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The Organizational Implications of Medical Imaging in the Context of Malaysian Hospitals

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Abstract

This research investigated the implementation and use of medical imaging in the context of Malaysian hospitals. In this report medical imaging refers to PACS, RIS/HIS and imaging modalities which are linked through a computer network. The study examined how the internal context of a hospital and its external context together influenced the implementation of medical imaging, and how this in turn shaped organizational roles and relationships within the hospital itself. It further investigated how the implementation of the technology in one hospital affected its implementation in another hospital. The research used systems theory as the theoretical framework for the study. Methodologically, the study used a case-based approach and multiple methods to obtain data. The case studies included two hospital-based radiology departments in Malaysia.

The outcomes of the research suggest that the implementation of medical imaging in community hospitals is shaped by the external context particularly the role played by the Ministry of Health. Furthermore, influences from both the internal and external contexts have a substantial impact on the process of implementing medical imaging and the extent of the benefits that the organization can gain. In the context of roles and social relationships, the findings revealed that the routine use of medical imaging has substantially affected radiographers' roles, and the social relationships between non clinical personnel and clinicians. This study found no change in the relationship between radiographers and radiologists. Finally, the approaches to implementation taken in the hospitals studied were found to influence those taken by other hospitals.

Overall, this study makes three important contributions. Firstly, it extends Barley's (1986, 1990) research by explicitly demonstrating that the organization's internal and external contexts together shape the implementation and use of technology, that the processes of implementing and using technology impact upon roles, relationships and networks and that a role-based approach alone is inadequate to examine the outcomes of deploying an advanced technology. Secondly, this study contends that scalability of technology in the context of developing countries is not necessarily linear. Finally, this study offers practical contributions that can benefit healthcare organizations in Malaysia.

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Dedication

I dedicate this thesis to my husband, Lavon Teng Then Kee, my father, Mohd Nor Saad and my mother, Ainon Mat Isa. Thank you for your love, support and encouragement.

Seri warisan seni halus,

Ku susunkan sirih buat junjungan,

Melangkau benua menongkah arus,

Ku tamatkan jua perjuangan.

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Introduction

1. INTRODUCTION

Computer-based technologies such as medical imaging systems are increasingly being used in health care organizations in developing countries. Despite the acknowledged expense and difficulties associated with introducing these technologies, several studies have argued that they can be a viable solution to some of the on-going problems and healthcare challenges experienced by these countries. For example, a number of studies have found that the use of medical imaging can increase the efficiency of accessing, viewing and sharing patient radiographic images and diagnostic reports, and can promote teleradiology and teleconsulting activities. Teleradiology and teleconsulting are potentially beneficial for developing countries in addressing problems such as shortages of medical specialists and the lack of access to adequate healthcare infrastructures and services (Androuchko and Parlette, 2006). Furthermore, the utilization of medical imaging has also been found to be useful in containing disease outbreaks within hospitals. In the case of the severe acute respiratory syndrome (SARS) outbreak[1] for instance, the technology enabled the radiographic images of SARS patients to be readily available to

[1] According to the World Health Organization (WHO), SARS is 'the first serious and readily transmissible disease to emerge in the 21st century' (Evans, 2004:1). In handling SARS cases, 'a suspected case is classified as a probable case when there are radiographic findings of pneumonia' (Tsou et al., 2003).

clinicians which facilitated clinical consultations between the hospital's clinicians and radiologists, and allowed consultations to be conducted via telephone (Tsou et al., 2003). In addition, the use of medical imaging has helped to reduce the unnecessary movement of staff and materials from the radiology department, which helped to minimize the spread of the SARS virus (Lim et al., 2003).

Whilst the potential benefits of medical imaging systems appear alluring for developing countries, hospital-wide implementation of the technology is nonetheless challenging and risky, particularly for those nations experiencing constraints upon their financial and technical manpower. The World Health Organization (WHO) has consistently noted how these factors (among others) can impair the deployment and use of important medical technologies and devices that can save many lives[2]. Whilst substantial investment has been made in computerizing hospital information systems globally, in practice, many of these projects have not been successfully implemented (Littlejohns et al., 2003). In one case study situated in the Limpopo Province in South Africa, a lack of understanding about the complexity of the project and the health culture were identified among the factors that contributed to the failure of the health information system project that cost nearly £14million (Littlejohns et al., 2003). Nevertheless to date, with regard to medical imaging, several developing nations have actively deployed the technology in their community hospitals (Gerner et al., 1997; Frost & Sullivan, 2006, 2008). Malaysia is an example of such a nation.

Malaysia, in comparison to developed nations such as the UK, the US and Japan, can be considered as a late adopter of medical imaging. In the UK for example, the technology was first implemented at Hammersmith Hospital in the early 1990s (Lemke, 2003). In Malaysia, the establishment of an IT-based community hospital that was equipped with Total Hospital Information System (THIS) in the late 1990s marked the first implementation of medical imaging in the country[3]. Unlike Malaysia, the utilization of medical imaging among community hospitals in the UK is increasing. This is due to the initiaves by the NHS (the National Health Service) through NPfIT (the National Programme for IT) that covers more than 300 organizations across England (Collin et al., 2008). The project, claimed to be the

[2] http://www.who.int/en/

[3] Medical imaging is one of the critical components in THIS infrastructure designed for these two hospitals.

largest civil IT programme in the world, is estimated to cost around £6.2 billion and aims to deliver four critical components as follows: (1) NHS Care Records Service, (2) Electronic Appointment Booking, (3) Electronic Transmission of Prescriptions, and (4) Electronic Transfer of Digital Images (Currie and Guah, 2007). In Malaysia, as of 2007, there were four IT-based community hospitals that have implemented and utilized medical imaging. Whilst the technology has been deployed and used in Malaysian hospitals, research investigation pertaining to its deployment, utilization and impacts is scarce.

In the past few years, the impact of implementing medical imaging has received significant attention in the literature. Whilst the technology has the potential to enhance radiology service, access and delivery, its application can significantly affect and disrupt the old ways of organizing and performing radiology practice in a hospital. The technological components of medical imaging systems, specifically the integration of imaging modalities such as CT (Computed Tomography), MRI (Magnetic Resonance Imaging) and others with PACS (Picture Archiving Communication System), RIS (Radiology Information System) and HIS (Hospital Information System) affect traditional radiology work practices. Whilst the evidence of the intended and unintended consequences of implementing medical imaging systems is extensive, there has been a wide disparity in the literature with regards to empirical work examining the technology implementation in the context of developing countries.

This thesis investigates organizational implications of implementing medical imaging systems in hospitals in Malaysia. Whilst there substantial evidence to suggest that in general terms the implementation of medical imaging can have both desirable and undesirable consequences, there is a lack of systematic understanding of the impact of such technologies on organizational roles, social relationships and networks. This research draws attention to the roles of external influences in shaping the implementation of medical imaging, and in turn, can impact upon the organizational roles, social relationships and networks. The following further explains the importance of the research, including its purpose and contributions, and also describes its empirical setting. At the end of the chapter, an overview of the structure of this thesis is presented.

1.1 IMPORTANCE OF THIS RESEARCH

The contribution of the present literature with regard to increasing the understanding of medical imaging implementation and utilization is irrefutable. However, from the perspective of implementing the technology in organizations, the existing literature is inadequate for two main reasons. Firstly, many existing studies are either descriptive without an underlying theoretical grounding or their theoretical framing is weak; secondly, and more importantly, a large number of the studies are situated mainly in developed countries. Consequently, whilst there have been different effects of implementing medical imaging reported in the literature, these research outcomes are inadequate to effectively inform existing and potential technology adopters in developing countries about what sort of organizational impacts to anticipate, and how to respond to them. Also, although it is widely acknowledged that external influences can affect the technology implementation and use in developing countries (see for instance Braa et al., 2004, 2007 and Walsham et al., 2007), hitherto empirical works that attempt to examine the relationship between external influences and the medical imaging implementation and use in an organization are scarce.

In the organization and technology literature, a number of well-known empirical works have offered valuable insights in advancing theoretical understanding of the impact of technology upon organizational roles, social relationships and networks. One of them is Barley (1986, 1990). He (1986) examined the introduction of CT scanners in radiology work practices and illuminated how the use of the technology altered traditional roles and the social relationships of healthcare professionals, particularly radiologists and technologists. In a subsequent study, Barley (1990) adopted a role-based approach and applied Nadel's (1957) contention regarding relational and non-relational roles to investigate how technology impacts upon organizational roles, social relationships and networks, and in turn can impact upon organizational and occupational structures. Barley's studies (1986, 1990), however have two limitations. Firstly, his research only covers a narrow range of actors; and secondly, he ignores the external context.

To highlight the identified limitations in the literature, this research examines the impact of medical imaging technologies in hospital-based radiology departments in Malaysian community hospitals. Further, it addresses the limitations of Barley's studies (1986, 1990) in two ways. One, it focuses on a wider range of actors who are affected by the implementation of medical imaging in a hospital. Two, this research is conducted in two hospitals in Malaysia and reflects the role of the external context in the implementation of medical imaging.

1.2 PURPOSE OF THIS RESEARCH

This research investigated the implementation and use of medical imaging in the Malaysian context. More specifically, it examined how the internal context of a hospital and its external context together influenced the implementation of medical imaging, and how this in turn shaped organizational roles and relationships within the hospital. This research further examined how the implementation of medical imaging in one hospital affected the implementation of the technology in another hospital.

The following are the guiding questions that this study attempts to answer in order to achieve the objectives of this research.

1. What are the effects of implementing medical imaging on work practices?
2. Who are the actors that are affected by the implementation of the technology?
3. Does the implementation and use of the technology impact on roles, relationships and networks, and in what ways?
4. What are the internal and external influences that affect the implementation and use of the technology, and how they are related?
5. How does the external context shape the implementation and use of the technology?

1.3 EMPIRICAL SETTING

1.3.1 Case Studies

This research was situated in the radiology departments of two Malaysian community hospitals. Chapter 3 presents the detail of these organizations. In the Malaysian context, there has been a lack of information regarding the progress of implementing computer-based technologies such as medical imaging in hospitals. Hence, prior to selecting the organizations as case studies, the researcher conducted Phase 1 of the investigation which involved several interviews with representatives from 11 healthcare organizations, 9 of which were community hospitals. The interviews were conducted with 3 hospital directors, a deputy director of a university hospital, 2 senior specialists who were heads of clinical departments, and 10 senior officers in charge of hospital patient medical records. The outcomes of the Phase 1 investigation were used as a guideline to determine potential organizations as case studies for further research.

Prior to undertaking fieldwork at these organizations, the researcher obtained official approval for research access to these organizations from the representative of the Ministry of Health at the State Level, the Directors of the hospitals and the Head of Department at each organization. This study also obtained ethical approval from the Clinical Research Office at Imperial College London, UK.

1.3.2 Hospital-based Radiology Department

A hospital-based radiology department offers radiology services to hospital clinical departments, clinics and wards. There are two kinds of radiology services available in a hospital-based radiology department. The non-interventional radiology service is a standard service that involves radiology examination using general x-ray, CT, MR, Ultrasound and other imaging modalities. At the end of the investigation, the radiologist[4] will prepare a radiology report for the clinician based on his or her interpretation of the radiographic images. Typically, radiologists seldom have personal contact with the patient during the radiology examination process. The

[4] A radiologist is a medical specialist that specialized in getting and interpreting radiographic images (http://www.radiologyinfo.org/). He or she may obtain specialization in one or more radiology subspecialties such as interventional radiology, neuroradiology, breast imaging etc.

radiographers[5] are usually responsible for handling and monitoring the whole procedure of the radiology examination. The interventional service, on the other hand, requires radiologists to have personal contact with patients. Interventional radiology is a sub-specialty of the radiology discipline, and interventional radiologists assume greater therapeutic roles and perform different radiology tasks from the diagnostic or non-interventional radiologists (Murphy, 2003).

1.3.3 Radiology Work Activities and Tasks

In a hospital-based radiology department - particularly in the context of non-interventional services - there are five generic areas of work activity that directly or indirectly involve patients as follows:

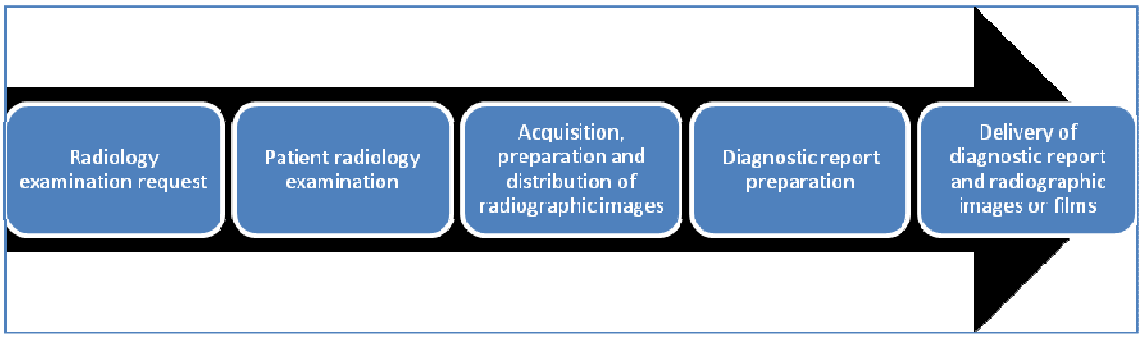


Figure 1.1: Five Generic Areas of Work Activities (Non-interventional Service)

(1) Radiology examination request: The process of admitting and registering a patient begins when a clinician, based on a clinical diagnosis, refers the patient to the radiology department. Traditionally, this request is submitted using X-Ray Request Form. In the context of medical imaging, patient registration is performed using the RIS (Radiology Information System) which is integrated with the HIS (Hospital Information System) database.

(2) Patient radiology examination: In the examination room in which the radiology examination is performed on the patient, there is frequent interaction between radiographers and radiologists, clinicians and sometimes nurses to facilitate the process. At all times, patient safety and well-being are the main priority.

[5] A radiographer is a healthcare profession that is trained either with the techniques of taking x-ray pictures or other images of the body parts for diagnostic radiology purposes. In the context of therapeutic radiology service, he or she is trained in the technique of treatment by radiotherapy (http://www.encyclopedia.com/doc/1O62-radiographer.html).

(3) Acquisition, preparation and distribution of radiographic images: Once the patient images are obtained, the radiographer prepares them (i.e., performing minor image editing such as image resizing, contrasting etc). In the case of using advanced modalities such as CT and MRI, the radiographer works closely with the radiologist in charge to make sure the right images are obtained. These images can be stored in hard copy (film-based) or soft copy (digital images).

(4) Diagnostic report preparation: When the images are ready, the radiologist will prepare a diagnostic report after reading and interpreting the image. The radiologist's experience, the nature of the patient case and the availability of patient medical records are important factors in preparing a diagnostic report. Typically, in complicated clinical cases, the radiologist and the patient's clinician will have clinico-radiological meetings to discuss the radiology findings or to review the patient cases. Sometimes, the radiologist may seek opinions from colleagues to assist them in preparing the report.

(5) Delivery of diagnostic report and radiographic images or films: The diagnostic report and the patient images/films are made available to the clinician.

1.4 DEFINITIONS

Medical imaging Medical imaging is defined in this research as an information system application that consists of a number of components, particularly imaging modalities, PACS (Picture Archiving Communication System), RIS (Radiology Information System) and HIS (Hospital Information System) where they are being linked and interfaced through a computer network.

PACS (Picture Archiving Communication System) PACS is a system that specializes in the acquisition, storage, processing, and distribution of radiographic image data (Ratib et al., 1996; Huang, 1999). A small-scale PACS installation can consist of a film digitizer, or a digital imaging modality such as a computed tomography (CT) linked to a display workstation, which is equipped with a small database to process and store the acquired images (Hynes et al., 1997; Huang, 1999). A large-scale PACS on the other hand, consists of wider system integration with various imaging modalities and other hospital systems. Large scale PACS is commonly termed Enterprise PACS (Huang, 2003).

RI S (Radiology Information System) RIS facilitates patient radiology examination scheduling, assists in tracking patient data and information, and permits online radiology diagnostic reporting.

HIS (Hospital Information System) HIS supports hospital administrative tasks such as patient registration, discharge and billing.

Imaging modality Imaging modality is used to obtain patient radiographic images. Examples of imaging modalities include CT (Computerized Tomography) scanner, ultrasound, MRI (Magnetic Resonance Imaging), General X-Ray etc.

1.5 ORGANIZATION OF THESIS

This thesis is organized in five chapters as follows.

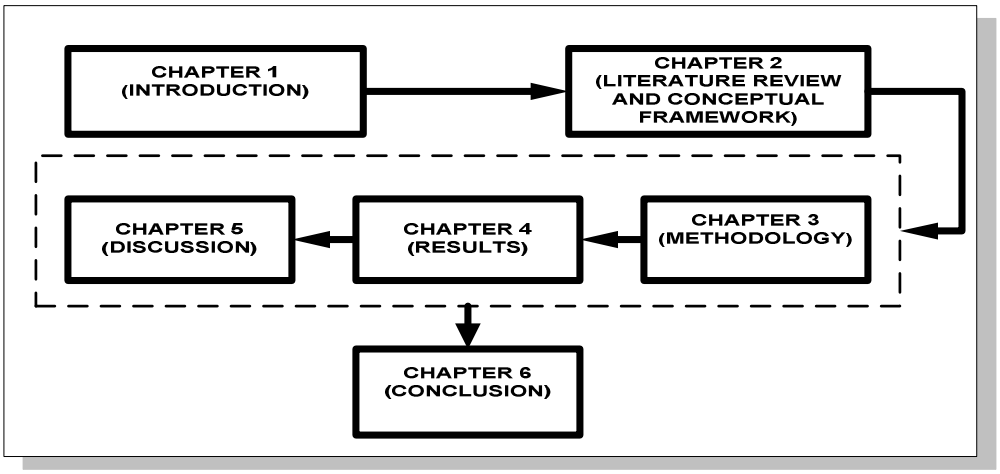


Figure 1.2: Thesis Component

Chapter 2 reviews the appropriate literature and presents the conceptual framework that guides the overall aspects of the research. This study in particular embraced the emergent perspective paradigm and systems theory in undertaking the research.

Chapter 3 describes the research methodology used in collecting data. This study used multiple research methods, and deployed a multi-level framework to systematically perform data analysis. This chapter also provides the descriptions of the case studies and presents the outcomes of the survey.

Chapter 4 presents the research findings. The description of the findings is framed in two related perspectives, namely medical imaging implementation and medical imaging use.

Chapter 5 discusses the findings further. The discussion is structured under the following three main headings: the relationship between the internal and the external contexts; the relationship between the technology and the organizational contexts; and the relationship between the technology and the user contexts.

Chapter 6 provides the conclusion from this research. It elaborates on the contributions of this research, and also the limitations of the study, in which opportunities for future research lie.

Chapter 2

Literature Review and Conceptual Framework

2. INTRODUCTION

Today, the design of computer-based technologies in healthcare is inarguably innovative and can offer a remarkable potential to facilitate healthcare practitioners in the process of making medical discoveries. In the field of radiology, the modern design of medical imaging systems bring enormous benefits and value to the healthcare practitioners who use them, but also present challenges to the organizations in which they are installed. It has been widely acknowledged that its implementation is risky, complicated and expensive. Nevertheless, medical imaging is generally viewed and accepted as a promising technology for developing nations to address many of their on-going problems.

In the present literature, there has been a growing interest in studying the impact of implementing and using medical imaging in hospitals. Based on the in-depth review of the current research, this study however found that the literature is presently overwhelmed with studies that put too much emphasis on the technological attributes of medical imaging and treated them as main causes that trigger organizational changes. Hitherto, there are only a handful studies that have made a serious attempt to systematically undertake research to investigate the impact of medical imaging from a different standpoint, i.e., deploying a qualitative approach. Whilst these

studies have shed some light on the potential institutional and organizational elements that influence the implementation and use of medical imaging, which can in turn shape its organizational impact, their findings are nonetheless confined within the experience of hospitals in developed nations.

Reflecting on the identified gaps in the literature, this study investigated the impact of deploying medical imaging from the experience of a developing nation, Malaysia, and considered several alternative theoretical views that could embrace multiple contexts and engage both macro and micro processes surrounding the technology implementation and use. Of the many potential theoretical standpoints, the emerging perspective paradigm, a structurational approach and systems theory to investigating the consequences of technology offered potential applications in the context of this research.

This chapter presents a review of the appropriate literature and the conceptual framework that guides this research. It has five sections and is organized as follows. The first section introduces the three theoretical paradigms used in the research, namely the technological imperative, the organizational imperative and the emergent perspective (Markus and Robey, 1988). Examples of empirical studies categorized under each of the paradigms are drawn from the information system literature. Subsequently, this section explains why the emergent perspective paradigm is relevant to this study. Thereafter, it reviews and elaborates structuration theory proposed by Giddens (1979, 1984). Then, it provides an analysis of studies from both organization theory and information systems research including influential empirical works by Barley, Orlikowski, Walsham, and DeSanctis and Poole that have applied and extended Giddens' ideas. A further review of empirical studies that deployed conceptual elements of structuration theory to examine the implementation and use of technologies in healthcare organizations is given. Thereafter, it provides justifications of why structruration theory is not appropriate for this research, and further explains why this study considers systems theory as applicable to the examination of the impact of medical imaging in the context of this study. This section ends with a discussion pertaining to the gaps identified in the literature.

The second section presents the conceptual framework of the research. This section further elaborates systems theory and explains how the theory and its assumptions are integrated into the research framework. It also elaborates on other relevant

theoretical concepts that are being deployed together with systems theory to achieve the research objectives.

