throughout South Africa.

The practice implemented a PACS system to replace its conventional film-based processes. It followed a phased approach in its implementation, commencing in 2010, and completing the project in 2013. The referring doctors access the central PACS server via the Internet, or a combination of the hospital and the private practice's network infrastructure. Each of the hospitals also has access to a local PACS server for faster access to imaging and reports generated by that hospital.

Mack et al. posit that it is not necessary to include an entire population when collecting data; only a subset of a population is selected for a given study (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). Marshall (1996) describes convenience sampling as the selection of the most accessible subset. A combination of convenience and purposive sampling was used in the recruitment of participants for this study. Because of the researcher's affiliation with a private radiology practice, access to referring doctor contact details was possible – with the permission of the practice, thus convenience sampling applies here. Purposive sampling, however, also applies; as only referring doctors with active PACS profiles were selected to participate.

1.6 DELINEATION

This study focused on private practice referring doctors based in the Nelson Mandela Metropolitan Area and surrounding towns. Private practice physicians can be defined as medical doctors, including general practitioners and specialists, who either own or work for a private medical practice. Radiologists are excluded. As stated in section 1.1.1, the terms referring clinician, physician and doctor are used interchangeably in this dissertation and refer to medical doctors with direct patient contact.

1.7 ETHICAL CONSIDERATIONS

All aspects surrounding ethics were handled in accordance with NMMU ethical guidelines and procedures. This research was exempted from formal human ethics clearance subsequent to a Faculty review. No confidential patient information was accessed or published for the purposes of this research project. Participation in the questionnaires was voluntary and participants remained anonymous. The general ethical principles of autonomy, beneficence, and

justice as outlined in the Belmont Report (Department of Health, 2014) were adhered to at all times.

1.8 CHAPTER OUTLINE

This section describes the chapters that make up the research dissertation.

Chapter 1 Introduction: The introductory chapter introduces the reader to the background of the research topic, the terminology, the research questions and the objectives, as well as the methodology.

Chapter 2 Research Methodology: The research design and methodology, including the data instruments, the sampling, the data analysis and the validation of the findings are discussed. The conceptual framework used in this dissertation is also introduced.

Chapter 3 Literature Survey: This chapter serves as a theory base and highlights the current body of knowledge in terms of the research topic. PACS acceptance and meaningful use factors from the literature are presented here.

Chapter 4 Empirical Analysis of the Primary Data: The data collection strategy is revisited; and the primary data collected are discussed in detail.

Chapter 5 Factors: The PACS acceptance and meaningful use factors identified from the primary data are discussed in detail. All the identified factors, including the factors from the literature are then collated and triangulated. An interpretation of the results is also provided.

Chapter 6 Conclusion: The final chapter concludes the dissertation by highlighting the important contributions and limitations of the research, while suggesting some possible future research areas.

1.9 CONCLUSION

Chapter 1 introduced PACS and discussed its importance and benefits in modern healthcare settings. It may be argued that PACS is superior in many aspects, when compared with traditional film environments. It was established that very few studies have focused on PACS acceptance and meaningful use amongst private practice referring physicians. Therefore, the problem statement of this research was formulated as: There is a lack of understanding on which

factors influence Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice.

The primary objective of this research is thus to identify and present these factors. The research methodology was briefly discussed in section 1.5. Chapter 2 discusses the research methodology in more detail. Finally, the research delineation and the ethical aspects were discussed; and a chapter outline offered a preview of what can be expected from the remaining chapters in the dissertation.

2 RESEARCH METHODOLOGY

In Chapter 2, the methodological foundations, the research process, and the theory of this dissertation will be explored. The chapter begins with a discussion on the mixed method research design. Next, the focus moves to the data collection instruments and participant recruitment. Pilot studies have shown its worth in testing the feasibility of a large project. Thus, its use in this study is discussed. Qualitative content analysis, descriptive statistics and logical argumentation are then discussed as data analysis techniques.

The penultimate section delves into the conceptual framework chosen as the theory base, before the chapter is concluded.

2.1 RESEARCH DESIGN

The research design is the blueprint for the collection, measurement and analysis of the data (Recker, 2012). The research design chosen for this study is a mixed methods design. This design advocates the collective use of qualitative and quantitative methods – thereby providing a greater understanding of the research problems than either method in isolation (Creswell & Plano Clark, 2010).

There has been a marked growth in studies using mixed methodology designs over the past few decades (Heyvaert, Hannes, Maes, & Onghena, 2013).

Creswell and Plano Clark (2010) identified six major mixed method design types. The authors suggested that the mixed methods researcher should consider a design best suited to the study, based on the appropriate level of qualitative and quantitative interaction, priority, timing and mixing. The six primary mixed method designs are (Creswell & Plano Clark, 2010):

- o **Convergent Parallel Design**: This design is used when the researcher conducts the qualitative and quantitative inquiries at the same time, and then prioritizes them equally, with independent analysis and combined interpretation.
- o **Explanatory Sequential Design**: Quantitative data are collected and analysed; and this is followed by the qualitative collection and analysis. The benefit of this design is that the results of the first (quantitative) phase can be used in the development of the second (qualitative) inquiry. Finally, the qualitative results can help to explain the preceding quantitative results.
- o **Exploratory Sequential Design**: Similar to the Explanatory design in timing, the Exploratory Sequential Design differs by leading with the qualitative phase. This followed by a quantitative phase, aiming to generalize the identified results.
- o **Embedded Design**: In the Embedded Design, a supplementary research strand is added to the main method: before, during, or after its completion in order to improve the overall study. In this design, either the qualitative or the quantitative main strand would take priority.

o **Transformative Design**: All decisions regarding the interaction, priority, timing and mixing of qualitative and quantitative strands fall within a chosen transformative theoretical framework.

o **Multiphase Design**: Both concurrent and sequential designs are combined over a period of time. This design is often used in program evaluation.

The convergent parallel design is not suitable for this study because the quantitative and qualitative strands do not take equal priority. Both the sequential design methods (explanatory and exploratory) rely on the completion of one strand before commencing the next. These methods are also not ideal for this study. The theoretical framework used in this study does not dictate research design criteria, thus the transformative design is not applicable. The multiphase design used in program evaluation is also not relevant to this study.

The design best suited to this research is the embedded design and the reasons are twofold:

o The explorative nature of the research, that aims to identify factors affecting PACS acceptance and meaningful use by private practice referring doctors, lends itself better to a qualitative research approach. The addition of a supplementary quantitative inquiry in the data collection instrument assists in achieving methodological triangulation.

o The combination of both methods in a single data collection instrument maximizes the data collection potential, without inconveniencing the study participants with additional follow-up questionnaires or interviews; since the participants are practising physicians with limited time.

A diagrammatic depiction of the embedded research design is shown in Figure 2.1.
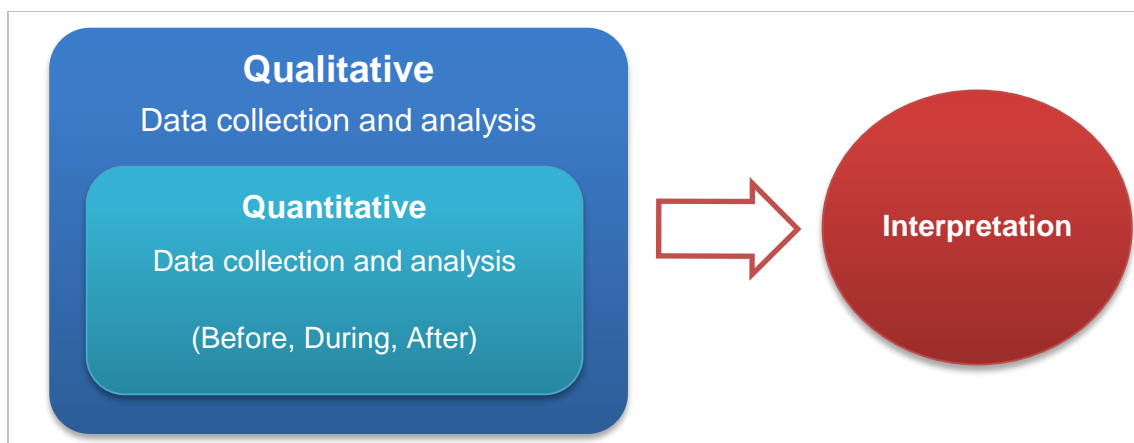
Figure 2.1: Embedded Research Design (Creswell & Plano Clark, 2010)

In the next section, the process of conducting this embedded mixed method design is discussed.

2.2   RESEARCH PROCESS

The research process can be outlined as follows and it is illustrated in Figure 2.2:

- o Conduct a thorough literature survey to study the current body of knowledge pertaining to PACS acceptance and meaningful use, as well as the methodology proposed;
- o Develop a data collection instrument (questionnaire);
- o Test the data collection instrument on a small sample (pilot study) and adapt it, if necessary;
- o Collect the data;
- o Interpret the data;
- o Present the factors affecting the acceptance and meaningful use of PACS by referring clinicians in private practice.
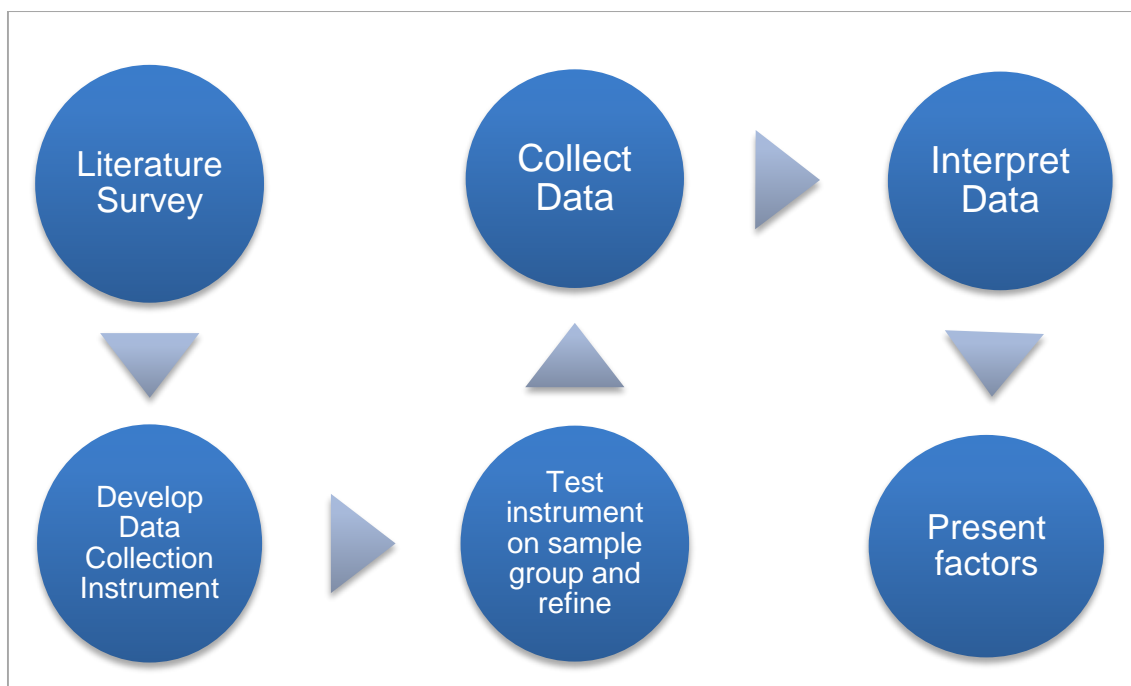
Figure 2.2: The Research Process

The process is in line with the embedded mixed-method design discussed in the preceding section. The collection, interpretation and presentation of the qualitative and quantitative data remain concurrent throughout. However, it is important to remember that due to the explorative nature of the research, the qualitative strand takes priority.

In the following sections, each of the above-mentioned steps of the research process are discussed in further detail.

2.3   DATA COLLECTION

The following sub-sections describe the role of the literature survey and the questionnaire, as data collection tools in this study. The data sampling techniques employed are also discussed.

2.3.1   Literature Review

The literature review is an essential component in academic research success (Hart, 1998). Literature reviews are crucial to establish a sound theory base for most research endeavours, while providing context, highlighting the significance of the research, and confirming its originality (Hofstee, 2006). Furthermore, Hart (1998) postulates that it not only shows an understanding of the research subject, but also the design and the methodology. An initial literature review

was conducted in March 2014 to gain a broad understanding of PACS acceptance and meaningful use. It also played a key role in identifying and substantiating the research problem. A more in-depth literature survey was conducted throughout the latter part of 2014 and first half of 2015. The in-depth search focused on identifying factors that contribute to PACS acceptance and meaningful use, identifying an appropriate theoretical framework, and formulating the data collection instruments and the analytical techniques.

The search protocol incorporated a variety of online publications and academic databases. These included: EBSCOhost, Sage, Sabinet, ScienceDirect, SpringerLink, Taylor & Francis as well as Google Scholar. Initially the search criteria were narrowed on topics related to PACS in private practice. These were broadened to include academic and public sector settings once it was established that the body of knowledge specific to private sector settings was limited. The search strings used included: "PACS", "PACS Acceptance", "PACS meaningful use", "PACS referring doctor or physician" and "PACS history". Chapter 3 presents the results of the literature survey related to PACS acceptance and meaningful use. Section 2.6 discusses the theoretical conceptual framework identified for this research.

2.3.2 Questionnaires

Questionnaires are a form of structured survey research where the respondents are asked the same questions and given the same options to answer them (Hofstee, 2006). Questionnaires are typically used to collect quantitative data; but they may also include a qualitative component when open-ended questions allow the respondents to answer the questions in their own words. The questionnaire in this research employs both quantitative and qualitative components to complement the mixed methodology approach of this study.

Pilling (2003) developed a questionnaire to measure the user acceptance of a PACS installed at the Norfolk and Norwich University Hospital, United Kingdom. This questionnaire was also used in two Turkish Hospitals to assess PACS physician acceptance by Top (2012); and it also served as a basis in developing the questionnaire used in this study. While Pilling's questionnaire addressed the topic of user acceptance, it does not fully cover the aspect of meaningful use as

required by this study. Therefore, additional questions were added to address this need.

2.3.3 Sampling

Sampling in qualitative inquiries are often based on smaller samples selected with purpose, allowing the extraction of rich information (Patton, 1990). In selecting a sample for the questionnaire, a combination of both purposeful and convenience sampling was employed. As noted above, purposeful sampling allows the researcher to select information-rich participants. Studies using content analysis techniques, where the researcher aims to engage with informants who have the richest information pertaining to the research topic, can benefit from purposeful sampling (Elo et al., 2014).

Convenience sampling was used to obtain a list of active referring doctors from the researcher's employer after the necessary permission was sought. Thereafter, the list was cross-referenced with PACS access records. A final list was created from referring doctors that had accessed PACS at least once in the period between 1 April 2014 and 31 March 2015, constituting purposeful sampling.

While the referring doctors were recruited from a single radiology practice, the data collection instruments did not limit them to report on their PACS experience relating to the single practice, since they may have had exposure to other private radiology PACS systems – both locally and abroad.

Adequate sample sizes are often difficult to predict in qualitative studies but researchers should ensure that the sample size adequately answers the research questions (Marshall, 1996). Marshall (1996) defines data saturation as the point where new categories, themes or explanations cease to emerge from the collected data. Patton (1990) argues that the quality of the information obtained in the qualitative data collection, in addition to the analytical skill of the research, is more important than the sample size.

In this research, the sample size amounted to 456 participants, with a response rate of 9.21% (42 questionnaires). The low response rate is attributed to the nature of the respondents' profession, which leaves little spare time to

participate in questionnaires. The aspect of data saturation is further discussed in Chapter 5, section 5.1.

2.4   PILOT STUDY

A pilot study presents an opportunity to test the feasibility of a large-scale research project (Thabane et al., 2010) and is typically used to test research protocols, logistics, data collection instruments and sampling strategies (van Teijlingen & Hundley, 1998). The presence of a pilot study with clear goals can help to improve the accuracy and the dependability of a qualitative research study (Kim, 2011). The main focus of the pilot study in this research was to test the questionnaire data collection instrument and the web-based platform.

Van Teijlingen and Hundley (1998) adapted a list of procedures to increase the internal validity of questionnaires from Peat et al. (Peat, Mellis, & Williams, 2002). The procedures are summarized in Figure 2.3.

Administer the questionnaire to pilot subjects using the same methods as to be used in the main study

Request subjects to identify ambiguities and difficult questions

Record time taken to complete the questionnaire and decide if reasonable

Discard unnecessary, difficult or ambiguous questions

Assess whether each question gives an adequate range of response

Establish if replies can be interpreted in terms of information required

Check that all questions are answered

Re-word or adjust the scale on any questions as needed

Shorten, Revise and if possible, pilot again

Figure 2.3: Pilot study process (Van Teijilingen and Hundley, 1998)

The questionnaire was designed by using an NMMU online-survey tool, namely WebSurvey. Prior to the distribution of the pilot questionnaires, the technical aspects involved in distributing the questionnaires and retrieving responses were tested on three members of the general public. Following the successful test runs, hypertext links were emailed to five private practice referring doctors selected to participate in the pilot study. The email contained a covering letter to introduce the study, its objectives, the researcher and the purpose of the pilot study.

The participants were asked to complete the questionnaire and comment on any potential problems, including but not limited to spelling or grammar mistakes, ambiguous questions, questionnaire length and complexity. Despite follow-up emails, only one referring doctor gave verbal feedback – stating that no mistakes were found, and that the length of the questionnaire was acceptable.

In order to gain further meaningful feedback, three experienced researchers in the NMMU School of Information and Communication Technology were approached to comment on the questionnaire in terms of the above-mentioned criteria. Suggestions were made to improve the layout, the readability, the language and the range of responses. The suggestions were incorporated where applicable and the questionnaire finalized for distribution.

2.5 DATA ANALYSIS

In order to analyse the qualitative and quantitative data collected, qualitative content analysis, descriptive statistics and logical argumentation were used.

2.5.1 Qualitative Content Analysis

The mixed methodology approach of this study aligns well with the content analytical techniques described by Elo and Kyngäs (2008). Content analysis can be applied to both qualitative and quantitative data, either inductively, or deductively. This study applies inductive content analysis techniques on the qualitative data gathered via the open-ended questions in the questionnaire. Inductive content analysis is used, when none, or very limited studies, exist dealing with the phenomenon under study.

This is also comparable to the conventional content analysis described by Hsieh and Shannon (2005); and it has the benefit of allowing the participants to divulge first-hand information without having biased notions imposed on them. As stated in Chapter 1, very few studies have investigated PACS acceptance and meaningful use in private practice, thus inductive content analysis is applicable. The method and its application will be revisited in Chapter 5.
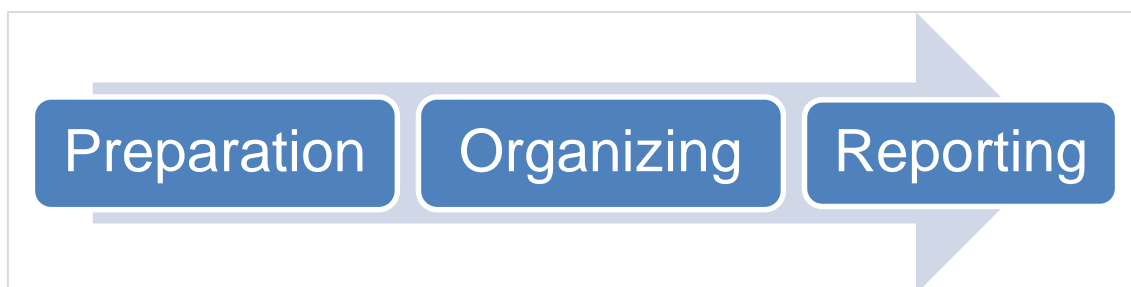
Figure 2.4: Phases of Content Analysis. (Adapted from Elo & Kyngäs, 2008)

As depicted in Figure 2.4, the three main phases of content analysis are: Preparation, Organizing, and Reporting. It is important to place the focus on trustworthiness, throughout each of the phases, to ensure credibility, dependability, conformability, transferability and authenticity (Elo et al., 2014). Aspects concerning the study's trustworthiness will be explored upon its conclusion in Chapter 6.

2.5.2 Descriptive Statistics

Descriptive statistics are well-suited to illustrate the characteristics of raw quantitative data in a manner more readily assimilated by an audience (Marshall & Jonker, 2010). Fisher and Marshall (2009) define it as the numerical and/or graphical representation of a given sample's characteristics. The quantitative data gathered in the questionnaire are presented using descriptive statistics.

2.5.3 Logical Argumentation

Argumentation is a popular technique used in most research projects and it aims to strengthen claims or statements by providing substantiating evidence in its support (Olivier, 2004). Logical argumentation will be used in Chapters 3, 4 and 5 for this very purpose, while presenting the data and the findings of the research.

2.6 CONCEPTUAL FRAMEWORK

Paré and Trudel (2007) developed a framework to categorize knowledge barriers influencing PACS acceptance during a study involving two Canadian hospitals. Their results demonstrated that, in order to maximize the chances of a successful PACS installation, a holistic approach is better suited than one solely focused on rolling out a new technology. The authors combined aspects of the Theory of Diffusion of Innovation (Rogers, 1995) and the Theory of Barriers to Innovation (Attewell, 1992; Nambisan & Wang, 1999; Tanriverdi & Iacono, 1998) to derive a new conceptual framework.

The framework, depicted in Figure 2.5, consists of two main sequential phases: Initiation and Implementation. These phases are further divided into five stages. During the Initiation phase, Agenda-setting aims to categorize the organizational issues to be addressed by implementing the new system or innovation.

Types of Knowledge Barriers	The Innovation Process in an Organization					
	Initiation Phase		A decision to invest in PACS is made	Implementation Phase		
	Agenda-Setting	Matching		Redefining / Restructuring	Clarifying	Routinizing
Project/Economic Barriers		X				
Technical Barriers				X	X	
Organizational Barriers				X	X	
Behavioural/Human Barriers					X	X

Note: Column "The PACS is deployed" separates the Redefining/Restructuring and Clarifying columns within the Implementation Phase.

Figure 2.5: Conceptual Framework (Paré & Trudel, 2007)

Thereafter, during the Matching stage, system qualities are aligned to the issues identified and analysed in terms of their ability to adequately address these issues. At this point, a decision is made whether or not to implement the innovation. If the project committee decides to go ahead with the project, the Implementation phase starts. During the Redefining/Restructuring stage, the innovation is moulded to the requirements of the organization, or *vice versa*.

During the fourth stage, Clarifying, the innovation is used more widely. Social aspects are important in this phase, in addition to technical and organizational aspects, as the users become more adept through common experience. When the innovation is finally routinized, it becomes part of the users' daily activities and ceases to be an innovation in the true sense of the word.

Paré and Trudel (2007) included an additional dimension in their framework, known as the four categories of knowledge barriers to PACS adoption in hospitals. These categories are shown on the left in Figure 2.5. The authors predicted at which stages the challenges to innovation would have to be solved to increase the likelihood of PACS project success. This is indicated by an "X" in Figure 2.5. The categories are:

- o **Project Barriers** reflect the economic, project and resource management difficulties met during the process of PACS assimilation.
- o **Technical Barriers** include infrastructure, computer hardware and software, as well as security barriers to PACS adoption as an innovation.
- o **Organizational Barriers** are problems inherent to introducing a new technology into established systems and processes, as well as supporting the new systems.
- o **Behavioural Barriers** pertain to human factors, such as individual resistance to change and socio-political dynamics.

Project barriers are of particular importance during the Matching stage, while the Technical and Organizational barriers would need to be addressed during the Redefining/Restructuring phase. During the Clarifying stage, Technical, Organizational and Behavioural challenges would need to be solved. Finally, the remaining Behavioural barriers are expected to be addressed during Routinizing. The lack of barrier categories falling under the Agenda-Setting phase could arguably be as a result of the limited involvement of referring doctors in the early stages of a PACS project.

This conceptual framework forms the theoretical lens through which factors affecting PACS acceptance and meaningful use are investigated in this dissertation. This includes both primary and secondary data analyses.

2.7 CONCLUSION

The second chapter of the dissertation has discussed the key aspects and decisions pertaining to the research design. An embedded mixed methodology approach was chosen as the most suitable approach. This strategy enables the researcher to qualitatively explore primary and secondary data, while supplementing the study with a quantitative angle. The major steps in the research project were discussed, followed by the data collection methods, consisting of a literature review and a questionnaire. The sampling strategies employed were also highlighted, namely: purposive and convenience sampling.

Qualitative content analysis, descriptive statistics and logical argumentation were discussed as the core methods employed to analyse the data.

Finally, the conceptual framework acts as a theoretical lens to analyse and present the research; and this angle was also discussed. The framework categorized PACS acceptance and meaningful use factors as: Project, Technical, Organizational or Behavioural. The factors are also categorized, according to the phases and stages in which they are most likely to be influential.

3 LITERATURE SURVEY

This chapter aims to identify factors that influence referring doctor PACS acceptance and meaningful use from available literature. The identified factors are presented using the conceptual framework developed by Paré and Trudel (2007) introduced in section 2.6. The framework was originally intended to categorize knowledge barriers to PACS adoption. This key difference to the objectives of this research is addressed in the first section of this chapter. The identified factors are categorized as either Project, Technological, Organizational or Behavioural and discussed in more detail. The factors are summarized in the penultimate section before the chapter is concluded.