The third and fourth sections of this chapter are presented as a supplementary literature review to elaborate on present medical imaging trends and their applications in radiology work practices. The literature review also examines the status of the Malaysian healthcare system and practices. These two sections are mainly focused on the relevant literature to advance the understanding of the research context, i.e. medical imaging implementation and use in hospital setting. Hence they are narrative reviews. Narrative reviews are deployed in order to gain a wide perspective on a particular research area (Cook and Mulrow, 1997).

The final section concludes this chapter.

2.1 TECHNOLOGY AND ORGANIZATION: THREE THEORETICAL PARADIGMS

Fifty years ago, Leavitt and Whisler (1958) speculated that in the1980s, information technologies and systems would have substantial effects on organizational forms, structures and management practices. They particularly anticipated that the use of technology would have a profound impact on middle and top management roles because it automates routine work, facilitates complex managerial decision making and enables information to be rapidly available. They argued that eventually the wide spread of technology would lead to more centralized organizations and also a reduction in middle management positions. They further contended that the use of technology would lead to radical transformation in many aspects of organizational practices and managerial roles.

Thirty years later, these insightful speculations have been confirmed by a number of researchers who have examined how technology affects organizations (Attewell and Rule, 1984; Pinsonneault and Kraemer, 1997). However, views and assumptions similar to Leavitt and Whisler (1958) with regard to the understanding about the nature of causality effect of technology upon organizations have been criticized as problematic and inadequate. In discussing a wide range of evidence on technology impact, Attewell and Rule (1984) for instance highlighted that the existing evidence is essentially mixed and situated in a variety of contexts. Due to this, they contended that it is inappropriate to just rely upon limited theories, assumptions and settings to

study the cause-effect relations regarding this subject. In the case of the Leavitt and Whisler (1958) predictions, there were also several contradictory views and evidence in the literature with regard to the effects of technology upon managerial and organizational practices (Attewell and Rule, 1984). Hence, Attewell and Rule (1984) suggested that it would be more constructive for the literature to have more empirical work that could examine the impact of technology from a variety of theoretical and methodological standpoints, and research settings. In the subsequent years, there have been many similar recommendations made by several prominent researchers such as by Markus and Robey (1988), Orlikowski and Baroudi (1991) and Walsham (1995).

Past studies particularly criticized the literature for the lack of clear conceptions and measures, and weakness in addressing conflicting research evidence (Markus and Robey, 1988; Orlikowski, 1992). It has been argued that whilst research about the consequences of implementing and using technology is clearly recognized as a subfield of information systems research (Culnan, 1986, 1987), the weak theoretical grounding and limited methodological approaches have created confusion and obstructed the progress of the literature (Markus and Robey, 1988; Benbasat and Zmud, 2003).

In tackling the issue about the nature of causality, i.e., what causes or shapes the impacts and why such impacts are happen that way, Markus and Robey (1988) suggest that it is important to examine the researcher's beliefs in theorizing the phenomenon. They highlight three theoretical paradigms existing in the literature, namely the technological imperative paradigm, the organizational imperative paradigm and the emergent perspective paradigm. They further suggest studies categorized under each of these paradigms have tendency to embrace either variance or process theories in building their own theoretical arguments, and adopt either micro-level, macro-level or mixed-level analysis in doing empirical studies. Markus and Robey's (1988) framework has been applied by a number of studies such as by: Klempa and Britt (1992) to classify prior research that examined the acquisition and diffusion of technology in organizations from two contexts, a rational view and a political view; Kurnia and Johnston (2000) to classify different types of theories with regard to technology diffusion and adoption; Jasperson et al. (2002) to analyze researchers' conceptions with regard to technology and organizational

power in information system and management research; and Sun and Zhang (2004, 2006) to systematically review the literature pertaining to the use of user technology acceptance model.

The following elucidates these theoretical paradigms.

2.1.1 Technological Imperative Paradigm

The technological imperative paradigm views 'technology as an exogenous force which determines or strongly constrains the behaviour of individuals and organizations' (Markus and Robey, 1988:585). Empirical studies that fit in this category tended to deploy variance theories, and framed the research theoretical constructs in term of variables (Markus and Robey, 1988). Variance theory aims to improve the predictive power of the regression equation by carefully selecting the right variables and modelling possible interactions among them (Franz et al., 1986). In such studies, 'antecedents are conceived as necessary and sufficient conditions for the outcomes to occur' (Markus and Robey, 1988:595). These studies treat technology as causal agent, and hence it enables or constraints change in organizations. In doing research, technology is treated as an independent variable, which in turn affects the dependent variable such as organizational structure (Sampler, 1996). Since technology 'determines the behaviour of the organization, organizational effort is directed toward identification and recognition of opportunities for using IT, resource requirements necessary to exploit these opportunities, and developing strategies and actions to accomplish the targeted objectives' (Klempa and Britt, 1992:346). Leavitt and Whisler's (1958) is an example of such study.

Franz et al. (1986) observed that in the early years of computing deployment in organizations, technology imperative paradigm is clearly reflected in the literature on computing and job contents. In their investigation about the impact of the Patient Care System on users' (nurses) attitudes and perceptions of task scope, they derived a number of variables based on the direction of the literature and constructed two hypotheses[6]. The survey results supported all of the hypotheses. The research found no significant change in nurses' attitudes and perceptions

[6] H1: The implementation of an online information system will not have significant impact upon users' perceptions of six job characteristics – variety, autonomy, feedback, dealing with others, task identity, friendship; H2: the implementation of an online information system will not have significant impact upon three attitudes of users toward the implemented computer system – performance, goals, urgency.

caused by the implementation of the technology. In reflecting on the outcomes of the study, they argued that the use a technological imperative paradigm to guide the research is rather restricted to account for an in-depth insight of the technology implementation and use in the hospital. They suggested that the research could increase its ability to explain the impact of the technology if it deploys an alternative view, particularly the interaction perspective model (i.e., emergent perspective paradigm) which is guided under process theory and places strong emphasis upon the process of change when a technology is implemented in an organization.

In the literature, it has been suggested that research guided under the technological imperative paradigm and is supported by variance theories, tends to be rather restricted and inadequate in addressing the dynamics within an organization setting (Franz et al., 1986; Markus and Robey, 1988; Orlikowski and Robey, 1991). The use of variance theories alone cannot capture the dynamics of the natural settings where technology is implemented and used (Kaplan and Duchon, 1988). Orlikowski (1992) further contended that the conception of technology under this paradigm is also very biased towards the materiality aspects of the artefact, and tends to ignore the role of human actors in developing, appropriating and modifying the technology.

2.1.2 Organizational Imperative Paradigm

Researchers guided under the organizational imperative paradigm hold a belief that there is 'almost unlimited choice over technological options and almost unlimited control over the consequences' (Markus and Robey, 1988:587). They view human actors as agents that enable and constrain organizational change, and treat technology as the dependent variable (Markus and Robey, 1988). The paradigm suggests that 'computer systems should be developed to fit the organizational context for which they are intended' (Franz et al., 1986). Human actions in designing and appropriating technology shape the consequences of implementing and using technology (Orlikowski, 1992). Most of the socio-technical studies can be categorized under this paradigm (Orlikowski, 1992). For example, in suggesting that technology can be an effective intervention strategy, Bostrom and Heinen (1977:18), by using socio-technical system theory has put forward a suggestion that 'the typical goal of an intervention into the technical system is an improvement in task accomplishment, while interventions which focus on the social system tend to look for improvement in QWL [quality working life]'. Technology designers and

organizational planners assume important control to make sure an organization can gain both technical and social improvement as a result of implementing the technology (Bostrom and Heinen, 1977). Another study by Francalanci and Galal (1998) adopted the organizational imperative view to study the productivity benefits of aligning IT investments and employee composition in the life insurance industry. They proposed three hypotheses[7] and used statistical techniques to analyze the data set of US life insurance companies of a 10-year period. The outcomes of the study (Francalanci and Galal, 1998:237) revealed that 'positive and negative effects on productivity may be related to higher IT expenses' and even if 'technology alone has a negative contribution to productivity', yet it is possible to uncover 'the positive effect of aligning IT expense and work composition' under an organizational imperative paradigm.

In the context of guiding research on the organizational impacts of computing, Franz et al. (1986) remarked that this paradigm offers a limited value because it imposes rather strict conditions on the design of technology.

2.1.3 Emergent Perspective Paradigm

The emergent perspective paradigm holds that the consequences of implementing and using technology 'emerge unpredictably from complex social interaction' (Markus and Robey, 1988:588). The body of research that adopts this view focuses on examining the dynamic interplay among human actors, technology and contexts. It has been acknowledged that this paradigm tends to admit 'greater complexity to the issue of causal agency and to the goal of predicting organizational changes' (Markus and Robey, 1988: 588-589). Research suggests that process theories fit with the views of the emergent perspective paradigm (Franz et al., 1986; Markus and Robey, 1988). Franz et al. (1986:38) mentioned that:

> '...process theory hopes to explain how and why outcomes occur in one situation by tracing the process through which various predictor variables interact with one another over time. Qualitative, longitudinal methods which capture the nature of the system development process are needed, rather than large sample methods which attempt to explain variance with regression equations...'

[7] H1: Increases in IT investments in conjunction with increases in the proportion of managerial workers are associated with positive increases in productivity; H2: Increases in IT investments in conjunction with decreases in the proportion of professional workers are associated with positive increases in productivity; H3: Increases in IT investments in conjunction with decreases in the proportion of clerical workers are associated with positive increases in productivity.

It has been highlighted that the emergent perspective paradigm with the support of process theories have more advantages than the technology imperative and organizational imperative with regard to exploring in-detail the process of change in organizations' natural setting (Franz et al., 1986; Markus and Robey, 1988; Orlikowski, 1992, 1993). A significant number of studies categorized under this paradigm have contributed immensely in the literature to advance the understanding about the impact of technology upon organizations. One of them is the category of studies that embraces structurational approach and adopts structuration theory by Giddens (1979, 1984). Structuration theory is 'an emergent, process theory which accommodates multiple levels of analyses, is contextually and temporally situated, and avoids the blinders of a historical accounts of social phenomena' (Orlikowski and Robey, 1991:164). The subsequent topics elaborate in detail about these studies.

The emergent perspective paradigm can offer insights to uncover the dynamic of interactions among relevant human actors surrounding medical imaging implementation and its use in hospital work setting. Its views are particularly relevant to guide the overall research of this study that focused on examining the impact of the technology in a developing country context. Walsham et al. (2007:324) observed that:

> '...Research topics in developing countries are normally deeply intertwined with issues of power, politics, donor dependencies, institutional arrangements, and inequities of all sorts. These are precisely the type of issues where critical work can "open up the black box" of accepted ways of doing things as an aid to deeper understanding..."

Hence, this study embraced the views of emergent perspective paradigm, particularly its assumption that the outcomes of deploying and using technology is influenced by and shaped through complex social interaction.

2.2 A STRUCTURATIONAL APPROACH

Investigating the organizational consequences of implementing and using technology from the context of structure has long been of interest to researchers of organization and technology research. Structuration theory particularly the conception of the duality of structure by Giddens (1979, 1984) has been widely referred and adopted in various research areas including organization and technology research. The following elaborates structuration theory and presents a review of several influential conceptual and empirical works from organization and technology research that applied structuration theory and have contributed directly or indirectly to its popularity in the present literature. A number of these empirical studies were recognized in the literature under the category of studies that hold the views of the emergent perspective paradigm i.e., Barley (1986, 1990), Orlikowski and Robey (1992), Orlikowski (1991) and Walsham (1993).

2.2.1 Structuration Theory

The conception of structure in analyzing and understanding a social phenomenon was originally derived from the social science discipline, specifically from sociology. Previously, Anthony Giddens (1979, 1984), a prominent British sociologist, reworked the classic conception of structure, in which he argued on the ground that these classical views that advanced by several well-known functionalists and structuralists are ontologically flawed and hence, inadequate for doing social analysis. He consistently maintained that the dualism view that has been deeply ingrained in the traditional conception of structure has encouraged the view of action and structure to be treated independently. He (1979) argued that this view is rooted in the objectivism and subjectivism paradigms of understanding social reality. According to Bourdieu (1989:14-15), objectivists '"treat social facts as things," according to the old Durkheimian precept, and thus leave out everything that they owe to the fact that they are objects of knowledge, of cognition-or misrecognition-within social existence', whilst subjectivists 'reduce the social world to the representations that agents have of it, the task of social science consisting then in producing an 'account of the accounts produced by social objects'. Subjectivists believe agents influence the creation and recreation of their social world through planned action and enactment (Orlikowski and Robey, 1991). Markus and Robey's (1988) conceptions of

technological imperative and organizational imperative paradigms share many resemblances with objectivism and subjectivism philosophical views, respectively.

In dealing with the issue of the dualism view in theorizing social change, Giddens (1979, 1984) proposed the duality of structure to replace the limitation of this view. The conception of duality of structure is at the heart of his theory, namely structuration theory. He (1984: 25) conceptualized structure(s) as 'rules and resources, or set of transformation relations, organizes properties of social systems'. The conception of the duality of structure holds that: 'structure is both medium and outcome of the reproduction of practices...enters simultaneously into the constitution of the agent and social practices, and 'exists' in the generating moments of this constitution...'(Giddens, 1979:5). Further, the process of structuration, according to Giddens (1984:25), is 'conditions governing the continuity or transmutation of structures, and therefore the reproduction of social system'. Giddens (1979, 1984) proposed three structural features of institutions in the process of structuration: signification; domination and legitimation. Signification is concerned with the codes or modes of coding, and 'new codes can be created, and symbols have the potential to stimulate new meanings through their associations with structures' (Riley, 1983:417). Legitimation 'concerns the interplay between value standards and sectional interests and does not necessarily imply collective agreement on common values' (Riley, 1983:417). Domination depends on the ability to deploy two types of resources: authoritative and allocative (Giddens, 1979, 1984). The following table differentiates the allocative and the authoritative resources.

Table 2.1: Allocative and Authoritative Resources (Giddens, 1984:258)

Allocative Resouces	Authoritative Resources
1. Material features of the environment (raw materials, material power sources)	1. Organization of social time-space (temporal-spatial constitution of paths and regions)
2. Means of material production/reproduction (instruments of production, technology)	2. Production/reproduction of the body (organization and relation of human beings in mutual association)
3. Produced goods (artifacts created by the interaction of 1 and 2)	3. Organization of life chances (constitution of chances of self-development and self-expression)

2.2.2 Empirical Studies in Organization Theory

Conceptual writings such as by Ranson et al. (1980), Wilmott (1981) and Pettigrew (1990) with regard to the theoretical insights of Gidden's structuration theory to rework the concept of structure in organization theory are very influential and have been widely referenced (Whittington, 1992). In studying organizational structures, Ranson et al. (1980:2) argued that whilst structure is typically understood as 'a configuration of activities that is characteristically enduring and persistent', yet many organization researchers have tended to treat structure as either 'a formal configuration of roles and procedures' which is more like 'the prescribed framework of the organization' or 'the patterned regularities and processes of interactions'. They argued that in order to convincingly explain 'how organizational structures change over time,' one has to go beyond these formal dimensions of structure because they are not unified and displayed 'a rather superficial relationship to the day-to-day work of an organization'. Drawing on Bourdieu and Giddens, they (1980) contended that 'the process of structuring itself defines and mediates organizational structures' because structuring process, in addition to create and recreate meanings and related to the element of power, is also shaped by two forms of organizational contextual constraints, namely organizational characteristics and environmental characteristics. However, the conceptual application of structuration theory by Ranson et al. (1980) has been criticized as too simplistic (Wilmott, 1981, 1990; Barley, 1986; Whittington, 1992).

Wilmott (1981) in his notable remarks on the study by Ranson et al. (1980) has argued that their conceptual stance, particularly with regard to the idea of contextual constraints is redundant and clearly detached from Gidden's original conception of structure. Wilmott (1981:471) mentioned that '...to account for the actual structuring of organizational structures, then the focus of our analysis must be upon how this structuring is practically accomplished...at the same time, it is equally important not to separate organizational structuring from the social totality that it serves to reconstitute...'. It is an inappropriate view to engage contextual constraints because in the conception of structuration theory, the external environment of an organization is also influencing and shaping the structuring process of an organization (Willmott, 1981). In adapting Gidden's conceptual ideas, Willmott (1990) particularly commended on the way Giddens had resolved the dualism view by linking the

conception of duality of structure closely with human actors' actions (agency) and structures in the process of structuring.

Pettigrew (1990), in explaining key assumptions to elucidate his theory of contextualism, has extended Giddens' (1979) conception of structure and referenced the adaptation of this concept by Ranson et al. (1980) to clarify the relationship between context and action. According to him (1990:270), context, in addition to serve as a stimulus environment, is also 'a nested arrangement of structures and processes where the subjective interpretations of actors perceiving, comprehending, learning and remembering help shape process...and processes are both constrained by contexts and shape contexts.' Process is 'a sequence of individual and collective events, actions, and activities unfolding over time in context' (Pettigrew, 1990: 338). He (1990: 270) proposed that structure and context should be conceptualized 'not just a barrier to action but as essentially involved in its production'. In other words, 'actions are embedded in contexts' (Pettigrew, 1997:338). Actors and groups mobilize aspects of structure and context as they focus to achieve results significant to them (Pettigrew, 1990). Pettigrew's theory of contextualism has been constantly adopted in research from various disciplines.

In addition to the abovementioned studies, there has been a series of other influential empirical research that have significantly contributed to the wide application of structuration theory, not just for organization theory but also for information systems research in examining the consequences of deploying technology in an organization. Barley's works (1986, 1990) are particularly influential in the information system literature (Pozzebon and Pinsonneault, 2000, 2001, 2005; Jones and Karsten, 2003, 2008; Jones et al., 2004). His studies (1986, 1990) are so far the most explicit in highlighting the organizational implications of using specific technologies. It was suggested in the literature that Barley's research approaches are an excellent example of dealing with Giddens's (1979, 1984) conception of the duality of structure (Pozzebon and Pinsonneault, 2005).

In studying how technology contributes to organization change, Barley (1986, 1990) has theoretically and empirically demonstrated that because of the organization's process of structuring, a similar kind of technology deployment contributes to very different organizational implications. He (1986) suggested that technology should be treated as occasions that trigger organizational structural change in order to resolve

research inconsistencies about how technology generates changes in organizations. Using ethnographic approaches, he (1986, 1990) investigated the implementation of CT scanners in two hospital-based radiology departments of two community hospitals in the United States and how the use of the technology alters roles, social relationships and networks. In both studies, Barley explicitly engaged Giddens' views of the duality of structure. He (1986:80) defined structures 'simultaneously as a flow of ongoing action and as a set of institutionalized traditions or forms that reflect and constrain that action'. Technology is one among many elements of social context that shapes day-to-day patterns of actions. Adapting negotiated-order theory and structuration theory, Barley (1986) went further by suggesting that organizational structural change as a result of deploying new technology is an outcome of the institutional template or structures modification. Explicitly, change of structures occurred because technology has disturbed or confirmed day-to-day patterns of action, and impacted on actors' interaction pattern. In the context of CT scanner implementation, Barley (1986) documented evidence of progression of change claimed that the deployment of CT scanners had changed traditional interaction pattern, organizational roles and social relationships.

In the subsequent study, Barley (1990) adopted a role-based approach and applied Nadel's contentions about relational and non-relational roles to investigate how technology impacts upon organizational roles and networks, and in turn can impact upon organizational and occupational structures. 'According to Nadel (1957), whilst 'relational roles cannot be played without an alter ego, a specific other who fills a complementary position in the social order', nonrelational roles in the other hand, demand 'no specific partners' (Barley, 1990:68). In his study, Barley (1990:68) treats roles as 'bundles of nonrelational and relational elements that can be separated only analytically'. He (1990:68-69) defined 'nonrelational elements encompass all the behaviours that individuals ordinarily perform as role incumbents, regardless of whether the behaviours are construed as obligations or are explicitly sanctioned'. He further suggested that 'because nonrelational elements of a role include skills and tasks, it is here that technologies are likely to have their most immediate impact'. He further contended that when technology alters tasks and skills (nonrelational elements), it will affect social relationships and also has potential to impact upon role's relational aspects. Organizational and occupational structures' transformation

occurs only when there is a spill over effect from the nonrelational elements to the role relational elements. As for impacts on networks, Barley (1990:69) focused on the change in 'the relationships that exist among all members of a collective'. He argued that social networks comprise of occupational and organizational structures. In the case of CT scanner implementation, Barley (1990) demonstrated how the technology transforms the role relations and social relationships in the two hospital-based radiology departments and affects the social networks. He contended that the change in role relations has altered traditional social networks. The introduction of CT scanner was found to contribute to 'higher status and prestige' among certain members, and also led to the divisions in social networks.

There are, however, two limitations of Barley's (1986, 1990) studies. First, his research was only focused on the interaction pattern between two technology users, namely radiologists and technologists in the situated practice of CT scan. While focused, this limits a richer understanding of social behaviour where 'action in the focal setting is conditioned by, and in turn conditions, social structure which extends beyond the focal setting' (Walsham, 1993:66). And second, despite acknowledging that the use of technology can impact upon networks, the research only focuses on the internal organizational social networks (i.e., professional colleagues such as clinicians, nurses, administrators and secretaries), and ignores the role of other actors external to the organization that can shape the overall impact of technology in organization. He (1990: 69) mentioned that 'if one conceives of structure as a global pattern that emerges from the relationships that exist among all members of a collective, then it is possible to link shifts in role relations directly and empirically to structural change by examining properties of social networks'. Yet, his analysis of the impact of technology upon networks was limited to the internal organizational context. Thus, Barley's works need to be extended to include the external environmental context to gain a more comprehensive understanding with regard to the consequences of implementing and using technology in organization.

2.2.3 Empirical Studies in Information Systems Research

In the information systems literature, there has been an increasing interest to engage structuration theory to gain an understanding about technology implementation and use, and how their impact upon users, organizations and societies.