3.1   DATA COLLECTION AND ANALYSIS

A recent study by Pynoo et al. (2012) claims to be the first investigating PACS acceptance and meaningful use by private sector referring doctors. The limited literature, based on the private sector context, thus necessitated the inclusion of literature based on the public sector context in the literature survey. The identified factors are triangulated with factors from the primary data in Chapter 5 to improve trustworthiness.

The conceptual framework described in the preceding chapter, section 2.6, identified various barriers to PACS adoption. However, the research objective of this study is to identify factors affecting the acceptance and meaningful use of PACS. The application of the framework, therefore, needs some further consideration.

It may be argued that a factor has both a negative and a positive connotation. If, for example, good training was identified as a contributor to PACS acceptance and meaningful use, the inverse of the factor would logically be an inhibitor, or in other words, a barrier. While semantically similar, it is important to highlight this differentiation in its presentation. Therefore, the primary and secondary data gathered in the questionnaires will be presented as factors influencing PACS acceptance and meaningful use, keeping in mind that a factor could both be interpreted as a barrier, or as a contributor.

PACS acceptance depends on both technical and non-technical factors (Ayal & Seidman, 2009; Crivianu-Gaita et al., 2000). Physicians' resistance to information technology has been well-documented (Paré & Trudel, 2007); and by identifying and mitigating factors contributing to this resistance, a higher success rate could be achieved. User acceptance of a PACS is a critical determining factor of PACS success (Aldosari, 2012). In the following sections the four categories of Project, Technical, Organizational and Behavioural from the Paré and Trudel (2007) conceptual framework are used as a lens to discuss the factors affecting referring clinician PACS acceptance and meaningful use, as identified from the literature.

3.2 PROJECT FACTORS

Project barriers to PACS adoption are particularly relevant during the matching phase. This includes any financial aspects to be addressed; how the project will be financed; whether there are any financial incentives for using the system, etc. The factors identified in the Project category will be subsequently discussed in sections 3.2.1 and 3.2.2.

3.2.1 Finance

PACS represents a major financial investment, including many direct and indirect costs (Ayal & Seidman, 2009). In a typical South African private hospital setting, PACS is generally procured and installed by radiology practices and they, therefore, carry most of the costs. These costs are offset against film savings and increased productivity (Ayal & Seidman, 2009; Paré & Trudel, 2007). The business case for a PACS is beyond the scope of this research, however, other financial aspects are still important to consider. Examples include the cost of hospital networks, training and image-viewing workstations (Ayal & Seidman, 2009); as well as determining who will meet these costs.

Referring doctors may have to purchase new or upgraded computers for their offices (Pynoo et al., 2012), which could lead to resistance.

3.2.2 Project team

Another important factor is the choice of a project team to lead the planning and implementation of the PACS (Paré & Trudel, 2007). The team should have the mandate and the necessary skills to effectively manage any project, technical, organizational and behavioural challenges that might arise. Failing to appoint a skilled project team could lead to a failed or sub-optimal implementation, which could lead to further physician resistance.

3.3 TECHNOLOGICAL FACTORS

A major determinant of PACS success is access to specialized technical knowledge. This includes the information and communication technology (ICT) infrastructure, hardware, software and security. It also includes radiographic-specific aspects, in which the advantages and disadvantages of the choices between different digital X-ray equipment become important (Paré & Trudel,

2007). The factors identified in the Technological category will subsequently be discussed in sections 3.3.1 - 3.3.10.

3.3.1 Access to radiology information

PACS facilitates the accessibility to radiology images on a level unmatched by traditional film environments; and this is an important factor in referring doctor acceptance. This view is shared by Pilling (2003) and Top (2012). In some cases, access to PACS may be limited to selected users; and as a result, this could hinder PACS acceptance (Top, 2012).

3.3.2 Technical expertise

Paré and Trudel (2007) argue that a lack in technical expertise when dealing with the specialized technical requirements of a PACS installation can have serious repercussions during the Redefining and Clarifying stages. The resultant technical problems may lead to the rejection of PACS by referring doctors.

3.3.3 Computer Hardware

Crivianu-Gaita et al. (2000) argue that technical factors are very important to the success of a PACS project. These may include computer workstations, servers and data storage platforms. The specifications, number and placement of image-review workstations and monitors in the hospital would have an important effect on workflow (Avrin, Wiggins & Bahr, 2003); and it would allow for simultaneous viewing of the same image (Strickland, 2000). If the hardware does not meet the system requirements of PACS, the subsequent poor computer performance may lead to physician resistance and sub-optimal use.

3.3.4 System Failure

Top (2012) and Pilling (2003) found system failures to be a barrier to PACS acceptance and meaningful use. Once a PACS installation has replaced a film-based workflow, it is imperative to guard against total system failure (Strickland, 2000), rendering redundant server architecture design very important. Server room infrastructure, such as Uninterrupted Power Supply (UPS) and redundant air-conditioning, are also important (Honeyman-Buck, 2003), in order to guard against failure.

System failure concerns are not necessarily limited to server infrastructure alone; and this would also apply to desktop computers, as well. For example, computer failure or power outages in physicians' consulting rooms could lead to an inability to access PACS; and the associated frustration may drive doctors to prefer film or paper-based hardcopies.

3.3.5 Network speed

Computer network downtime can be caused by a variety of problems; and this can have a significant impact on a PACS environment (Honeyman-Buck, 2003). Network speed or bandwidth both influence the performance of a PACS system and these are important factors in the time taken to display an image to the user (Lewis, Horton, Kinsey, & Shelton, 1999). Referring doctors expect timely access to images in their consulting rooms, wards and theatres (Avrin, et al, 2003).

3.3.6 Ease-of-use

Pynoo et al. (2012) found ease-of-use (user-friendliness) to be a major factor in private practice referring doctor PACS acceptance – even more than the usefulness of the system. Not all users of the PACS system, including referring doctors, would have a high level of computer literacy. Therefore, the interface should be as intuitive and user-friendly as possible, in order to encourage acceptance and meaningful use (Strickland, 2000).

3.3.7 PACS Security

There are two aspects to PACS security: system security and patient privacy (Gutiérrez-Martínez, Núñez-Gaona, Aguirre-Meneses, & Delgado-Esquerra, 2012). The latter will be discussed in the section on Organizational factors.

PACS system security measures must guard against unauthorized access or leakage of private information (Gutiérrez-Martínez, et al., 2012; Harding, Gac, Reynolds, Romlein, & Chacko, 2000). Such measures include firewalls, secure password policies and encryption. Physical security, for example restricting access to vital equipment, is also important (Honeyman-Buck, 2003). If the security of the PACS is compromised, it could lead to physicians' distrust, which could negatively influence acceptance and meaningful use.

3.3.8 Image quality

Variable image quality can lead to resistance from referring doctors (Pilling, 2003). There are a variety of factors contributing to image quality, including PACS image compression (Engelmann, Mu, Meinzer, Schro, & Heidelberg, 2007) and radiographic technique (Huda, Scalzetti, & Levin, 2000). While the latter may not be a PACS-specific factor, from a physician's point-of-view, the differentiation may not be so clear. Therefore, a consistently high level of radiology image quality can contribute to improved PACS acceptance and meaningful use.

3.3.9 Image manipulation

In the survey conducted by Pilling (2003), image manipulation was listed as a benefit by the PACS users. It could, therefore, be argued that image manipulation tools on PACS are a factor in referring physicians' acceptance and meaningful use. This inference is further strengthened by the fact that users in Pilling's survey found the available tools to be limited in that particular PACS' web-interface.

3.3.10 Remote Access

In the results published by Top (2012), as well as those of Pilling (2003), the respondents reported on the advantage of remote consultation introduced by PACS. This allows doctors to view images and reports from home, or while travelling, leading to greater efficiency and patient care. Remote access to PACS is, therefore, a factor in referring doctors' acceptance and meaningful use.

3.4 ORGANIZATIONAL FACTORS

The Redefining and Clarifying stages take place directly before and after PACS deployment, respectively. Organizational factors are very important during these stages. The factors represent challenges with inserting and integrating PACS in existing structures or workflow, as well as supporting its use. The factors identified in the Organizational category will subsequently be discussed in sections 3.4.1 to 3.4.7.

3.4.1 Training

Training was identified in two independent questionnaire-based studies as a possible barrier to PACS acceptance and meaningful use (Pilling, 2003; Top, 2012). Aldosari (2012) states that poor pre-installation training can lead to resistance. This is supported by Ayal and Seidman (2009), who postulated that training greatly increases the potential for a successful PACS implementation. Crivianu-Gaita et al. (2000) argue that continuous review in the training strategy is often excluded; and that could lead to problems.

Pilling (2002) concludes that any obstacles to training should be removed to avoid physicians' frustration; since this could impact on patient care.

3.4.2 System support

PACS or system administrators need to ensure that the system runs correctly. Private hospitals should have strong support structures to encourage PACS usage, according to Pynoo et al. (2012). Many healthcare professionals, including referring doctors, lack a fundamental understanding of clinical information systems and the presence of technological experts could help encourage the use of PACS (Crivianu-Gaita et al., 2000).

3.4.3 Workflow

The introduction of PACS brings about many changes in workflow, not only in the radiology department, but throughout the healthcare environment. In one of their case studies, Paré and Trudel (2007) found workflow redesign to be a key factor. Therefore, redesigning organizational workflow should not be ignored in order to achieve the full benefits of PACS (Siegel & Reiner, 2003). An example of a change in workflow could be a change in how and when surgeons plan their procedures, using PACS. If PACS is configured correctly, planning can be done from home, thereby positively influencing workflow efficiency.

3.4.4 Ward access

PACS access in wards may be limited, due to the number of computers available (Pilling, 2003). The inability to view or show images to patients at the bedside is also a perceived negative by physicians (Top, 2012). If steps are not taken to mitigate this factor, it could lead to referring doctors' resistance.

3.4.5 Patient privacy

As mentioned in section 3.3.7, while PACS security is more related to the technical aspects, there are also organizational decisions pertaining to patient privacy, which could have a profound influence on PACS' acceptance and meaningful use (Gutiérrez-Martínez et al., 2012). While it is important to have policies and procedures in place to protect privacy, a potential downside is that these may inhibit a referring doctor's accessibility of information. For example, a policy may be in effect to limit referring doctors from accessing patients referred by other doctors. This may negatively affect continuity of care, especially in emergency situations. Finding the correct balance between patient privacy and accessibility is important in physicians' PACS acceptance and meaningful use.

3.4.6 Education

The results published by Pilling (2003) include the teaching benefits introduced by PACS. Some PACS products will allow for the creation of a digital library of interesting cases accessible from anywhere, thereby further extending the educational benefit. The results also indicate that patient education increases with the use of PACS. Education is, therefore, a factor in referring doctors' PACS acceptance and meaningful use.

3.4.7 Repeat examinations

Respondents in the survey conducted by Top (2012) reported a decline in the amount of duplicate imaging. Referring doctors with access to the full radiological history of the patient would be able to avoid sending patients for unnecessary examinations, if the study was ordered by another physician. This may also result in less unnecessary radiation exposure for the patient.

3.5 BEHAVIOURAL FACTORS

Behavioural factors are generally addressed in the clarifying or routinizing phases; and therefore, they tend to be retrospective, according to Paré and Trudel (2007). These factors include resistance to change, and other social factors, such as organizational power dynamics. The factors identified in the Behavioural category are subsequently discussed in sections 3.5.1 - 3.5.3.

3.5.1 Resistance to change

As previously noted, physician resistance to information technologies is well-known. Users are more likely to resist PACS if technical issues still plague the installation; or, if film is still provided (Crivianu-Gaita et al., 2000). Clinician resistance may prove to be a significant barrier to the success of a PACS installation (Aldosari, 2012).

3.5.2 Social aspects

Pynoo et al. (2012) argue that physicians should experience strong support in their social environment in terms of PACS usage. A study conducted by the above-mentioned authors has shown that social influence can have an effect on physicians' acceptance of clinical information systems, especially in private-sector hospitals.

3.5.3 Patient satisfaction

Patient satisfaction was listed as a factor by respondents in the survey conducted by Top (2012). It may be argued that by improving patient satisfaction, PACS assists in the acceptance and meaningful use by referring doctors.

3.6 SUMMARY OF FACTORS

Using the conceptual framework, as devised by Paré and Trudel (2007), factors influencing referring doctors' PACS acceptance and meaningful use were identified in the literature and categorized in Table 3.1. The table illustrates how the various factors are categorized in terms of the factor types and the stages where they are most relevant. Some of the factors are relevant in more than one stage. These factors will be triangulated with the primary data in Chapter 5.

Types of Barriers/ Factors	Initiation Phase		Implementation Phase		
	Agenda-Setting	Matching	Redefining	Clarifying	Routinizing
Project		• Finance • Project Team			
Technical			• Access to radiology information • Lack of technical expertise • Computer hardware • System failure	• Network speed • Ease of use • PACS security • Image quality • Image manipulation • Remote access	
Organizational			• Training • System support • Workflow • Ward access	• Patient privacy • Education • Repeat examinations	
Behavioural				• Resistance to change	• Social aspects • Patient satisfaction

Table 3.1: Literature survey factors affecting referring clinician PACS acceptance and meaningful use

3.7 CONCLUSION

Chapter 3 commenced by discussing some of the aspects of the data collection and analysis relevant to the literature survey. These included the key semantic difference between the terms 'barriers' and 'factors', as relevant in this study. Each of the identified factors was then discussed in terms of the four main categories: Project, Technical, Organizational and Behavioural. The factors were summarized in Table 3.1, according to the conceptual framework categories, phases and stages.

The limited availability of private practice PACS acceptance and meaningful use of the data was echoed by the literature survey results. The importance of the research objectives is, therefore, further underlined.

In the next chapter, the primary data collection methods are revisited and the empirical analysis of the questionnaires is presented.

4 EMPIRICAL ANALYSIS OF THE PRIMARY DATA

In Chapter 4, the primary data collection process, as well as the results are discussed in detail. Aspects of the questionnaire design and distribution are also discussed. The results of the quantitative data collected through the questionnaire are reported by means of descriptive statistics. The results are presented, in accordance with the thirteen sections that comprised the questionnaire.

4.1 DATA COLLECTION

4.1.1 Sample

The researcher was able to obtain a database of referring doctors with permission from a radiology practice in the Eastern Cape. The database included doctors from various locations in South Africa, not merely those limited to the Eastern Cape. The initial list contained 1454 doctors of various specialities. In order to obtain a meaningful sample, it was filtered to generate a list of 475 doctors. This forms part of the purposeful sampling strategy, as described in Chapter 2, in order to identify doctors that actively use the PACS system and who might be in a position to provide meaningful feedback.

The database was filtered using the following criteria:

- Doctors marked as Active, identifying them as actively practising medicine and referring patients to the practice;
- Doctors with a media preference of 'Web', indicating PACS users;
- Doctors with listed email addresses. By selecting doctors with email addresses listed on the system, it enabled the researcher to reach a wider sample in a short amount of time – and this forms part of the convenience sampling strategy;
- Therapists, dental professionals, chiropractors and bio-kineticists were excluded;
- Radiologists were also excluded, as the objective of the study is to focus on private practice referring doctors outside the radiology department.

In the questionnaire distribution phase, 19 further doctors were excluded from the list – due to erroneous email addresses. Thus, the final sample comprised 456 participants.

4.1.2 Questionnaire distribution

The questionnaire was designed and hosted on the Nelson Mandela Metropolitan University "Our Web Survey" System, which facilitates electronic distribution and collection of the results. This allowed doctors to complete the questionnaire via the Internet when convenient. The full questionnaire is attached in **APPENDIX D – Questionnaire**.

An initial email was sent to the referring doctors on 24 July 2015. The email contained a link to the web-based questionnaire, as well as a covering letter explaining the objectives of the study.

A follow-up email was sent on 3 August 2015, as a reminder of the 10 August 2015 deadline. After the deadline had passed, 42 questionnaires were completed on the web-based system, thereby indicating a 9.21% final response rate. The low response rate is attributed to the nature of the respondents' profession, which leaves little spare time to participate in questionnaires. However, the low response rate does not negatively impact on the validity of the study due to its explorative nature, which lends itself better to qualitative research. The study does not aim to measure the level of PACS acceptance and meaningful use within the given sample. Thus the study does not aim to generalise the results of the research which implies that a smaller dataset will suffice for the purposes of this study.

4.1.3 Questionnaire design

The questionnaire was largely adapted from Pilling's design in his study of PACS users at a hospital in the United Kingdom. It was again used by Top (2012) in two public Turkish hospitals. Although the questionnaire covered many aspects relevant to this study, it did not completely cover all the necessary aspects to satisfy the research objectives of this dissertation. A number of additional questions were therefore formulated, in order to gain insight into which factors encourage or hinder PACS acceptance and meaningful use – without trying to lead the responses or introduce any personal bias.

Another important change introduced in this questionnaire was to convert from a 6-point Likert scale system, to a 5-point Likert scale. This offers respondents a neutral position to neither agree nor disagree with the question/statement. According to Garland (1991), research suggests that the introduction of a mid-point or neutral position on a Likert scale can cause some respondents to choose a socially acceptable answer, rather than choosing a positive or negative position. However, the context should be considered; and the use of a neutral position remains a question of the researcher's preference. The decision

was made to include a mid-point in the Likert scales for this study, in order to give doctors the opportunity to indicate whether PACS neither positively nor negatively affects a given aspect of their workflow. It could be argued that if a participant felt truly neutral about a given aspect, the absence of a mid-point could force an answer in a particular direction, which might distort the results.

The questionnaire consisted of 13 parts, each with three to five questions spread over five pages. Most of the questions were set as required, preventing participants from continuing to the next pages if the question was not completed.

The next sections (4.2 – 4.14) of the chapter discusses the primary data gathered for this study. Note that the text formatted in italics indicate verbatim quotes from the free text-fields in the questionnaire.

4.2 SECTION 1 – BIOGRAPHICAL INFORMATION

The first section was designed to gather biographical information from the respondents.

4.2.1 Gender

Of the forty-two (42) respondents, thirty-three (79%) were males, compared with nine (21%) females.
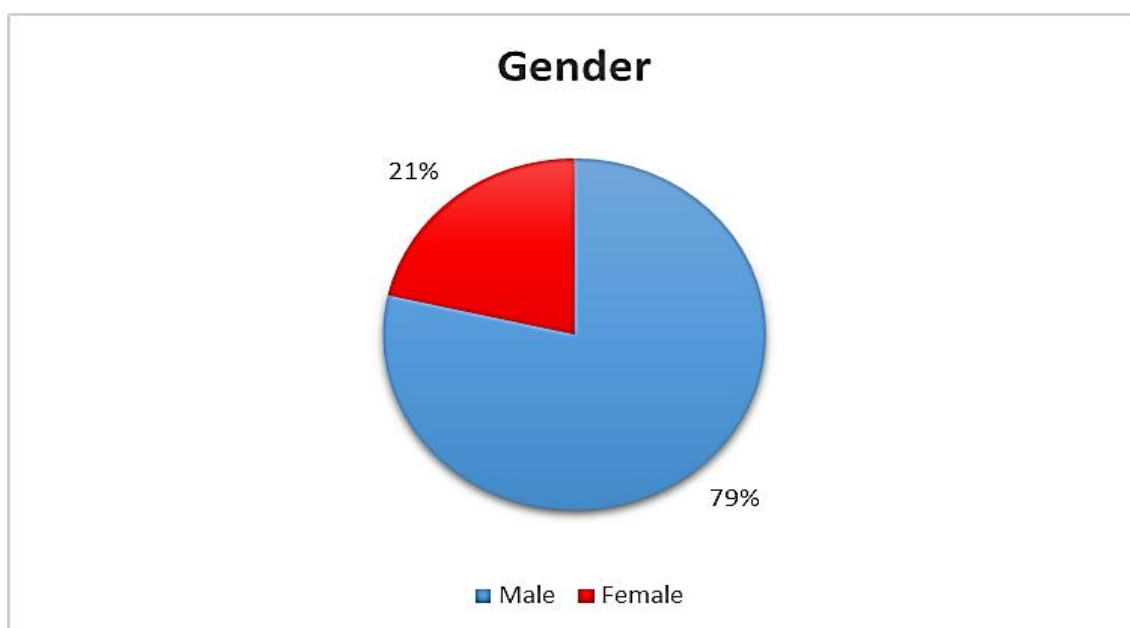
Figure 4.1: Gender

4.2.2 Age

More than half (twenty-six) of the respondents were between the ages of 40 years and 59 years. One respondent was relatively young (25-29 years) compared with the rest of the participants.
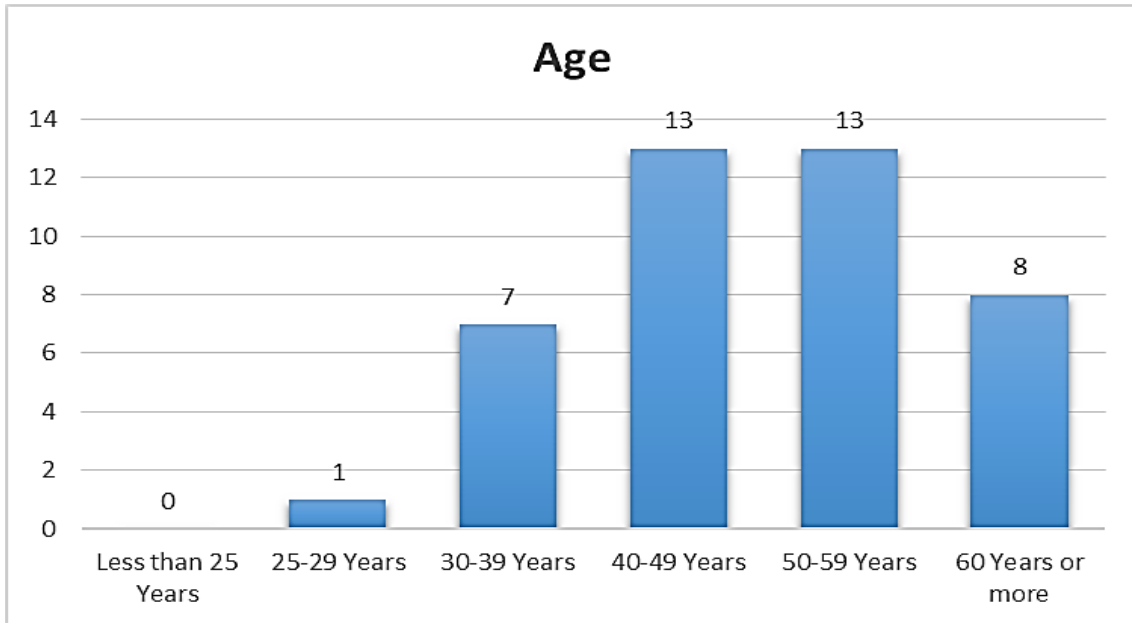
Figure 4.2: Age

4.2.3 First Language

The only first languages represented were Afrikaans and English.
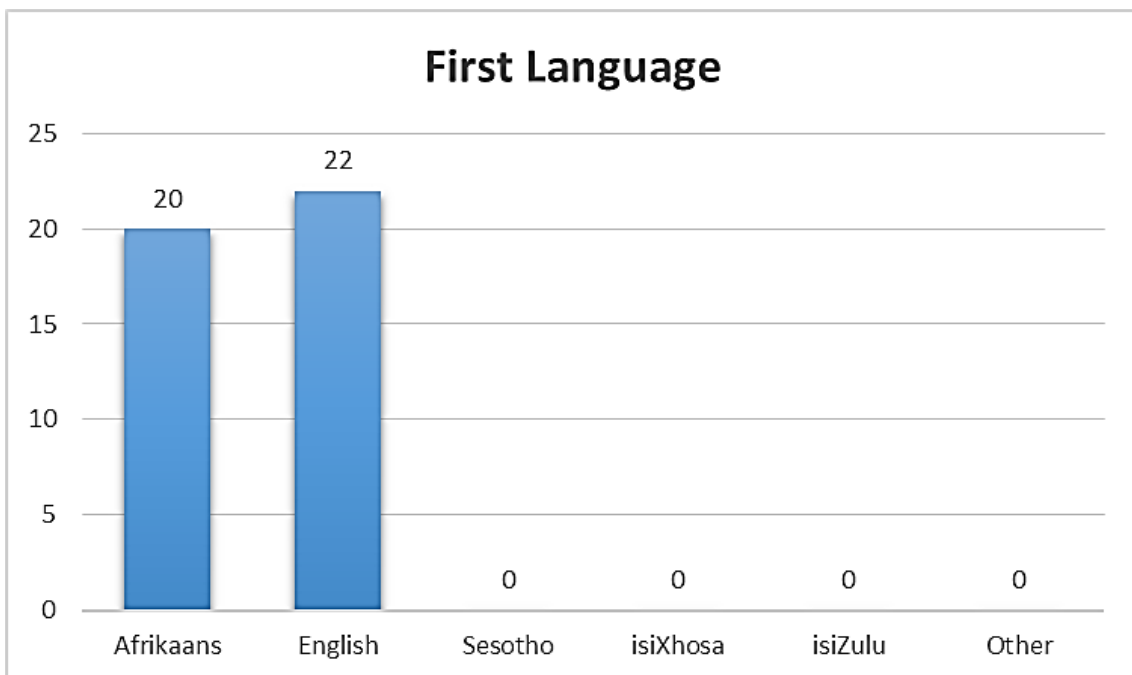
Figure 4.3: First Language

4.3   SECTION 2 – EXPERIENCE

This section highlights the professional experience of the participants, their area of speciality in medicine, their PACS experience and their level of computer literacy.

4.3.1   Primary area of work in medicine

Twenty-five (60%) of the respondents were identified as specialists, while seventeen (40%) were general practitioners.
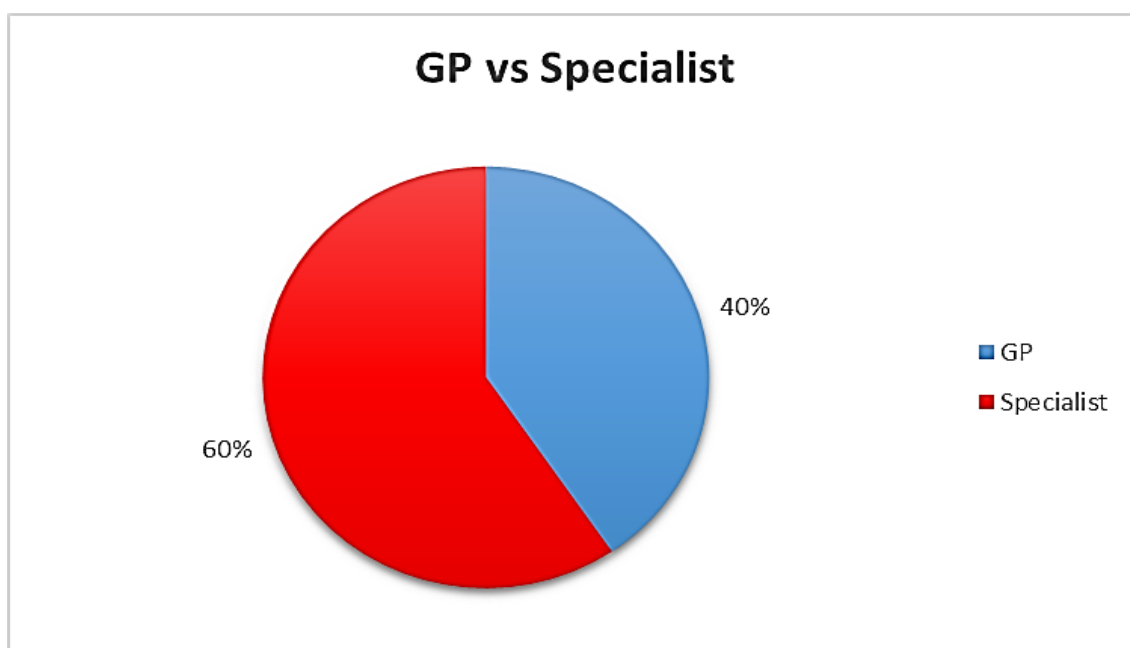
Figure 4.4: Primary area of work in medicine

The participants were asked to indicate their primary type of medical speciality. The specialities identified are depicted in Figure 4.5.

The largest group represented comprised orthopaedic surgeons, followed by oncologists.
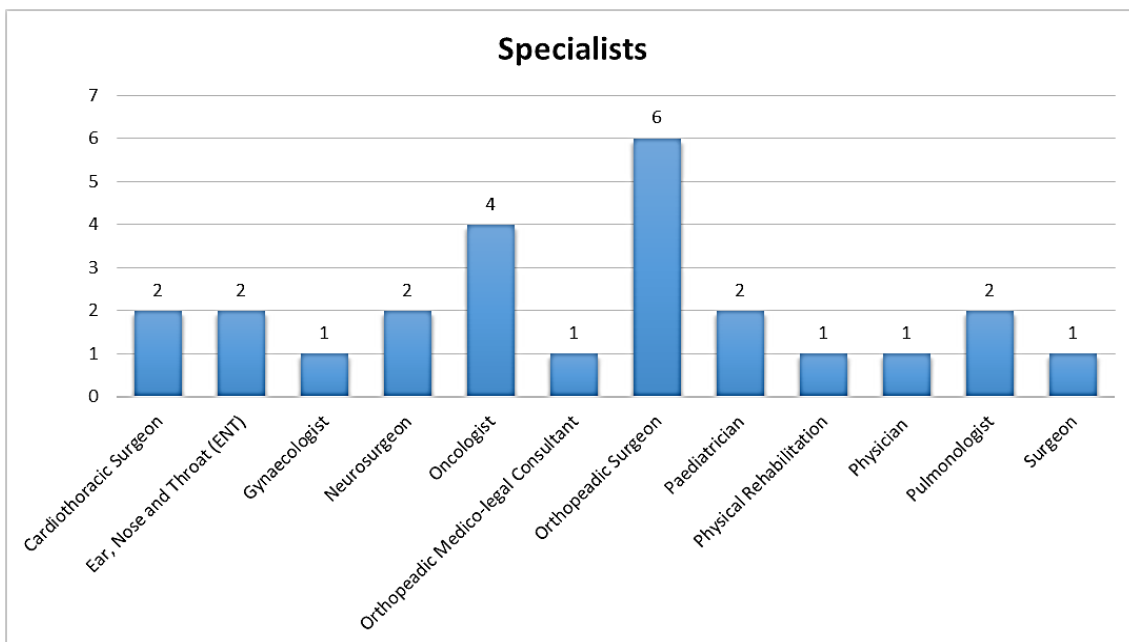
Figure 4.5: Specialities

4.3.2 Years of Experience

The questionnaire participants have a relatively high level of experience, with thirty-one (more than 70%) of the respondents having practised medicine for more than 20 years. In comparison, their years of experience with PACS was low. It is clear that PACS is a relatively new technology for most of the respondents. Exactly 50% of the respondents have had less than 5 years of experience with private sector PACS systems.
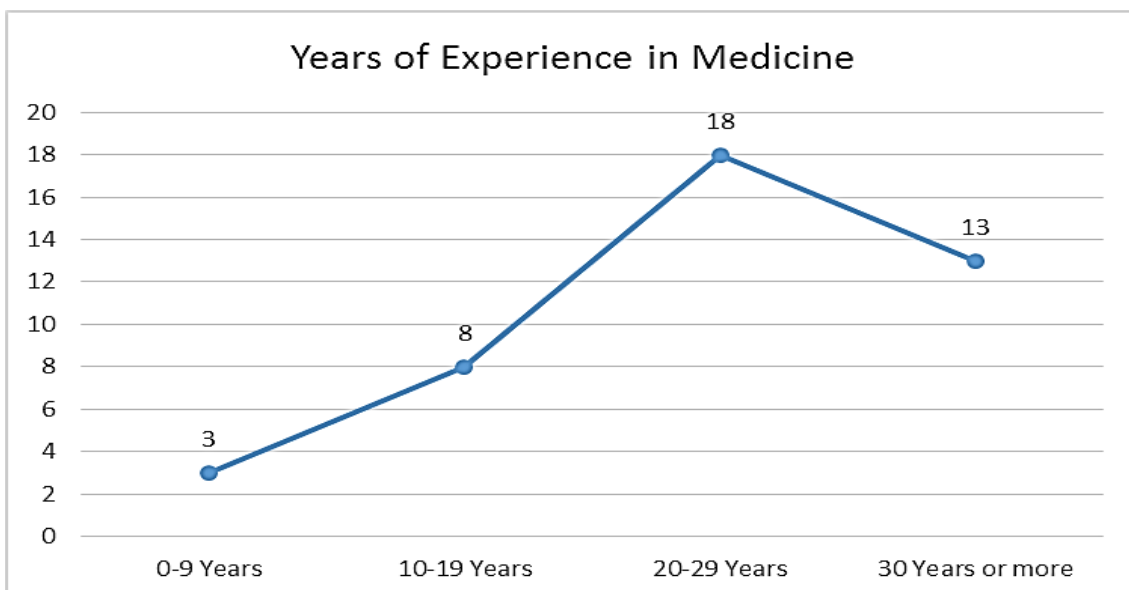
Figure 4.6: Years of experience in medicine
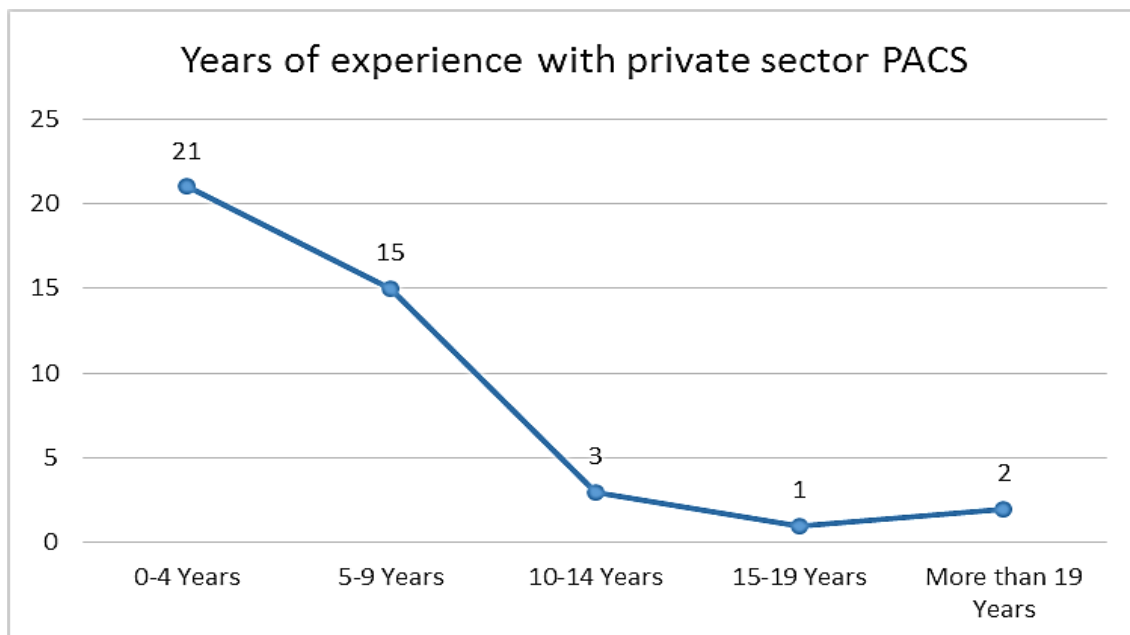
Figure 4.7: Years of experience with private sector PACS

4.3.3 Computer Literacy

The respondents reported a relatively high level of computer literacy. No respondents reported that they were not computer literate; while thirty-seven (81%) claimed to be between an intermediate level and an advanced level.
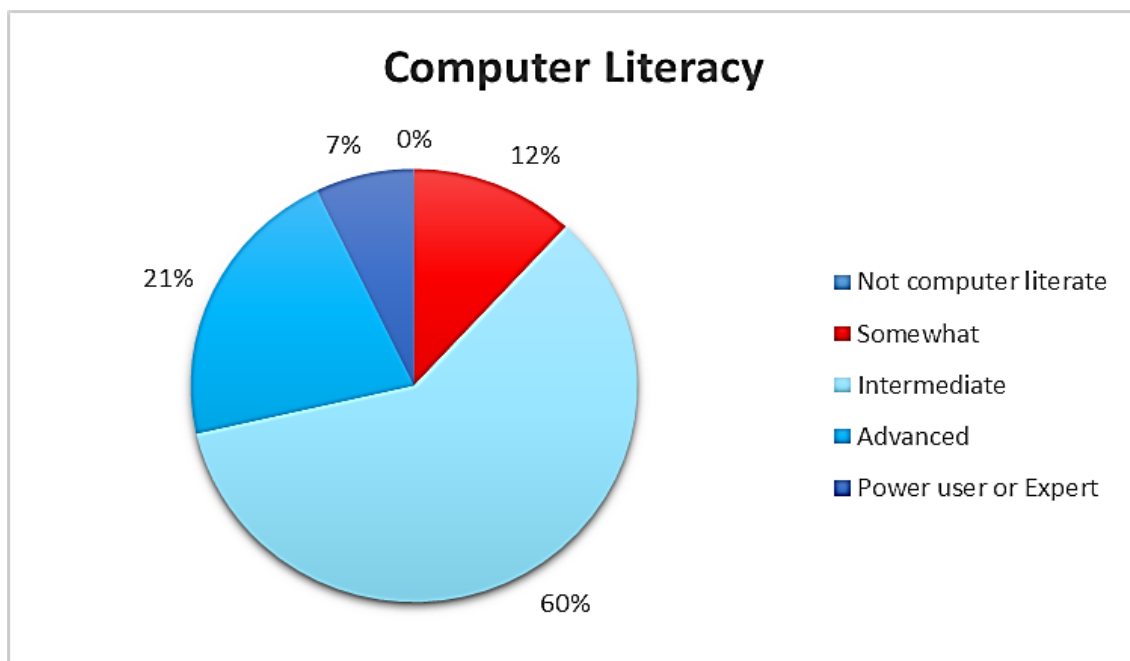
Figure 4.8: Computer Literacy

4.4 SECTION 3 – TRAINING

This group of questions aimed to ascertain the importance of training in PACS acceptance and its meaningful use.

4.4.1 Necessity of Training

The participants were asked to rate the necessity of PACS training on a 1 to 5 Likert scale, where "1" rates as "Strongly Disagree" and "5" as "Strongly Agree". As can be observed in the graph below, seventeen (40.5%) of the respondents agreed or strongly agreed that PACS training is necessary, representing the largest group; while ten (23.8%) disagreed or strongly disagreed. Fifteen (35.7%) of the respondents felt that they neither agreed nor disagreed, thereby representing a significant portion.

This could point to the quality and amount of training received as being inadequate, or that PACS is generally user-friendly and a minimal amount of training is required to use it.
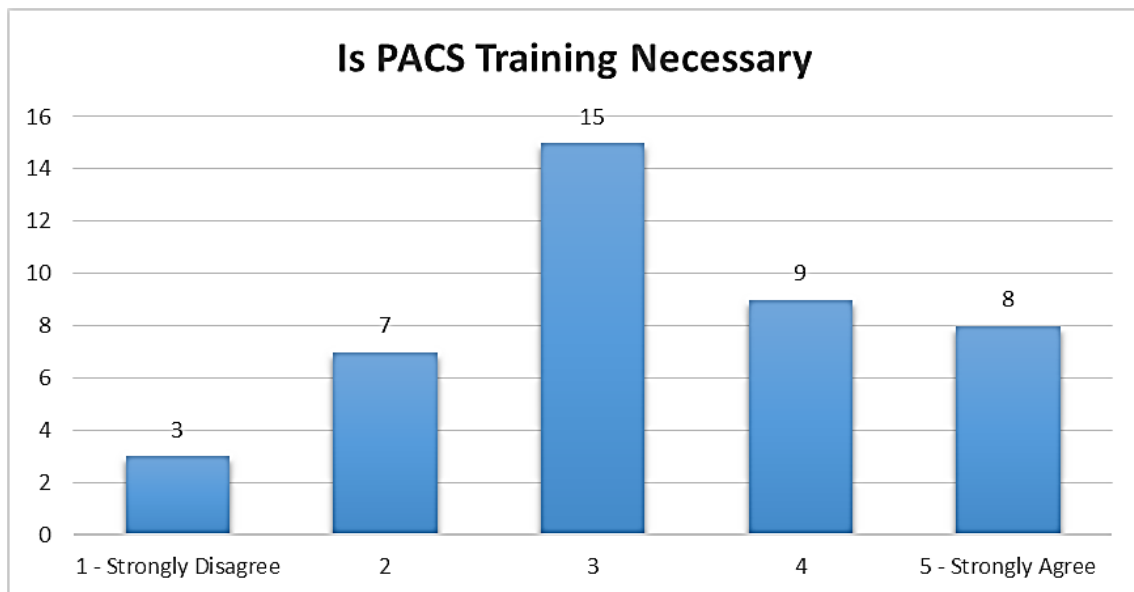
Figure 4.9: Is PACS training necessary?

4.4.2 Amount of Training

The respondents were asked to indicate how much PACS training they had received, and whether or not they felt that it was enough. More than half of the respondents (twenty-two) indicated that they had received less than one hour of training; while sixteen doctors had received no training at all. Overall, nineteen

out of the forty-two (45.2%) respondents felt that they had not received enough training.

Amount of Training	Was the Training enough?		Total
	No	Yes	
None	11	5	16
1 Hour or less	7	15	22
More than 1 Hour to 2 Hours	1	3	4
More than 2 Hours to 3 Hours	0	0	0
More than 3 Hours	0	0	0
Total	19	23	42

Table 4.1: Amount of training

The results indicate that there is no set amount of training time applicable to all the doctors and the exact amount of training would depend on individual needs.

4.4.3 Effect of Training on PACS usage

The following graph indicates whether or not the respondents felt that training has a positive effect on PACS usage.
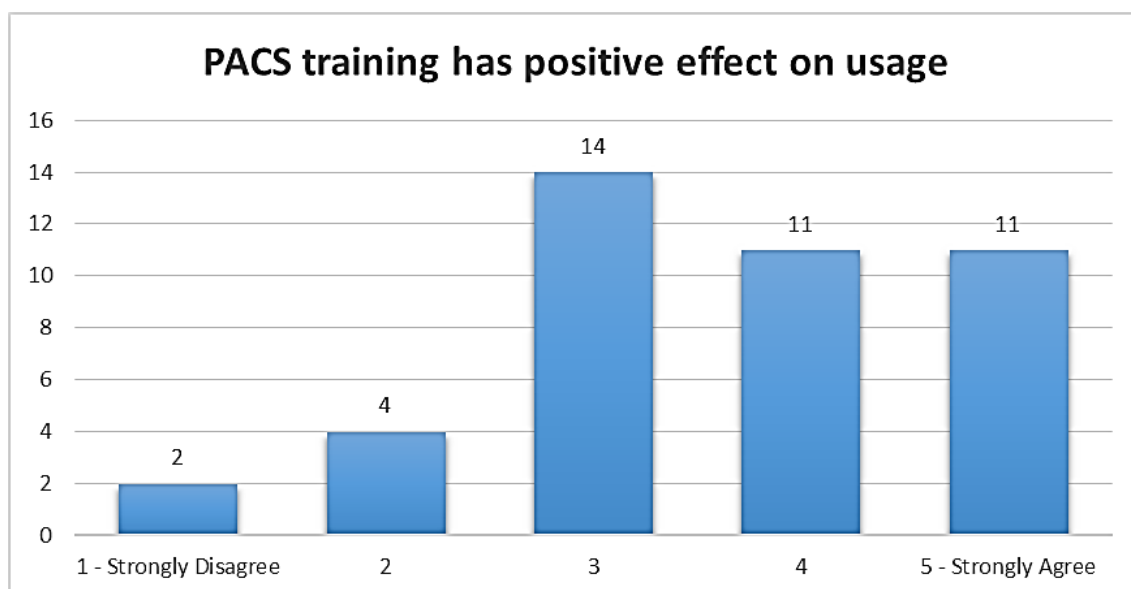
Figure 4.10: Effect of training on PACS usage

The results indicate that the majority (52.3%) feel that PACS training has a positive effect on usage. There is again a relatively high level of indifference in

terms of the positive effect of PACS training, with one third (33.3%) choosing option "3". However, there is enough evidence in the data to identify training as a relevant factor in the acceptance and meaningful use of PACS.

4.5 SECTION 4 – PACS IN GENERAL

In section 4, the questionnaire explores acceptance and it seeks to ascertain whether PACS has a positive effect on doctor workflow, as well as some usage patterns.

4.5.1 PACS access frequency

The respondents were asked to report on their frequency of accessing PACS. The results show that thirty-five (84%) access the system at least twice a day.
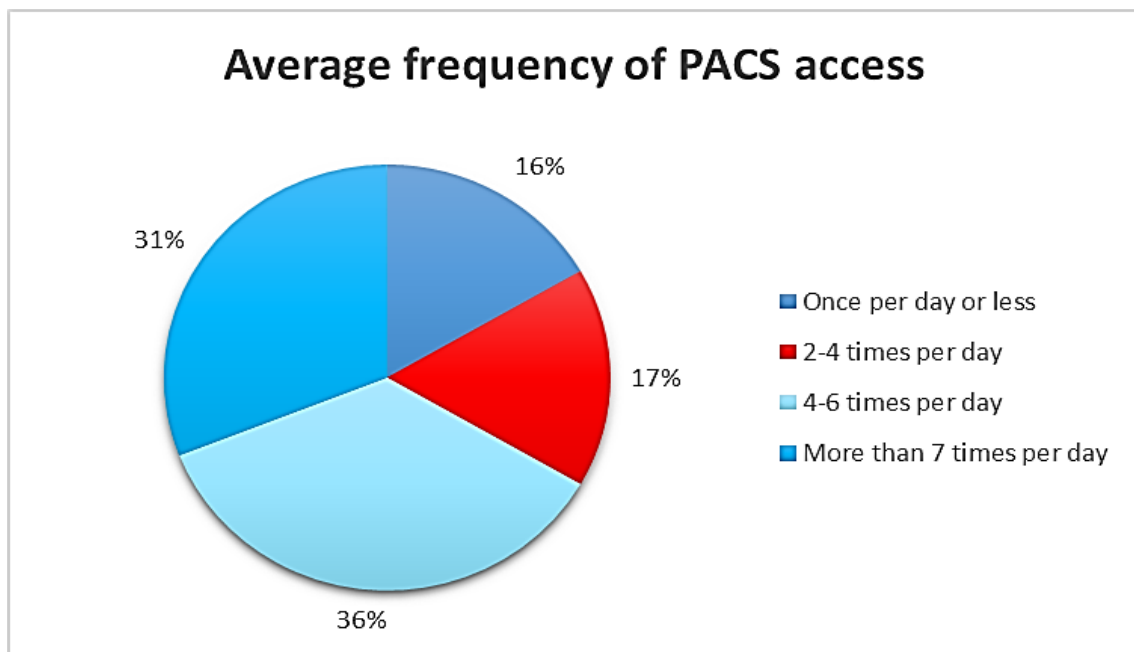
Figure 4.11: Average frequency of PACS usage

This high level of frequency points to a large dependency on the availability of radiology images and reports.

4.5.2 PACS usefulness

The participants were asked if they agreed with the statement: "PACS is a useful advancement for your Practice".
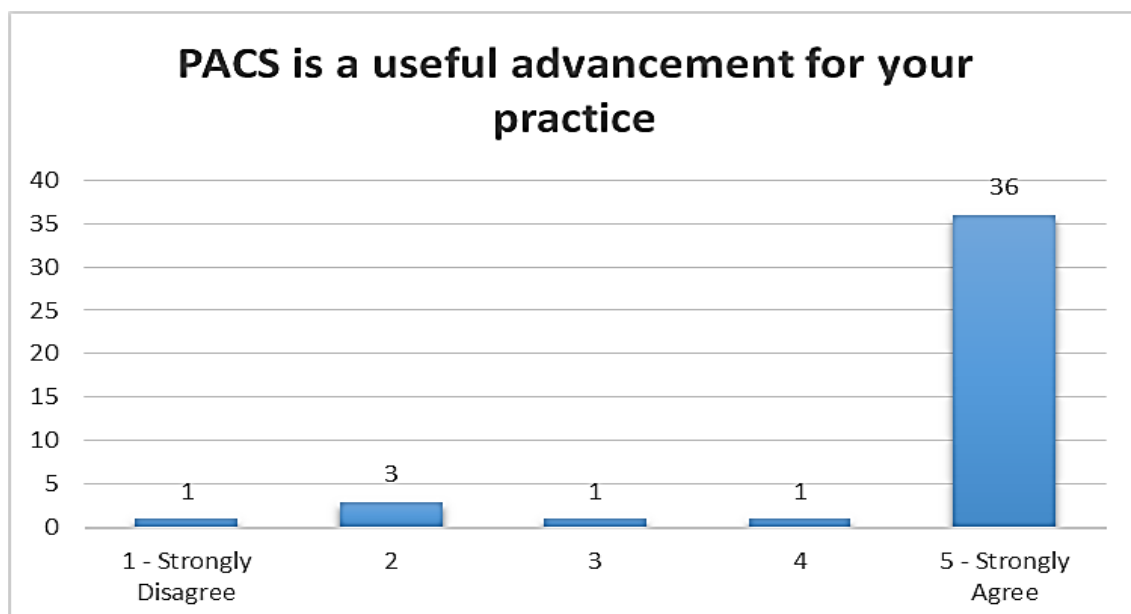
Figure 4.12: PACS is a useful advancement for your practice

The results indicated that most of the respondents (85.7%) strongly agreed with the statement, and it may thus be argued that PACS acceptance in this sample is very high. This high acceptance rate is very much in accordance with the results obtained by Pilling (2003) and Top (2012).

The respondents were also given the opportunity to elaborate on their selection in a free-text field and their comments further supported the results depicted in Figure 4.12. The general consensus is that PACS has introduced many benefits to improve the efficiency and accessibility of radiological information. The following quotes support this position:

***

"Very helpful, need not rely on pt (patient) bringing scans, get report and can see the plates within an hour of the test, can see pts on the day of the test, saving them visits, speeding up decision-making."

***

"Easy access to any radiology plus reports without having to rely on hard copies, no storage worries, easy referral of x-rays for second opinion etc."