Jones et al. (2004), in their critical assessment of Giddens' contributions in information systems research, have argued that whilst much of Giddens' works have tended to address high-level theoretical issues, yet many of his ideas and concerns are essential to the understanding of information systems' phenomena particularly with regard to the new technology implementation and use to support day-to-day work activities and practices. According to Jones and Karsten (2008:128), despite 'the almost total neglect of the technological artefact and its abstract, non propositional character', yet Giddens' structuration theory is appealing to many due to: 'its provision of a non-dualistic account of the structure/agency relationship, which may be seen to avoid determinism of either the technological or social kind (Markus and Robey 1988)'; 'its dynamic conceptualization of structure as being continuously produced and reproduced through situated practice, which facilitates the study of change (Orlikowski 2000)'; and 'its broad-ranging account of social processes, which takes in many phenomena of interest to IS researchers'. Previous reviews such as by Pozzebon and Pinsonneault (2000; 2001; 2005), Jones and Karsten (2003) and Poole and DeSanctis (2004) also made almost similar remarks regarding structuration theory's potential insights into researching information systems phenomena. Poole and DeSanctis (2004) specifically noted that structuration theory has its strong point in accommodating the study of change because the theory can embrace multiple research views, possibilities and levels of analysis. The following table, excerpted from Jones and Karsten (2008:135), presents the selected conceptual elements and assumptions of structuration theory, and their potential implications in the context of information systems research.

Table 2.2: Aspects of Structuration Theory That Impinge Most Generally upon Problems of Empirical Research in the Social Sciences and Some Potential Implications for IS Research (adapted from Giddens 1984, pp. 281-284)

	Key Feature	Implications for IS Research
1	All human beings are knowledgeable agents	Researchers should consider social actors as being highly knowledgeable about what they do (even if they are not always able to express it verbally) and as actively involved in the enactment of social practices (rather than being controlled by structural forces of which they are unaware)
2	The knowledgeability of human agents is always bounded on the one hand by the unconscious and on the other by the unacknowledged conditions and unintended consequences of action	Social actors' understanding of their practices is necessarily limited, so researchers should consider their accounts as offering only a partial explanation of their actions, which needs to be supplemented by other evidence
3	The study of day-to-day life is integral to the analysis of reproduction of institutionalized practices	If researchers want to understand large-scale, institutional, social phenomena that persist over time, they need to study the everyday practices of the relevant social actors that constitute them
4	Routine, psychologically linked to the minimizing of unconscious sources of anxiety, is the predominant form of day-to-day social activity	Most everyday social practices that researchers study are routinized (tending to reproduce social structures), and hence stable over time, because this is psychologically reassuring for social actors
5	The study of context, or of the contextualization of interaction, is inherent in the investigation of social reproduction	To understand how social practices are sustained over time, researchers need to study the particular setting in which they take place (rather than ignoring, or seeking to control, this setting)
6	Social identities, and the position-practice relations associated with them, are "markers" in the virtual time-space of structure	Although structure is virtual, its effects can be observed indirectly through its influence on the social roles that people play
7	No unitary meaning can be given to constraint in social analysis	A variety of different types of constraint (material, sanction, and structural) may enable and restrict social actors in a particular setting
8	Among the properties of social systems, structural properties are particularly important, since they specify overall types of society	Different types of society are characterized by different structural properties (that shape the norms, meanings, and power relations of social practices)
9	The study of power cannot be regarded as a second-order consideration in the social sciences	Accounts of social practices need to give particular attention to the operation of power relationships
10	There is no mechanism of social organization or social reproduction identified	People can always learn about social researchers' accounts of how society works and may draw on these in their actions

Source: Excerpted from Jones and Karsten (2008:135)

In the literature, in addition to Barley's studies (1986, 1990), it has been widely acknowledged that empirical works particularly by Orlikowski, DeSanctis and Poole, and Walsham have contributed substantially in advancing the popularity of structuration theory in information systems research (Pozzebon and Pinsonneault, 2000, 2001, 2005; Jones and Karsten, 2000, 2003; Jones et al., 2004). The following discusses their research contributions, including how they have applied structuration theory in their empirical studies.

Orlikowski's contributions to the literature can be seen in two ways. First, her (1992) initial conceptual propositions that information systems and technologies are embodied with structures is a bold attempt to provide insights into the innovative characteristics of the technology and to depart from the generic views of understanding technology as just merely 'hardware' or 'a social object'. She highlighted that these generic views create boundaries and measurement ambiguity, tend to overlook insights into how human agents use artefacts, and further restrict the ability to compare the technology use across studies and settings. Adapting from Giddens' conception of duality of structure, she proposed Structurational Model of Technology and further argued that this model can address the unclear and confusing conceptions of the role of technology in generating changes in organizations such as addressed by Markus and Robey (1988). The model has two central premises, that is (1) the view that 'technology is physically constructed by actors working in a given social context, and technology is socially constructed by actors through the different meanings they attach to it and the various features they emphasize and use'; (2) technology is interpretively flexible, and hence technology is 'potentially modifiable throughout their existence' (Orlikowski, 1992:406-408). In another study, Orlikowski and Robey (1991) further articulated the model and demonstrated how it can be integrated explicitly within structuration theory's dimensions of duality of structure proposed by Giddens. Examples of research that use Structurational Model of Technology in theorizing information systems phenomena can be drawn from studies such as by Brooks (1997) and Devadoss et al. (2003). Although Orlikowski's Structurational Model of Technology is attractive because it directs the research to take into account the contexts of technology design and use, yet the model is lacking of in-depth insights into the most important issues such as how and where technology enables and restricts action (Monteiro

and Hanseth, 1995). Most importantly also, Orlikowski's conceptions that technology is embodied with social structures have been criticized as inconsistent with Giddens' conceptions of the duality of structure (Orlikowski, 2000; Jones and Karsten, 2003). In structuration theory, Giddens avoids ascribing material existence to structures (Orlikowski, 2000).

Second, in the later attempt to address the limitations of her prior works, Orlikowski (2000:405) proposed 'technologies-in-practices' views, which is 'a practice-oriented understanding of the recursive interaction between people, technologies, and social action'. She (2000:407) emphasized on 'technologies-in-practices' structure, in which she defined as 'the sets of rules and resources that are (re)constituted in people's recurrent engagement with the technologies at hand'. She (2000:407) maintained that this structurational perspective on technology 'makes no assumptions about the stability, predictability, or relative completeness of the technologies…and the focus is on what structures emerge as people interact recurrently with whatever properties of the technology are at hand'. She demonstrated the application of 'technologies-in-practices' views using her previous ethnographic data, i.e., the use of Lotus Notes in three organizations to explain how technology impacts upon users and organizations. Boudreau and Robey's (2005) research findings with regard to the implementation and use of ERP system supported Orlikowski's (2000) contentions that the implications of technology for organizations are enacted in use.

Another influential work, by DeSanctis and Poole (1994) had adapted Giddens' duality of structure, and proposed adaptive structuration theory to examine the implementation and use of advanced information technologies (AIT) in organizations. They embraced similar views with Orlikowski and Robey (1991) and Orlikowski (1992) that technology embeds with social structures. In the case of advanced information technologies such as group decision support system (GDSS), the study suggested that the technology embodies with two forms of structural properties, namely the structural features and the spirit of this feature set. Structural features are 'the specific types of rules and resources, or capabilities, offered by the system'; the spirit of the technology is 'the official line which the technology presents to people regarding how to act when using the system, how to interpret its feature, and how to fill in gaps in procedure which are not explicitly specified' (DeSanctis and Poole,

1994:126). They proposed six hypotheses[8] and adapted Barley's (1990) research approach – diachronic, synchronic and parallel analyses[9] - to analyze the use of group decision support system by a small group of users. DeSanctis and Poole (1994:143) claimed that: AITs 'trigger adaptive structurational processes which, over time, can lead to changes in the rules and resources that organizations in social interaction'; and the consequences of using these technologies on group outcomes really depend upon 'the structural potential of its technology (i.e., its spirit and structural features), how technology and other structures (such as work tasks, the group internal system, and the larger organizational environment) are appropriated by group members; and what new social structures are formed over time. Adaptive structuration theory has been widely referenced and adopted in research focusing on the application of group support system. The theory however has been criticized as 'pursuing a very different agenda from that which motivated Giddens's original objectives in developing structuration theory, of which the rejection of positivism was a central feature' (Jones and Karsten, 2003). Pozzebon and Pinsonneault (2005) remarked that adaptive structuration theory is lacking of processual perspectives, and much of the subsequent studies that applied the theory embraced strongly upon variance approaches in conducting their research.

As for Walsham, most of his studies tended to address social aspects related to the outcomes of implementing and using technology. Walsham (1993) integrated structruration theory in his theoretical framework that ties the conceptual elements of content, context, process, and context/process relationship. Walsham (1993) argued that in the study about technology consequences in organizations, there has been too much focused in the literature with regard to the content of change, but very little emphasis on understanding the process of change and its relationship with the wider

[8] H1: AITs provide social structures that can be described in terms of their features and spirit. To the extent that AITs vary in their spirit and structural features sets, different forms of social interaction are encouraged by the technology; H2: Use of AIT structures may vary depending on the task, the environment, and other contingencies that offer alternative sources of social structures; H3:New sources of structure emerge as the technology, task, and environmental structures are applied during the course of social interaction; H4: New social structures emerge in group interaction as the rules and resources of an AIT are appropriated in a given context and then reproduced in group interaction over time; H5: Group decision processes will vary depending on the nature of AIT appropriations; H6: The nature of AIT appropriations will vary depending on the group's internal system.

[9] Barley (1986, 1990) deployed three comparative designs in his research, namely synchronic, diachronic and parallel. Synchronic analysis focuses on a comparison of within-case phenomena; diachronic analysis focuses on a transformation of phenomena; parallel analysis focuses on a comparison of phenomena across cases, and at a present of moment of time (Sandelowski, 1999).

contexts of organizations. In his theoretical framework, content of change reflects changes from organizational aspects (i.e. products, processes, systems) and the technology aspects (i.e. hardware/software/systems), whereas context captures social relationship aspects related to the changes caused by the implementation of technology. Context includes infrastructure, workplace setting and other relevant aspects that are significant to the social interpretation of the phenomenon. Walsham (1993) specifically deployed Giddens' structuration theory to provide a conceptual link between the elements of context and process. He suggested that Giddens' proposed modalities of structuration i.e., interpretative schemes, facilities and norms that tie action and structure, can enable in-depth analysis on the context and process of change in organizations. In another study, Walsham (2002) used structuration theory as a conceptual tool to examine cross-cultural working issues relevant to the context of information systems development and use. Based on two cross-cultural case studies, he demonstrated that structuration theory can permit a detailed analysis pertaining to individual and cultural sub-groups' differences. Walsham (2002) argued that structuration theory can address the limitation of Hofstede-type of studies that tended to aggregate differences between cultures using scores on variables such as power distance, individualism, masculinity, uncertainty avoidance, and long-term orientation.

Based on a review of the prior works that used structuration theory, Poole and DeSanctis (2003:220) proposed that there can be at least five ways of integrating structuration theory in designing a study of structuration in information systems research. The following table summarized these choices.

Table 2.3: Important Choices and Options for Researchers Studying Structuration

Choices	Optional Approaches
System level analysis	Institutional Global Micro
Structural focus	Related structure (s) Diverse structures
Framing	Structure view: influence of structure on action Actor view: actors' structural moves Alternating: structure and actor views
Dynamics	System change System stability
Stance	Positive Skeptical Critical

2.2.4 Empirical Studies Focusing on Healthcare Organizations: A Reflection

In the literature, it has been widely acknowledged that implementing hospital-wide information systems and technologies[10] in organizations is challenging and complicated. The intricate process of introducing and integrating new technology into hospital's work system is attributed by many factors particularly those rooted within the organization, the environment and the institutional contexts surrounding the technology implementation and use. Under structurational view, these factors in turn will shape the impact of using the technology in the organization. Whilst it has been highlighted that a research guided under the emergent perspective paradigm and supported by theoretical elements of structuration theory will be able to uncover multiple contexts and factors that contribute to the dynamic of shaping the outcomes of using technology, yet the interest to engage these theoretical perspectives is rather limited in the current literature. This study only found a small number of studies in the literature and the following provides a review of these studies, namely from Hussain et al. (2004), Rodriguez and Pozzebon (2005) and Brooks et al. (2008).

Hussain et al. (2004) adopted structuration theory as a sense making tool to examine how information system developers obtained end-users' acceptance of adopting an Intranet development project in one community healthcare institution in UK. The study integrated structuration theory's conception of legitimation with activity theory to analyze relevant organizational activities in achieving legitimation. 'Legitimation concerns formal and informal approval of stakeholders as social agents, whereby they agree to something that conforms to their social and personal norms' (Hussain et al., 2004:408-409). Legitimation is one of the three proposed structures in the process of structuration suggested by Giddens (1979, 1984). The other two are the signification structure and the domination structure. Activity Theory emphasizes upon a work activity as the unit of analysis (Hussain et al., 2004). The research produced the Legitimation Activity Model to identify the activities and processes relevant to legitimation, and utilized legitimition structure of structuration theory to further sensitize the research context. Based on a longitudinal case study approach, the study demonstrated that seeking legitimation to obtain stakeholder

[10] Medical imaging defined in this research is an example of a hospital-wide information system application.

acceptance of adopting an organization-wide information system application can generate many positive outcomes particularly in the context of influencing users in using the technology.

Brooks et al. (2008) have extended the conceptions of structuration theory with actor network theory to examine human actors' roles that commonly associated in the organization's clinical audit process. The study specifically argued that whilst the information system application such as Electronic Patient Record (EPR)[11] is gaining wide acceptance among UK healthcare organizations, yet the current clinical audit process in organizations is lacking of elements of patients' empowerment with respect to their decision pertaining to the health services provided to them. Clinical audit is performed to provide clinicians with 'a means of constantly improving both health care delivery and clinical outcomes against prescribed criteria' (Brooks et al., 2008). In the case of promoting 'patient-centred audit', the study particularly highlighted that, at present, 'the complex interaction between humans and technology is poorly understood by actors involved in the clinical audit process including managers, policy makers, information professionals and academic researchers alike' (Brooks et al., 2008). Brooks et al. (2008) developed a conceptual framework, termed StructurANTion. StructurANTion is a hybrid theoretical framework that integrates the conceptions of structuration theory and actor network theory. Brooks et al. (2008) suggested that actor network theory which emphasizes upon 'focal actor' in a complex socio-technical network can theoretically address the limitations of structuration theory in conceptualizing the role of technologies. The StructurANTion framework 'posits that, just as humans are facilitated in their agency by having an innate capability to draw on the modalities of the social system structurated order within which they exist and which, through their actions (re)create, so do non-humans, technologies; albeit, in a limited form' (Brooks et al., 2008). Information system software applications and infrastructures have 'structurated orders' inscribed in them during their development and implementation, and when these applications are utilized, 'they are translated into a network and used to carry out agency' (Brooks et al., 2008). Applying the framework to analyze the clinical

[11] EPR is a subset of Electronic Health Record (EHR); EPR 'describes the record of periodic care provided mainly by one institution' whilst EHR concerns with 'the concept of a longitudinal record of patient's health and healthcare – from cradle to grave' - combining both the information about patient contacts with primary healthcare as well as subsets of information associated with the outcomes of periodic care held in the EPRs' (cited from Griew and Currell, 2000:61).

audit practice within a primary care trust organization healthcare context, the study found that while there was a shift in the structurated order from clinician to patient centred in the audit activity, it was one of accommodation rather than a totally transformational one. Patients although may participate in the clinical audit process, yet they are not the one who is empowered in the activity. Brooks et al. (2008) further argued that the extension of Giddens' conception of reflexivity has been very useful to explore the role of reflexivity and emancipatory practices in their research context. In structuration theory, reflexivity is a concept related to 'self consciousness and also the monitored character of the ongoing flow of social life' and it is 'grounded in the continuous monitoring of action which human beings display and expect others to display' (Giddens, 1984:3).

Lastly, Rodriguez and Pozzebon (2005) applied structuration theory with critical discourse analysis[12] to provide insights into how the implementation of a Clinical Information System (CIS)[13] impacts upon healthcare organizations. The study specifically focused on 'how decisions and actions of CIS project managers contribute to the structuring of new technological solution within two complex organizations in two periods: CIS selection and pre-implementation'. Rodriguez and Pozzebon (2005) conceptualized CIS as a type of configurable technology and argued that both organizational requirements and technology design features of CIS have to fit each other in order to ensure the successful implementation of the technology. Using an in-depth longitudinal case study approach, the study reported that the CIS project managers of the organizations although they were aware of the organizational implications of implementing CIS, yet their decisions and actions were mainly driven by financial and political concerns between different decision makers' groups that were involved in the technology implementation process. The critical role of physicians in the pre-implementation process has been undermined because the CIS managers were consumed with issues pertaining to managing budget and most of their actions influencing by external social actor such as the Ministry of Health and the computer vendors. Whilst their research revealed several interesting findings, yet

[12] According to Phillips and Hardy (2002), discourse analysis views that 'social reality is constructed through the interconnection of various types of texts and their situated contexts' (cited from Rodriguez and Pozzebon, 2005).

[13] In general terms, a CIS is a computer-based application that is developed for the purposes of collecting, storing, manipulating and sharing clinical information important to physicians in the healthcare delivery process (http://www.biohealthmatics.com/technologies/his/cis.aspx).

Rodriguez and Pozzebon (2005) were not explicit in theorizing the phenomena using structuration theory and critical discourse analysis approaches.

Further, with regard to examining medical imaging implementation and use, this study found a rather limited empirical work that directly engages structuration theory and embraces the emergent perspective paradigm like Barley (1986, 1990) to provide in-depth insights toward understanding the phenomenon.

Studies by Davidson and Chismar (1999, 2007) adopted Barley's (1986, 1990) framework but the research focused on examining the impact of a computerized physician order entry (CPOE) system in hospital. Although their study (2007) did not cite or discuss Giddens' structuration theory directly, but the research has extended Barley's findings and engaged clearly how the complex interaction of an organization's institutional environment and technology implementation is reflected through role networks' transformation in hospital context. Explicitly, Davidson and Chismar (2007:740) reported that their research found that although 'the IT artefact was a proximate trigger of role change, but change processes were triggered ultimately by the hospital's response to change in the institutional environment'. They further argued that 'change in role networks preceded technology change, and the IT artefact per se was altered by network members'. Davidson and Chismar (2007) specifically drew upon Barley's (1990) framework for the alignment of social structure and technology and combined the approach exclusively with Barley and Tolbert's (1999) contentions that institutional (structural) changes are enacted at micro-analytic level. The research used an in-depth case study approach that involved one hospital and utilized multiple data collection techniques. Davidson and Chismar (2007) identified two institutionally triggered and one technology-triggered change processes in the research. They are the actions by the hospital leaders, the-on going institutional change and the implementation of the CPOE system. The following diagram illustrated their findings with regard to institutional change and the implementation of CPOE system.

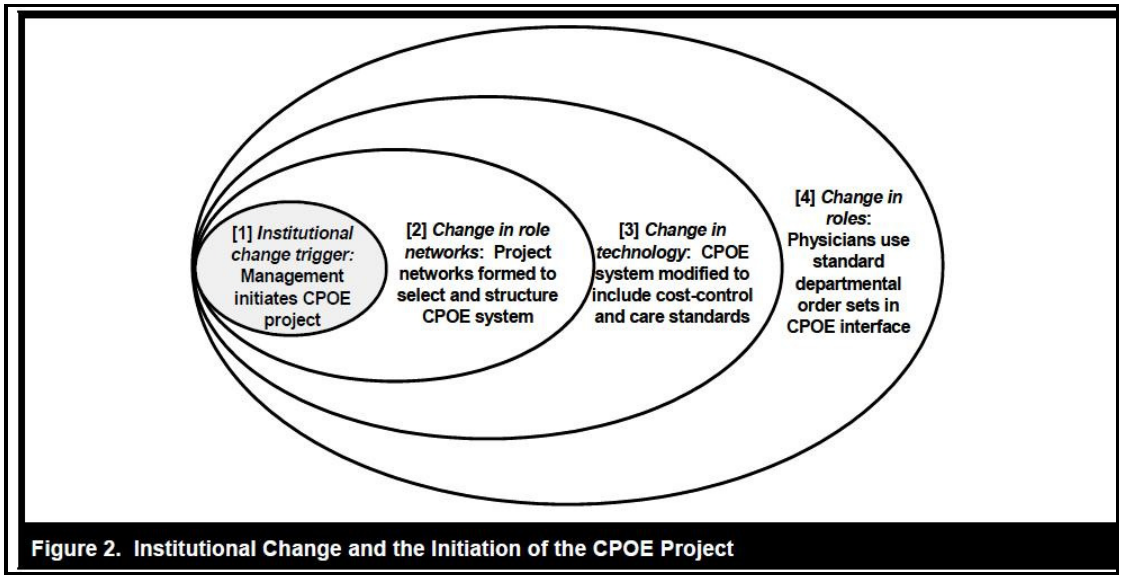


Figure 2.1: Davidson and Chismar's (2007:745) Research Findings

In addition to extend Barley's (1986, 1990) findings, the research also uncovered a number of relevant actors internal and external to the organizations and explained quite explicitly how their participation in the organizational interaction context is shaping the organizational outcomes of implementing the technology. In comparing with Barley's (1986, 1990) examination of CT scanner implementation, Davidson and Chismar (2007:754) remarked that 'the CPOE did not radically alter non-relational roles of physicians, nurses, or ancillary staff and thus has less of "ripple" effect than the imaging technologies Barley studied'.

2.2.5 The Appropriateness of Structuration Theory: A Reflection

Structuration theory, from the standpoint of this study, seems to offer great potential as a theoretical tool that can enhance the understanding of the impact of medical imaging upon roles, social relationships and networks. Under a structurational lens, the impact of deploying technology is assumed to have resulted from the interplay of organizational structures or institutions. Barley (1986) asserted that in the context of an organization, technology should be treated as occasions that instigate structural changes. In information systems research, few prominent researchers further extended the concepts of structuration theory to highlight the roles of technology users and designers, and at the same time directed the focus onto the innovative attributes of the technology in studying the implications of technology in organization (Orlikowski and Robey, 1992; Orlikowski, 1991; DeSanctis and Poole, 1994). Because technologies are simultaneously social and physical artefacts, both users and designers are involved in their design and appropriation (Orlikowski and Barley, 2001). Orlikowski (2000) went further to suggest that when users utilize a particular technology routinely, they will enact technology-in-practice structure. Theoretically, according to her (2000:410):

> '...When people use a technology, they draw on properties comprising the technological artefact – those provided by its constituent materiality, those inscribed by the designers, and those added on by users through previous interactions... People also draw on their skills, power, knowledge, assumptions, and expectations about the technology and its use, influenced typically by training, communication, and previous experiences...'

Further, there have been a number of recommendations put forward in the literature for new research to engage both macro and micro perspectives, and to consider the potential of structuration theory's concepts as a sensitizing device to study technology deployment and organizational change. Orlikowski and Barley (2001: 154) contended that engaging institutions (structures) can facilitate the development of 'a more structural and systemic understanding for how technologies are embedded in complex interdependent social, economic, and political networks, and how they are consequently shaped by such broader institutional influences.'

However, as a structuration theory works at a higher level of abstraction and ignores the role of technological artefact (Jones and Karsten, 2008), deploying it to conduct empirical research can be very challenging. This study identified one issue where

engaging the original ideas by Giddens (1979, 1984) can be problematic in the context of this research. Explicitly, from a theoretical standpoint, structuration theory implies that an organizational environment is attached with the organization's own structures (Willmott, 1981; Whittington, 1992). Although not directly referencing Giddens (Jones, 1999), Manning's (1982) structurational views contained many similarities and is very focused on the study of organizations. Therefore, his views are worth highlighting here. Manning (1982:130) argued that organizations 'do not exist except as images, as subjective congeries of experience which are bounded and located spatially and temporally'. With regard to the relationship between the organization and the environment, he (1982:122) described that to a certain extent, 'organizations define, structure, and shape the environment in which they are operating'. According to Manning (1982:122): 'the 'social construction' of the environment results as the interpretative work of organizational members is accomplished: they are socialized into organizational motives, contingencies, and team work, such that they can collectively make sense of negotiated situations; they engage in interactional sequences which serve to differentiate and integrate organizational segments; they absorb tacitly shared assumptions and emergent definitions of contingent situations; and they learn the principles, working rules and practices thought to be the commonsense basis of the occupation'. From this perspective, the environment also can be considered as an image. Its externality seems real. However, whilst the environment appears to be external and independent from the organization, he (1982) maintained that in reality it is difficult to draw a line between internal properties and external features that exist in the relationship between organization and environment.

From the standpoint of this research, Giddens and Manning's views on the relationship between organization and environment can pose theoretical and methodological challenges. Explicitly, from the theoretical standpoint, the above views do not support the aims of the research, particularly to examine the role of internal and external influences in shaping the implementation and use of technology, which can in turn impact upon roles, relationships and networks. They do not allow this study to conceptually distinguish elements or influences as being external or internal to the organization. Further, from a methodological standpoint, they also indirectly imply the need to deploy longitudinal research such as

ethnography. Under time and resource constraints, ethnography is not a feasible methodological choice to undertake this research.

In the literature, past research has demonstrated conceptually and empirically that the innovative attributes of information systems and technologies do not just reorganize work practice and social structure, but also substantially affect organizations and their environment. Boddy (2002) for example provides evidences on how the external context can shape the organizational members' actions, i.e., the users of the technology. His study was based on the implementation and utilization of computer-telephony integration systems in one organization. Boddy (2002) argued that the role of external users, explicitly the customers, cannot be ignored because they also influence the implementation and utilization of a technology within the organizational context. Past studies that have described the roles and the relationships between the external members and the members of organization with regard to the use of technology include: client-consultancy relationship (Pozzebon and Pinsonneault, 2005; Rodriguez and Pozzebon, 2005); user-IT designer relationship (Orlikowski, 1992; Bardram, 2005); organization- government agency relationship (Braa et al, 2004; Mohan et al., 2004; Chang et al., 2006); organization-industry relationship (Kim and Michelman, 1990); organization-customer relationship (Boddy, 2000); and user-patient relationship (Cox, 2002).

Tassabehji et al (2007) went further to suggest that structuration theory has restrictions in addressing the dynamic development of e-commerce and online technologies that create e-environment. They (2007:16) asserted that 'e-environments have moved organizational theory beyond Giddens' (1984) structuration theory, to an extended structuration theory that must also incorporate the features of the new complex and dynamic domain' of the e-environments. The application of structuration theory, when charting the relationship between the dimensions of technology, organizational form and function as well as the socio-environment, according to them (2007: 19), demonstrates: 'the direct impact of technology on organizational structure is the lowest, and the perceived human impact is greatest but the predicted organizational structure is weakest and uncertainty is greatest'.

Due to the above reasons and justifications, this study contends that it is more constructive to deploy systems theory and other relevant concepts including a contextual approach proposed by Pettigrew (1990) to undertake the research. These chosen theories and concepts provide pragmatic tools for this research to study the role of internal and external influences and the ways in which they affect the implementation and use of medical imaging in organizations. Their views permit the research to clearly identify the kind of influences that shape the implementation of the technology including the pertinent social actors and their roles at various levels. Hence, this study adopts these theories and views to undertake the research. They are further discussed in section 2.4 Conceptual Framework.

2.3 GAPS IN THE LITERATURE

Based on the literature review, this study has identified three gaps. The first gap is about the limitations of Barley's works (1986, 1990) and in what ways his works can be extended in the context of examining medical imaging implementation and use. The second gap concerns with the inadequate number of systematic empirical works that examines the organizational implications of medical imaging in hospital. Finally, the third gap addresses the concerns about the lack of empirical studies that examines medical imaging implementation and use in the context of developing countries. The following elucidates further these identified gaps.

(1) Addressing the limitations of Barley's works (1986, 1990)

As explained before, Barley's (1986, 1990) studies are rather restricted in term of actors identified in the research and the extent of the dynamics of the external context, in which as shown in the literature (i.e., Rodriguez and Pozzebon (2005), Davidson and Chismar (2007)) can affect organizational roles, relationships and social networks. It is within the intention of this study to fill these limitations of Barley's studies (1986, 1990).

(2) Lacking of systematic, qualitative empirical works in the study of medical imaging in hospital

This study has found a significant number of studies that investigated the impact of medical imaging in organization, in which they had conducted their study without a proper theoretical provision or guideline, and were very unsystematic in collecting their data[14]. These have led to serious doubts about the validity of their works and the reported research outcomes. Also, at present, several studies that examined the implications of using medical imaging in radiology work practices are predominantly positivist and quantitative in nature. Although these studies have contributed significantly to the literature, but they are unable to address the complexities and the subtleties of issues related to the implementation of medical imaging, and how the use of technology affects roles, relationships and networks. This study contends that it is more constructive for the literature to have more

[14] See for example Lindhardt (2001), Jorulf et al. (2001), Kinnunen and Pohjonen (2001), Maass et al. (2001), Pilling (2002), Kalinski et al. (2002), Hruby et al (2005), Mariani et al (2006), Yoo et al. (2008) and several others.

interpretive and qualitative studies that embrace the emergent perspective paradigm and use concepts from systems theory to provide in-depth understanding in this area of interest. These approaches permit research to include multiple levels of analysis, and hence they enable various contexts pertaining to a particular research topic to be examined. In the context of this study, such approaches can vigorously address the intricate phenomena linked with the implementation and the utlizatiion of technology in a developing country such as Malaysia.

(3) Lacking of research focusing on developing countries' context

Whilst the global trend has shown an increased use of medical imaging across developing countries, yet the research that examines the implications of implementing the technology in their context is sparse. This phenomenon however is not isolated. Walsham and Sahay (2005) and Walsham et al. (2007) for instance, in reviewing the literature about information systems in developing countries, have made a call for more research that can engage the perspective of these countries with regard to implementing complex and wide-scale technologies. Previously in the case of using PACS (a medical imaging component) in radiology research, Ozsunar et al. (2003) has reported that based on their systematic review on two journals in the field, the majority of the articles originated from the North America or Europe. North America particularly has published more than four times the articles compared to Asia region (Ozsunar et al., 2003). This large disparity of evidence in the current literature is a real stumbling block. The accumulation of research findings limited within a particular research context or setting undeniably can introduce biases, particularly in generating theories in the area of technology and organization change. In the context of this research, an empirical study of the implementation of medical imaging in Malaysia can contribute to inform academic and practitioner communities with regard to the technology impacts upon work practices, roles, social relationships and networks.

2.4 CONCEPTUAL FRAMEWORK

Past research has empirically demonstrated that the implementation of information systems and technologies generates changes to organizations when the routine use of the technology reorganizes work practices, affects organizational roles and mediates social relationships. In the context of medical imaging, only a handful of studies have made an attempt to examine the impact of implementing and using the technology from a qualitative standpoint, and to engage multiple levels of analysis that can illuminate the role of external influences. To address the present gaps in the literature, this study deployed general systems theory - particularly the views expressed by Katz and Kahn (1978) and Luhmann (1983, 1996, 2006) - as well as other relevant concepts, such as those developed by Pettigrew (1990) to investigate the organizational implications of medical imaging in the Malaysian context. The following elaborates, and discusses further the relevant theories, assumptions and concepts adopted to guide the research.

2.4.1 Systems Theory

Systems theory has a long history and has been widely referred and adapted in various disciplines. Whilst there have been many domains of the theory, all of them regardless of the knowledge areas, follow the basic conception that a system is composed of interrelated elements (Kast and Rosenzweig, 1985). The following figure presents the key concepts of general systems theory that have wide acceptance in various fields and knowledge areas (Kast and Rosenzweig, 1985).

Subsystems or Components: A system by definition is composed of interrelated parts or elements. This is true for all systems – mechanical, biological, and social. Every system has at least two elements, and these elements are interconnected.
Holism, Synergism, Organicism, and Gestalt: The whole is not just the sum of the parts; the system itself can be explained only as a totality. Holism is the opposite of elementarism, which views the total as the sum of its individual parts.
Open Systems View: Systems can be considered in two ways: (1) closed or (2) open. Open systems exchange information, energy, or material with their environments. Biological and social systems are inherently open systems; mechanical systems may be open or closed. The concepts of open and closed systems are difficult to defend in the absolute. We prefer to think of open-closed as a dimension; that is, systems are relatively open or relatively closed.
Input-Transformation-Output Model: The open system can be viewed as a transformation model. In a dynamic relationship with its environment, it receives various inputs, transforms these inputs in some way, and exports outputs.
System boundaries: It follows that systems have boundaries which separate them from their environments. The concept of boundaries helps us understand the distinction between open and closed systems. The relatively closed system has rigid, impenetrable

boundaries; whereas the open system has permeable boundaries between itself and a broader suprasystem. Boundaries are relatively easily defined in physical and biological systems, but are very difficult to delineate in social systems, such as organizations.
Negative entropy: Closed, physical systems are subject to the force of entropy which increases until eventually the entire system fails. The tendency toward maximum entropy is a movement to disorder, complete lack of resource transformation, and death. In a close system, the change in entropy must always be positive; however, in open biological or social systems, entropy can be arrested and may even be transformed into negative entropy – a process of more complete organization and ability to transform resources – because the system imports resources from its environment.
Steady State, Dynamic Equilibrium, and Homeostasis: The concept of steady state is closely related to that of negative entropy. A closed system eventually must attain an equilibrium state with maximum entopy – death or disorganization. However, an open system may attain a state where the system remains in dynamic equilibrium through the continuous inflow of materials, energy, and information.
Feedback: The concept of feedback is important in understanding how a system maintains a steady state. Information concerning the outputs or the process of the system is fed back as an input into the system, perhaps leading to changes in the transformation process and/or future outputs. Feedback can be both positive and negative, although the field of cybernatics is based on negative feedback. Negative feedback is informational input which indicates that the system is deviating from a prescribed course and should readjust to a new steady state.
Hierarchy: A basic concept in systems thinking is that of hierarchical relationships between systems. A system is composed of subsystems of a lower order and is also part of a suprasystem. Thus, there is a hierarchy of the components of the system.
Internal Elaboration: Closed systems move toward entropy and disorganization. In contrast, open systems appear to move in the direction of greater differentiation, elaboration, and a higher level of organization.
Multiple Goal-Seeking: Biological and social systems appear to have multiple goals or purposes. Social organizations seek multiple goals, if for no other reason than that they are composed of individuals and subunits with different values and objectives.
Equifinality of Open Systems: In mechanistic systems there is a direct cause and effect relationship between the initial conditions and the final state. Biological and social systems operate differently. Equifinality suggests that certain results may be achieved with different initial conditions and in different ways. This view suggests that social organizations can accomplish their objectives with diverse inputs and with varying internal activities (conversion processes).

Figure 2.2: Key Concepts of General Systems Theory (Kast and Rosenzweig, 1985: 450)

Overall, this study integrates several philosophical assumptions and views of general systems theory to clarify the relationship between organization and environment. This study particularly follows the stream of studies guided under the theory that views information systems and technologies as socially constructed. The subsequent subsections elucidate in detail these assumptions and views that are relevant to this research.

2.4.2 Luhmann's Views: Relationship between System and Environment

The prominent German philosopher Niklas Luhmann (2006)[15] exploited the theory of distinction to put forward his own philosophical views with regard to the relationship between system and environment. In elaborating on his conceptual views, he emphasized upon principles. Firstly, he (2006:38) proposed that 'a system is the difference between system and environment'. This statement implies that there is a boundary between system and environment, with the environment remaining outside. Secondly, because a system exists via the relationships between elements, he proposed that a system only needs a single mode of operation in order to reproduce the distinction between system and environment. According to him (2006:46), 'the effect of the operation contributes to the creation of a system' and sustains the existence of the system. In applying these concepts to social systems, he (2006:47) maintained that the mode of operation must meet the following conditions: it must be one single operation; it must always be the same; and it must possess connectivity. He stated further (2006:49) that a system that aims 'to control its own conditions of connectivity must have at its disposal a type of operation...call self-observation'. He (2006) argued that this concept was applicable when operating under the assumption that systems can reproduce themselves through communication. Thirdly, he (2006:37) proposed that 'every (social) system observes internally (i.e. within the system) its own system/environment distinction, there is a re-entry of the system/environment distinction into the system'. He (2006:54) further explained that:

> '...It depends on the distinction that is drawn by an observer who is capable of distinguishing whether his own distinction, between system and environment (which could be another system or, if the observer is involved in reflection, an earlier state of his own system) is meant, or whatever he is speaking of the distinction that is made within the observed system itself. The observer can make his appearance in two ways: as an external observer who sees that another system is observing itself, or as a self-observer, which is to say somebody who observes himself, refers to himself and states something about himself...'

Finally, he (2006:37) argued that 'every social theory is part of the social domain and as such part of what it describes'. He (2006:55) maintained that the researcher's standpoint is one of external observer where 'we observe society and see that society presents itself as a self-decribing system'.

[15] 'This text is an edited and translated transcript of a lecture that Luhmann held at the University of Bielefeld in December 1991' (Luhmann, 2006:56).

2.4.3 Organization as a System

Krikorian (1935:122) views an organization as 'a manifold of elements, each element being distinct, in a set of relations forming a whole'. He proposed that a relation that is important to the connotation of a particular organization is an intrinsic relation, and a relation that is accidental is an extrinsic relation. There are many elements, but the whole is always one (Krikorian, 1935). Based on systems theory, Krikorian (1935) further compartmentalized the three essential traits of organization - elements, relations and whole - to suggest the varied modes of organization. According to him, five distinct modes of organization exist, in this case: logical or the mathematical organization; spatio-temporal organization; substantial organization; causal organization; and purposive organization. Each mode has different and distinctive laws (Krikorian, 1935).

From the organizational standpoint, Lawrence and Lorsch (1967) conceptualized an organization as 'a system of interrelated behaviours of people who are performing a task that has been differentiated into several distinct subsystems, each subsystem performing a portion of the task, and the efforts of each being integrated to achieve effective performance of the system'. They contested that each of the subsystems develops certain attributes in response to its relevant environment. Despite some distinct characteristics of the subsystems, they (1967:4) suggested that there is a process of integration, in this case, 'the process of achieving unity of effort among the various subsystems in the accomplishment of the organization's task'.

Katz and Kahn (1978:63), from a wider perspective, viewed an organization as a subsystem of one or larger systems, and its relationship or integration with these systems influences its mode of operation and its level of activity. At the organizational level, they argued, there will be a process of integration that tends to be intricate due to the diverse dynamics of the organizational subsystems. With regard to the role of technology, they (1978:137) proposed to use the term "technological environment" to refer to 'the knowledge about technical processes and machine design existing outside the organization itself, more precisely as a specific type of informational milieu'. Technology will be part of the organization when the organization deploys and uses it (Katz and Kahn, 1978).

2.4.4 Organization as a social system

An organization as a social system has social structures (Katz and Kahn, 1978). 'A social system is a structuring of events or happenings rather than of physical parts and it therefore has no structure apart from its functioning (Allport, 1962)' (Katz and Kahn, 1978:36). Luhmann (2006) maintained that social systems produce and reproduce themselves through communication. He (2006:47) explained that:

> '...communication can be conceived as the synthesis of information, utterance and understanding. That is to say that communication happens when information that has been uttered is understood...'

According to Luhmann (1996:345), organizations are 'social systems based on communications that have to be interpreted as decisions'. He (1996) argued that, in addition to representing the self-observation of the system, the decision itself also has to recognize and acknowledge input from the external environment in its content.

At the organizational level, the social system is made up of a network of membership. For simplicity's sake, this study differentiates between the internal and external organizational members as follows: The external members refer to the people who do not belong to the organization but constantly interact with members of the organization; the internal members are the members of the organization. The term 'internal member' also implies 'a distinct organizational unit having (a) its own internal polity and economy, (b) some degree of autonomy from deterministic environmental forces, and (c) some ability to affect, shape, or manipulate its environment (Zeitz, 1980:74). Luhmann (1996) argued that via membership, decisions are made and remembered.

In an organization, internal members may carry multiple organizational roles, and each role that they carry, may involve various activities (Katz and Kahn, 1978). This study follows a recommendation by Barley (1990:68) to treat organizational roles as consisting of 'bundles of nonrelational and relational elements that can be separated only analytically'. Relational elements concern interactions, dependencies, and expectations between organizational roles (Davidson and Chismar, 2007). Non-relational elements consist of other aspects such as skills and tasks (Barley, 1990). Studies have empirically shown that the implementation of technology will have a direct impact on the nonrelational elements of roles (Barley, 1990; Davidson and Chismar, 2007).

2.4.5 Conception of Networks

Organizations as open systems carry certain patterns of activities, and they deploy and transform resources obtained from the internal and external environment (Katz and Kahn, 1978). From this philosophical view, 'an organization does not run down, because it can import energy from the world around it' (Katz and Kahn, 1978: 23).

Also because organizations are connected in their organizational field or environment, they tend to influence each other, becoming involved in the isomorphism process (DiMaggio and Powell, 1983; Husse and Krücken, 2008). The organizational field is referred to 'those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services of products' (DiMaggio and Powell, 1983). 'Isomorphism is a constraining process that forces one unit in a population to resemble other units that face the same set of environmental conditions' (Hawley, 1968 cited from DiMaggio and Powell, 1983:169). According to DiMaggio and Powell (1983), the organizations influence each other in their organizational field via four mechanisms, namely: (1) an increase in the extent of interaction among organizations in the field; (2) the emergence of sharply defined interorganizational structures of domination and patterns of coalition; (3) an increase in the information load with which organizations in a field must contend; (4) the development of a mutual awareness among participants in a set of organizations that they are involved in a common enterprise. They (1983) further proposed three mechanisms of institutional isomorphic pressures – coercive, mimetic and normative – that can contribute to the process of homogenization of organizations (isomorphism) in their organizational fields. According to Dimaggio and Powell (1983): coercive pressures are derived from the influence of institutional and political agencies such as ta mandate imposed by the government; mimetic pressures are derived from the environmental uncertainty, where the organizations imitate other organizations to deal with the nature of the uncertainty; and normative pressures stem mainly from professionalization in which the powerful group of professions (key actors) pressure organizations to conform their values and expectation.

Further, organizations as social systems are built from networks of social relationships. In the context of studying technology's impact on social structure,

Barley (1990) contested that because social relationships subsist among all members of a collective, it is possible to relate changes in role relations to the change of structure through the examination of properties of social networks. He (1990:70) explicitly proposed that:

> '...When introduced into a work setting, new technologies initially modify tasks, skills and other nonrelational aspects of roles. These modifications in turn, shape role relations. Altered role relations either transform or buttress the social networks that constitute occupational and organizational structures. Ultimately, shifting networks should either sustain or modify institutions, since the latter represent blueprints for ongoing action...'

Barley (1986, 1990) focused on the impact of technology on role relations and networks only at the organizational level, i.e. the hospital-based radiology departments. Because he excluded the details of the implementation context of the technology, his research could only account for the human actors (radiologists and technologists) that used the technology. Also, as the CT scanner system under study was a standalone application, the technology's application was limited within the workplace of radiology personnel.