***

49

"Has transformed practice I access from iPad and other remote making decisions on the fly with other specialists, radiologists and gp's"

***

4.5.3   PACS expectations

The participants were asked whether they agreed with the statement: "PACS has met your expectations".
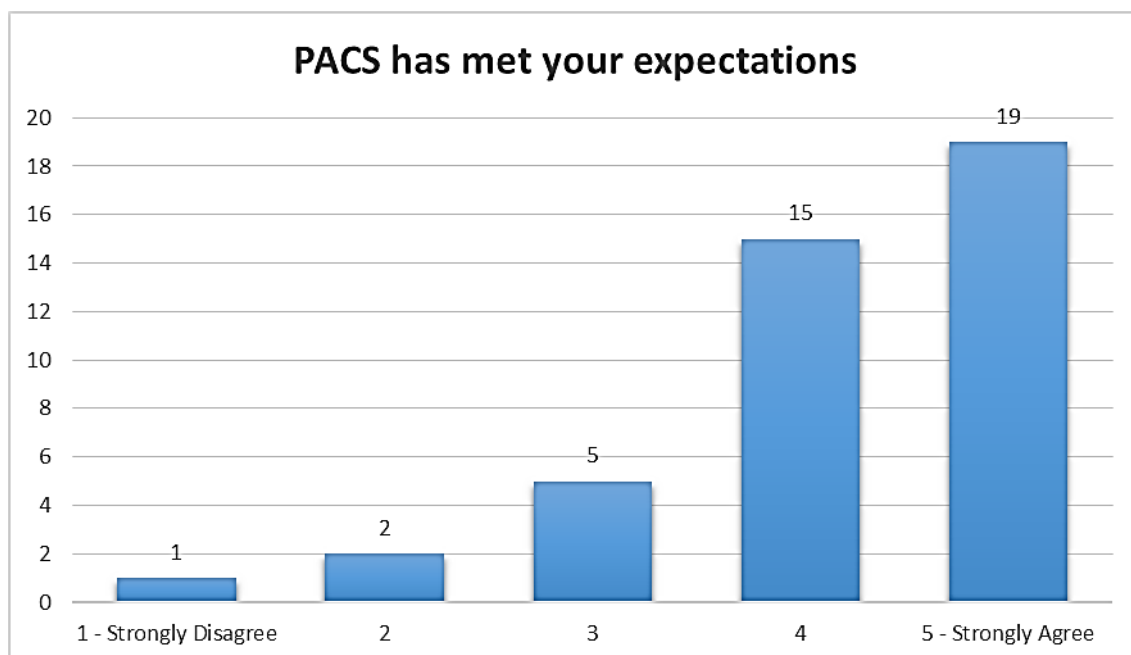
Figure 4.13: PACS has met your expectations

As can be observed in the results, only three (7.1%) respondents felt that PACS did not meet their expectations, following the conversion from a film-based workflow. The doctors were asked to elaborate, based on their selection in the next question. Some of the barriers include restrictive access policies limiting patient access for general practitioners to their own referrals by default. The effects of load-shedding negatively affect PACS users, especially where emergency power is not available.

Load-shedding was introduced by Eskom, South Africa's primary energy producer, to prevent a total electrical grid black-out; and it involves shutting down electricity systematically for a few hours at a time – to ensure that demand does not exceed supply. If a referring doctor's area experiences load shedding, PACS would not be accessible, which might impact patient care.

50

Local network and Internet stability also play major roles. The importance of mobile PACS viewers is also noted.

One respondent also submitted that orthopaedic template software is lacking. However, the overwhelming majority (80.9%) agreed that PACS did, in fact, meet their expectations, adding to the body of evidence that the level of PACS acceptance is generally high.

<p align="center">***</p>

<p align="center">*"cannot imagine working without it. safes me a great amount of time"*</p>

<p align="center">***</p>

<p align="center">*"It's an out of office extention to my practise"*</p>

<p align="center">***</p>

<p align="center">*"Reasons as above. Frustrations include inability for GP to excess request by specialists, other GP's.Dependancy on fallible technology e.g. loadshedding"*</p>

<p align="center">***</p>

<p align="center">*"made no difference. sometimes a hassle when network is down."*</p>

<p align="center">***</p>

<p align="center">*"Mobile addition is an absolute necessity"*</p>

<p align="center">***</p>

<p align="center">*"only problems are eskom failure and that our hospital system does not have a templating system for orthopaedic implants"*</p>

<p align="center">***</p>

<p align="center">*"Often delayed reports"*</p>

<p align="center">***</p>

A participating doctor also submitted that delayed reports on the system lead to frustration. The cause of delayed reports could also be due to a busy radiology department and is not necessarily PACS related.

4.5.4 PACS improvement of professional life

The participants were asked if they agreed with the statement: "PACS has improved your professional life". When analysing the results, it is significant that not a single respondent "Strongly Disagreed" with the statement. This again underlines the high level of PACS acceptance in the given sample.
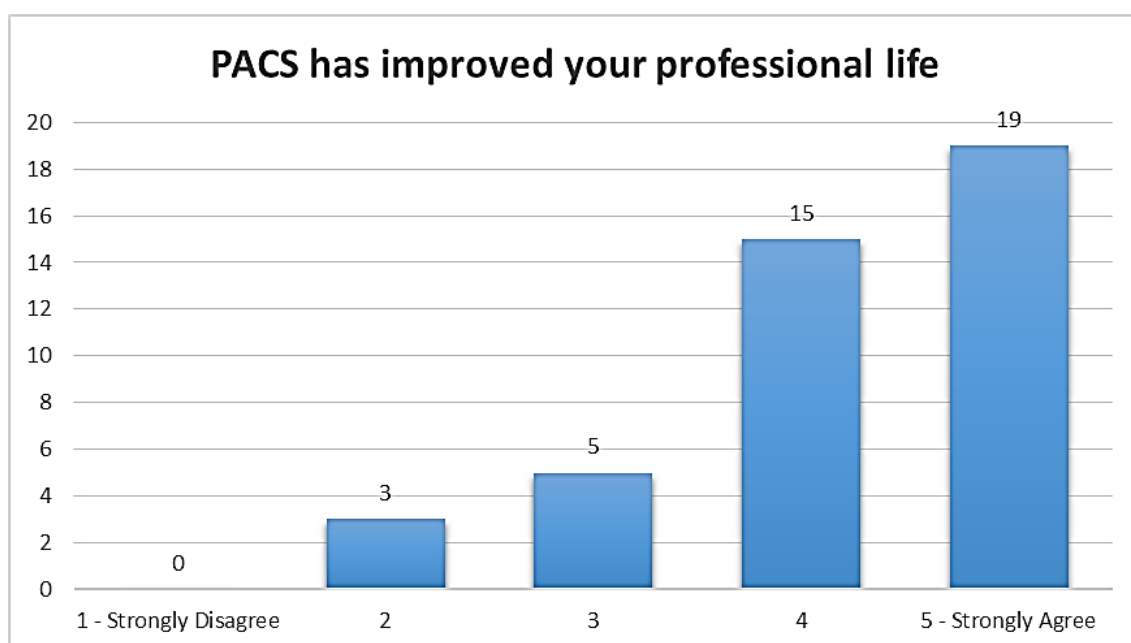
Figure 4.14: PACS has improved your professional life

The respondents elaborated on their selections in a free-text field and the following quotes stood out:

***

"1. Save time 2. Avoid redundant test 3. Progress of the disease 4. Education (patient, health professionals) 5. Communication with other health professionals"

***

"continuity of care, patient information available"

***

"ONLY BENEFIT IS THE REDUCTION IN WAITING TIME FOR PATIENTS AND STORAGE/ARCHIVING OF PRINTED IMAGES NO LONGER AN ISSUE"

***

"Influences treatment decisions - best decisions can be made"

***

"Has trimmed hours off my week. Radically improved efficiency and patient management"

***

"Works fine when you use the web but is horrible when a patient come with a CD as this takes a long time to open, often have an unknown PACS program and the worst is when it eventually opens the images are of such bad quality that it is useless"

***

"Could be easier"

***

Many of the known benefits were repeated, such as improved accessibility, efficiency, time-management, continuity of care, and clinical decision-making. A few important factors or barriers were identified as well. The fact that CDs are still widely used causes frustration to some doctors because of reported variable image quality, slow loading speed, as well as the large variety of different viewing software included on the disc. One respondent noted that PACS could be easier to use; therefore, user-friendliness could be an important factor in acceptance and meaningful use.

The system also improves communication with other healthcare professionals; therefore, a PACS systems with more advanced communication features, such as instant-messaging could further assist in physicians' acceptance of PACS.

4.6   SECTION 5 – PACS IN CONSULTATIONS

Referring doctors were asked a number of questions to assess whether PACS had a positive impact during patient consultations in their consulting rooms. The results are summarized in the table below (Table 4.2).

Questions	Response Numbers (%)				
PACS has a positive impact on your consultations…	1	2	3	4	5
1. Showing patients their radiology images	1 (2.4%)	4 (9.5%)	8 (19.0%)	11 (26.2%)	18 (42.9%)
2. Time spent finding patient radiology images	2 (4.8%)	3 (7.1%)	4 (9.5%)	10 (23.8%)	23 (54.8%)
3. Time spent finding patient radiology reports	2 (4.8%)	2 (4.8%)	4 (9.5%)	13 (31.0%)	21 (50.0%)
4. Overall efficiency of consultations	1 (2.4%)	2 (4.8%)	5 (11.9%)	13 (31.0%)	21 (50.0%)

Table 4.2: PACS in consultations

The results show that the introduction of PACS has had a very positive effect on patient-doctor interaction during consultations – by improving on how doctors present and discuss imaging with patients. It has also vastly decreased the time required to access radiology images and reports, ultimately resulting in increased overall efficiency.

4.7   SECTION 6 – PACS IN WARD ROUNDS

The participants were asked three questions to assess whether PACS has had a positive impact on physicians' ward rounds. The first question requested participants to indicate their level of agreement with the following statement: "PACS has a positive impact on the way ward rounds are conducted".
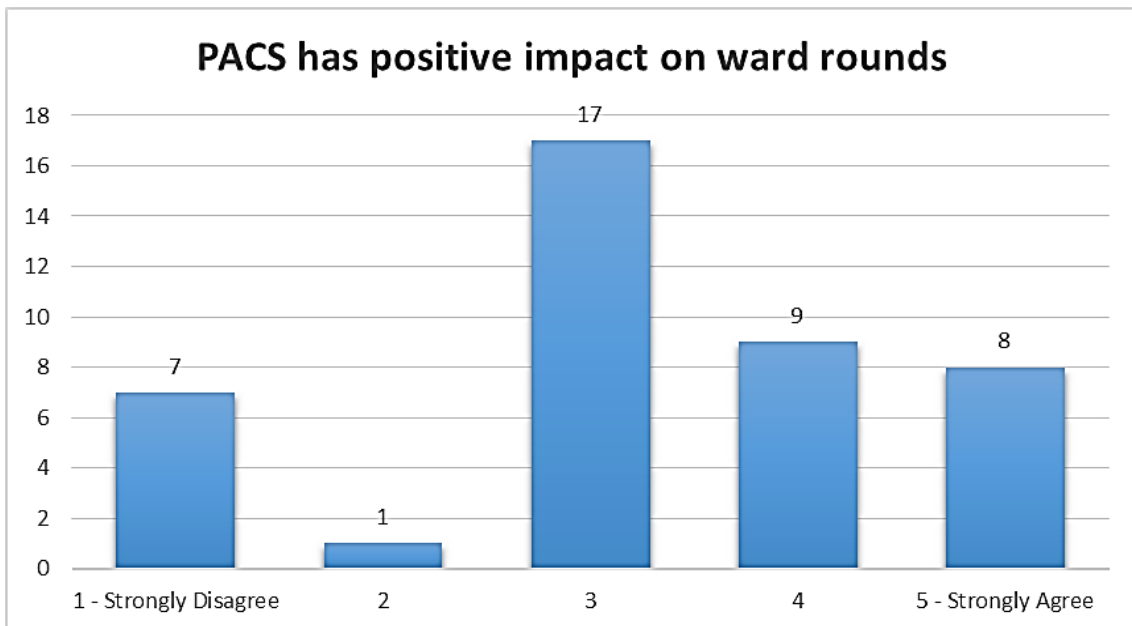
Figure 4.15: PACS impact on ward rounds

From the results, it is apparent that physicians are less optimistic about PACS in terms of ward rounds. A total of seventeen (33.3%) doctors selected a "3" on the Likert scale, indicating that they neither agreed nor disagreed with the statement. This number corresponds with seventeen doctors indicating in the free-text feedback that they do not conduct ward rounds. The same amount of doctors (33%) leant towards the positive side of the scale, agreeing that PACS has had a positive effect on their ward rounds.

Seven (16.6%) doctors selected a "1", indicating that they strongly disagreed with the statement. The results show that while PACS in wards are generally good, there is some room for improvement in that environment.

The respondents were asked to elaborate on their selection in the preceding question in a free-text field and their feedback is discussed below.

***

"can give immediate feedback to patient"

***

"Prompt access to images during ward rounds make it much easier to make clinical decisions"

***

"difficult to see patient in bed with PACS as mostly wall mounted which causes it to be disjointed. I have actually built a mobile TV screen with laptop for my grand rounds"

***

"xrays not at pt bedside view after/before seeing pt - disjointed ward round"

***

"Hospital pacs systems frequently lacking, compared to base stations. Could have dedicated wireless station in ward for rounds obviating individual pad requirements or printed images as certain doctors still prefer"

***

"I don't use PACS on ward rounds. Only in my offices"

***

"Cannot show the images to a patient that is in bed"

***

Some of the doctors enjoy the fact that PACS can give access to images and reports immediately in the wards. Only one PACS computer and monitor is installed in hospital wards normally, which may lead to frustration having to visit the PACS workstation between each patient consultation. Before PACS was introduced, radiology would routinely deliver X-ray film and reports to the ward staff, which would then conveniently place the information in a folder at the patient's bedside. Doctors would then be able to access information, or show the imaging to their patients during their bed-side consultations.

One of the respondents constructed a mobile viewing station to overcome the limitations of a single stationary workstation. The limitations of PACS in a ward environment places more importance on the availability of a convenient mobile PACS platform using a mobile computer or a tablet solution.

Finally, doctors were asked to indicate whether they routinely view ward patient images before or during the round. This is to ascertain current physician workflow patterns with the view to train/suggest more efficient alternatives in the future.
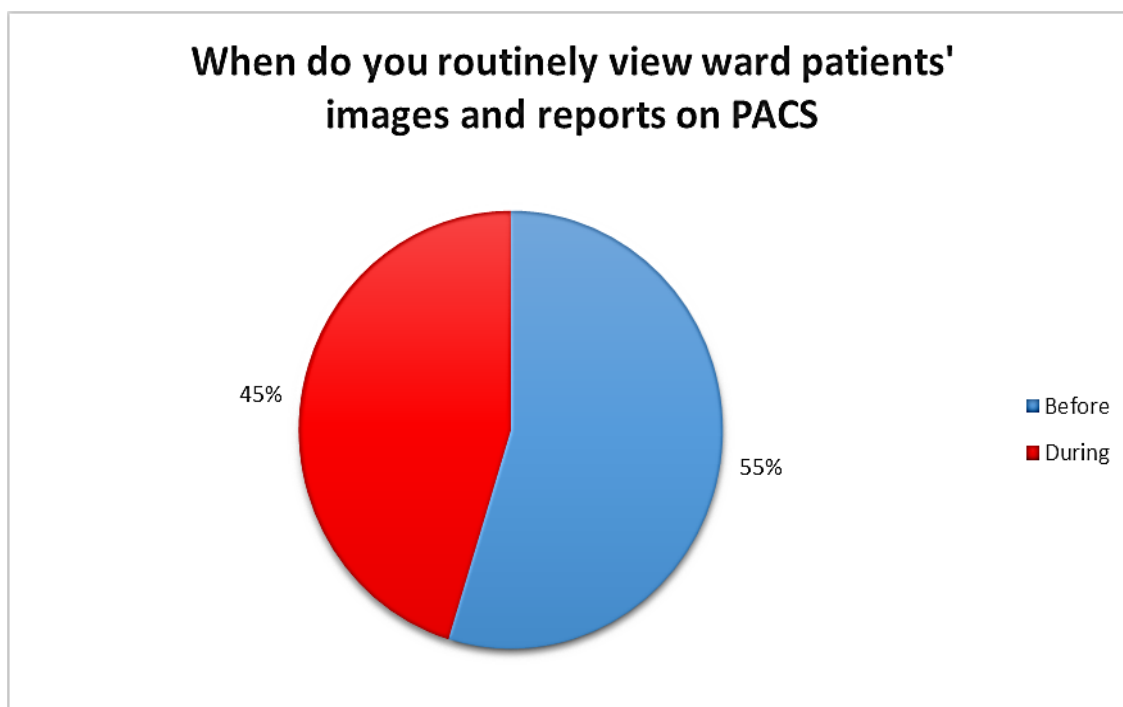
Figure 4.16: PACS viewing habits for ward patients

The results show a marginal difference in the options given, with 5% more doctors viewing images before their rounds.

4.8 SECTION 7 – PACS IN THEATRE

The doctors were asked if PACS had a positive impact on the planning and execution of theatre procedures. The results of the two Likert scale questions were combined in the graph below. A total of seven doctors indicated that the question was not applicable to them.

In terms of planning theatre procedures, eighteen out of thirty-five (51.4%) of the doctors agreed that PACS has a positive effect, while six doctors (17.1%) expressed a negative sentiment.

PACS approval rates during execution of procedures are at a slightly lower level at 48.5%, while negative sentiment has also decreased to 14.2%.

More than a third of the participants (37.1%) felt that PACS neither positively nor negatively affected the execution of theatre procedures. In terms of planning, eleven out of thirty-five (31.4%) results indicated an indifferent attitude.
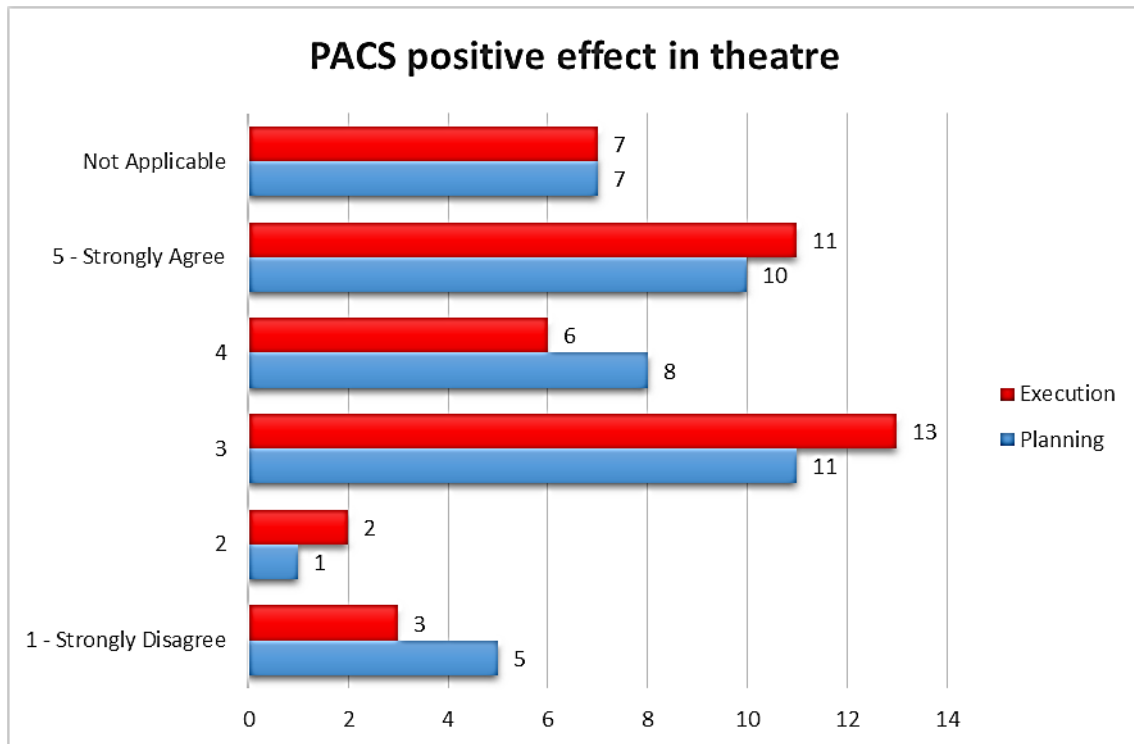
Figure 4.17: PACS effect in theatre

In summary, it can be argued that PACS has had an overall positive effect on the planning and execution of patient procedures in medical theatres.

4.9 SECTION 8 – PACS MEDIA AND ACCESS

The questions in Section 8 of the questionnaire focused on PACS network access, as well as aspects around the physical media, namely: film and compact discs (CDs).

4.9.1 PACS vs Film

The participants were asked to indicate their level of agreement with the statement: "PACS is more effective than using film" on a Likert scale.

Out of the forty-two respondents, thirty-five (83%) indicated that PACS is more effective. This includes twenty-four "Strongly Agree" responses, representing 57% of the overall opinions.
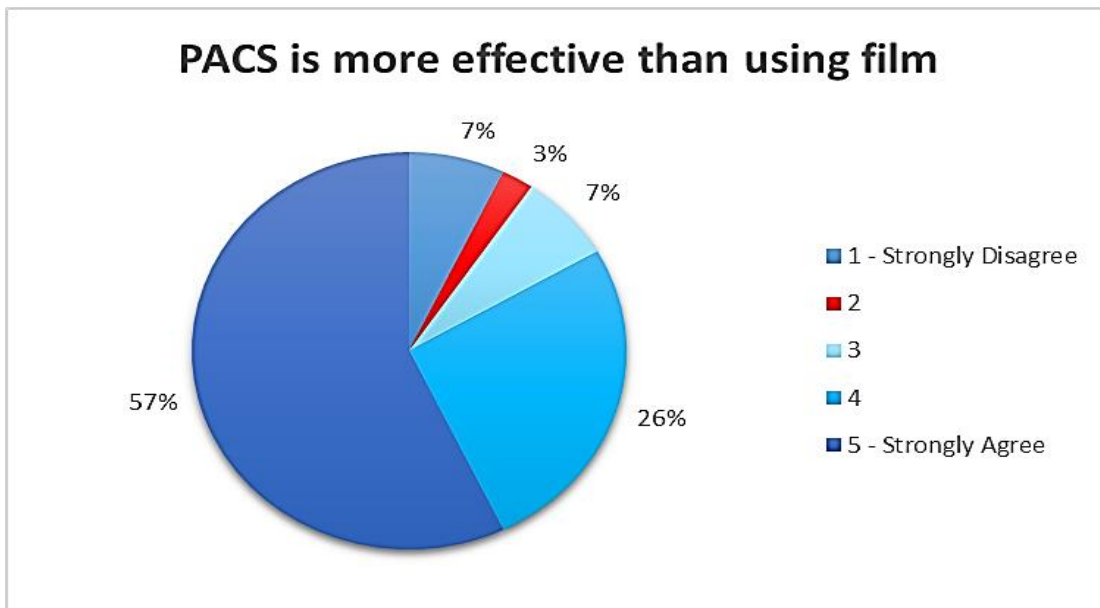
Figure 4.18: PACS is more effective than film

The results indicate an overwhelming positive response in favour of PACS and this is another important indicator in gauging PACS acceptance and meaningful use. When doctors are still heavily reliant on film post-PACS, it not only has major cost implications; but it could also indicate a failure in adapting to PACS, thereby threatening the project as a whole.

4.9.2 Physical media

Referring doctors' reliance on physical media was further probed by asking whether they still use film, CDs and paper hard copies, in addition to PACS.
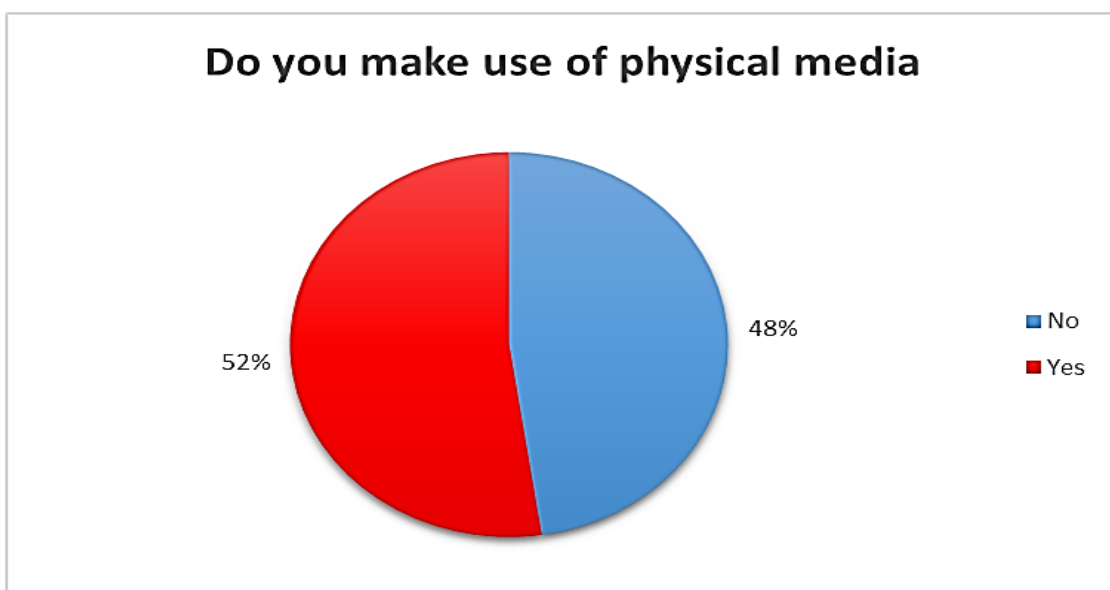
Figure 4.19: Physical media usage

The results highlight an interesting phenomenon, with just over half of the respondents indicating some form of physical media usage. While sentiment is greatly in favour of PACS, there is still a definite reliance on film, paper and CDs. The phenomenon was further explored in the next question, where the participants were asked to elaborate on their choice.

<div align="center">***</div>

<div align="center">*"When referring a pt out of town, although they can access PACS"*</div>

<div align="center">***</div>

<div align="center">*"for reports"*</div>

<div align="center">***</div>

<div align="center">*"if pacs is not available"*</div>

<div align="center">***</div>

<div align="center">*"MEASURE BETTER ON FILMS"*</div>

<div align="center">***</div>

CDs are often used, when the patient needs to visit a referring doctor who is not set-up to use PACS. Film does still have an important function in some scenarios, for example, medical prosthesis measurements and templating. The reliance on film can be reduced through specialized orthopaedic template software. This is usually an expensive third-party integration package and it does not form part of a typical PACS system toolset.

Some respondents have a preference for hard copy reports to be placed in patients' folders. Reports can be either faxed, emailed, or printed directly from the PACS. The physical media can fulfil an important back-up role, should PACS be unavailable for any reason. However, physical media can be lost; and these media are subject to logistics.

4.9.3 PACS usage out of office

The participants were asked to: "State the frequency of using PACS out of office (e.g. from home, or while travelling, but not including wards and theatres)". The following scale was used to measure the responses:

- Never

- Seldom: Once per month or less

- Sometimes: Two to three times per month

- Often: Four to eight times per month

- Very Often: More than 8 times per month
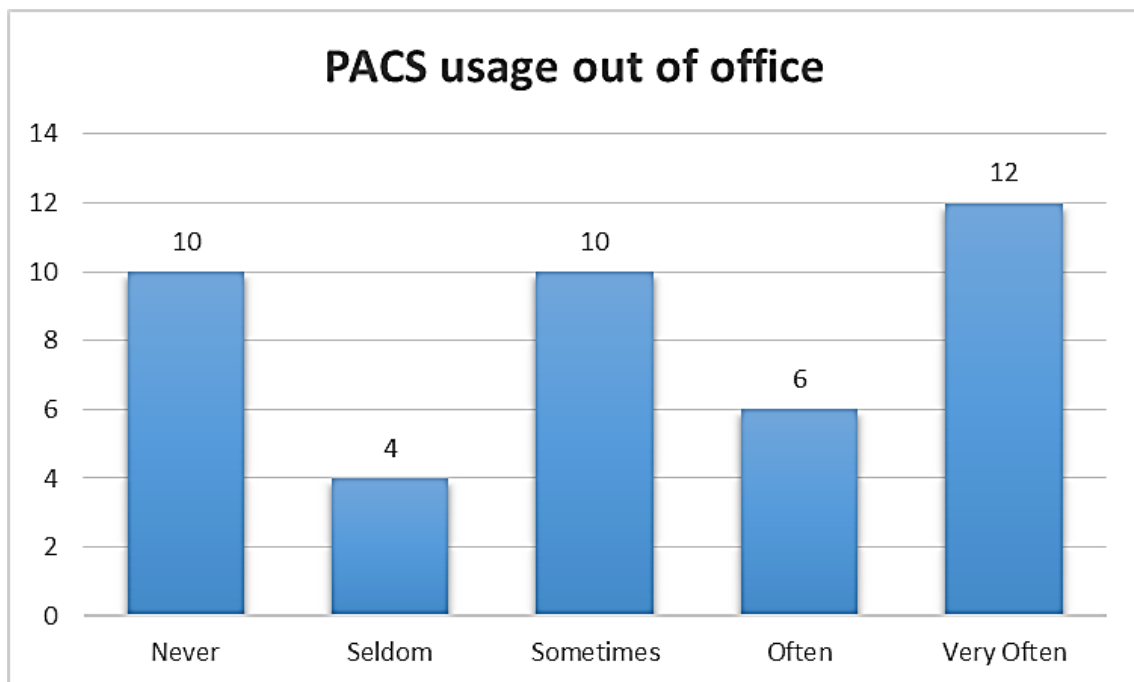
Figure 4.20: PACS usage out of office

The necessity for a stable and secure Internet published PACS service, in addition to local area connectivity (LAN) in hospital, is illustrated in the results above. At least eighteen out of the forty-two (42.8%) respondents access PACS four or more times per month.

4.9.4 PACS network connectivity

The following question aims to get a better understanding of the network connection types used by referring doctors. The results may differ in other settings, depending on whether the referring doctor base is mainly located inside or out of hospital, and whether a PACS local area network (LAN) is

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provided for in-hospital. The options given were: fixed line internet (ADSL), local area connection (e.g. hospital LAN), mobile broadband internet, wireless internet service provider, others and not sure.
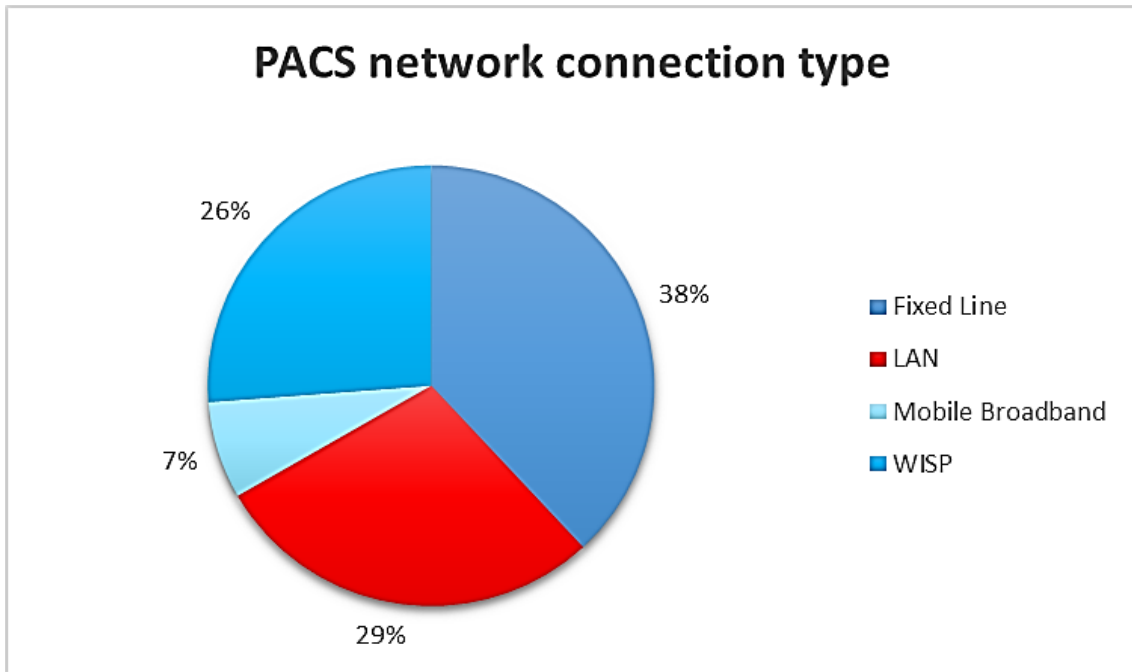
Figure 4.21: PACS network connection type

In this sample, a high percentage of respondents totalling 71% use internet services to access PACS. This again necessitates the availability of a high performance, stable internet published PACS to facilitate acceptance and meaningful use. Where local area connections are available to access PACS in hospital, sufficient resources should be allocated, in order to ensure continued and stable operations.

4.9.5 Radiology reports on PACS

The final question in this section requested the participants to indicate the importance of having radiological reports on PACS by using a five-point Likert scale, with a selection of "1" being "Not important" and a "5" indicating "Very important".
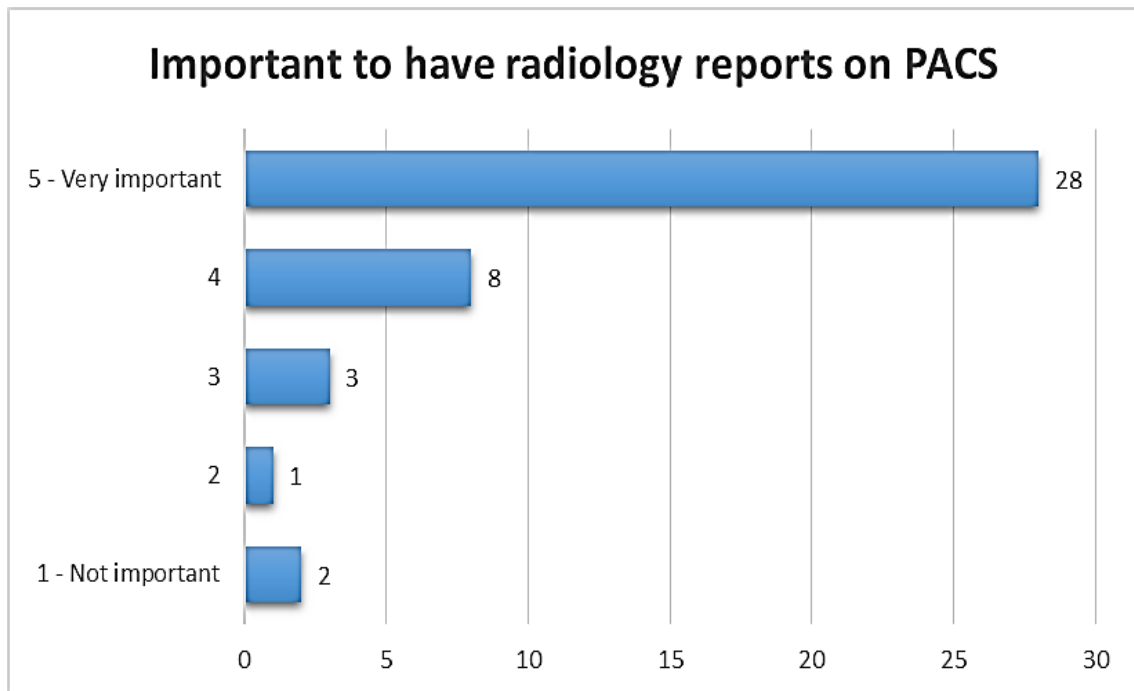
Figure 4.22: Radiology reports on PACS

The results show that having reports available on PACS is important, or very important, to the vast majority of participants, with thirty-six respondents (85.7%) indicating as such.

4.10 SECTION 9 – PACS APPLICATION TOOLS

Section 9 of the questionnaire focuses on the tools that PACS users have at their disposal to manipulate imaging, and to assist in diagnosis and treatment plans. Examples of such tools include: basic image zoom, window/levelling (brightness/contrast) and region of interest measurements as well as more advanced tools, such as multi-planar reconstructions (MPR) and Maximum Intensity Projection (MIP).

It is also important to investigate the usage patterns to establish their importance in referring doctors' training and workflow.

In the first question, the referring doctors were asked whether, in their opinion, knowledge and proficiency with these tools is important. A strong majority (78.6%) of the responding doctors felt that the tools were important to them.
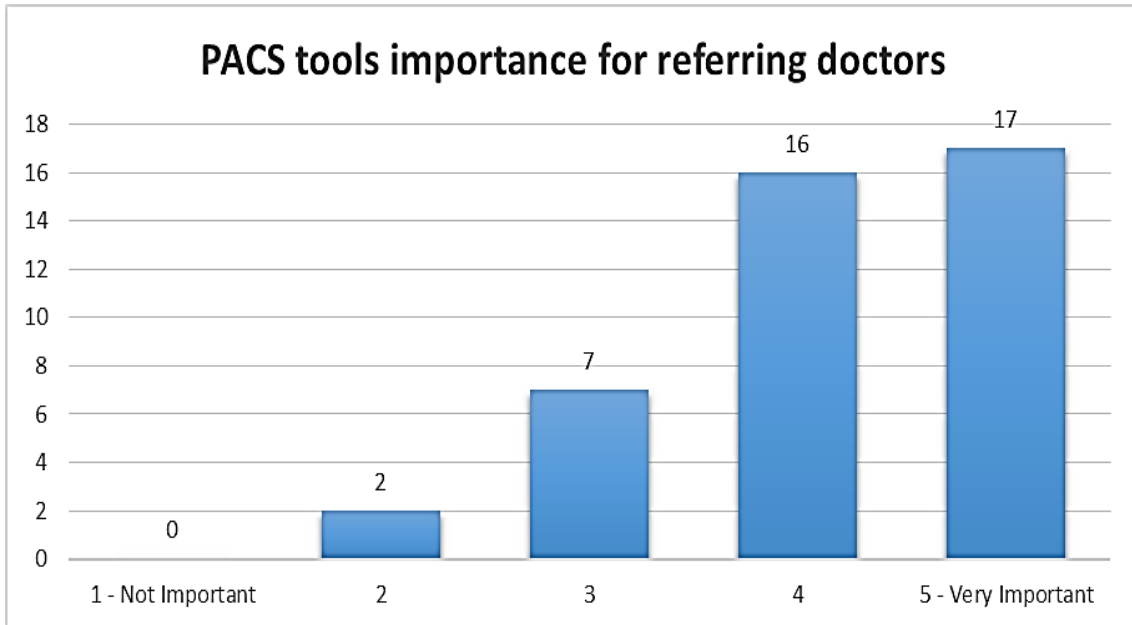
Figure 4.23: Importance of PACS tools

The frequency of use is generally high, as illustrated in the graph below.
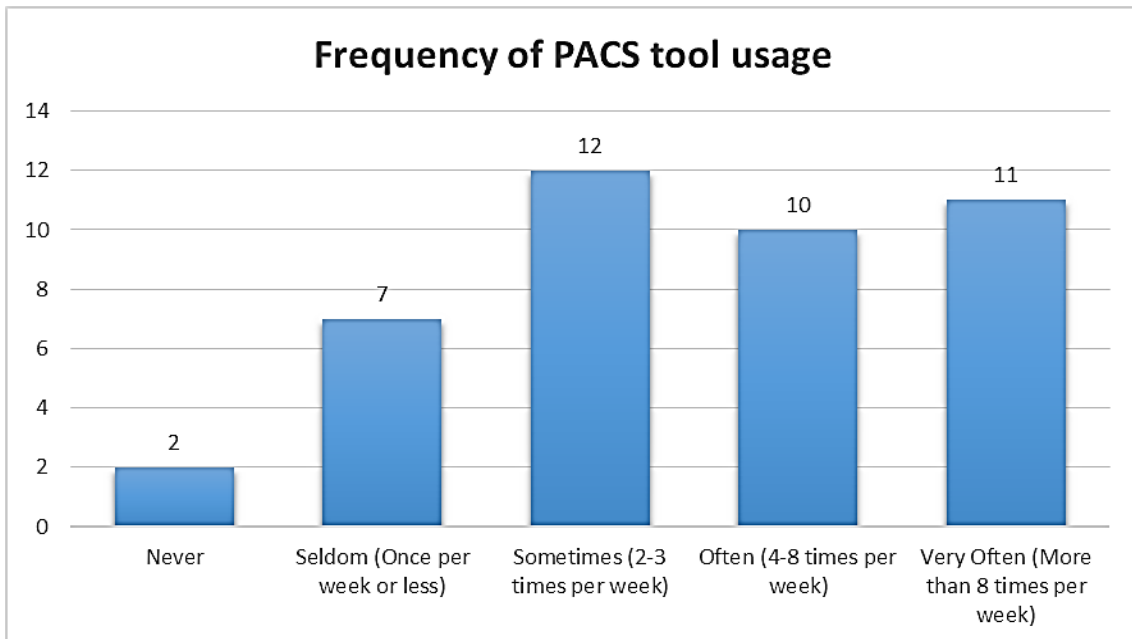
Figure 4.24: Frequency of PACS tool usage

Finally, the doctors were asked to report on their main usage of the tools by selecting all the options applicable to them. The available options were: Plan procedures, verify clinical findings, and to highlight pathology; and if it was of no diagnostic use to them. Only two (4.8%) reported no diagnostic use while twenty-nine (69%) used it to verify the clinical findings. A third (33.3%) of the

doctors in this sample used it to plan procedures and twenty-four (57.1%) used the tools to highlight pathology.
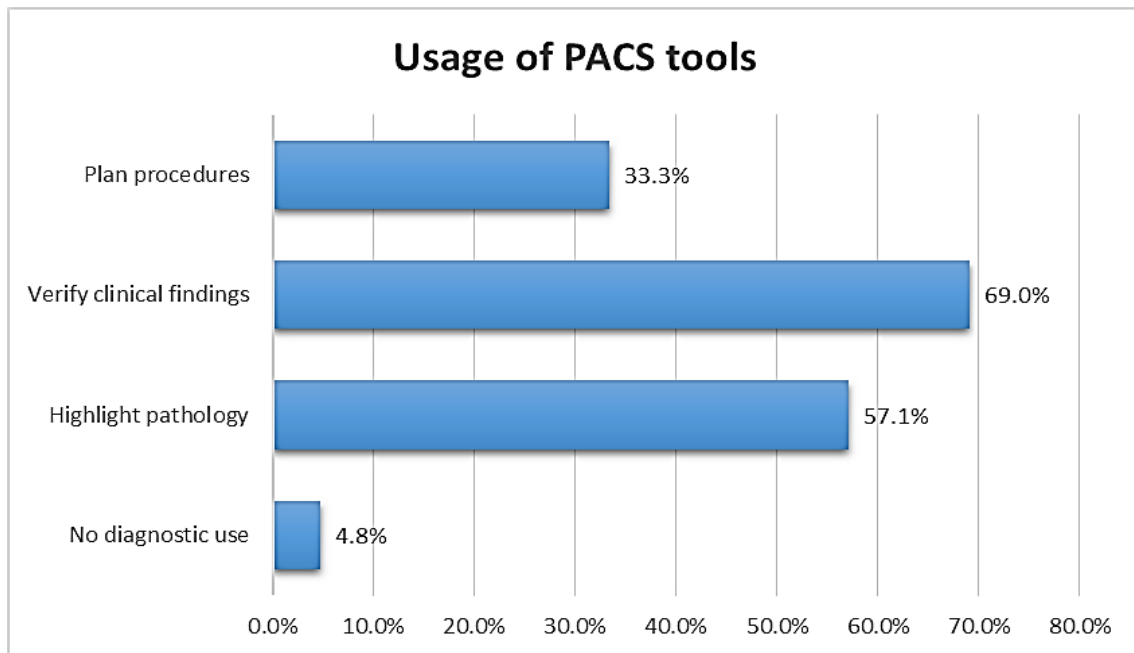
Figure 4.25: Usage of PACS tools

The results highlight the importance of these tools in the workflow of referring doctors.

4.11 SECTION 10 – ELECTRONIC MEDICAL RECORDS

In Section 10 of the questionnaire, the doctors' usage of electronic medical records (EMR) is explored and how it relates to PACS usage.

Firstly, the respondents were asked to indicate whether or not they make use of EMRs to manage the clinical history of their patients in their respective practices. The results indicated that twenty-three out of forty-one* (57%) doctors did not use EMRs. Of the 43% that have implemented some kind of electronic patient record keeping, ProfDoc/Mosaic was reported to be the most widely used system. Two doctors reported developing their own system. One doctor reported using Microsoft Word to manage patient records, which does not qualify as a true EMR system, and is consequently excluded from the results.

Thus, the results are calculated out of forty-one responses, as indicated by the asterisk (*).
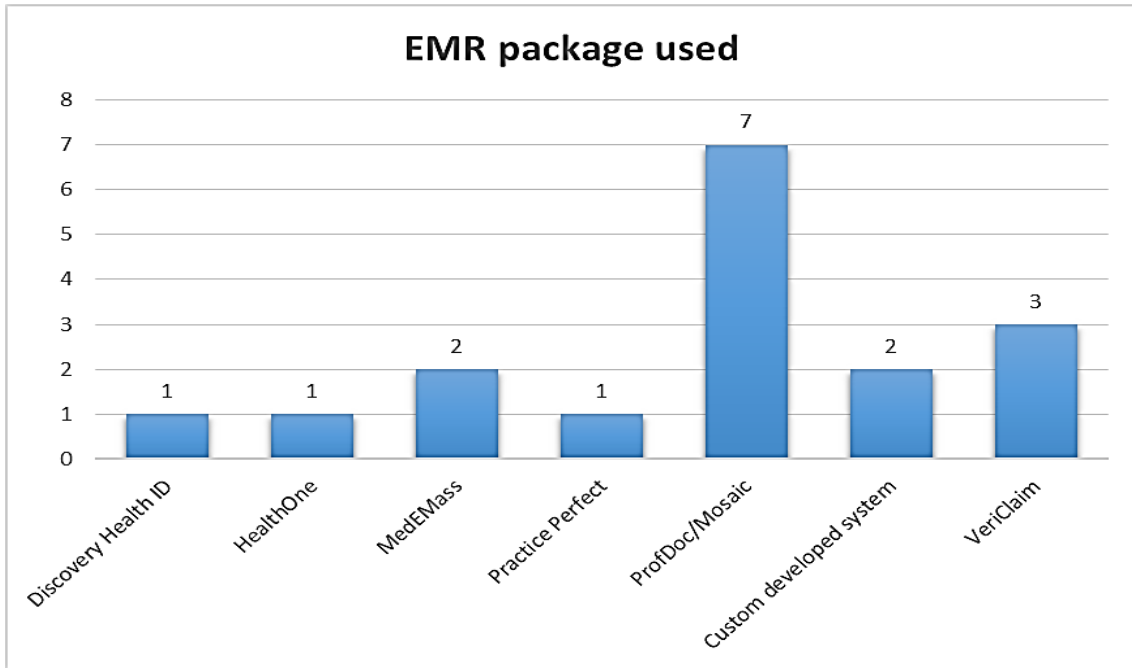
Figure 4.26: EMR package used

The participants were then asked whether or not they routinely import the radiology images (or a subset of key images) and reports into their EMRs to provide a holistic view of the patients' entire clinical history. The researcher would like to point out that there is no automatic import/export interface between PACS and the EMRs in this radiology practice. Referring doctors would have to manually import the image and/or report into their respective EMRs.
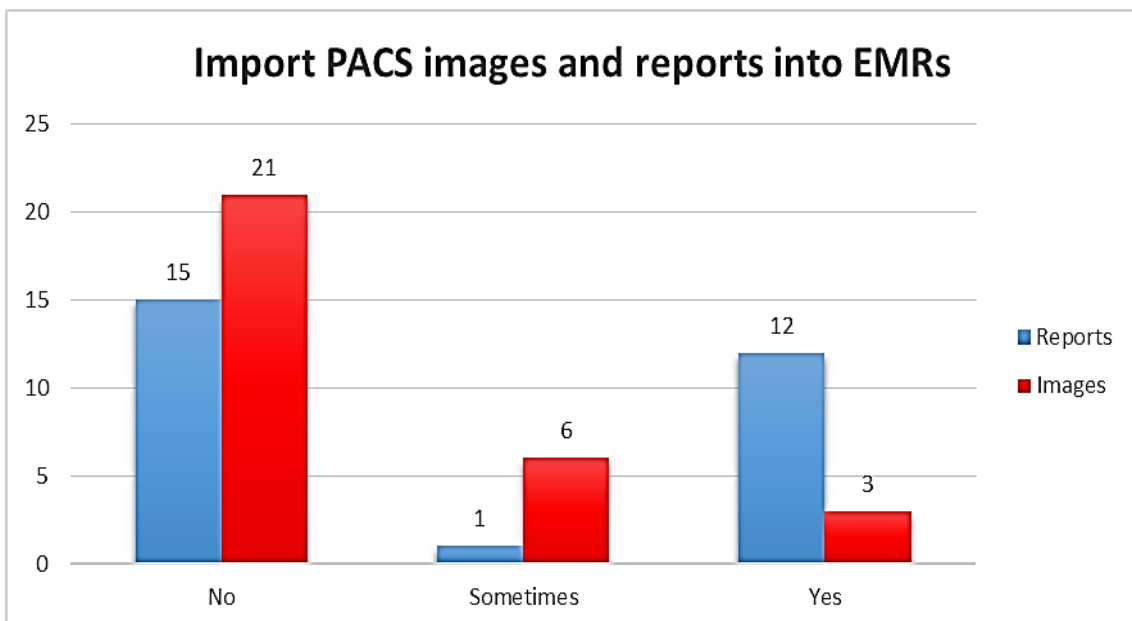
Figure 4.27: Import PACS images and reports into EMRs

Twelve out of forty-one (29.2%) of the participants routinely import radiology reports; while only three (7.3%) include images. This figure could increase if a user-friendly and convenient interface between the systems existed. As the physicians' EMR uptake increases, the necessity of such an interface may become a higher priority for all the stakeholders involved.