Today, in the healthcare sector, many studies have acknowledged that because of the complexities of social and political structures, combined with a scarcity of economic and human resources, networking is essential for developing and non-rich countries to facilitate the development and diffusion of complex health information systems and technologies (Hannan et al., 2000; Siika et al., 2005; Braa et al., 2004; Braa et al., 2007). As networks are built from social relationships that exist among all members of a collective (Barley, 1986), it will be interesting to see in what ways networking aspects shape the implementation and use of medical imaging in the Malaysian context. Since medical imaging is perceived as a viable solution for the ongoing problems in the healthcare sectors of these countries, this study speculates that in the context of their community hospitals, the implementation of the technology in one organization will have some impact on other organizations.

2.4.6 Technology, Its Implementation and Use in Work Practices

This study views information systems and technologies such as medical imaging as a configurable technology. Fleck (1993) defined configurable technologies as 'technologies that are highly parameterizable, being built up from a range of components' to meet organizational specifications (cited from Pozzebon and Pinsonneault, 2005). In work practice context, this group of information systems and technologies can radically reorganize traditional work practices and can be complicated to implement in the organization (Pozzebon and Pinsonneault, 2005). Medical imaging, which consists of critical technological components such as PACS, RIS and HIS integrated under an extensive computer networking platform, has the potential to be extended beyond a single organization and to be accessed remotely via web technologies or wireless applications.

By recognizing medical imaging as a type of technology, the design of which can be reconfigured or extended, this study does not treat medical imaging as a fixed or stable technology throughout its period of use in the organization. In this sense, this study is different from Barley's (1986, 1990) assumptions with regard to the conception and use of technology in organizations. Orlikowski (1992) remarked that Barley's treatment of technology as a social object that is assumed to remain stable across time and its context of use can be problematic in the context of highlighting the innovative technological features of information systems applications. Understanding technology as a configurable artefact is compatible with Orlikowski's theoretical views that when users routinely utilize technology, a 'technologies-in-practices' structure emerges from this on-going interaction. This structure 'serves essentially as a "behavioural and interpretive template" (Barley 1988, p.49) for people's situated use of the technology (Orlikowski, 2000:410).

Also, at the analytical level, this study differentiates between the contexts of implementing and using technology. Orlikowski (1992:408) recommended that 'in attempting to understand technology as continually socially and physically constructed, it is useful to discriminate analytically between human action which affects technology and that which is affected by technology'. In the literature, the discourse pertaining to technology implementation in organizations generally focuses upon the dynamic interactions between different groups of social actors who participate in the technology's development and implementation; in the context of

technology use, the literature discourse generally focuses upon users' situated use of the technology.

This study proposes that by analytically differentiating the technology implementation context from the technology use context, it can explicitly identify the relevant human actors (internal and external members of an organization), their roles and in what ways they affect - and are being affected by - the technology. Unlike a standalone CT scanner application such as that observed by Barley (1986, 1990), medical imaging systems, as explained, emphasize the connectivity of multiple system applications (PACS, RIS, HIS, various modalities) via a computer network. In the context of use, medical imaging will bring in not just radiologists and radiographers (technologists) as users, but also clinicians and nurses. In the context of implementation, medical imaging implementation which can be reconfigured to promote telehealth activities will also illuminate the roles of other organizations and how the application (if any) will impact on organizational work activities.

In the situated use of technology, actors as users, who are influenced by their previous knowledge, experience and skills, may choose whether to utilize the technology and may use the technology according to their preferences (Orlikowski, 2000). Lamb and Kling (2003:202), integrating the views from structuration theory and institutional perspective, further proposed that users as social actors are 'pressured to perform legitimate actions and interactions within institutionalized arrangements'. Explicitly, their roles and social relationships are shaped via networks of their organizational and professional affiliations, the environment, their interaction with other social actors and their identities.

2.4.7 Adopting Contextual Approach

By nature, information system studies are contextual because they concern issues related to the organization's technology implementation and use (Avgerou, 2001). For this reason, it is not surprising why there have been a number of proposals in the past for new research to adopt a contextual approach to examining the implementation and use of information systems and technologies in organizations. Walsham and Sahay (2006) explicitly demonstrated the usefulness of using the contextual approach to examining the information system phenomena relevant to the context of developing countries.

The contextual approach was explicitly developed and engaged by Pettigrew (1988) to research about strategic change in organizations. Pettigrew (1988) proposed the consideration of two aspects of context, namely the inner and outer contexts of the organization, as well as the elements of content and process. According to him (1988:5), 'the 'what' of change is encapsulated under the label content, much of the 'why' of change is derived from an analysis of inner and outer context, and the 'how' of change can be understood from an analysis of process. Pettigrew (1990) termed contextualism as a theory of method. He highlighted the following key elements with regard to adapting the contextual approach. The first is to engage the interconnected levels of analysis in the study; the second is to associate and locate change with temporal context; the third is to explore the relationship between context and action; and the fourth is to embrace the assumption that change is neither linear nor singular. With regard to context and action, he (1990:270) argued that:

> '...Context is not just a stimulus environment but a nested arrangement of structures and processes where the subjective interpretations of actors perceiving, comprehending, learning and remembering help shape process. Thus, processes are both constrained by contexts and shape contexts, either in the direction of preserving or altering them...'

In the context of information systems research, Walsham (1993) demonstrated further how the contextual approach is useful in providing an in-depth understanding with regard to analyzing change as a result of implementing and using information systems and technologies. Walsham (1993) adapted and expanded the elements of content, context, process and context/process relationship in building the analytical framework to examine the social impact of technology. In his framework, he used structuration theory to provide a link between context and process. Further, Walsham and Waema (1994) empirically demonstrated the application of the framework to examine the development and implementation of strategy pertaining to information system implementation in one organization. In addition to using data from in-depth interviews, the study also relied upon internal documentary evidence (i.e. meetings minutes, internal memos etc) and external documentary evidence (i.e. newspapers and other articles from secondary sources).

This study adopts the contextual approach and further embraces the concept of content, process and context/process relationships to build the theoretical framework of the research.

2.4.8 Research Conceptual Framework

The following figure depicts the general outline of a conceptual map that encapsulates the above-mentioned elements of systems theory and the relevant concepts and views adopted in this study. This conceptual map serves as a framework that guides this study to achieve its objectives.

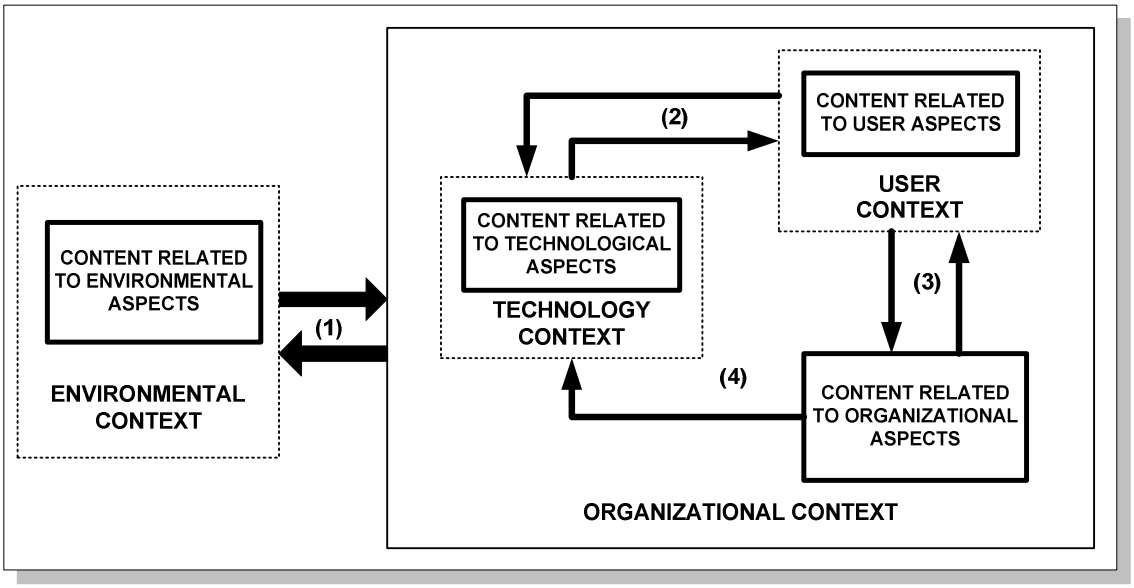


Figure 2.3: Research Conceptual Framework

The following further elucidates the framework:

1. Contexts [Organization, Environment, Technology and User]

- *Organizational Context* directs the focus on the aspects related to organizational and institutional elements that affect the implementation of the technology and shape users' ways of using the technology.
- *Environmental Context* focuses upon the activities of the organizational field which can affect the implementation and use of technology in an organization.
- *Technology Context* is concerned with the technology design characteristics infrastructures.
- *User Context* focuses upon users' roles, their work activities and the way they use technology to perform their work.

2. Contents [Environment, Organization, User and Technology]

- *Content Related to Environment:* This directs the research to identify the environmental influences, including the human actors that shape the implementation of the technology in the organization.

- *Content Related to Organization:* This directs the research to identify the organizational and institutional influences, including the human actors that shape the implementation of the technology and affect the users' behaviour in using the technology in the organization.
- *Content Related to User:* This directs the research to identify the users of the technology and focuses upon their behaviours, the way they interact with the technology and how the technology affects them.
- *Content Related to Technology:* This directs the research to focus on and to identify the specific attributes of the technology that are repeteadly used, and as a result, enact the 'technology-in-practice' structure.

3. Relationships [Arrow 1, Arrow 2, Arrow 3, and Arrow 4]

- *Arrow 1:* Organizations interact in their their organizational field; the external environmental factors shape technology implementation in an organization; the active roles of agency are reflected in this relationship;
- *Arrow 2:* Users enact technology-in-practice structure when interacting with technology; users' actions influence technology implementation and use;
- *Arrow 3:* Users' actions influence the organization's approaches and vice versa; the active roles of other human actors are reflected in this relationship;
- *Arrow 4:* The organization's approach shapes the implementation of the technology; the active roles of users and other social actors are reflected in this relationship.

2.5 GLOBAL TRENDS IN MEDICAL IMAGING IMPLEMENTATION

It is suggested that the demand for radiology service will continue to rise (see for example McLoud (2000), Smith and Baird (2007), Editor (2008) and Smith-Bindman et al. (2008)). Studies have attributed the ever increasing demand for radiology service to factors such as the global increase in illnesses (i.e., respiratory problems, cancer, stroke etc), the increase in world population (including aging citizens), the rise in urbanization and the worldwide healthcare programs and reforms (Mettler, 1987; Mettler et al., 1990; Sinclair, 1998; Sikora, 2002). In order to cater for this growing demand it is becoming increasingly common for healthcare organizations especially in developed countries to outsource some form of radiology service to foreign countries. For example, Nighthawk Radiology Services, US[16] which has used teleradiology to create business opportunity and to take advantage of the increasing demand for radiology service (Washington Times, 2008).

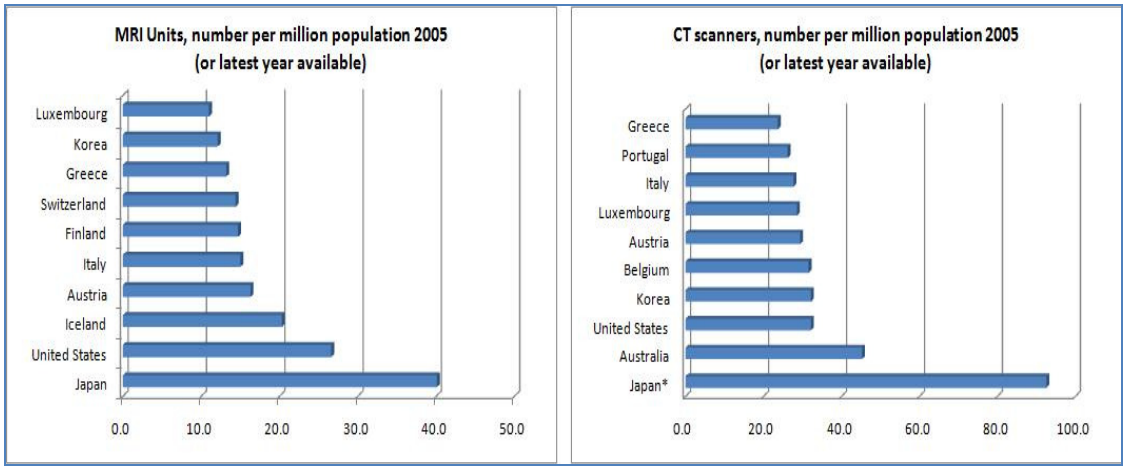
To meet the increasing demand for radiology services over the past few years, there has been a growing trend toward implementing medical imaging across hospitals worldwide. The following presents an overview of the global deployment of the various components of medical imaging such as imaging modalities, Picture Archiving Communication System (PACS), Radiology Information System (RIS) and Hospital Information System (HIS).

2.5.1 Imaging Modalities

According to the Freedonia Group Inc. (2007), in the year 2010, the market demand for medical imaging equipment for the United States will exceed US$16 billion, with an expected 6.8 percent annual growth from 2005[17]. The report anticipates that CT scanners will lead the market growth. Another report (2008)[18] states that Europe represents the largest market for 3D imaging applications and this market segment will be driven further by the continuous growth of MRI, CT and Ultrasound. In 2007, the OECD published a report on the availability of advanced modalities such as CT and MRI across OECD countries for the year 2005. In the report, Japan was ranked as having the highest number of CT and MRI units per capita, followed by Australia

[16] http://www.nighthawkrad.net/
[17] http://www.redorbit.com/news/health/863550/us_demand_for_medical_imaging_products_to_reach_214_billion/index.html
[18] http://www.electronics.ca/presscenter/articles/970/1/Global-3D-Medical-Imaging-Market-to-Reach-39-billion-by-2012/Page1.html

for CT units and the United States for MRI units. Turkey, Hungary and Mexico were ranked the lowest. It was suggested that factors such as national income and total health spending could play a role in influencing the diffusion of these technologies. Figure 1, excerpted from the OECD (2007) report, shows the top ten countries for CT and MRI units per capita.



*In Japan, data for CT scanners relate to 2002 rather than 2005, because the 2005 data is more limited in terms of coverage of institutions and type of CT scanners.

Figure 2.4: Top Ten OECD Countries for MRI and CT Units Deployment

Research suggests that a country's wealth and health expenditure can influence the rate of diffusion of expensive medical technologies particularly in radiology. Oh et al. (2005) statistically tested five categories of variables, namely purchasing power, patient needs, physician demand, government regulation and payment methods on the data of thirty OECD countries to examine the factors that influence the diffusion rate of CT and MRI. The study found that purchasing power which is represented by a nation's total annual health expenditure and economic incentives to hospitals can influence the diffusion rate for CT and MRI. Oh et al. (2005) research outcomes hence, confirmed many similar views about why there has been a huge disparity with regard to deploying advanced imaging modalities between developed and developing or non-rich countries. See for example a study conducted by Hutubessy et al. (2002) which found a low diffusion rate of MRI in several Asia countries[19].

There is a notable trend in the increasing frequency of use of advanced modalities. In the United States, from 1992 to 2001, there was an increased utilization of MRI and interventional radiology, but a relatively unchanged level of use for radiography

[19] China, India, Indonesia, Republic of Korea, Malaysia, Philippines, Thailand and Hong Kong

(Bhargavan and Sunshine, 2005). Another study by Khorasani et al. (1998) that examined in-patient radiology utilization trends from 1984 to 1993 in one tertiary hospital in the United States reported a significant increase in the use of CT and MRI, and a decrease in conventional imaging studies (plain films and fluoroscopy). A follow up study conducted by Matin et al. (2006) using a similar method to examine in-patient radiology utilization from 1993 and 2002, also reported a similar trend. According to Tanner et al. (2000), in the UK, from April 1997 to March 1998, there were about 41.5 million medical and dental x-ray examinations conducted annually[20]. Among NHS hospitals, the study found that the highest increment in frequency came from CT, interventional radiology and mammography examinations. For the period from 1997 to 2002, there was a constant increased demand for CT, MRI and non-obstetric ultrasound procedures and a relatively slight growth for ultrasound, radiographs, fluoroscopy, nuclear medicine and obstetric ultrasound among English NHS hospitals (Hart and Wall, 2004).

2.5.2 PACS

It is generally acknowledged that the innovative features of PACS have substantially transformed conventional radiology work practices and have been widely implemented across hospitals all over the world[21].

In Europe and North America, it is projected that by 2011, the PACS market will reach $8.6 billion (Marketwatch, 2007). In the United States, some analysts were optimistic that 90% of the health care facilities in the country would be equipped with PACS by 2010 (Jackman, 2004). According to the UK NHS (National Health Service), under the NPfIT (National Programme for IT) initiatives[22], as of 2007, there were about 127 trusts in England with PACS. By early 2008, the UK Department of Health announced that the NHS had completed the installation of PACS across all UK hospital trusts under the NPfIT initiative[23]. In the Asia Pacific region, Japan has been a leading player in PACS technological developments. Hence, it is not surprising that several studies mention the rapid growth of PACS installations in Japanese hospitals since the 1980s (Saranummi et al., 1992; Inamura et al., 2001;

[20] Obtained from http://www.hpa.org.uk/
[21] Details about the technological components of PACS can be read from Ratib et al., (1996), Huang (1999) or Branstetter (2007).
[22] http://www.connectingforhealth.nhs.uk/newsroom/news-stories/pacs-rollout
[23] www.cbronline.com

Inamura et al., 2003). As of 2002, it was reported that 1468 PACS units had been installed across Japanese hospitals (Inamura et al., 2003). The same study also mentions the increasing diffusion of PACS among hospitals in Korea and Hong Kong, although in the context of Hong Kong public hospitals, Cheung et al. (2005) state that the utilization of PACS usually does not expand outside the radiology department. The growing diffusion of PACS is also reported in Taiwan (Chang et al, 2006) and China (Fu et al., 2003).

In other developing countries such as in the South East Asia region, it has been suggested that PACS has a slow diffusion rate. Frost & Sullivan (2006)[24] attributed the slow growth in this region to factors such as high cost, under-developed health care facilities and a lack of ability to deliver the high-technology infrastructure. Nevertheless, due to the proactive role of the government and the increasing demand in the medical tourism sector such as in the case of Malaysia, Thailand and the Philippines, Frost & Sullivan anticipated a positive growth for the South East Asia market in 2009. As for third world countries, the status of PACS diffusion is unknown. However, there have been several on-going projects that capitalize on the innovative features of PACS to provide healthcare radiology assistance under e-health and telemedicine initiatives to help the third world countries such as Africa and others (Ferguson et al., 1995; Mbarika, 2004).

2.5.3 RIS/HIS Integration

A large scale PACS installation will include RIS and HIS applications. Whilst PACS enables the efficient storage, processing, management and retrieving of image data, RIS on the other hand, permits online diagnostic reporting, patient scheduling, tracking of patient images and billing. For PACS and RIS to effectively support radiology in a hospital, important data such as patient registration, admission and discharge needs to be obtained from the HIS database[25]. A study, that surveyed more than 275 sites that had implemented PACS, reported that over 75% of the sites had an interface with RIS, and about 48% had an interface with HIS (Ondo, 2004). According to Cannavo (2008), the growth of the RIS market is largely pushed by the expansion of the filmless work environment. RIS was argued to have low usage in a film-based radiology work practice (Cannavo, 2008). Initiatives such as Integrating

[24] http://www.frost.com/prod/servlet/press-release-print.pag?docid=82721303
[25] Some technical detail can be read from Huang et al. (1993) or Boochever (2004).

the Health Care Enterprise (IHE) taskforce that is responsible for establishing common integration standards such as DICOM and HL7 have facilitated the complex integration and interface between these major components of medical imaging (Boochever, 2004; Hood and Scott, 2006).

2.5.4 Learning from the Global Trends

There are two issues which can be drawn from the current trends in implementing medical imaging technologies. First, the increasing deployment of advanced imaging modalities such as CT and MRI will continue to drive greater demand for PACS installations. It is widely acknowledged in the literature that the use of advanced imaging modalities will lead to a higher volume of radiology images that need to be stored, processed and retrieved. PACS has been developed specifically to deal with the storage, access, distribution and retrieval of images. This dependency, suggests that there will be an increasing number of healthcare organizations particularly hospitals which will consider moving from a film-based to a filmless work environment. Second, despite the fact that acquiring medical imaging requires a substantial amount of resource, yet the technology has been increasingly deployed in developing and non-rich countries. Garner et al. (1997) argue that there is a trend amongst the governments of these countries to expand the public radiology service infrastructure and access including obtaining advanced imaging modalities and applications. Due to the government initiatives, Frost & Sullivan (2006, 2008) have positively anticipated the growing demand for medical imaging particularly in the case of South East Asia and the Eastern Europe regions. To date in the literature, the role of government is one of the least understood influential factors in the context of technology implementation in an organization.

2.6 MEDICAL IMAGING IN RADIOLOGY WORK PRACTICE

A hospital is a complex organization with a heterogeneous group of professional health care workers (Griew and Currel, 2000; Güler and Müldür, 2001). It was mentioned that the complex nature of the hospital work system contributes to high levels of ambiguity in the work processes (Spear, 2005). Explicitly, 'ambiguity over exactly who is responsible for exactly what, when and how' contributes to task redundancy, medical mistake and waste of resources such as labour time and money (Spears, 2005:82). Hence, many studies have recommended that the use of information systems and technologies is an appropriate organizational strategy to manage the complexities of the hospital work system.

In the context of this study, medical imaging supports five areas of radiology work namely: (1) the request for a radiological examination, (2) the examination process (3) the acquisition, preparation and distribution of radiographic images, (4) the diagnostic report preparation, and (5) the delivery of the diagnostic report and radiographic images or films. To facilitate the understanding of how medical imaging has challenged and reorganized the old ways of doing things, the following presents some pertinent issues surrounding these work activities.