4.12 SECTION 11 – MOBILE PACS VIEWERS

The referring doctors' opinions on the importance of mobile PACS viewers were assessed in Section 11. The radiology practice that provided the referring doctors' data developed a custom web-based mobile PACS viewer for tablets and smartphones. It was aimed mainly at Apple iPad devices but it is compatible with other devices, as well. The PACS system (General Electric PACS IW 3.7.3) implemented in 2010, does not have a mobile-device viewer included. The system aimed to provide a means of mobile access to non-diagnostic images and reports to assist in workflow challenges, such as showing ward patients their images in a PACS environment. Mobile viewers could potentially overcome certain PACS workflow challenges, specifically in wards. Therefore, its role in PACS acceptance and meaningful use warrants further investigation.

The first question asked whether mobile viewers are seen as an important feature of PACS.
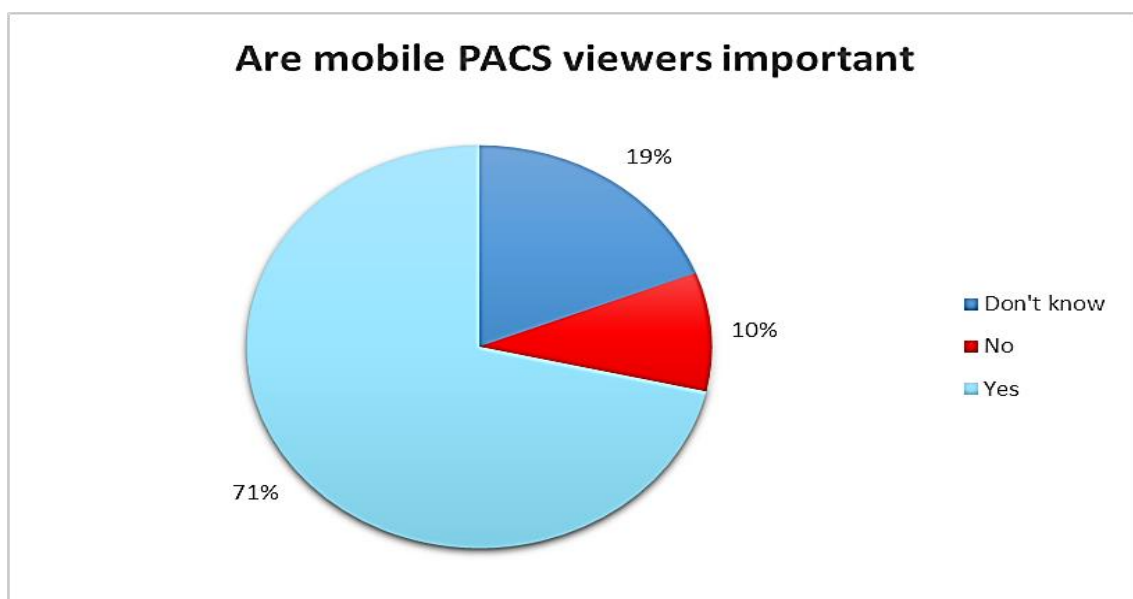
Figure 4.28: PACS mobile viewer importance

While thirty (71%) of the referring doctors agreed that mobile PACS viewers are important (refer to Figure 4.27), seventeen (40%) reported never having used it (refer to Figure 4.28).
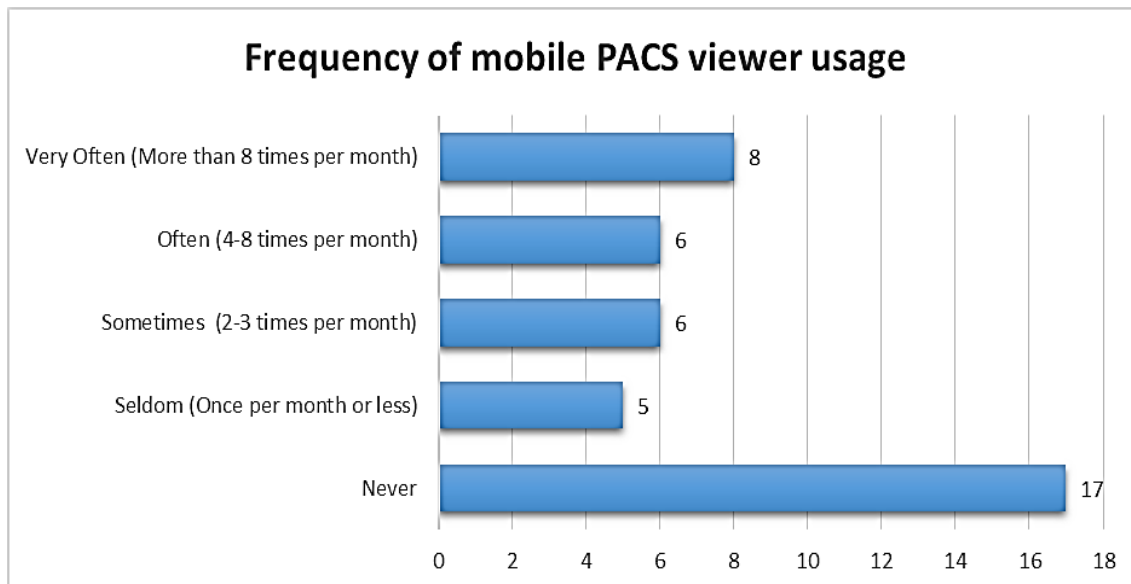
Figure 4.29: Frequency of mobile PACS viewer usage

This contradicting phenomenon could be caused by the limited marketing of the mobile PACS viewer in this radiology practice. The system was intended as a temporary solution – until a commercial system could be implemented and it was therefore not designed to accommodate a large user base. Other contributing factors to the relative low usage could be the limited tablet computer ownership or the low amount of referring doctors doing ward rounds in this sample.

The final two questions in this section asked the current users of the mobile viewer to comment on its usefulness during consultations and ward rounds. The results are summarized in the graph below. According to the respondents, there seem to be more positive sentiments towards mobile-viewer impact in consultations than in ward rounds. There appears to be a level of indifference to mobile viewers – in both ward rounds and consultations, contradicting its reported importance in the first question of this section. This may indicate room for improvement in the current system, due to its aforementioned limitations. However, there is little negative sentiment towards mobile viewers in either consultations or in ward rounds.
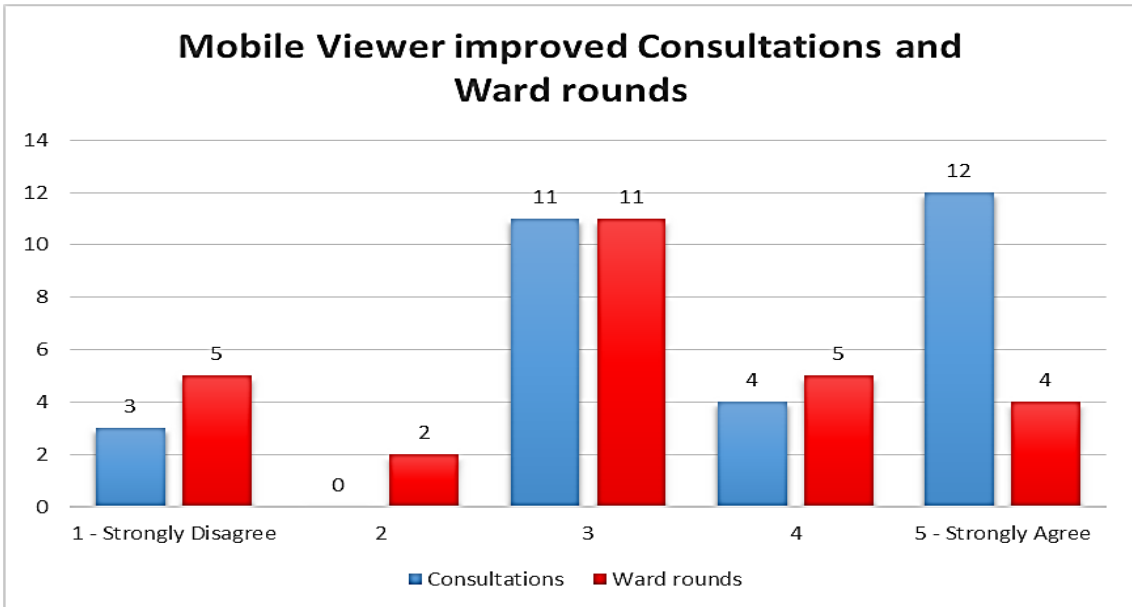
Figure 4.30: Mobile viewer improved consultations and ward rounds

4.13 SECTION 12 – PACS SUPPORT

Section 12 investigated the role of PACS systems support in the acceptance and meaningful use of the participants. Thirty-one (73.8%) of the referring doctors in the sample indicated that they had needed initial assistance to set up PACS on their computers. When analysing the frequency of PACS support needs post-installation, the relatively low amount of support needs points to a generally stable and user-friendly system. Twenty-one doctors (50%) report making use of PACS support once or less per year.
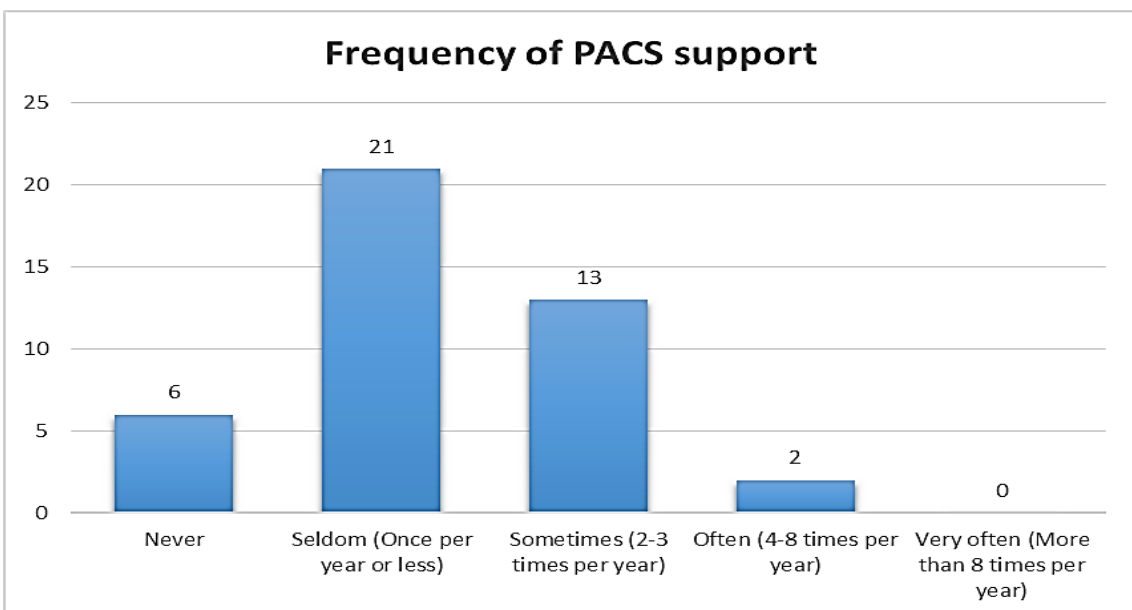
Figure 4.31: Frequency of PACS support

Finally, the doctors were asked how important the availability of high quality PACS support is in terms of their usage. From the results, it is clear that referring doctors find the availability of PACS support very important as twenty-nine (69%) indicated it as being important to very important
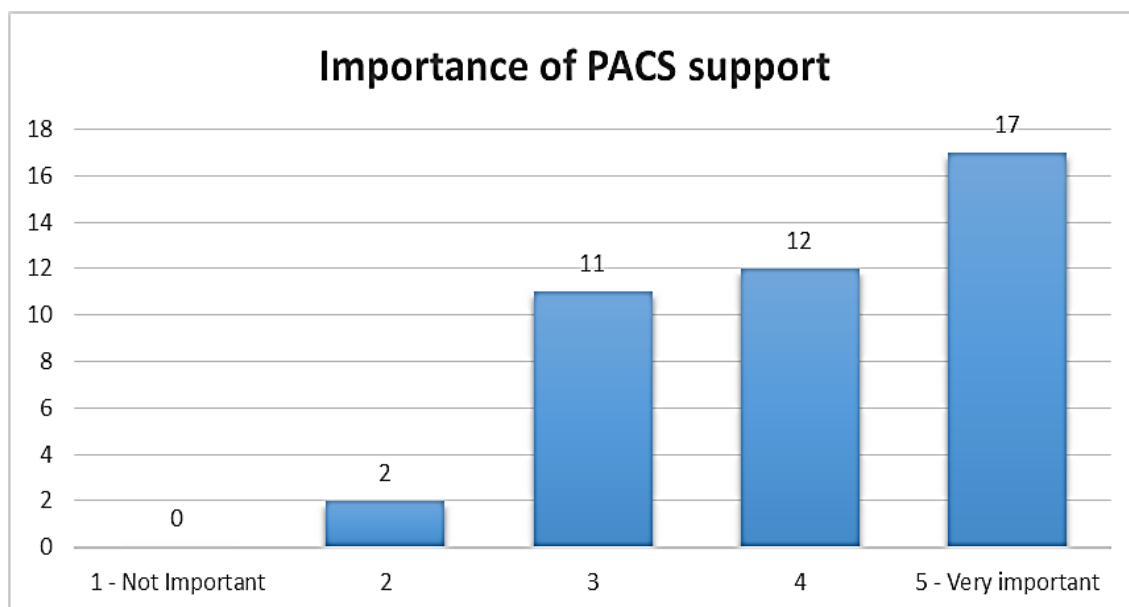
Figure 4.32: Importance of PACS support

4.14 SECTION 13 – CONCLUSION

The final section consists of three open-ended questions, in order to gather qualitative data about the advantages and disadvantages, as well as any other important aspects regarding PACS that the participants may wish to highlight. The benefits and disadvantages can be transposed into important factors and barriers to PACS acceptance and meaningful use.

4.14.1 Advantages of PACS

The first question is: "List three work-related benefits you have encountered since the introduction of PACS".

***

"1.ease of access to records 2.easy to use tools 3.proper and accurate diagnosis"

***

"Convenient Easy to use even without extensive training of literacy Search for older xrays easy, no need for storage"

***

"1. Improve quality of clinical work 2. Time saver 3. Cost saving (avoid redundant test) 4. Education"

***

"Ease of accessibility. Speed of accessibility. No longer have to bother with film or CDs."

***

"Ease of access to record (films) Ease of access to report (radiologist report) Easy of explanation to patients Improved patient satisfaction"

***

The benefits are well-documented in both the literature and from previous questions in this questionnaire. Most of the respondents highlighted ease-of-access to the full patient radiology history (examinations performed at any of the branches of the private practice), as a major benefit. Other important factors that were mentioned include ease-of-use/user-friendliness, improved diagnosis, education, less dependence on physical media, and improved patient satisfaction.

4.14.2 Disadvantages of PACS

The second question in this section was: "List three work-related disadvantages you have encountered since the introduction of PACS". This is an important question to give users an opportunity to discuss any negative aspects about PACS that they may have encountered. The # symbol is used to anonymize town names.

***

"Inability to manipulate images - not enough training"

***

71

"none, I think it has revolutionised our work and time management"

***

"Internet failure. Bad in # Slow system (internet related)"

***

"Unable to see requests from other specialists Difficulty with out of town doctors able to view Certain instances e.g.home affairs still needs written reports or disks"

***

"Network problems Ability to see other professional's investigations not simple and needs permission etc Reports have been been incorrectly allocated and this created some problems"

***

"Annoying chronic problem with access to the PACS using Chrome (compatibility view setting) Slow!!!"

***

"wall mounted PCs in wards, every practice uses difference software, loss of ability to do supine bending views for whole spine, small screen sizes generally"

***

"NOT AVAILABLE ON MOBILE DEVICE CONNECTIVITY ISSUES COMPATIBILITY ISSUES WITH WINDOWS 8, INITIALLY"

***

"ward patient and xrays separated difficult to show ward patient the pathology, GP's don't have same level of access therefore they often repeat radiology unnecessarity cos they not aware someone else already did it"

***

"Privacy of patients in the 'not my patient' category is compromised."

***

"System down time when there is poor outage a problem. Poor internet connection can limit access Files too big to import into my patient records"

***

"X-rays not at patient's bedside if in hospital. No printed report in file. Slow response on the computer that I use most in theatre is frustrating, seems to be associated with the touch screen type of computer that Cuyler hospital uses?"

***

"Eskom powercuts Computer not working or accepting pacs system after an update of software"

***

"Nil at this stage"

***

The high acceptance ratio of PACS does not guarantee that there are no potential problems with the system. While some doctors can list no disadvantages, others reported an extensive list of potential barriers to PACS usages. Firstly, the lack of training can impact on doctors' ability to effectively use the system. Slow and intermittent network failure is another reality with which some doctors have to contend. This is mainly prevalent when doctors access PACS via the Internet. Restricted patient access for certain doctors is a problem, which have been put in place for patient-confidentiality reasons.

A potential downside to this, however, is that it may lead to repeat examinations if referring doctors are not aware that the examination had already been requested by another doctor.

The inability to completely avoid physical media, such as printed reports and CDs frustrate some doctors; while others find the lack of a printed report at the patient's bed-side a negative aspect. User-error can cause images or reports to be mismatched – leading to frustration, as one doctor noted. The PACS system

currently in use at the private practice is only compatible with Internet Explorer, due to its reliance on ActiveX controls, prompting some doctors to call for a cross-browser compatible PACS system.

The location and specifications of ward and theatre PACS computers are potential barriers to their acceptance and meaningful use, as well as the inability to show images to the patients. Limited access on smartphones and tablet computers is another factor that was identified. One doctor mentioned difficulty to import images into his electronic patient record. Load-shedding was again mentioned as a barrier. Operating and system application software upgrades may lead to PACS access problems, thence leading to further frustrations.

4.14.3 Other aspects of PACS

The last question asked the participants was to list any other aspects about PACS that they would like to bring to the researcher's attention.

***

"I have found the PACS IT support in # very good."

***

"There needs to be standardization and systems integration or we will have problems when different products come up in future"

***

"PATIENT CONFIDENTIALITY AND THE ETHICS SURROUNDING THAT, PACS ALLOWS ACCESS TO PATIENT CLINICAL/RADIOLOGICAL HISTORY."

***

"need fast connections"

***

"Needs to be used more in public sector"

***

"iPhone and iPad App needs a little more work Still not working on Mac computers"

***

Some of the factors identified in the previous questions again came up in the last question: for example, training, support and the need for a fast networking infrastructure.   The issues around patient access and confidentiality merit thorough research – not only from a medico-legal point of view, but also from a practical workflow standpoint. This complex factor is outside the scope of this dissertation. One respondent commented that PACS need to be used more in the public sector, which is also outside the scope of this dissertation; since this research focuses on the private sector. The final quotes mentioned the need for a well-designed mobile application, as well as a cross platform-compatible PACS interface.

4.15 CONCLUSION

This chapter has discussed the questionnaire distribution and the data collection in considerable detail. The results from the questionnaire were systematically presented and discussed. Given the explorative nature of the research, the data collection instrument provided ample opportunity for the respondents to give qualitative feedback for further analysis. This is further analysed and presented in Chapter 5, as a list of the factors affecting PACS acceptance and meaningful use by private practice referring doctors. Each factor is discussed in detail individually, and then triangulated with the secondary data.

5 FACTORS

In this chapter, the qualitative data from the questionnaires are presented as factors for the acceptance and meaningful use of PACS by private practice referring doctors. The conceptual framework introduced in Chapter 2, and used in Chapter 3, is revisited before presenting each factor, according to the categories of the framework. After presenting the factors, an interpretation of the findings is offered. Finally, the chapter is concluded.

5.1 DATA ANALYSIS

The primary data analysis process started with the collation of all the free text question responses from each of the forty-two respondents. Each questionnaire submission was given a response number and placed in an Excel spreadsheet tab, containing all the relevant question numbers and their answers. The researcher coded one submission at a time – by reading through all the questions and answers in the responses, and identifying the key phrases or thoughts in the text. Whenever a new code was identified, it was given a unique number and noted in a summary sheet.

If a key phrase already existed, its unique number would be noted next to the response. Some answers contained more than one key phrase. When the coding for each of the questions in the submission had been completed, the researcher would move on to the next questionnaire.

All the codes or key phrases were placed in a summary spreadsheet tab containing their unique number, the category, and a set of columns representing each response numbered "1" to "42". If the key phrase was identified in the given response, a value of "1" (one) was placed in the column. The researcher could then count the total number of responses that contained the particular key phrase. Given that the content analysis process is qualitative in nature, the number of times a particular factor was identified had no bearing on its inclusion or omission.

The category assigned to each key phrase represents the conceptual framework barriers to PACS adoption, as introduced in Chapter 3. The categories are: Project, Technical, Organizational and Behavioural. The summary sheet also contained a column identifying the response where the key phrase was first identified. This allowed the researcher to analyse data saturation, as well as easily find the original source of the key phrase. As the content analysis process progressed, it became apparent that the gap between new key phrases being identified became wider, finally reaching the point of data saturation for this sample.

Data saturation is defined by Mack et al. (2005) as the point where the data yield no further insights on the research questions.

After the analysis of the responses from each of the forty-two respondents had been completed, a total of twenty-nine key phrases or codes were identified and categorized, according to the conceptual framework barriers. Each of these codes was then re-evaluated to identify the factors. Some of the codes were combined with others – if overlapping concepts were found. The results were discussed with the research supervisor and the suggestions were incorporated. Figure 5.1 shows an excerpt of the qualitative content analysis spreadsheet.

KEY	KEY PHRASE	FIRST ADDED BY	FACTOR CATEGORY	NUMBER OF TIMES IDENTIFIED	IDENTIFIED BY			
					1	2	3	4
1	Access to Radiology Information	1	Technological	39	1	1	1	
2	Training	1	Organizational	6	1			
3	Ease of Use	3	Technological	9			1	
4	Power Outages	3	Technological	8			1	

Figure 5.1: Qualitative content analysis example

 A final list of twenty-five factors emerged as important determinants influencing private practice referring doctors' PACS acceptance and meaningful use. Each of these factors will be discussed in detail in this chapter.

5.2   CONCEPTUAL FRAMEWORK REVISITED

This section briefly revisits the conceptual framework derived by Paré and Trudel (2007) introduced in Chapter 2 (refer to Figure 2.5). The framework is a combination of two existing models, allowing knowledge barriers to be categorized in terms of an innovation process in an organization.

The innovation process consists of two major phases, namely: Initiation and Implementation. During the Initiation phase, the Agenda-setting and Matching stages are concerned with identifying and prioritizing the issues to be resolved, as well as matching the properties of the innovation to these issues. When a decision is made to go ahead with the project, the Implementation phase starts. This phase consists of three stages. During the Redefining/Restructuring stage, the organizational processes and the innovation adapt to each other. Technical and Organizational barriers are particularly important during this stage.

When the system is deployed and more widely used, the Clarifying stage begins. During this stage, the user becomes more confident with the innovation

and the initial doubts start to subside. Technical and Organizational barriers continue to be important, in addition to Behavioural barriers. The final stage, Routinizing, is when the users start to dissociate from the technology or system as an innovation and it becomes a normal part of their day-to-day activities.

In the following sections, each of the barriers, or in this case, the factors, will be discussed. Supporting quotes from qualitative primary data are included where applicable.

5.3 PROJECT FACTORS

While a few Project factors were extracted from the literature, none were prevalent in the primary data. The possible reasons for this are further discussed in section 5.8.3.

5.4 TECHNOLOGICAL FACTORS

5.4.1 Access to radiology information

The ability to efficiently access a patient's radiological history and compare scans or x-rays from other sources, is one of the major benefits of PACS. This came to the fore when analysing the primary data. Therefore, every effort should be made to make PACS as accessible as possible. This encompasses many technical and non-technical factors – many of which will be discussed in this chapter. Accessibility is also largely dependent on the implementation strategy of the radiology practice responsible for PACS.

Decisions, such as digitizing old film and publishing PACS on the internet could have a bearing on the acceptance of PACS. Doctors would also find the availability of radiology reports on PACS very important, as illustrated in Chapter 4, Figure 4.22.

The following quote supports the importance of accessibility:

"give immediate access to XR requested by myself gives information about XR requested by other doctors. you can compare things done to previous XR etc"

Restrictive PACS access policies may have a negative effect on the PACS acceptance by the affected doctors. The following quotes highlight this issue:

"…Ability to see other professional's investigations not simple and needs permission etc…"

The balance between access and patient privacy is a complex issue. On the one hand, radiology needs to maximize accessibility and the workflow efficiency that PACS brings, but on the other hand, it should also prevent unnecessary or unauthorized access. PACS access policies and patient privacy are two sides of the same coin, the latter issue will be discussed later in this chapter.

5.4.2 Ease-of-use

Ease-of-use is an important factor in PACS acceptance and meaningful use; and it should feature prominently, when considering a PACS. The easier a system is to use, the less training should be required, as indicated by the following quote:

"Convenient Easy to use even without extensive training of literacy"

Some of the respondents also mentioned they found PACS more difficult to master. The following verbatim quote supports this statement, and was in response to a question to elaborate on whether PACS improved their professional lives:

"Could be easier"

A thorough objective evaluation of PACS ease-of-use prior to product selection can, therefore, assist in its acceptance and meaningful use.

5.4.3 Power outages

As mentioned in Chapter 4 section 4.5.3, the effects of rolling electrical blackouts, or load-shedding, affects PACS users when no back-up electricity is available. Generally, hospitals are exempt from load shedding; since they have uninterrupted power supplies (UPS) and generator power to minimize the effect of electrical outages. However, many referring doctors practise from out-of-hospital offices, and would be responsible for their own emergency power supply in order to continue accessing PACS during an outage. The quote below supports this position:

"I use ADSL, so if there's load shedding, I can't access the x-rays or reports. no other problems come to mind."

5.4.4 Computer networks

A significant portion of the doctors (71%) in this sample, access the PACS system using broadband Internet services, thereby resulting in longer waiting periods - especially when accessing larger radiology studies. Some of the respondents have indicated frustration with slow system speeds, as well as general connectivity outage, as supported by the following quote ("#" symbol indicates anonymous location):

"Internet failure. Bad in # Slow system (internet related)"

Referring doctors mainly access PACS on gigabit local area networks (LAN), as is normally the case in hospitals, should not be affected by the same connectivity issues. Internet infrastructural limitations present a difficult technical problem to overcome.

5.4.5 Computer hardware

The specifications, placement and number of PACS workstations can have an impact on the acceptance and meaningful use by referring doctors. The doctors are generally responsible for the purchase, installation and maintenance of computers in their offices. PACS workstations in wards and theatres are generally the responsibility of the hospital. The quote below was in response to a question asking the respondents to elaborate on the impact of PACS on ward rounds:

"Hospital pacs systems frequently lacking, compared to base stations. Could have dediicated wireless station in ward for rounds obviating individual pad require,ents or printed images as certain doctors stillprefer"

The next quote also refers to screen types installed in theatre ("#" symbol indicates anonymized hospital):

"X-rays not at patient's bedside if in hospital. No printed report in file. Slow response on the computer that I use most in theatre is frustrating, seems to be associated with the touch screen type of computer that # hospital uses?"

5.4.6 Physical media

There are positive and negative aspects when it comes to compact discs (CDs), paper and film, collectively referred to as physical media. If orthopaedic templating software is not available, surgeons may need access to film to plan their surgeries.

"MEASURE BETTER ON FILMS"

The same respondent further explained when asked to provide three disadvantages to PACS:

"CANNOT MEASURE ACCURATELY …"

When analysing the two quotes above, it could be argued that measurements on PACS are not as accurate as on film. Radiology should keep this in mind when removing dark rooms and wet-film processing. In the digital environment, dry film processors should be available to meet this need.

Doctors often find CDs cumbersome and slow to use, as illustrated in the quote below:

"Works fine when you use the web but is horrible when a patient come with a CD as this takes a long time to open, often have an unknown PACS program and the worst is when it eventually opens the images are of such bad quality that it is useless"

However, it remains a necessity to provide CDs on a request basis, when patients consult doctors in remote locations or without any access to the relevant PACS.

"Only when patients get transferred to other areas . they would get CD to take with them to Cape town etc"

While networked access to PACS is the preferred method of image access, ignoring the referring doctors' physical media needs could lead to problems.

5.4.7 Mobile PACS Application

Mobile access to PACS is a very important feature of modern PACS products; and it can assist in some of the limitations of PACS workflows, for example in wards. This is illustrated in the following verbatim quote:

"Mobile addition is an absolute necessity"

There are various components needed to make this service available to referring clinicians. The PACS should include a tablet and smart phone application or compatible web viewer. PACS access should also be made available – either on wireless local area networks (WLANs) or when given sufficient access to mobile broadband internet in hospitals. The mobile PACS component should not be confused with remote access to the primary PACS interface. This will be discussed in the next section.

5.4.8 Remote access

A large number of questionnaire respondents indicated that they frequently access PACS out of the office, as reported in Chapter 4, section 4.9.3. Of the forty-two respondents, eighteen (42.8%) had access to PACS remotely four or more times per month. The following quotes support this:

"Saves time, allows me to be more mobile and improves access to patient information."

"Easy access to new and old investigations Acces examinations from home after hours"

Therefore the remote PACS access needs of the referring doctors should receive priority attention during infrastructure planning and deployment.

5.4.9 Standardization and Integration

There are a multitude of PACS vendors with different interfaces and functionality. There is a concern amongst some referring doctors that, as more of these systems become available, it would have a negative effect on usability.

"There needs to be standardization and systems integration or we will have problems when different products come up in future"

This is further elaborated on below by another doctor:

"The problem is that every radiologist has a different program and embed their DICOM files into the program with the result that one has to learn a lot of different programs. Would make much more sense to just have the DICOM images without a program; this would allow one to use one program to read the images"

If a clinician refers patients to various radiology practices – each providing a different PACS interface – it may lead to confusion and complications. One possible solution would be the integration of the various studies through a central point (Health Information Exchange), allowing doctors to use their own familiar systems to access imaging from disparate systems.

5.4.10 Browser compatibility

As previously mentioned, the PACS in use at the primary private radiology practice to which the questionnaire respondents refer patients, is a General Electric Centricity PACS IW version 3.7.3. This version is only compatible with Microsoft Internet Explorer. This leads to frustration and possible PACS access problems, if referring doctors install third-party browsers that become the default application to open web shortcuts from their Microsoft Windows desktops.

"Annoying chronic problem with access to the PACS using Chrome (compatibility view setting) Slow!!!"

"The fact it is IE based. Lacks versatility. I can't get it to work with other browsers, eg, Chrome"

More modern versions of PACS may include cross-browser compatibility, or a so-called zero-footprint viewer; since it does not require any component downloads or installation. These viewers are also generally able to run on a variety of smart phones or tablet computers, as well as Apple Macs. Therefore browser compatibility is an important factor, when choosing a PACS.

5.4.11 Image manipulation tools

PACS has the benefit of giving referring doctors access to more radiology images than would be the case in a film environment. This, coupled with the image quality of modern digital imaging equipment and the ability to manipulate these images through functions, such as zoom and window/levelling, greatly assist in diagnosis and treatment planning. The importance of these PACS tools was clearly demonstrated in Chapter 4, section 5.4.11. When asked to elaborate on some of the advantages of PACS, one respondent commented:

"…Manipulation of x-rays possible to aid in interpretation"

Multi-slice modalities, such as CT and MRI can generate thousands of images, making it difficult to give referring doctors access to the full complement of images on film. It can, therefore, be argued that the added imaging capabilities contribute to PACS acceptance and meaningful use by referring doctors.

5.5 ORGANIZATIONAL FACTORS

5.5.1 Training

There is a definite need for an effective training regime, to ensure a smooth transition from a hard-copy-based workflow to a fully digital PACS workflow. This is supported by the quantitative and qualitative results of the questionnaire, as well as in the literature. Training should cover all the PACS tools required to ensure meaningful usage, since ineffective training could lead to serious issues. This is supported by the following quotes:

"Inability to manipulate images - not enough training"

"CANNOT MEASURE ACCURATELY CANNOT ACCES REPORTS KNOW TOO LITTLE"

5.5.2 Workflow

PACS has a major impact on physicians' workflow. Patients do not have to return to referring doctors with the results as these can be accessed on PACS, thereby resulting in further time-saving. The doctor can contact the patient telephonically when convenient, further streamlining his/her workflow. This point is supported by the quotes below:

"Very helpful, need not rely on pt bringing scans, get report and can see the plates within an hour of the test, can see pts on the day of the test, saving them visits, speeding up decision-making."

"Has trimmed hours off my week. Radically improved efficiency and patient management"

Workflow is, therefore, a factor in private practice referring doctor PACS acceptance and meaningful use.

5.5.3 PACS access in wards

While not all doctors routinely conduct ward rounds, the results of the questionnaire showed that there is some negative sentiment towards PACS access in wards amongst the doctors that do. This can be explained by the fact that imaging and reports are no longer present at the patient's bedside, making it difficult to show patients their imaging, as shown in the quote below ('#' symbol indicates anonymous hospital):

"X-rays not at patient's bedside if in hospital. No printed report in file. Slow response on the computer that I use most in theatre is frustrating, seems to be associated with the touch screen type of computer that # hospital uses?"

This potential pitfall can be mitigated through the introduction of mobile-computer workstations, tablet computers, or by adjusting ward workflow by viewing relevant imaging and reports before conducting rounds. The questionnaire indicated that 55% of the respondents have already made this adjustment.

The effect of this particular factor could differ vastly between different hospital settings; and it is dependent on how PACS is deployed in the wards. Stakeholder engagement at the Redefining/Restructuring stage is therefore critical to avoid problems further down the project. For example, physicians could be given the opportunity to comment on the number and placement of PACS workstations in wards.

5.5.4 Systems support

Section 12 of the questionnaire investigated the importance of PACS systems support. The results indicated that support is extremely important. Other than initial set-up assistance, ongoing support is also very important to ensure limited interruption to PACS access. Operating system or application updates, for example, Anti-Virus software, could lead to PACS access issues, as shown in the quote below:

"Eskom powercuts Eskom powercuts Computer not working or accepting pacs system after an update of software"

5.5.5 Patient Privacy

Protecting patient privacy was highlighted in the primary data as a concern. The following verbatim quote supports this:

"PATIENT CONFIDENTIALITY AND THE ETHICS SURROUNDING THAT, PACS ALLOWS ACCESS TO PATIENT CLINICAL/RADIOLOGICAL HISTORY"

Patient privacy is not a new problem, and it is certainly not limited to PACS systems. One could argue that issues surrounding patient privacy existed in a film-based workflow as well - anyone could read patient folders if these were misplaced or lost.

There are also legislative aspects to consider in addition to the ethical concerns. In the United States of America, the Health Insurance Portability and Accountability Act (HIPAA) governs the privacy of individually identifiable health information. The Republic of South Africa has gazetted the Protection of Personal Information Act (POPI) of 2013, of which the purpose is to safeguard and regulate access and the processing of personal information (Protection Personal information Act, 2013).

The POPI Act was signed into law by the President on 19 November 2013; and it was published in the Government Gazette Notice 37067 on 26 November 2013. Once the Act is made effective, companies will be given a year's grace period to comply with the Act, unless this grace period is extended, as allowed by the Act. The President has signed a proclamation declaring some parts of the Protection of Personal Information Act No 4 of 2013 effective from 11 April

2014. When the act is made effective, it might also impact the usage and administration of PACS in South Africa.

5.5.6   Repeat examinations

There is potential for negative consequences in applying restrictive access policies on PACS. As discussed in section 5.5.4, patient confidentiality is an important factor: both ethically and legally. However, if patients are not in the position to disclose full or accurate medical histories to their care-givers, it may lead to unnecessary repeated examinations. Besides the cost implications, it can also expose the patient to unnecessary radiation. The quote below reinforces this:

> *"… GP's don't have same level of access therefore they often repeat radiology unnecessarity cos they not aware someone else already did it"*

While it can be argued that the same problem may apply to a film environment, effective information management can help alleviate the problem, and ultimately benefit the patient.

5.5.7   Data inconsistency

The following quote suggests, amongst other problems experienced, that incorrect report allocations on the PACS can lead to problems:

> *"…Reports have been been incorrectly allocated and this created some problems"*

System bugs or errors made by users in the radiology departmental workflow can lead to data integrity problems and diminished trust in the PACS by referring doctors.

5.5.8   Education

A number of referring doctors identified education as an important factor in their PACS usage. Two components were identified in the primary data. Firstly, some doctors find that PACS assists in patient education, as supported by the quote below:

> *"… and use the pictures for patient education as well as diagnosis."*

Furthermore, PACS also positively influences referring doctor education in terms of improved diagnostic skills. This suggestion is further supported below:

"... Improved diagnostic skills"

Therefore, the education of both doctors and patients plays a role in PACS acceptance and meaningful use.

5.5.9 Digital templating software

Orthopaedic templating is the customary approach to pre-operative joint replacement and fracture repairs (Steinberg, Shasha, Menahem, & Dekel, 2010) and this can be achieved through film template overlays, or by using software such as TraumaCad™. When asked if PACS met their expectations, one referring doctor responded as follows:

"only problems are … and that our hospital system does not have a templating system for orthopaedic implants"

It can be argued that the presence of templating software can assist with the acceptance and meaningful use of PACS by certain doctors.

5.5.10 Delayed reports

Two participants in the questionnaire mentioned that delayed radiology reports lead to frustration. The quote below supports this:

"Frustration over delayed reports"

Possible delays could include system problems and high departmental workloads. Given the importance of radiology reports on PACS, as shown in the quantitative results of the questionnaire (Chapter 4 section 4.9.5), every effort should be made to mitigate potential report delays.

5.5.11 PACS in public sector

Referring doctors were asked in the final question of the questionnaire if there were any other aspects about PACS they would like to highlight for the researcher. One doctor made the following remark:

"Needs to be used more in public sector"

While public sector PACS is not within the scope of this research, it is worthwhile discussing possible conclusions to be drawn from this comment. It is possible that the benefits of PACS in the private sector are not fully realized in the public sector; and the reasons behind this could be the subject of future research in the South African context. Also, integration between private and public sector systems could lead to better patient care.

5.5.12 Continuity of care

PACS assists in the communication between healthcare professionals and it ultimately leads to better continuity of care. When asked to elaborate on whether PACS improved their professional lives, one doctor responded:

"continuity of care, patient information available"

This is further endorsed by the opinion below:

"… making decisions on the fly with other specialists, radiologists and gp's"

Continuity of care is an important factor in improving physician workflow and it can therefore influence PACS acceptance and meaningful use.

5.6   BEHAVIOURAL FACTORS

5.6.1   Patient Satisfaction

Some referring doctors reported improved patient satisfaction since the introduction of PACS, as shown in the quote below:

"Speed Accuracy Patient satisfaction"

This could in part be due to the fact that patients no longer have to wait for their results in the radiology department:

"SAVE PATIENT WAITING TIME FOR PRINTING OF IMAGES NO NEED TO STORE OR ARCHIVE IMAGES, OR RISK OF LOSING IMAGES EASILY ACCESS FOR SPECIALISTS"

The efficiencies introduced by PACS lead to increased patient satisfaction and they ultimately benefit the referring doctor as well. Therefore, it can be argued that patient satisfaction is a factor in acceptance and meaningful use.

5.6.2 Informal opinion requests

Some doctors have negatively perceived an increase in the number of informal opinion requests from other doctors. This is supported by the following quote in response to the question asking respondents to list three negative aspects of PACS:

"Multiple `free` telephonic opinions taking up lots of time No hiding from being potentially available"

5.7 FACTOR SUMMARY

In this section, all the identified factors are summarized, from both primary data and the literature survey. Figure 5.1 represents the number of factors for each category type. Technical factors are the most numerous – with fifteen factors (45.5%), followed by Organizational factors – with twelve factors (36.4%). Project and Behavioural factors have two (6.1%) and four (12%) factors, respectively in total. Note that the number of factors per category does not represent importance over another category type.
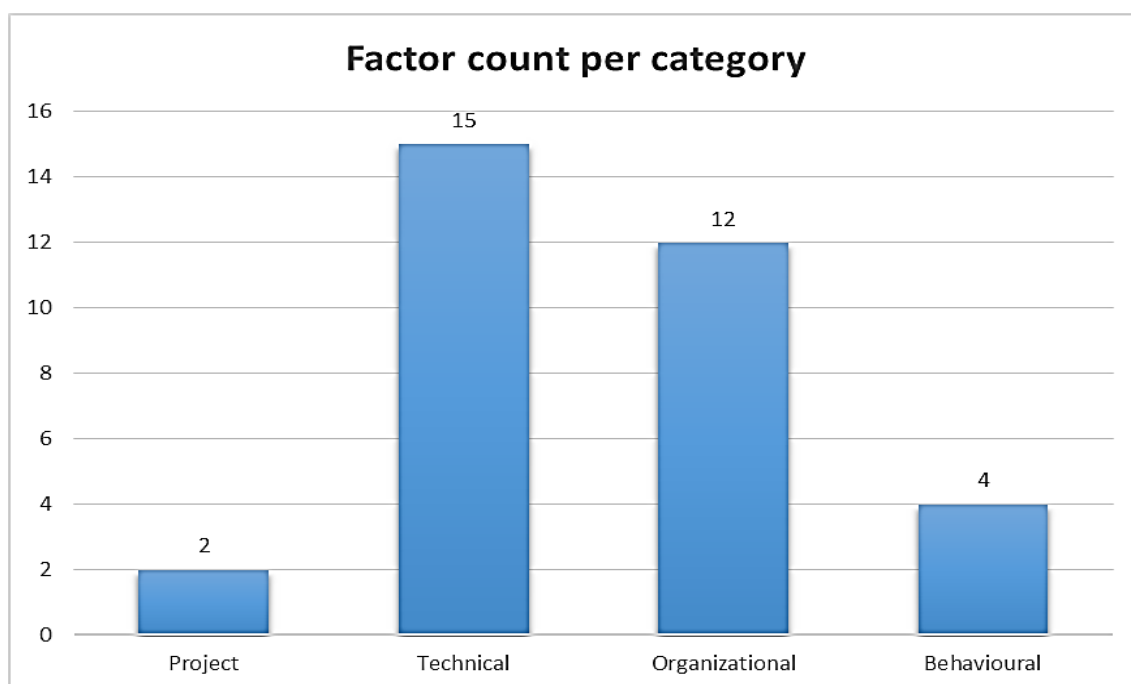
Figure 5.2: Factor count per category

In Table 5.1, the factors are grouped, according to the relevant category; and they appear in no particular order. Each of the listed factors is also marked with a "Y" in the Questionnaire and Literature columns, to indicate whether it was

identified in the primary or secondary data. Note that due to the explorative nature of the study, factors were not excluded if they were not present in both the primary and secondary data.

Factor	Questionnaire	Literature
Project Factors		
Finance		Y
Project Team		Y
Technical Factors		
Access to radiology information	Y	Y
Ease-of-Use	Y	Y
Power Outages	Y	
Computer Networks	Y	Y
Computer Hardware	Y	Y
Factor	**Questionnaire**	**Literature**
Physical Media	Y	
Mobile PACS Application	Y	
Remote Access	Y	Y
Standardization and Integration	Y	
Browser Compatibility	Y	
System Failure		Y
PACS Security		Y
Image quality		Y
Image manipulation	Y	Y
Technical expertise		Y
Organizational Factors		
Training	Y	Y
System Support	Y	Y

Workflow	Y	Y
Ward access	Y	Y
Repeat Examinations	Y	Y
Data consistency	Y	
Education	Y	Y
Digital templating software	Y	
Delayed reports	Y	
PACS in public sector	Y	
Patient Privacy	Y	Y
Continuity of Care	Y	
Behavioural Factors		
Patient satisfaction	Y	Y
Informal opinion requests	Y	
Factor	**Questionnaire**	**Literature**
Resistance to change		Y
Social aspects		Y

Table 5.1: Summary of factors in primary and secondary analysis

5.8   INTERPRETATION OF THE FINDINGS

This section highlights some of the key findings emerging from this study. The interpretation is discussed in terms of PACS acceptance, the prevalence of Technical and Organizational factors, the importance of Behavioural factors, the low number of Project factors, and the limitations of the theoretical framework.

5.8.1   PACS acceptance

The primary data of this study have shown that private practice referring doctor acceptance of PACS is very high. This argument is supported by the data presented in section 4.5. Firstly, the usage frequency is high – with 84% of the users surveyed, who reported using PACS more than twice a day. The majority of the respondents (85.7%) in the questionnaire strongly agreed with the statement: "PACS is a useful advancement for your practice", indicating a positive acceptance of the technology.

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In this setting, PACS was marketed to referring doctors as a highly beneficial system. Thirty-four (81%) agreed or strongly agreed that PACS had met their pre-installation expectations. The following quote puts the sentiment into perspective:

"cannot imagine working without it. safes me a great amount of time"

Finally, in section 4.9.1, thirty-five (83%) of the referring doctors indicated that PACS is more effective than film, indicating that they have successfully navigated the change cycle between the two workflows.

As previously stated, most PACS acceptance and meaningful use research was conducted in public and university hospitals, making comparisons between this research and that of other private sector settings difficult. Pynoo et al. (2012) claimed to be the first study investigating PACS acceptance and meaningful use in the private sector. While the aforementioned study aimed to identify the predictors of PACS acceptance and meaningful use, it did not measure the acceptance level.

The literature survey conducted for this dissertation did not deliver any additional studies conducted in the private sector. However, the high acceptance level of PACS in this study is in accordance with that of other key research in the public sector (Pilling, 2003; Top, 2012). The conclusion can therefore be drawn that PACS acceptance is, consequently, high in both private and public sectors.

5.8.2 Prevalence of Technical and Organizational factors

From the primary data, it is evident that Technical and Organizational Factors emerge as the predominant determinants of PACS acceptance and meaningful use for private practice referring doctors. Technical and Organizational factors are predicted to be more important during the Redefining and Clarifying stages, which fall under the Implementation phase. This is a critical phase that can make or break a PACS project; failure to adapt to the challenges could lead to failure.

A total of fifteen Technical and twelve Organizational factors were identified in the primary data and during the literature survey. Many of the Technical and

Organizational factors were identified in both the primary and the secondary data. This triangulation points to the importance of these factors in a successful PACS implementation. Examples of these factors include training and system support. While the high number of the factors in these two categories is not insignificant, it would be difficult to claim superiority over the Project and Behavioural categories based on this alone. This study does not aim to rank the importance of any factor category or of individual factors.

5.8.3 Low number of Project factors

Project factors are concerned with the funding and project management of a PACS and this occurs during the Matching phase. Private and public hospitals vary significantly in terms of staffing, IT infrastructure and education (Pynoo et al., 2012).

In the South African private healthcare environment, radiology practices are largely responsible for the funding and implementation of PACS. The absence of Project factors emanating from the primary data is thus not surprising, and confirms that referring doctors are seldom involved in the early stages of PACS implementation. The financial impact for referring doctors is generally limited to personal computer needs during the implementation stages of PACS.

In some cases, referring doctors may be enlisted in a change-champion capacity during a PACS implementation. Their involvement on the project team may lead to valuable insights, such as for example, PACS influence on clinician workflow.

The lack of Project factors may not be the case in other settings, where hospitals are structured differently in terms of PACS funding and project management roles and responsibilities. Another point to consider is that the study was conducted five years after PACS was introduced to the majority of the respondents.

Further research in the South African private healthcare space is needed to ascertain the role of Project factors in referring doctors' acceptance and meaningful use. A longitudinal study could also help to identify how the factors performed at various important project intervals.

5.8.4 Importance of Behavioural factors

As previously discussed, Behavioural factors relate to issues with individual resistance to change and institutional power dynamics and they are generally managed in the final two stages of the Implementation phase (Paré & Trudel, 2007). A relatively low number of Behavioural factors were identified, compared with the Technical and Organizational factors. Firstly, it is possible that there are only a limited number of Behavioural factors relevant to PACS acceptance and meaningful use. However, this supposition needs to be tested further in other similar settings, before a conclusive deduction can be made.

In-depth interviews may reveal more information if the subjects are probed on Behavioural factors. Finally, the lack of factors could be explained by the time span between PACS implementation and conducting this study.

The low number of factors found in this category does not imply that it is any less important than other factor types. Physicians' resistance to information technology is well-documented (Paré & Trudel, 2007); and it could be a serious threat, if left unmanaged. Pynoo et al. (2012) found social factors to be a key factor in PACS usage during their study of physicians' PACS acceptance in a private hospital in Belgium.

5.8.5 Extension of framework

Chapter 2 introduced the conceptual framework described by Paré and Trudel (2007) as the Innovation Process in an Organization. This framework lists four categories of knowledge barriers and the phases or stages, in which they are most likely to be prevalent. The authors state that the final stage, Routinizing, starts when the technology becomes a natural part of an organization's workflow.

In this research, the radiology practice, to which the majority of the respondents refer patients started their PACS implementation in 2010 and therefore, many of the doctors would have had a number of years to routinize PACS usage. Chapter 4, Figure 4.7 shows their private practice PACS experience in years. Given the number of Technical and Organizational factors identified in the primary data, it can be argued that the potential exists for these factor categories to re-emerge – if they were not adequately addressed during the

Redefining and Clarifying stages. Some factors, like systems support, are an ongoing process. Therefore, continuous positive acceptance and meaningful use in the medium to long term may rely on the extension of the theoretical framework's boundaries past the Implementation phase. PACS proponents need to plan strategically to prevent any regression of PACS acceptance and meaningful use during this proposed "Maintenance" phase.