2.6.1 Request for a Radiology Examination

In the traditional work practice, an X-Ray Request Form is used to transmit information between clinicians and radiology personnel, particularly the radiographers and the radiologists (Hanseth and Lundberg, 2001; Triantopoulou et al., 2005; Longrigg and Channon, 2006). In Malaysia, the sample in Appendix A is an example of an X-Ray Request Form used in the country. Besides clinical information, the X-Ray Request Form also carries important information such as patient contact details, age, any allergies, weight, pregnancy status and patient mobility conditions (i.e. wheelchair, trolley or able to walk). This information, is used by radiographers to facilitate the examination process and also to justify their decision in setting up the radiation exposure (if applicable) to the patient (Triantopoulou et al., 2005; Longrigg and Channon, 2006). For radiologists, clinical indicators given by the clinician in the Request Form will be used to decide if the requested examination is justified. This decision can be difficult especially if the patient's clinician has failed to provide

adequate information to justify the request (Triantopoulou et al., 2005). It has been noted in the literature that this kind of decision making can also create a dilemma for radiologists particularly if their decision 'is not in favour of the clinician's opinion' (Triantopoulou et al., 2005:309). In practice, both radiologists and clinicians have apprehensions in making any decision related to patients because of the legal responsibility (Harpole et al.,1997; Triantopoulou et al., 2005). To date, empirical studies have found that the use of an ordinary X-Ray Request Form is inefficient as a communication means between clinicians and radiology personnel. Incomplete information given such as the lack of a patient's demographic details, missing clinical justification for the examination request, missing clinician contact details and illegible handwriting are some of the most frequently mentioned drawbacks (Triantopoulou et al., 2005; Longrigg and Channon, 2006; Oswal et al., 2008).

With medical imaging, the radiology examination request is performed online using RIS application. The use of online ordering in radiology services is commendable because the application helps to overcome the inefficiencies related to the use of X-Ray Request Forms (Triantopoulou et al., 2005; Longrigg and Channon, 2006; Oswal et al., 2008). More significantly, research has found that online ordering (i.e., using RIS) can help to address on-going problems such as the inappropriate use of diagnostic examination. Harpole et al. (1997) for example discovered that online ordering where there is a function that enables 'real time, automated critiques on the ordering of radiologic tests', can be extremely beneficial to support clinical decision making. In their study, they found a positive outcome with regard to using such online ordering systems to curb the inappropriate use of abdominal radiographs. The result of the research revealed that whilst the clinicians appeared not to cancel their orders, they were willing to substitute an alternative radiology examination. The study also reported cost savings resulting from the implementation of online ordering applications. Other research that examined clinician ordering patterns for neuroradiology imaging studies, also reported a positive outcome of changed behaviour as a result of using online ordering system that had a decision support function. According to the study, about 60% of the clinicians had agreed with the guidelines for use of brain MRI (Sanders and Miller (2001) cited from Kuperman and

Gibson, 2003). The study also reported an increased use of brain MRI without contrast[26].

A significant number of studies have reported beneficial impacts to online ordering (laboratory tests, radiology exams and administering drug/medicine) in healthcare organizations. Kuperman and Gibson (2003) report in a systematic literature review that online ordering impact is associated with positive outcomes such as reduced medical error, increased compliance with several types of clinical guidelines, reduced costs and reduced hospital length of stay. In term of reducing medical errors (i.e., adverse drug reactions), Bates et al. (1998) based on a study at a large tertiary care hospital, reported that even for a modest system, as long as it has the attributes such as 'a dose selection menu, simple drug-allergy and drug checking and the requirement that clinicians indicate the route and frequency of drug doses', it can effectively help to reduce medical errors. In supporting clinical decision making, Davidson and Chismar (1999:5) report that their research participants (i.e., physicians) treat the online ordering system 'as a decision-making tool, because it enables them to obtain results faster, provides some cost information for selecting alternative medications, and, through the departmental or personal order sets, serves as a checklist and reminder when placing an order'. Davidson and Chismar (1999) concluded that online ordering can affect healthcare professions' (doctors, nurses, other clinical and non-clinical support staff) roles, relationships, social interactions and networks. In more detail elaboration, Davidson and Chismar (2007) observed that, in addition to skills and knowledge, the use of the application has affected physicians and nurses' tasks in performing clinical order. They however did not observe any role change as what Barley (1986, 1990) had documented in his study about the use of CT scanner. They concluded that because online ordering system is primarily a communication and coordination technology, hence its impacts upon organizations were explicitly found in the area related to interdepartmental activities and decision making.

[26] MRI contrast agents sometimes are required to be given to a patient undergoing MRI to increase the visibility of body parts such as brain, spinal cord, and heart. The contrast agents can lead to several side effects and may pose certain risks to certain patients (http://www.ismrm.org/special/EMEA2.pdf).

2.6.2 The Examination Process

The effective handling of radiological examinations leads to the optimal use of radiology personnel time and modalities. In practice however, their work is affected by many factors such as the type of modality, whether there is a requirement for special procedures, the patient, and the radiographer's skills and so on.

There are three categories of patients that use hospital radiological services, namely referral outpatients, inpatients and emergency patients. In the context of handling CT patients, Reiner et al., (1998:482) described the radiographer's tasks to include the following: 'discussion with the patient including questions and answers'; 'obtaining patient consent for intravenous administration of contrast material when applicable'; 'patient registration into the radiology information system, including retrieval of laboratory information'; 'positioning of the patient on the scanner'; and 'setup of the CT scanner, including entry of patient and study information'. Hence, radiographers - who mostly deal with the patients - must acquire skills in communication to ensure that the patients receive the best care and safety while undergoing the radiology examination.

There are two ways in which patients can affect the efficiency of this activity. First, research reports that undergoing a radiology examination can be a tense experience for some patients. Davies and Channon (2004) for example describe the stressful experiences and difficulties of experienced by deaf patients due to communication problems. According to the study, in the case of MRI, 'a significant proportion of hearing patients consider an MRI scan to be an unpleasant experience, reporting feelings of 'panic, claustrophobia and considerable apprehension' (Davies and Channon, 2004:104). In the literature, these anxiety-related reactions are frequently mentioned as factors that cause MRI examination failure (Dantendorfer et al., 1997; Sarji et al., 1998). In practice, under these circumstances, an immediate cessation of the examination is necessary to ensure patient safety. The alternative option is either to reschedule the examination or use an alternative radiological examination for the patient. Second, it has been noted in the literature that the on-going problems with outpatients arriving late, not showing up, or making last minute appointment cancellations can obstruct efforts to attain effective patient scheduling. Empirical studies reported that such problems will lead to an increased in waiting lists and contribute to an economic loss for the hospital (Geitung and Gothlin, 1994; Lyon and

Reeves, 2006). The highlighted problems will contribute to a vacant slot in the radiology examination room.

To date, whilst empirical studies have reported that medical imaging use can positively impact on inpatient clinical care, the length of hospital stay and overall hospital productivity (Siegel and Reiner, 2003; Nitrosi et al., 2007), there are no attempts yet to examine in what ways the medical imaging features that permit quick access to hospital information such as up-to-date patient registration information and status, as well as patient contact details can facilitate the handling of patient radiology examination. Explicitly, the question of whether medical imaging assists radiology personnel (i.e., radiographers and radiologists) in making arrangements to effectively manage the abovementioned circumstances and problems.

2.6.3 Acquisition, Preparation and Distribution of Radiographic Images

Traditional ways of preparing radiographic images were laborious and time consuming process. Using a darkroom could cause long-term health problems to personnel because of prolonged exposure to chemical agents. The term 'darkroom disease' described common symptoms such as respiratory, dermatological and cardiac disorders experienced by some personnel (Nallon et al, 2000). When the automatic film processor and laser printer reached the mass market, the darkroom was no longer needed to process films.

Nowadays, imaging technologies mean that the radiographer's activities, with regard to the acquisition, preparation and distribution of radiographic images can be performed more quickly and efficiently. In comparison to a film-based environment, PACS can reduce a significant number of the steps in the process and the time to prepare and to transport the images to radiologists (Reiner et al., 1998; Siegel and Reiner, 2002; Siegel and Reiner, 2003; Mariani et al., 2006). The following diagram excerpts from Reiner et al. (1998:484) is an example to show a comparison of filmless and film-based work environments in the context of radiographer's activities in preparing a CT image for radiologists.

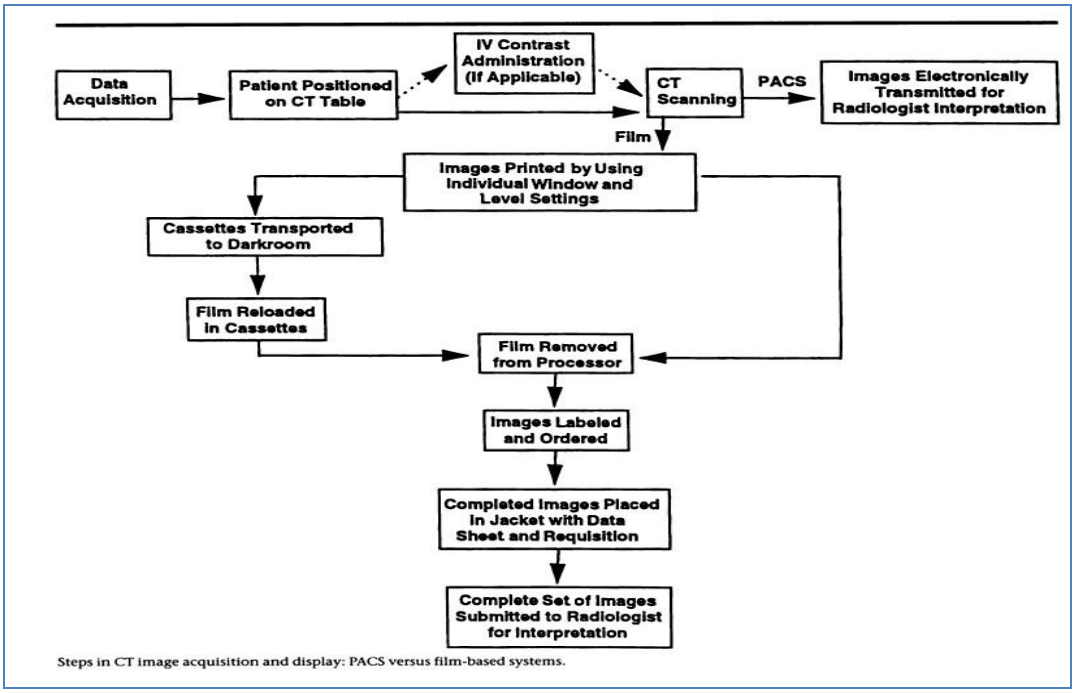


Figure 2.5: Steps in CT image acquisition and display: filmless versus film-based (excerpted from Reiner et al., 1998:484)

In the preparation of CT images (starting from handling the patient in the examination room, performing the CT exam, and preparing images for radiologists) , Reiner et al. (1998) reported a reduction of 45% in terms of the time taken with a filmless system in comparison to the conventional system. In the film-based environment, the 'miscellaneous and delay' times in work operation were largely caused by common interruptions such as: (1) entertaining frequent requests by clinical personnel to retrieve CT films from the printer, and (2) temporary mechanical problems associated with the film processors. Image despatch (including historical images) to radiologists is undoubtedly faster than the film-based environment because it can be performed online.

In handling non-routine, special radiology examinations or procedures, close interaction between the radiographers and the radiologists is needed to ensure that the images meet the radiologist's requirements. In practice, this is important as it serves as a mechanism to prevent unnecessary radiation exposure or mistakes that might harm patients. Barley (1990:84) wrote his observation on the relationship between radiologists and radiographers (technologists) as follows:

> "...In the main departments, radiologists played a relatively minor role in all procedures. They took no part in routine x-rays and were present during fluoroscopic exams and IVPs only long enough to perform the fluoroscopy or administer and injection of iodine dye, both of which required no more than five minutes to complete. During an IVP or a fluoroscopic exam, techs were at various points required to show a radiologist the films they had taken in order to receive additional instructions. These encounters usually occurred in the radiologist's office and lasted no more than a minute. In contrast, the newer modalities brought radiologists and technologists together for longer periods of time. During special procedures, radiologists and technologists worked side by side in surgery atmosphere. Radiologists assigned to CT spent considerable time with technologists at the scanner's console..."

2.6.4 Diagnostic Report Preparation

In doing diagnostic report, radiologists read and interpret the image first. In the context of complicated clinical cases, clinico-radiological meeting will be initiated between the radiologist and the patient's clinician (Weatherburn et al., 2000). In clinical practice, the outcome of the radiologist's diagnosis will affect the clinicians' approaches and strategies in treating the patient.

In the literature, a large number of studies have reported a wide range of outcomes related to the use of PACS and RIS in the abovementioned activities. The following discusses some of the research findings pertaining to the use of PACS and RIS in supporting the radiologist's work.

It is acknowledged that the use of PACS has greatly facilitated image reading and interpretation because it enables efficient image retrieval and viewing (i.e., see for example Kundel et al., 1996; Stacul, 1998; Langlois et al., 1998; Watkins, 1999; Watkins et al., 2000; Lindhardt, 2001; Yu and Hilton, 2005 etc). However, it is also reported that although this capability of PACS contributes to an increase in the number of images viewed per reporting session and hence radiologists' workload (Bryan et al., 1998; Pilling, 2002; Reiner et al., 2000; Siegel and Reiner, 2003; Nayak et at., 2008. Further, it is argued that PACS positively affects the quality of reporting practices. In comparison to the film-based environment PACS permits easy access to previous (historic) patient radiology images, and hence allows the radiologists to perform efficient image interpretation (Stacul, 1998; Bryan et al., 1998; Strickland, 1998; Reiner et al., 2001; Bennett et al., 2002). A number of studies report that by enabling immediate availability and simultaneous viewing of patient images, PACS has led to the improvement in clinical diagnostic reporting, decision making and patient management (Kundel et al., 1996; Bryan et al., 1998; Watkins, 1999; Crowe and Sim, 2005), as well as contributing to a substantial change in the level of communication between radiologists and clinicians (Kundel et al., 1996; Reiner et al., 1999; Siegel and Reiner, 2003).

Whilst empirical studies report that the use of PACS and RIS indeed could generate positive outcomes to both radiologists and clinicians, yet consistent findings surrounding the substantial reduction in face-to-face clinico-radiological meetings is

a worrying trend. For instance, Baker (1999:1174) with regards to the outcome of a study by Reiner et al. (1999) wrote the following: '...How can we continue to provide face-to-face consultation when the images we interpret are simultaneously available in our referrers' offices, not only initially but persistently? It is time to rethink how we position ourselves in a PACS environment, both in an administrative and in a physical sense...' The study by Reiner at al. (1999) was based on a longitudinal observation and survey data of clinician consultations with radiologists in the radiology department of the Baltimore Veterans Affairs Medical Center. The study found an 82% decrease in the consultation rate for general radiography consultations, and a 44% decrease for cross-sectional imaging despite an increase in the volume of studies. Reiner at al. (1999) argued that the decrease in clinician consultations is directly related to the filmless work environment led by a hospitalwide PACS installation. Previously, Kundel et al. (1996) also reported a significant decrease in clinicians obtaining input from radiologists when PACS was first implemented in the Medical Intensive Care Unit of their organization. From the qualitative research standpoint, several studies argue that this changing trend should be understood as a result of a dynamic socio-technical network process, where the medical imaging implementation has become part of the complex workplace system (Lundberg, 1999; Hanseth and Lundberg, 2001).

Finally, there have been contradictions across studies with regard to whether the use of PACS and RIS have shortened the time of radiologists in preparing diagnostic reports (dictation turnaround time). For example, whilst Lepanto et al. (2006) reported a decrease in time in their organization, Bryan et al. (1998), Pilling (2002) and Nishitani et al. (2005) found no significant difference when compared with the film-based environment. Further, another study found that although clinicians can have immediate access to images, yet the delay in accessing a diagnostic report has triggered clinicians' dissatisfaction (Kinnunen and Pohjonen, 2001). According to the study, the delay was caused by the lack of effective mechanisms such as digital voice dictation systems in the Finnish language to assist the radiologists in dictating reports. Another interesting aspect about the study is their intervention strategy to redesign the system in such a way that it minimizes the drawbacks of delay in obtaining radiological reports in order to ensure a smooth interaction process between radiologists and clinicians.

2.6.5 Delivery of Diagnostic Report and Radiographic Images or Films

In a standard radiology workflow, the final step in the work process is to deliver a diagnostic report and images/films to hospital clinicians and outpatients (Tellioğlu and Wagner, 2001; Mariani et al., 2006). With medical imaging, hospital clinicians can access both report and images electronically from designated workstations located at their work area. Images can be viewed using a PACS workstation or via web-based PACS; a radiology report can be accessed via RIS/HIS applications. In practice, patient images can also be delivered offline using optical data storage devices such as DVD or CD-ROM. It was reported that this off-line mode such as using a CD-ROM is practical in the case of obtaining secondary diagnostic opinions or storing selected images for reference (van Ooijen et al., 2005). Usually, these CD-ROMs will be shipped to relevant medical specialists in other institutions.

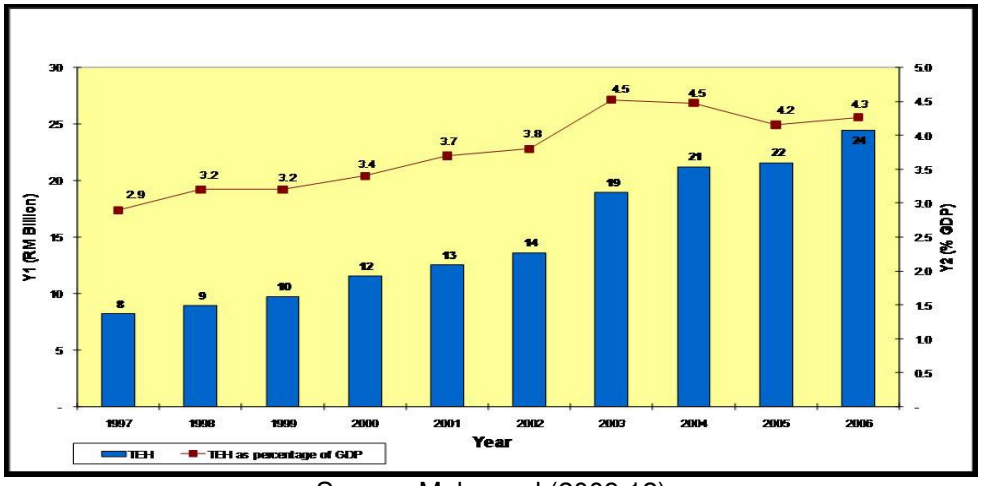
2.7 THE MALAYSIAN HEALTHCARE SYSTEM AND ITS STATUS

2.7.1 A Brief Overview

Malaysia[27], since gaining her independence from the British Government in 1957, has progressively expanded the nation's healthcare facilities, services and access. Ramesh and Holliday (2009) suggested that the British colonial legacy, particularly the outstanding trait of having a strong state role in healthcare systems, has enabled Malaysia to provide good healthcare services at remarkably low cost. It is true indeed that since independence, the state (i.e., the government) has formed a fundamental part of the Malaysian healthcare system. The long adopted welfare-based model, where healthcare funding is largely obtained from the government (Roemer (1991) cited from Barraclough, 1999), has shaped Malaysia's approaches to formulating health policies, programmes and planning.

Malaysia, as of 2009, had a population of 28. 31million[28]. The life expectancy at birth for males and females was 71.7 years and 76.5 years[29], respectively. In 2008, the total health expenditure of Malaysia as a percentage of GDP was 4.7% (Health Informatics Centre, 2009). The following diagram illustrates the trend of the total health expenditure of Malaysia as a percentage of GDP from 1997 to 2006.

Figure 2.6: Trend of Total Expenditure on Health (TEH), 1997-2006 (RM, Nominal Value)



Source: Mohamad (2009:12)

[27] Malaysia was established in 1963 with 11 states (the Federation Malaya), and three additional members (Sabah, Sarawak and Singapore). Singapore had withdrawn from Malaysia in 1965. Today, Malaysia consists of 13 states, and three Federal Territories (Kuala Lumpur, Labuan and Putrajaya).
[28] The statistic was updated in 31 July 2009 and obtained from http://www.statistics.gov.my.
[29] The latest statistic data is for year 2007 and was updated on 2nd January 2009 (http://www.statistics.gov.my).

In 2008, it was reported that public expenditure as a percentage of total expenditure on health was 44.81% (Health Informatics Centre, 2009). The private sector contribution was therefore 55.19%. In 2006, according to a survey conducted by the Malaysia Ministry of Health[30], the major contributor to the out-of-pocket payment was from the Chinese ethnic community.

With regard to healthcare facilities, Malaysia has achieved remarkable progress since the implementation of the First Malaysia Plan (1966 – 1970)[31]. In general, public health care facilities are constituted by community clinics, health clinics, district and state level hospitals, national referral institutions and university teaching hospitals (Lim, 2001). For remote areas such as the rural villages located around Sabah and Sarawak, the flying doctor service is available (Ariff and Lieng, 2002). According to a report by UNPAN[32], the ratio of rural and urban health clinics to population, respectively, was 1:13,194 and 1:25,853 in 1999 (see the following table). For public hospital facilities, the following table shows that there was a significant improvement in the ratio of acute beds to population in 1999 as compared to 1995 (1:846 to 1:495).