This phase is illustrated in Figure 5.3. Example stages may include PACS systems support and planning for future capacity and feature upgrades.
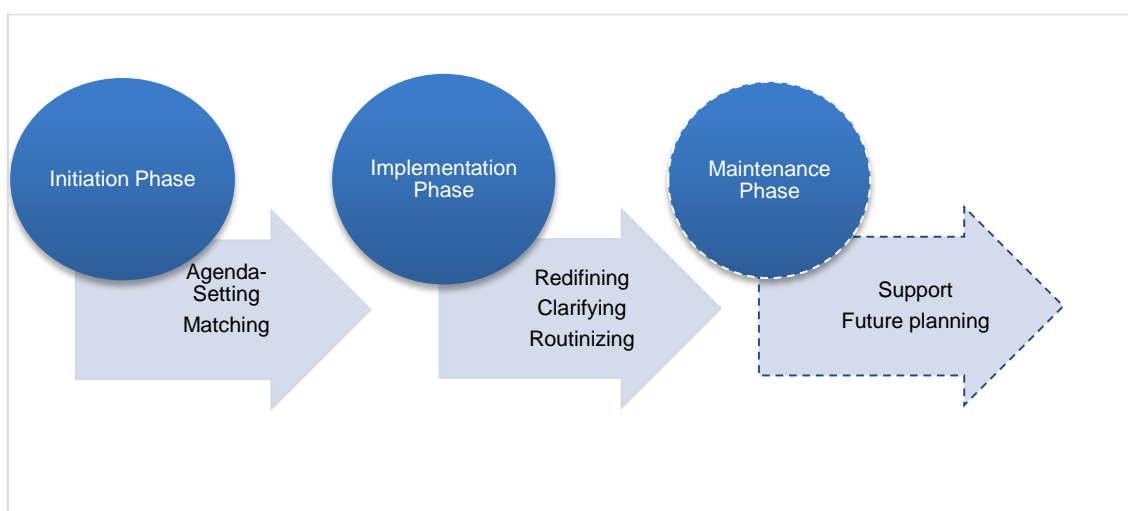
Figure 5.3: Maintenance phase

Another consideration is the impact on individuals introduced to an established PACS environment. Doctors without any prior PACS experience that start to practise in a PACS environment may find themselves navigating through a number of the factors – ranging from the Matching stage to the Routinizing stages, and beyond. While the radiology department (responsible for PACS in this case) may have successfully implemented PACS for the majority of the referral base, they need to be sensitive to the needs of new individuals and to assist with the change management required to routinize PACS.

This proposed addition to the conceptual framework would require further research – in order to formalize a new extended framework.

5.9 CONCLUSION

This penultimate chapter has discussed each factor identified in the primary data, as they relate to PACS acceptance and meaningful use. The chapter started with a practical explanation of the qualitative content analysis technique applied to identify these factors. The conceptual framework of relevance in this research was revisited, in order to facilitate the understanding of its use.

Following the discussion of each individual factor, the final list of factors was summarized. An interpretation of the research findings was offered before concluding the chapter.

6 CONCLUSION

The final chapter of this research reflects on the dissertation's contribution and aspects pertaining to the validity of the results. Each chapter is briefly reflected on in terms of its role as a building block in the dissertation. The research problem statement and objectives are revisited. Finally, the chapter is concluded by discussing the research limitations and future research opportunities.

6.1   SUMMARY OF CHAPTERS

A brief summary of each chapter of the dissertation is offered below.

6.1.1   Chapter 1 – Introduction

The first chapter introduced PACS as a technology, its background and role in healthcare provision. The problem statement of this dissertation was formulated as: There is a lack of understanding on which factors influence Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice. The problem statement permitted the development of the primary and secondary research questions and objectives.

The methodology was briefly discussed, as well as the delineation and ethics pertaining to the research.

6.1.2   Chapter 2 – Research Methodology

The methodology chapter described the research process and the methods chosen to reach the objectives set in Chapter 1. The data collection and analytical methods were also discussed. An overview of the pilot study used to refine the data collection instrument was provided. The conceptual framework that was used as a theoretical lens to analyse the data, and to present the findings of the research, was introduced.

6.1.3   Chapter 3 – Literature Survey

The literature survey chapter aimed to investigate and present the available literature on PACS acceptance and meaningful use. It was established that private sector information is limited; and therefore, the data from the public sector were also analysed. The factors affecting PACS acceptance and meaningful use were presented and discussed in terms of the Project, Technological, Organizational and Behavioural categories, as defined by the conceptual framework.

6.1.4   Chapter 4 – Empirical Analysis of the Primary Data

Chapter 4 revisited questionnaire design and distribution aspects, and presented the results. Given the mixed methodology approach, the results contained both qualitative and quantitative information.

6.1.5 Chapter 5 – Factors

In this chapter, the factors identified in the primary data using qualitative content analysis were discussed in detail. All the identified factors, including those from the literature survey, were then summarized and presented. The chapter concluded by offering an interpretation of the results.

6.1.6 Chapter 6 – Conclusion

The final chapter concludes the research by revisiting the research objectives, their contribution and limitations – and it also recommends some future research paths.

6.2 RESEARCH QUESTIONS AND OBJECTIVES

The problem statement for this research was originally defined in Chapter 1.

Problem Statement
There is a lack of understanding on which factors influence Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice.

Table 6.1: Problem Statement

In order to fully address the problem statement, a set of research questions and objectives were formulated in Chapter 1. The research questions and objectives are discussed below, as well as how the objectives were met.

Research Question 1	Research Objective 1
What is the state of Picture Archiving and Communication Systems acceptance and meaningful use in healthcare provision?	Investigate the state of Picture Archiving and Communication Systems acceptance and meaningful use in healthcare provision.
Chapter 1 provided a background to PACS in the healthcare industry. The importance of PACS in the modern clinical setting was emphasized. It was established that literature confirming public sector PACS acceptance was more readily available, and that the context of the referring clinician in the private sector was the least-researched and published. The literature survey in Chapter 3 expanded on the current state of PACS acceptance and meaningful use, while presenting the influencing factors.	

Table 6.2: Research Question & Objective 1

Research Question 2	Research Objective 2
Which factors affect referring clinician acceptance and meaningful use of Picture Archiving and Communication Systems in private practice?	Identify which factors affect the acceptance and meaningful use of Picture Archiving and Communication Systems amongst private practice referring clinicians.
Factors affecting referring clinician PACS acceptance and meaningful use were identified through a literature survey (Chapter 3) and a questionnaire administered to private practice referring clinicians (Chapters 4 and 5). The final list of factors was presented in Chapter 5, where some factors were unique to the results from literature, others were unique to the empirical data and some were identified through both the methods of the data collection.	

Table 6.3: Research Question & Objective 2

Research Question 3	Research Objective 3
How can the identified factors be theorised to obtain a broader understanding of Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice?	Theorise the identified factors to obtain a broader understanding of Picture Archiving and Communication System acceptance and meaningful use by referring clinicians in private practice.
The theoretical lens that was applied to acquire a broader understanding of referring clinicians' PACS acceptance and meaningful use in private, was introduced early in the dissertation (Chapter 2). This approach facilitated theorising throughout the data collection, analysis and interpretation stages of the research. This culminated in the final list of factors presented in terms of the conceptual framework, as well as further interpretation of the findings, which included a proposal to extend the framework to include a maintenance phase.	

Table 6.4: Research Question & Objective 3

This study has succeeded in expanding on the current body of knowledge pertaining to PACS acceptance and meaningful use by specifically exploring these concepts in private practice.

6.3 VALIDITY

The trustworthiness of qualitative research is often put into question by quantitative researchers since quantitative constructs for validity cannot be directly applied to the qualitative findings (Anney, 2014; Shenton, 2004). In Chapter 2 (section 2.1), it was mentioned that the explorative nature of this research lends itself better to qualitative research. Section 2.1 further discussed the embedded design of this research and how the qualitative strand takes priority over the quantitative strand.

It can therefore be argued that when evaluating the research validity, qualitative strategies would be more suitable. Guba (1981) posited four criteria for establishing trustworthiness in qualitative research: credibility, transferability, dependability and confirmability. The application of each of the criteria in this research is discussed in the following subsections.

6.3.1 Credibility

Credibility, defined as the confidence that can be placed in the accuracy of a study (Anney, 2014), can be achieved through various methods (Shenton, 2004). Examples include the adoption of well-established research methods, familiarity with the culture of the participants, triangulation, etc. Chapter 2 (section 2.1) discussed the mixed methodology approach employed in this research. The use of methodological triangulation was cited in Chapter 1 (section 1.5.1) to answer the primary research question of this research. The researcher's employment in the private practice radiology sector assisted with experience in the cultural aspects of the research participants.

6.3.2 Transferability

A study's transferability defines how applicable the results are when applied in other situations (Shenton, 2004). Shenton postulates that the research should provide sufficient background information on the setting, to enable the reader to draw conclusions on the transferability of the research results. This information is provided in Chapter 1, as well as in section 4.1. Due to the explorative nature of this study, the transferability of this study is not an issue of primary concern. The study does, however, include sufficient background information to give readers the opportunity to assess the transferability of the results to other settings.

6.3.3 Dependability

A study is defined as dependable if another researcher obtains the same results when employing the same research techniques on the same sample (Anney, 2014). By providing detailed research process and design information, researchers make it possible to test the dependability of their results, should this be required. In this research, Chapter 2, as well as sections 3.1, 4.1 and 5.1, provide this information.

6.3.4 Confirmability

Confirmability is concerned with the objectivity of the study, where the results should represent the views of the participants and not those of the researcher (Shenton, 2004). Triangulation is described as a suitable method to enhance

confirmability, which is applied in this research through qualitative and quantitative inquiries in the questionnaire, as well as in the literature survey.

6.4 RESEARCH CONTRIBUTION

The benefits of PACS are well-documented (Becker & Arenson, 1994; Bryan & Weatherburn, 1999; Schulze et al., 2009) and its influence on radiology and referring doctor workflow is far-reaching.

PACS acceptance in the public sector is generally high, based on published results (Pilling, 2003; Prasad & Wright, 2003; Top, 2012; Watkins, Weatherburn, & Bryan, 2000); and this study has indicated that the private sector has the same positive view. This dissertation is one of a limited number of studies researching PACS acceptance and meaningful use in the private sector. It is the first published research on this topic in South Africa. It is also the first study applying the conceptual framework developed by Paré and Trudel (2007) to a private practice environment.

By applying a mixed methodology research approach, this study was able to gather quantitative and qualitative data from the participants. The results revealed a rare insight into private practice referring doctor attitudes towards PACS. By applying research rigour, the identified determinants of PACS acceptance and meaningful use are presented as a set of factors that could determine the success or failure of a PACS project. These factors are categorized as: Project, Technological, Organizational and Behavioural; and they are presented in Table 6.5.

This represents the most important contribution of this research. Recommendations were also made to extend the afore-mentioned conceptual framework into a more complete PACS lifecycle management framework.

The financial investment of PACS is considerable and it can run into millions of U.S. dollars (Ayal & Seidman, 2009; Becker & Arenson, 1994), regardless of who is responsible for its initiation and implementation. The costs are often offset against film processing and storage expenses, as well as the staff cost savings introduced by PACS efficiencies. If physician acceptance and meaningful use are not realized, the cost offsets may fail to materialize, placing

the radiology practice at risk. When considering the impact of failure, the importance of this research contribution is put into perspective.

This research should therefore play a role in the success of PACS implementation in private radiology practices, and the overall advancement of Information and Communication Technology research and implementation in this field.

Factors Categories	Initiation Phase		Implementation Phase		
	Agenda-Setting	**Matching**	**Redefining**	**Clarifying**	**Routinizing**
Project		• Finance • Project Team			
Technical			• **Access to radiology information** • Technical expertise • **Computer hardware** • System failure • Physical media • Mobile application • Browser compatibility	• **Computer networks** • **Ease of use** • PACS security • Image quality • **Image manipulation** • **Remote access** • Power Outages • Standardization and integration	
Organizational			• **Training** • **System support** • **Workflow** • **Ward access** • PACS is public sector • Continuity of care	• **Patient privacy** • **Education** • Repeat examinations • Data consistency • Delayed reports • Digital templating software	
Behavioural				• Resistance to change • Informal opinion requests	• Social aspects • **Patient satisfaction**

Table 6.5 Factors affecting referring clinician PACS acceptance and meaningful use in private practice   (Red: Literature survey only; Purple: Primary data only; Bold Black: Both Literature survey and Primary data)

6.5 LIMITATIONS

The sample of private practice referring doctors participating in this study was primarily located in the Eastern Cape, South Africa. The doctors mainly refer to one private radiology practice, with multiple branches situated in and around the Nelson Mandela Bay Metropole. The respondents to the survey, therefore, had a limited frame of reference when reporting on their experiences and perceptions of PACS.

This cross-sectional study was also conducted five years after the radiology practice started implementing PACS in 2010. Consequently, the data gathered are reliant on accurate participant recollection of early PACS challenges to acceptance and the meaningful use thereof.

As previously stated, the small body of knowledge pertaining to private practice PACS acceptance and meaningful use presented a challenge, when conducting the literature survey.

6.6 FUTURE RESEARCH

The limited published research available on private practice referring doctor PACS acceptance presents an opportunity to broaden this body of knowledge. Future research applying the same conceptual framework in more private sector settings would help to confirm its transferability. A broader scope of participants, for example on a national level, would help extract information from a wider range of PACS contexts. These contexts should include urban, peri-urban, rural and resource-constricted settings. This would assist in confirming factors and may result in the addition of other factors.

A cross-sectional approach to measure PACS acceptance and meaningful use factors at various stages of the conceptual framework could produce more accurate point-in-time results – instead of relying on retrospective recollection by the participants.

The impact of patient privacy requirements on PACS remains an important area for further research, specifically the medico-legal aspects. Clear guidelines would help all the role players involved, including: radiology, referring doctors and patients.

Future research could investigate the extension of the conceptual framework used in this study past the Routinizing stage. The extended phases could, for example, account for the continual maintenance and improvements of a PACS implementation. This notion was briefly discussed in section 5.8.5.

Finally, the conceptual framework and the identified factors could make a meaningful contribution in studying PACS acceptance and its meaningful use in the South African public healthcare sector.

6.7 FINAL WORD

The financial impact of a PACS project failure could be devastating to private radiology practices. Physicians' acceptance and meaningful use is one of the key contributors to its success; and efficient patient care may ultimately suffer the consequences of any failure to implement this system to its full potential.

The researcher hopes that this study contributes to the expansion of the available body of knowledge, while playing some part in the success of current and future PACS implementations.

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APPENDIX A – Data Access Permission

P O Box 77000
Nelson Mandela Metropolitan University
Port Elizabeth, 6031
Summerstrand North Campus
Faculty of Engineering, the Built Environment & Information Technology
Tel . +27 (0)41 504-3278 Fax. +27 (0)41 504-3313

24 March 2015

Bayradiology
2nd Floor Execu Business Centre
36-38 Newton Street
Port Elizabeth
6045

Request for permission to access referring doctor contact information

Dear Sir/Madam,

I am conducting research towards a Master's degree in Information Technology (M Tech IT). The title of my dissertation is "A framework for the acceptance and meaningful use of Picture Archiving and Communication Systems by referring doctors in private practice". The study is conducted under the supervision of Prof. Dalenca Pottas, director of the School of ICT, NMMU.

I hereby request permission to access data for the purposes of distributing an online survey via email to referring doctors of the practice. Firstly, referring doctors with active PACS profiles that have logged on to the system at least once between 1 April 2014 and 31 March 2015 will be obtained. The logins will be cross-referenced to obtain email addresses. The questionnaire will seek to ascertain which factors influence PACS acceptance and meaningful in private practice. All referring doctor contact details collected will remain confidential and will be used for the sole purpose of collecting primary data in this research. Referring doctor participation in this study is voluntary and their identities will remain confidential at all times.

A copy of the research proposal can be made available on request, as well as a sample questionnaire. Furthermore, a copy of the full research report can be made available to the practice upon completion.

If you require any further information, please contact me via email s20312464@live.nmmu.ac.za, or phone 0825069011.

Thank you for your time and consideration.

Yours sincerely,

Gustav André d'Assonville
Student Number: 20312464

APPENDIX B – Pilot Study Covering Letter

Nelson Mandela Metropolitan University

for tomorrow

Summerstrand North Campus
Faculty of Engineering, the Built Environment & Information Technology
Tel: (041) 504-9100

17 April 2015

Dear Doctor

My name is Gustav d'Assonville, I'm enrolled as a Master of Technology student under the supervision of Prof. Dalenca Pottas in the faculty of Engineering, the Built Environment and Information Technology at the Nelson Mandela Metropolitan University in Port Elizabeth. I am conducting research in the field of acceptance and meaningful use of PACS (Picture Archiving and Communication Systems), specifically amongst private practice referring doctors. PACS systems are used to access X-Rays, scans and radiology reports on computers. Although this area has received some attention in the public sector, very few studies have conducted research in the private sector.

I will be collecting research data by means of a questionnaire and interviews. The first step before collecting the data is to pre-test or pilot the questionnaire to identify any problems relating to content, wording, lay-out, length, clarity, etc. I kindly request your assistance in this regard.

For your convenience, all correspondence will be done electronically. The questionnaire can be accessed via the following link:

http://forms.nmmu.ac.za/websurvey/q.asp?sid=1412&k=upetzzrkek

Answer each of the questions in the questionnaire. Bear in mind that the data that are captured, will not be retained as part of the study. You are only completing the questionnaire with a view to providing feedback on problems experienced while completing the questionnaire. Upon completion, send your feedback to the following email address: s20312464@live.nmmu.ac.za

In your feedback, comment on the follow criteria:

- Questionnaire length and time required to complete;
- Repetitive questions;
- Ambiguous questions;
- Unclear questions;
- Any other comments or suggestions to improve the questionnaire.

Note that participation is completely voluntary and will remain confidential. All necessary permissions have been sought and the ethical aspects have been met.

The final data collection instruments for this research will include a questionnaire and interviews. Should you be willing to participate in the interview phase, kindly let me know.

Thank you for your kind consideration.

Yours sincerely,

Gustav d'Assonville

NMMU Student Number: 20312464

APPENDIX C – Questionnaire Introduction Letter

Dear Participant,

<u>RE: REQUEST TO PARTICIPATE IN ACADEMIC QUESTIONNIARE</u>

My name is Gustav d'Assonville, I am enrolled as a Masters student under the supervision of Prof. Dalenca Pottas in the faculty of Engineering, the Built Environment and Information Technology at the Nelson Mandela Metropolitan University in Port Elizabeth. I am conducting research in the field of acceptance and meaningful use of PACS (Picture Archiving and Communication Systems), specifically amongst private practice referring doctors. PACS systems are used to access X-Rays, scans and radiology reports electronically. Although this area has received some attention in the public sector, very few studies have focused on the private sector, which will be the focus of my research.

The primary research data will be collected by means of a questionnaire. Your participation in this questionnaire will be greatly appreciated. Note that participation is completely voluntary and will remain confidential.

For your convenience, the questionnaire can be accessed and completed electronically via the following web link:

http://forms.nmmu.ac.za/websurvey/q.asp?sid=1412&k=upetzzrkek

Please note that anonymous results may be presented or published for academic purposes. All necessary permissions have been sought and ethical aspects have been met. Should you have any questions, please contact me (details below).

Many thanks in advance.

Yours sincerely,

Gustav d'Assonville

NMMU Student Number: 20312464
Cell Nr: 0825069011
Email: s20312464@nmmu.ac.za

APPENDIX D – Questionnaire

Questionnaire - 20312464

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A Framework for the Acceptance and Meaningful Use of Picture Archive and Communication Systems by Referring Doctors in Private Practice.

1. Biographical Information

1.1 *	Sex	○ Male ○ Female
1.2 *	Age (Years)	○ Less than 25 Years ○ 25-29 Years ○ 30-39 Years ○ 40-49 Years ○ 50-59 Years ○ 60 Years or more
1.3 *	First Language	○ Afrikaans ○ English ○ Sesotho ○ isiXhosa ○ isiZulu ○ Other
1.4	Please state first language if selected `Other` in question 1.3	[ ]

2. Experience

Work and PACS experience

2.1 *	Primary area of work in medicine	○ General Practitioner ○ Specialist
2.2	If Specialist, please specify	[ ]
2.3 *	Years of experience in medicine	○ 0-9 Years ○ 10-19 Years ○ 20-29 Years ○ 30 Years or more
2.4 *	Years of experience with private sector PACS	○ 0-4 Years ○ 5-9 Years ○ 10-14 Years ○ 15-19 Years ○ More than 19 Years
2.5 *	Rate your level of computer literacy	○ Not Computer Literate ○ Somewhat ○ Intermediate ○ Advanced ○ Power user or Expert

3. PACS Training

In terms of PACS Training

3.1 *	PACS training is necessary	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.2 *	Approximately how much PACS training have you received?	○ None ○ 1 Hour or less ○ More than 1 Hour to 2 Hours ○ More than 2 Hours to 3 Hours ○ More than 3 Hours
3.3 *	Based on your answer above, do you think it was enough training?	○ Yes ○ No
3.4 *	PACS training has a positive effect on PACS usage	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

Asterisk (*) indicates mandatory field. Student: Gustav d'Assonville | Student Nr: 20312464

4. PACS in general

General questions regarding PACS

4.1 *	On average. how frequently do you access PACS?	○ Once per day or less ○ 2-4 times per day ○ 4-6 times per day ○ More than 7 times per day
4.2 *	PACS is a useful advancement for your practice	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.3 *	Elaborate based on your selection above in question 4.2	
4.4 *	PACS has met your expectations	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.5 *	Elaborate based on your selection above in question 4.4	
4.6 *	PACS has improved your professional life	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
4.7 *	Elaborate based on your selection above in question 4.6	

5. PACS in consultations

PACS has a positive impact on your consultations in terms of the following aspects:

5.1 *	Showing patients their radiology images	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.2 *	Time spent finding patient radiology images	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.3 *	Time spent finding patient radiology reports	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
5.4 *	Overall efficiency of consultations	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

6. PACS during ward rounds

Please rate the impact PACS made on ward rounds in terms of the following:

6.1 *	PACS has a positive impact on the way ward rounds are conducted	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
6.2 *	Based on your answer in 6.1 above, elaborate:	
6.3 *	When do you routinely view images and reports on PACS for the purposes of ward rounds?	○ Before starting ward rounds ○ During ward rounds

7. PACS in theatre

In terms of theatre procedures:

7.1	PACS has made a positive impact on planning of theatre procedures	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
7.2	PACS has made a positive impact on execution of theatre procedures	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree

Asterisk (*) indicates mandatory field. Student: Gustav d'Assonville | Student Nr: 20312464

8. PACS media and access

Questions relating to media and network access

8.1 *	PACS is more effective than using film	strongly disagree ○1 ○2 ○3 ○4 ○5 strongly agree
8.2 *	Do you make use of physical media (e.g film, CDs and paper prints) in addition to PACS?	○ Yes ○ No
8.3	Based on your answer in 8.2 above, elaborate if answered Yes:	

8.4 * State the frequency of using PACS out of office (e.g. from home or while travelling but not including wards and theaters)?

○ Never
○ Seldom (Once per month or less)
○ Sometimes (2-3 times per month)
○ Often (4-8 times per month)
○ Very often (More than 8 times per month)

8.5 * Select the type of network connection most frequently used to access PACS

○ Local Area Connection (e.g. Hospital Network)
○ Internet - Fixed Line (e.g ADSL)
○ Internet - Mobile Broadband (e.g. 3G/HSDPA/LTE)
○ Internet - Wireless Internet Service provider
○ Other
○ Not sure

8.6 * Is it important to have access to radiology reports on PACS?   Not important ○1 ○2 ○3 ○4 ○5 Very important

9. PACS application tools

In terms of PACS image manipulation tools (e.g. zoom, window/levelling (brightness/contrast), measurements, multi-planar reconstructions (MPR), Maximum Intensity Projection (MIP), etc.):

9.1 * In your opinion, knowledge and proficiency of these tools are important for referring doctors   Not important ○1 ○2 ○3 ○4 ○5 Very important

9.2 * How often do you use these tools?

○ Never
○ Seldom (Once per week or less)
○ Sometimes (2-3 times per week)
○ Often (4-8 times per week)
○ Very often (More than 8 times per week)

9.3 Please select all that apply. I use the tools to:

☐ Verify clinical findings in radiology reports
☐ Highlight pathology to discuss with patients or colleagues
☐ Plan surgeries or other procedures
☐ I have no diagnostic use for the tools

10. Electronic Medical Records

In terms of Electronic Medical Records (EMR) (e.g. ProfDoc, MedEMass, etc):

10.1 *	Do you use EMRs to manage the clinical history of your patients in your practice?	○ Yes ○ No
10.2	If Yes, specify which product	
10.3	If Yes, do you import radiology images into your patients' EMR from PACS?	○ Yes ○ No ○ Sometimes
10.4	If Yes, do you import radiology reports into your patients' EMR from PACS?	○ Yes ○ No ○ Sometimes

11. Mobile PACS Viewers

In terms of mobile PACS image and report viewers for smartphones and tablets:

11.1 *	Are mobile viewers an important feature of PACS?	○ Yes ○ No ○ Don't know
11.2 *	How frequently do you use mobile viewers?	○ Never ○ Seldom (Once per month or less) ○ Sometimes (2-3 times per month) ○ Often (4-8 times per month) ○ Very often (More than 8 times per month)
11.3	If used, state your level of agreement with the statement: It has improved my consultations	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
11.4	If used, state your level of agreement with the statement: It has improved my ward rounds	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

12. PACS systems support

In terms of PACS systems support:

12.1 *	Did you make use of systems support to assist with PACS installation?	○ Yes ○ No
12.2 *	How frequently do you require PACS system support post installation?	○ Never ○ Seldom (Once per year or less) ○ Sometimes (2-3 times per year) ○ Often (4-8 times per year) ○ Very often (More than 8 times per year)
12.3 *	Is the availability of high quality PACS support important to PACS users?	Not important ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Very important

13. Conclusion

13.1 *	List three work related benefits you have encountered since the introduction of PACS	
13.2 *	List three work related disadvantages you have encountered since the introduction of PACS	
13.3	Are there any other aspects about PACS that you would like to highlight to the researcher?	

Asterisk (*) indicates mandatory field. Student: Gustav d'Assonville | Student Nr: 20312464

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