Table 2.4: Public Health Facility and Coverage for Malaysia, 1995 and 2000

Category	Number		Facility Ratio to Population and Coverage (%)	
	1995	2000[1]	1995[1]	2000[1]
Health facilities				
Rural Health Facilities				
Community Clinics[3]	1,987	1,992	1: 4,717	1: 4,758
Health Clinics	721	725	1: 12,998	1: 13, 194
Mobile Units[4]	284	194		
Urban Health				
Maternal & Child Health Clinics	102	107		
Health Clinics	51	54	1: 22,909	1: 25,853
Patient Care Services				
Hospitals	118	119		
Acute Beds[5]	24,454	24,780	1: 846	1: 495
Dental Units[6]	2,327	2,597	1: 8,91	1: 8,540
Beneficiaries ('000)				
Outpatient Visits[7]	24,290	27,039		
Inpatients[7]	1,448	1,543		
Rural Water Supply	7,397	8,398[2]	85.8	93.5[2]
Sanitary Latrines (Rural)	8,132	8,761[2]	94.9	99.0[2]
School Dental Clinics	2,808	4,029	63.4	83.1

[30] Source:http://www.nih.gov.my/NHMS/abstracts_03.html
[31] Malaysia practices 5-year plan for strategic national planning.
[32] The United Nations Online Network in Public Administration (www.unpan.org)

Supplementary Feeding	510	528	19.0	18.4
Immunization (Under one year)				
BCG	554	479	100.0	100.0
Diphteria, Pertussis and Tetanus (3rd dose)	501	499	93.7	94.1
Hepatitis B (3rd dose)	485	483	90.7	91.1
Measles	458	457	85.5	86.2
Polio (3rd dose)	500	495	93.5	93.4

Notes:
1. Figures for 1999.
2. Figures for 2000.
3. Includes klinik desa and midwife clinics which were upgraded into community clinics.
4. Refers to Dispensary Services, Village Health Teams, Flying Doctor Services and Mobile Dental Services.
5. Refers to hospital beds under the Ministry of Health and does not include chronic beds.
6. Refers to dental chairs in Government Clinics.
7. Refers to attendances in public health services.

As of 2003, there were about 39,545 beds in public health care organizations (community hospitals and special medical institutions)[33]. The following table presents a comparison of the available health facilities between 2006 and 2008[34]. As of 2008, there were 130 community hospitals available in Malaysia.

Table 2.5: Malaysia Health Facilities, 2006 and 2008

HEALTH FACILITIES	2006*	2008**
MOH Health Clinics	807	802
MOH Rural/Community Clinics	1,919	1,927
MOH Maternal & Child Health Clinics	88	95
MOH Dental Clinics	2,407	2910
MOH Mobile Teams	154	193
MOH Hospitals (Beds)	128 (30,021)	130 (33,004)
MOH Medical Institutions (Beds)	6 (4,740)	6 (5,000)
Non-MOH Hospitals (Beds)	6 (2,926)	7 (3,245)
Private Hospitals (Beds)	245 (11,655)	209 (11, 689)
GP Clinics	7000	6,371

Notes: * Data were obtained from Hadis (2007)

**Data were obtained from Health Informatics Centre (2008)

In terms of healthcare manpower, until now, Malaysia still continues to face a shortage of medical professionals particularly doctors. In 1998, there were 15,016 doctors and the majority of them (55%) were attached to the private sector (Marnoch and Lian, 2002). By 2006, the percentage of doctors attached to the public sector (61% out of 21,937) had increased significantly (Ministry of Health, 2007)[35]. The ratio of doctor-to-population in comparison to the year 2000, however, only shows a slight

[33] Source:http://www2.treasury.gov.my/pdf/ekonomi/le/0506/JP9_1.pdf
[34] Source: Hadis (2007) and Health Informatics Centre (2008)
[35] Source:http://www.intanbk.intan.my/cda/m_ppa2007/PPA/drnasir.pdf

improvement (from 1:1490 in 2000 to 1:1214 in 2006). The following table presents the number of selected healthcare professionals in 2008. Overall, Malaysia had 25,102 doctors and about 60% of them worked with the public sector.

Table 2.6: Selected Health Manpower Distribution for Malaysia, 2008

	Public	Private	Total	Professional: Population
Doctors[1&2]	15,096	10,006	25,102	1:1,105
Dentists[1&3]	1,922	1,718	3,640	1:7,618
Pharmacists[1&4]	3,070	3,327	6,397	1:4,335
Asst. Medical Officers[1&6]	8,310	768	9,078	1:3,054
Asst. Pharmacy Officers[1]	2,778*	n.a	2,778*	1:9,982
Medical Lab. Technologists[1]	4,039*	n.a	4,039*	1:6,865
Occupational Therapists	426*	n.a	426*	1:65,091
Physiotherapists[1]	593*	n.a	593*	1:46,760
Radiographers[1]	1,518*	n.a	1,518*	1:18,267
Nurses[1&7]	38,575	15,633	54,208	1:512
Community Nurses[1&4]	18,143	500	18,643	1:1,487

Source: Health Informatics Centre (2008)

Notes: * MOH only

1. Human Resource Dvision, MOH
2. Malaysian Medical Council
3. Malaysian Dental Council
4. Pharmacy Board Malaysia
5. Malaysia Optical Council
6. Medical Assistant Board
7. Malaysia Nursing Board

For radiology specialists, i.e., radiologists, at present there is no accessible detailed data or an official publication by the Ministry of Health about the number of specialists and the distribution of radiology sub-specialties in Malaysia. As for radiographers, as of 2008 there were 1,518 of them attached to community healthcare institutions.

2.7.2 Medical Imaging Implementation and Status

In 1897, the first x-ray machine was introduced by the British Government. This event marked the introduction of radiology in the country[36]. To date, non-interventional and basic interventional radiology services are widely available across public and private hospitals. However, due to the shortage of radiology specialists, special radiology services (e.g. interventional radiology) can only be performed in large hospitals. It was acknowledged in the Ministry of Health 2005 Report that there has been slow progress with regard to developing manpower resources in radiology. As shown in Table 2.8, for the period from 2002 to 2005, there has been an increase in the demand for radiology examinations in community hospitals. More importantly the data shows that there has been a growing trend of utilizing advanced modalities such as CT and MRI in radiology. As more and more digital imaging modalities are deployed into the government healthcare hospitals and clinics, there has been a growing concern by the Ministry of Health with regard to the development of expertise in radiology.

Table 2.7: Radiology Examinations in Government Hospitals, 2002 to 2005

Imaging modalities	2002	2003	2004	2005
General radiography	2,158,694	2,276,705	2,478,354	2,680,627
Special radiography	26,529	35,663	28,586	30,440
CT Scan	80,243	89,541	101,830	114,267
MRI	8,690	11,845	16,037	16,432
Ultrasound	152,400	159,553	203,469	239,442
Other additional exams	23,837	26,270	28,165	36,095
Total	**2,450,393**	**2,599,577**	**2,856,441**	**3,110,542**

Source: The Ministry of Health 2005 Report

Since Multimedia Super Corridor (MSC) was launched in mid 1996, the government through the Ministry of Health has progressively undertaken efforts to integrate medical imaging in community hospitals. The establishment of two IT-based hospitals at the end of the 1990s marked the first implementation of medical imaging in Malaysia. These hospitals served as a prototype of paperless and filmless hospitals in the country (Hashim and Hadis, 2004).

Medical imaging, in addition to other healthcare information technologies and systems, forms part of the ideal vision of Malaysia having a healthcare system that enables ‘seamless care’ or ‘health facilities without boundaries’ (Abdul Manaf, 1996).

[36] Source: http://www.radiology.malaysia.org

Medical imaging is one of the critical components of Total Hospital Information System (THIS). The following table illustrates the scope for basic HIS, intermediate HIS and THIS, and the overall nationwide plan with regard to extending these applications.

Table 2.8: Scope of Basic, Intermediate and Total Hospital Information System (Suleiman, 2008)

BASIC HIS	INTERMEDIATE HIS	TOTAL HIS
Patient Management System Clinical Information System Order Management and Reporting System Billing System	Basic HIS + Pharmacy Information System + Laboratory Information System	Intermediate HIS + Radiology Information System + PACS + Administration + Financial + Inventory + Personnel + Kitchen + Operating Room Management Systems + Decision Support + Case Mix System
Teleradiology and Teleconsultation Systems Longitudinal Health Record System and Health Information Management Reporting System Linkage to National Smart Card System and E-government application and Lifetime Health Record Application		

Medical imaging in particular can be extended to support teleradiology and teleconsultation systems. The American College of Radiology[37] defined the goals of teleradiology as follows:

- Providing consultative and interpretative radiological services in areas of need
- Making radiological consultations available in facilities without onsite radiological support
- Providing timely availability of radiological images and radiological image interpretation in emergent and non-emergent clinical care areas
- Facilitating radiological interpretations in on-call situations
- Providing subspecialty radiological support as needed
- Enhancing educational opportunities for practicing radiologists
- Promoting efficiency and quality improvement
- Sending interpreted images to referring providers
- Supporting telemedicine
- Providing direct supervision of off-site medical imaging

Sellaliah (2004), a consultant radiologist from a community hospital in Malaysia, remarked that whilst the teleradiology application is undeniably strategic in the Malaysian context, staffing (frequent turnover of staff) and funding issues faced by the community healthcare organizations posed a great challenge to using the application effectively.

[37]Source: http://www.biohealthmatics.com/healthinformatics/telemedicine/telerad.aspx

2.7.3 The Ministry of Health (MOH): Roles and Functions

The present MOH structure is based upon three levels of management, namely Federal, State and District. These management levels are differentiated by the amounts of authority, accountability, supervision and access to information they have (Juni, 1996). At present, the MOH consists of more than 30 departments or units[38].

Several studies have noted that the MOH's roles and functions cover a wide range. Chee (2008) for example has suggested that the expansion of the MOH bureaucracy has been influenced by multiple vested interests driven by the present socio-political framework of the nation. These vested interests, he argues, can be seen operating in various contexts, such as healthcare privatization and financing, the awarding of long-term contracts, and even in the development and promotion of health tourism. With regard to the latter, it was recently announced by the Health Minister Datuk Seri Liow Tiong Lai that the Malaysian Healthcare Travel Council (MHTC) would be established as a department within the ministry[39]. Currently, the MOH assumes a full role under the guidance of the Federal Government and the relevant agencies in the appointment of technology contractors to handle matters related to the development, maintenance, upgrading and supply of critical and expensive machinery and technology infrastructures to the community hospitals. Nambiar (2006) and Mohd Nawawi (2007) explained some of the bureaucratic practices and procedures involved in this matter. Nambiar (2006) also has gone further to criticize the MOH actions and decisions in relation to outsourcing, which he argues are lacking in standards and transparency[40]. Baba and Mohammed (2008), however in their preliminary analysis with regard to contract documentation claim that the community hospitals tend to have more comprehensive contracts that define the roles and expectations of the relevant actors, i.e. the contractor and the hospital's personnel, than the Malaysian private hospitals.

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[38] Source:http://www.MOH.gov.my

[39] Source:http://www.bernama.com (21 July 2009)

[40] Similarly, it was reported in 2008 in the local news (www.nst.com.my) about the controversial in the procurement of three x-ray machines at a cost of MYR 33 million by MOH via direct negotiation where the appointed company was not registered with the Contractor Service Centre. The report also mentioned that the subcontractor of the company that responsible 'to certify the quality and safety of the PET CT Scan, was not qualified or licensed to handle radioactive material and X-ray equipment, as required under Section 13(2) of the Atomic Energy Licensing Act'. The same report also mentioned that about 40 components of the PET CT Scan and Cyclotron machines at a cost of RM658, 800 were unused and among the reasons given by the two hospitals were that the components had either been purchased too soon, or were unsuitable for use.

Whilst it has been suggested by the World Health Organization (WHO) that the overall performance of the Malaysian healthcare system is good, a consultative report (Shepard et al., 2002)[41] proposed that the MOH should reform its current structure in order to address the problems of a shortage of resources and a lack of flexibility. In the proposed reform strategy, the report emphasized preserving "the sense of public mission among the staff". Barraclough (1999), previously contended that despite the fact that there has been a signal from the government to reform the present healthcare system, barriers rooted in the Malaysian socio-economic and political contexts will slow the reform process. In the context of the MOH's role in this matter, he (1999:65) states that 'it is difficult for the Ministry of Health, a portfolio traditionally allocated to one of the minor parties in the ruling coalition, to prevail against the wider economic agenda of the Ministry of Finance and the Economic Planning Unit of the Prime Minister's Department which have promoted privatization, corporatization and constraints on public expenditure'. From the standpoint of the MOH, the following statement further clarifies the relationship between the MOH and the portfolio of the Ministry of Finance with regard to financing community healthcare organizations.

> '...public health expenditure is subject to strict cost control since the budget of the Ministry of Health is determined by the Ministry of Finance, and all personnel including physicians in the public sector are paid by salary, and supplies and equipment need to be forecast with some degree of precision...' (Juni, 1996:762).

2.7.4 Technology Implementation: The Federal and the MOH Initiatives

In the Malaysian context, the MOH's decision to implement a Total Hospital Information System (THIS) to include medical imaging in community hospitals was in line with the federal agenda to develop an integrated national e-health/telehealth system. The MOH developed the National Telehealth Policy that contains 'the high level policies to ensure the successful implementation of telehealth' (Mohan and Yaacob, 2004:218). Telehealth was defined as 'the integration of information telecommunication, human-machine interface technologies and health technologies to deliver health care, to promote the health status of the people and to create health'[42]. 'The telehealth initiative has subsequently been developed into a national e-health system integrating the different players in the health enterprise' and the

[41] Source:http://www.who.int/health_financing/documents/malaysia-reform-initiatives.pdf
[42] Source:http://www.MOH.gov.my

types of companies that have been invited include 'computer hardware and software vendors, system integrators, R&D organizations and relevant high-tech service providers' (Mohan and Yaacob, 2004:218). The MOH planned to integrate IT-based hospitals into the e-health/telehealth project (Suleiman, 2001; Mohan and Yaacob, 2004). To facilitate the integration, the MOH has designated the Telehealth Division to develop health informatics standards and policies[43] . These standards are concerned with the compliance of all health data, including that generated from the hospital clinical systems, to meet international standards such as ACR/ENEMA, ASTM, HL7, IEEE and EDIFACT (Mohan and Yaacob, 2004). Varghese and Scott (2004) categorized Malaysia as proactive with regard to promoting telehealth.

The nationwide telehealth project championed by the MOH was implemented, but not without several glitches. In 2003, the failure of the appointed technology consultant, Medical Online, to develop, deliver and transfer the telehealth projects according to the signed contract was reported as affecting the progress of diffusing telehealth across community healthcare organizations[44]. Medical Online's failure had affected a number of hospitals that participated in the projects. The telehealth project was revived in 2005, and in 2007, the Deputy Health Minister of the MOH announced that the pilot project using a telehealth system that integrated 38 hospitals across the country had been successful. The news publisher (NST, 2007) reported that:

> '...For a start, teleconsultation, one of the major applications of telemedicine, is being used for five disciplines – radiology, cardiology, dermatology, accident and traumatology, and neurosurgery. Put in place by WorldCare Health (Malaysia) Sdn Bhd, it also allows for peer-to-peer transmission of film-based radiological images as well as scanned paper documents, voice annotations, digital images, and ECG scans. Dr Abdul Latiff said teleradiology enabled physicians to seek primary and secondary diagnosis of radiological images, such as x-ray films, computer tomography (CT), magnetic resonance imaging (MRI) sans and ultrasound imaging...'

The MOH's plans and initiatives to deploy new information systems and technologies into community healthcare organizations can be traced back to the Seventh Malaysian Plan (1996-2000) and 8th Malaysian Plan (2001-2005). In the Seventh Malaysian Plan, the MOH put a strong emphasis on the implementation of new information systems and technologies into community hospitals to promote the concepts of "seamless care" and "health facilities without boundaries" (Manaff, 1996).

[43] Malaysia Health 2005 (2005)
[44] The Star Online (2003)

Afterwards, in the Eighth Malaysian Plan, it was reported[45] that a total of 33 hospital projects had been approved for construction. It was projected that THIS would be further implemented into another six hospitals whereas HIS would be implemented into 25 small- and medium-size hospitals. In the evaluations of the MOH's performance in the Seventh Malaysian Plan and 8th Malaysian Plan, Taha et al. (2005:5-6) reported the following:

> '...Both 7MP and 8MP evaluations showed that the physical expansion of some of the MOH facilities has not been in pace with the need and utilisation patterns. The planning and use of new technologies should also be in pace with the needs of the nation. The infrastructure support, in terms of computerisation of health facilities and lack of intellectual capacity will add further to the problems in implementing telehealth initiatives. Therefore, the need for the development of a National ICT Strategic Plan in the MOH...'

In mid 2007, it was reported in a local newspaper[46] that the MOH Director General Tan Sri Dr. Ismail Merican acknowledged the difficulties with THIS implementation. According to the news, the MOH however would continue to maintain the thirteen community hospitals that had been equipped with THIS. The Director General stated that for all other hospitals, HIS would be implemented in stages.

Later, in early 2007, the Health Ministry Director-General admitted that the THIS application "did not work out too well" for the two hospitals that first implemented the technology. Based on the experience of these hospitals, the Health Ministry Director-General highlighted that the challenges of implementing the technology and the mindset of the healthcare providers had hampered the objectives of achieving a truly paperless and filmless hospital.

[45] The United Nations Online Network in Public Administration (www.unpan.org)
[46] The Star, March 26, 2007

2.8 CONCLUSION

Based on an extensive and wide-ranging literature review, this chapter has illuminated the importance of this research. More explicitly, it has shown how this research, guided under systems theory and influenced by the emergent perspective theoretical paradigm, can address the three identified gaps in the literature. By adopting multiple theoretical perspectives, this study developed its own conceptual framework to guide the research. In the following chapter, it is demonstrated how this study has operationalized the framework in performing data collection and analysis. Research results are also presented.

Chapter 3

Methodology

3. INTRODUCTION

The purpose of this study is to investigate the implementation and use of medical imaging in the Malaysian context. Chapter 1 has outlined the research objectives that this study aims to achieve. Specifically, the research examined in what ways the internal and external contexts together influence the implementation and use of the technology, and further shaped the organizational consequences of the technology upon roles, social relationships and networks. Embracing a theoretical orientation of understanding the impact of technology from the qualitative standpoint requires the research to embrace both micro and macro-level data. The micro-level data provide an opportunity to perform a cross-comparison of work practice between the conventional radiological works and the radiological works driven by medical imaging application. Significant transformations in the nature of work according to Barley and Kunda (2001) should correspond with significant changes related to organizational aspects and the day-to-day experience of the organizational members. The macro-level data on the other hand give an opportunity to uncover the related elements of social, political, cultural and economic relationships surrounding the implementation and use of medical imaging in the organizational context. This study hence utilized multiple research methods, namely in-depth case study, direct observation, semi-structured interview, survey and documentary evidence from secondary resources.

This chapter elucidates in detail the research methodology. It is structured as follows. This chapter begins with a description of the interpretive approach that has guided the overall process of collecting, processing and interpreting data. The theoretical assumptions of the emergent perspective paradigm and the pertinent theories and concepts are compatible with an interpretive mode of enquiry. Subsequently, it explains the research methods and elucidates the data analysis strategies. Then, it presents the profiles of the two case studies, and the survey results. This chapter ends with a conclusion section.

3.1 THE INTERPRETIVE APPROACH

The grasp of knowledge about the consequences of implementing and using technology in organization is shaped by the ontological and epistemological stances of a research. Broadly, there are three competing philosophical traditions, namely positivist, interpretive and critical social theory that shape the ontological and epistemological direction of the research.

Positivist approach uses a deductive logic to empirically observe human behaviour and to test a set of probabilistic causal laws in order to predict general patterns of human activity (Neumann, 2000). Typically, data is obtained using methods such as survey or control experiment, and inferential statistics is used as the data analysis strategy to verify or falsify the tested causal laws (Orlikowski and Baroudi, 1991). It has been suggested that information systems research in the early years was predominantly positivist (Orlikowski and Baroudi, 1991; Walsham, 1995; Weber, 2004). The critical social theory approach, places less emphasis on 'fixed laws of human behaviour because the laws are seen as changing' (Nuemann, 2000:79). According to Ngwenyama and Lee (1997:151), in contrast to the positivist tradition, the social theory approach posits that '(1) there is a difference between observing nature and observing people and (2) inquiry into social activity should focus on understanding their meanings from within the social context and lifeworld of actors'. Usually, action research is used to obtain primary data under this perspective.

This study embraces an interpretive approach to guide the overall process of collecting, analyzing and interpreting data. Interpretive approach in general, is 'the systematic analysis of socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understandings and

interpretations of how people create and maintain their social worlds' (Neumann, 2000:71). This approach asserts that reality and our knowledge are 'social products and hence incapable of being understood independent of social actors (including the researchers) that construct and make sense of that reality' (Orlikowski and Baroudi, 1991:13). In contrast to the positivist tradition, the interpretive research holds that data cannot be value-free (Walsham, 1995; Neuman, 2000). In doing interpretive research, two conditions exist (Walsham, 1995). First, the researcher's own preconceptions guide the process of research; and second, the interactions between the researcher and the human participants (subjects) can influence and change perceptions of both parties.

3.2 RESEARCH METHODS

In general, there were two phases of data collection undertaken in this research. The following figure illustrates the timeframe and the specific methods of obtaining data in these phases.

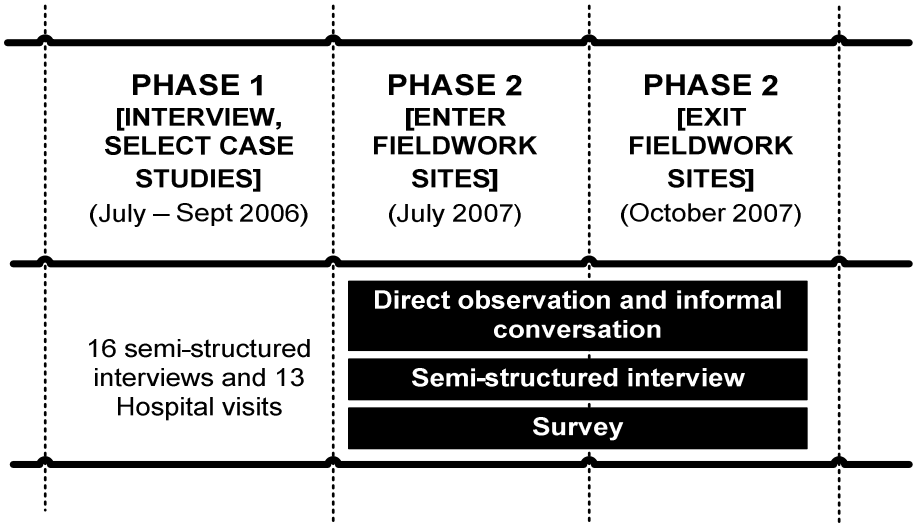


Figure 3.1: Two Phases of Data Collection

The purpose of undertaking Phase 1 is twofold. First is to establish an understanding of the general status of information systems and technologies in the context of Malaysian hospitals; and second is to determine suitable case studies for this research. As explained in Chapter 1, the outcomes of the Phase 1 data collection were used as a guideline to choose potential organizations as case studies. Data from Phase 1 was used to support core findings of this research.

Phase 2 of data collection was conducted in 2007. Field work was undertaken in two organizations for approximately 3-months duration. To protect the identity of the organizations, this study will use COV-DPMT for the radiology department that maintains features of conventional radiology work practices and PACS-DPMT for the radiology department that implements medical imaging. COV-DPMT serves as a baseline for doing comparative analysis to identify the outcomes of implementing and using medical imaging in PACS-DPMT. Both case studies are hospital-based radiology departments from two Malaysian community hospitals. The selection of these case studies is deemed strategic for this research for three reasons.

First, Malaysian healthcare services are largely subsidized by the government, hence the use of COV-DPMT and PACS-DPMT as case studies will permit the research to capture the dynamics of the external context and influences that shape the implementation and use of medical imaging in the hospitals, and in turn, can also influence the organizational consequences. Second, both organizations have certain historical significance in the context of Malaysian hospitals. Explicitly, in radiology work practice of Malaysian community hospitals, COV-DPMT being one of the oldest radiology departments, till now, serves as a reference point for other institutions to emulate. This is particularly common with regard to aspects such as learning new radiological work activities associated with the use of new radiology machines or techniques. Also, in constructing PACS-DPMT's organizational structure and activities, few existing key radiology personnel such as Head of Department, Chief Radiographer, radiologists as well as radiographers of PACS-DPMT were recruited from COV-DPMT. These key personnel worked together to establish a standard of practice and workflow working through the use of medical imaging at PACS-DPMT based upon their past experience, skills and knowledge of working at COV-DPMT. From the standpoint of this study, such historical context is pragmatic for the purpose of doing comparison to examine in what ways medical imaging transforms radiology work practice at PACS-DPMT. Because the research focus is on the situated use of radiological artefacts in their work practice, hence, the organization's age factor is not an important issue here. This study attempts to research situated activity and action, and therefore, such inquiry is meant 'to take place at a very fine-grained level of minutely observed activities, inextricably embedded in a particular situation' (Nardi, 1996:71). Examples of research that have qualitatively studied and compared

the organizational radiology workflow and activities in relation to the use of technological artefacts can be found in Barley (1986, 1990), Francesconi (2008), Kjaer and Madsen (2008) and Hurlen et al. (2008). Francesconi (2008) for example examined and compared the use of medical imaging at five hospitals in Northern Italy. Their research, like Barley (1986, 1990), also did not place too much concern upon the organization's age factor. Lastly, the locality of the case studies is strategic for doing fieldwork under time and financial constrains.

Letters together with the description of this study were sent in May 2007 to the Director of hospitals and the Head of Department at each organization. The researcher also sent a formal letter to the Director of the Health State Department to inform and to seek support for using COV-DPMT and PACS-DPMT as case studies for this research. In June 2007, the researcher had obtained positive feedbacks from the top management of PACS-DPMT and COV-DPMT hospitals, and also from the Deputy Director of the State Health Department. Following that, the researcher had set up a meeting with the Head of Department at each organization in early July 2007. The purpose of the meeting was to brief them about the research and to entertain any queries with regard to the way the field work will be undertaken at the department. The researcher began the field work study at COV-DPMT in mid-July 2007 and PACS-DPMT in early August 2007. Also prior to undertaking the fieldwork, this study had obtained ethical approval from the Clinical Research Office of the Imperial College London, UK.

Multiple research methods were deployed to obtain data. The findings based on the analysis of fieldwork data are the main outcomes of this research.

3.2.1 In-depth Case Study

In-depth case study method complements the interpretive approach. According to Yin (1994:13), case studies are conceptualized as 'research situations where the number of variables of interest far outstrips the number of data points' (cited from Yin, 1999:1211). Case study method investigates 'a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organisations)' (Benbasat et al., 2005). It uses contexts to understand a phenomenon of interest and is flexible in dealing with research uncertainty (Yin, 1999). It has been suggested that case study is a highly

appropriate research method in the context of researching new technology application in organization where 'there is little understanding of how and why processes or phenomena occur, or where the experiences of individuals and the contexts of actions are critical' (Darke et al,1998:279).

Table 3.1: Key Characteristics of Case Studies

Key characteristics of case studies
1. Phenomenon is examined in a natural setting.
2. Data are collected by multiple means.
3. One or few entities (person, group, or organization) are examined.
4. The complexity of the unit is studied intensively.
5. Case studies are more suitable for the exploration, classification and hypothesis development stages of the knowledge building process; the investigator should have a receptive attitude towards exploration.
6. No experimental controls or manipulation are involved.
7. The investigator may not specify the set of independent and dependent variables in advance.
8. The results derived depend heavily on the integrative powers of the investigator.
9. Changes in site selection and data collection methods could take place as the investigator develops new hypotheses.
10. Case research is useful in the study of 'why' and 'how' questions because these deal with operational links to be traced over time rather than with frequency or incidence.
11. The focus is on contemporary events.

Source: Excerpted from Benbasat et al. (2002:82)

Case study method hence is undoubtedly an appropriate strategy to achieve the objectives of this research. This study used multiple case studies instead of a single case study. The multiple case studies enable research findings to be compared for theoretical replication (Yin, 2003).

3.2.2 Undertaking Fieldwork

Fieldwork, according to Burgress (1982:1) is a research process where a researcher is involved in 'observing and analysing real-life situations, of studying actions and activities as they occur'. Fieldwork unquestionably is the essence of ethnography. According to Van Maanen (1995:4), ethnography as a research method is when a researcher undertaking a fieldwork 'lives with and lives like those' who are under the investigation for a certain period of time, usually a year or more. In a broader sense, Wolcott (1995:82-83) termed ethnography as 'both to the processes for accomplishing it – ordinarily involving original fieldwork and always requiring the reorganization and editing of material for presentation – and to the presentation itself, the product of that research, which ordinarily takes its form in prose'. To date, ethnography as a research method has been widely adopted across a variety of disciplines, including information systems research. Harvey and Myers (2002) for instance mentioned that ethnography has been widely used in the study of information systems in organizations (Harvey and Myers, 2002). They (2002:177) argued that ethnography can offer 'a rigorous approach to the analysis of the institutional contexts of information systems practices, with the notion of context being one of the social construction of meaning frameworks'.

This study has greatly benefited from the use of fieldwork - a central element of ethnography - to conduct in-depth case study research at COV-DPMT and PACS-DPMT. For clarification purposes, this research used Myers's (1999:4) explanation as follows to differentiate between in-depth case study research and ethnography:

> 'The main difference between case study research and ethnographic research is the extent to which the researcher immerses himself or herself in the life of the social group under study. In a case study, the primary source of data is interviews, supplemented by documentary evidence such as annual reports, minutes of meetings and so forth. In an ethnography, these data sources are supplemented by data collected through participant observation. Ethnographies usually require the researcher to spend a long period of time in the "field" and emphasize detailed, observational evidence [Yin, 1994].'

This study has adopted elements of doing ethnography to guide the whole process of undertaking fieldwork at the research sites. These elements also were useful for the purposes of performing data analysis, data interpretation and presenting findings.

3.2.3 Field Notes and Sampling Strategies

While doing fieldwork, two aspects were taken into consideration to obtain good quality of interpretive qualitative research. First is on the sampling strategies in doing fieldwork; and second is on the aspect of field notes to record the 'first-hand' data at the fieldwork sites. The following describes the sampling and note taking strategies, as well as the frequency of research access to both sites.

Sampling Strategies

Deploying sampling strategies from the standpoint of qualitative research is significantly different from doing sampling in quantitative studies. As 'how' and 'why' inquiries are at the centre of the research focus, a random sampling for instance does not work in qualitative research. Marshall (1996) for example argued that elements such as small sample size, difficulty in determining the characteristics of the participants under study and dependency on informers to obtain rich data have made it impossible to apply a random sampling strategy. Hence pragmatically, the sampling strategies in qualitative research can come in many forms and approaches. Pole and Lampard (2001) discussed several popular types of non-probability qualitative sampling such as convenience/availability sampling, snowball sampling and theoretical sampling. Also, many have emphasized that in an effort to devise sampling strategies in doing qualitative research, one must take into account the nature of the qualitative inquiry and the methods to obtain data (i.e., see Burgress, 1982; Strauss and Corbin, 1990; Miles and Huberman, 1994; Pole and Lampard, 2001). In the context of doing fieldwork and for pragmatic purposes, Burgress (1982) suggests four elements – the selection of a research site, time, people and events – to be considered in the sampling strategies. While undertaking fieldwork, this study adopted Burgress's (1982) suggestion upon taking into account these elements in its sampling strategies. Table 3.2 in the subsequent page illustrates the sampling strategies used in this study.

Table 3.2: Sampling Strategies in Undertaking Fieldwork Research

Elements	Sampling Strategies (research adaptation)
1. Selection of a site 'Sampling begins in field research when the researcher selects one research site rather than another in relation to the research problem that has been formulated' (Burgress, 1982:76).	***Strategy: Convenience sampling*** After a few weeks of doing intensive observations at both radiology departments, the researcher decided to focus on three subunits of radiology, namely: CT Scan, MRI and General Radiology. These specific localities were chosen because of the convenience for research access. For example, from the inside of the panel room such as in the case of CT Scan and MRI units, the researcher was able to observe day-to-day interactions and relationships of the participants under study with other social actors such as patients, clinicians, nurses and sometimes with contractors or technology consultants.
2. Time '...to sample the activities that occur over a period of time...as well as activities that occur at particular hours in the course of a day' (Burgress, 1982:76)	***Strategy: Time sampling*** For PACS-DPMT and COV-DPMT, three time dimensions were noted as follows: • *Morning* – Important activities such as patient scheduling and staffs' duty re-arrangement will take place. Also, work disruptions due to the technology and network breakdown that may happen in the morning will impact the whole day operation of the radiology activities of the unit. • *Mid-afternoon* – Usually, radiologists and MO radiologists will be present and will engage in an intensive discussion to prepare for patient diagnostic report. • *Evening* – Activities such as radiology report discussion, patient schedule re-arrangement, negotiating and sharing the use of modalities usually occur around this time.
3. People ' ...decisions about the people who are to be researched' (Burgress, 1982:77)	***Strategy: Snowball sampling*** In the first few weeks of doing fieldwork, the researcher identified few key informants among the radiographers at both sites. It was difficult to have key informants among the radiologists because of the nature of their work. The researcher however benefited from the MO radiologists who were always present at the CT or MRI units. 'Key informants not only provide detailed data on a particular research setting, but also provide the researcher with introductions to other informants and to other situations' (Burgress, 1982:77). Using snowball sampling through key informants, the researcher was able to reach certain groups of people from different levels and roles in both departments.
4. Events '...by routine events, they have in mind situations that regularly occur; special events are defined as situations that are fortuitous, but nevertheless anticipated; untoward events are defined as emergency situations (Schatzman and Strauss (1973) cited from Burgress (1982:77).	***Strategy: Convenience, time and snowball sampling*** The use of convenience, time and snowball sampling strategies has greatly facilitated the researcher to have the opportunity of observing not just the routine work but also special events such as in the case of having problems with computer network, PACS servers and modalities.

Field notes

Field notes were used in this research as means to record data from carrying out observations and engaging in informal conversations. This research adopted five basic principles suggested by Burgress (1982: 191) in doing data recording while undertaking fieldwork research.

Table 3.3: Basic principles in Field Note Taking

Basic principles in Field Note Taking
1. A regular time and place should be set aside for writing field notes.
2. All field notes should contain data, time, location and details of the main informants.
3. Field notes should be written in duplicate or in triplicate (making several copies)
4. The researcher needs to consider what is to be recorded and what is to be omitted from field notes and the theoretical criteria that are used to reach these decisions.
5. Field notes can be used to begin data analysis alongside data collection.

Source: Burgress (1982: 191)

The researcher carried a small notebook with her at all time at the field sites. Notes were taken immediately when observing the technical aspects of radiology activities such as the way the radiographers use modalities and other PACS technological components, and also the way the radiologists or MO radiologists use PACS diagnostic workstations to perform image interpretation and doing radiology reports. Examples of observational data pertaining to these activities are reported in the subsequent chapters.

It was acceptable to take notes while doing observations in the panel room of CT or MRI units. Based on experience in the first few weeks, the participants did not feel threatening or uneasy. Instead, in many occasions, they (the radiographers and sometimes the MO radiologists) assisted the researcher to make sure the medical and technical terminologies were correctly spelled and written, and also the technical steps of their work activities were recorded accordingly. The researcher believed that such treatments from the participants were probably contributed by the fact that both sites – PACS-DPMT and COV-DPMT- functioned not just as training sites for radiography colleges in Malaysia, but also as sites to train local postgraduate (MO radiologists to become radiologists) and undergraduate medical students (i.e., to become medical officer). On several occasions, the researcher observed for example, the radiographer trainees asking questions to the senior radiographer, and the postgraduate medical students discussing and exchanging idea with the senior radiologists about the image findings in their usual discussion on what to write in the radiology reports. Due to this kind of work environment, the participants had been

very supportive in facilitating the researcher in documenting the participants' day-to-day tasks through a note-taking and sometimes with an audio-tape. However with regard to informal conversations, the researcher did not interfere or made the participants feel uneasy by taking notes during the conversations. Typically, notes regarding the conversations were written during lunch hour break if the observations were done in the morning, or immediately after the completion of the observations for that particular day.

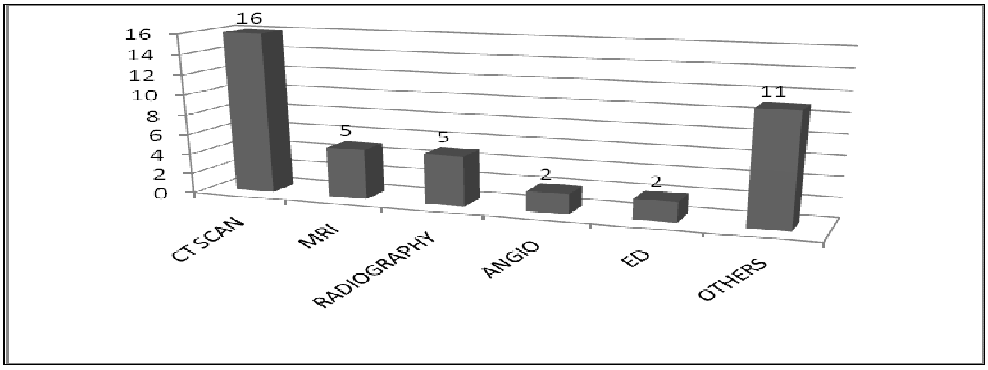
Jackson (1995) examined the relationship between the field notes and the anthropology fieldworkers, and reported various meanings, emotional attachments and functions of field notes to the fieldworkers. For example in the context of writing field notes, fieldworkers associated it with 'obsession with completeness', 'a ritual', 'memories of the events' and so forth (Jackson, 1995:47). Jackson (1995) further mentioned that field notes can also disrupt the flow of fieldwork, and writing and processing field notes are hard work and lonely activities. The fieldworkers' experiences such as described by Jackson (1995) are quite similar to what the researcher's has had experienced while undertaking the fieldwork research.

In an effort to increase the quality of data obtained from note taking, the researcher made use of an audio device to record a number of events while doing direct observation. The use of the audio device is a practical and necessary choice for the researcher to deal with the unfamiliar surroundings particularly in the context of understanding the participants' interactions (i.e., used of many technical and medical jargons). An example of a complete field note is attached in Appendix A.

Access to Sites and Frequency

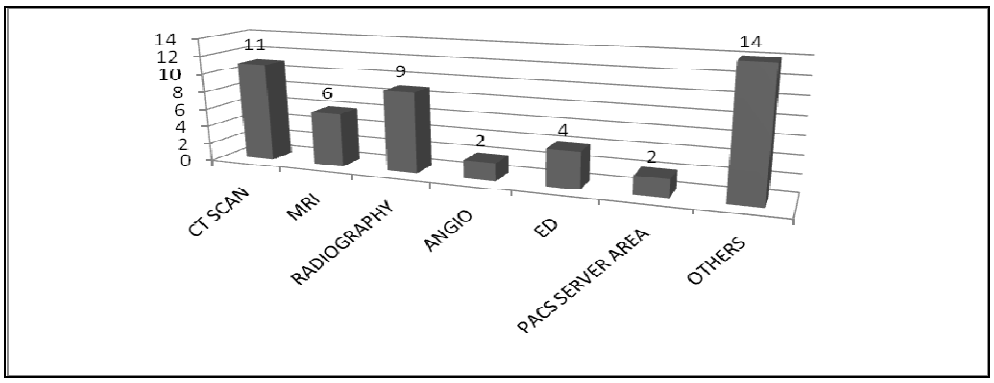
Due to the time constraints, after doing several intensive observations, the researcher decided to concentrate on three areas of radiology work activities – the CT Units (both single slice and multi slice), the MRI Units and the General Radiology Units. This decision was also made based on the outcomes of the preliminary analysis using the data derived from field notes.

The following figures describe the frequency access to work area at COV-DPMT subunits and PACS-DPMT subunits, respectively.



Note: (1) ED Unit in COV-DPMT uses a single slice CT.
(2)Other work areas include sites such as reception counters, internal seminar meeting, patient waiting area, wards and the medical record department.

Figure 3.2: COV-DPMT's Work Area and Frequency Access



Note: (1) ED Unit in PACS-DPMT offers general x-ray examination including mobile x-ray.
(2) Others include sites such as a reception counter, internal seminar meeting, patient waiting area, the specialist office, the wards and the medical record department.

Figure 3.3: PACS-DMPT Access Work Area and Frequency

3.2.4 Direct Observation and Informal Conversation

In using direct observation to conduct an interpretive case study research, Walsham (2002) suggested two general roles of a researcher, namely the outside observer and the participant observer. The outside observer is a view where the researcher 'is seen as not having a direct personal stake in various interpretations and outcomes, and thus personnel will often be relatively frank in expressing their views, provided a rapport of trust can be established'; the participant observer in the other hand 'involves the researcher being a member of the field group or organization, or at least becoming a temporary member for some period of time' (Walsham, 2002: 107). Previously, Gans (1982) classified three roles based on the researcher's emotional relationship to the people that are being examined – the total participant, the researcher participant and the total researcher. Regardless of what roles that the researcher assumes while doing the observation, all roles somehow will involve in the process of 'double hermeneutic' (Walsham 2002). According to Giddens (1984:374), double hermeneutic is:

> 'The intersection of two frames of meaning as a logically necessary part of social science, the meaningful social world as constituted by lay actors and the meta languages invented by the social scientists; there is a constant 'slippage' from one to the other involved in the practice of the social sciences.'

In layman's terms, this is the inevitable process where the researcher influences the interpretations of those people who are being investigated (Walsham, 2002).

Generically, direct observation method reflects the following features (Jorgensen (1989:13-14):

- a special interest in human meaning and interaction as viewed from the perspective of people who are insiders or members of particular situations and settings;
- location in the here and now of everyday life situations and settings as the foundation of inquiry and method;
- a form of theory and theorizing stressing interpretation and understanding of human existence;
- a logic and process of inquiry that is open-ended, flexible, opportunistic, and requires constant redefinition of what is problematic, based on facts gathered in concrete settings of human existence;
- an in-depth, qualitative, case study approach and design;
- the performance of a participant role or roles that involves establishing and maintaining relationships with natives in the field; and
- the use of direct observation along with other methods of gathering information

In this study, observations were made regularly for an average of 3 to 5 hours at the fieldwork site (excluding weekends). The longest day of an observation is about 6 hours, and the shortest is about 2 hours. Direct observation has enabled the researcher to gain an in-depth understanding not just in the aspect of work activities of the radiology department, the organizational members' roles and relationships, but also in the aspects related to social interaction and work culture in their natural setting. More importantly also, the researcher, on a number of occasions, was able to observe the dynamic interactions of the department's members with other social actors such as clinicians, technology consultants/contractors, patients and others.

Based on the fieldwork experience, the researcher's role as an outside observer has had few advantages as well as disadvantages as depicted in the following table.

Table 3.4: The Researcher's Experience as an Outside Observer

Advantages	Disadvantages
Her presence was viewed by the department personnel of both sites as less threatening because the researcher did not have any personal interest in the department, the hospital or the Ministry of Health.	She had to take time to become familiar with the medical terms and jargons that are commonly communicated among the radiology personnel and the hospital staffs. It was a long and tedious process in writing the field notes due to this factor.
Trust was easily established between the researcher and the personnel at both sites.	The researcher did not have any opportunity to attend the department's meetings or to have access to the minutes of meetings, etc.
Many strategic issues and problems pertaining to the work practice environment were discussed openly between the researcher and the department personnel.	Due to the unfamiliar surroundings and the nature of the hospital work environment, the researcher had to spend considerable time studying the content of the radiology work tasks through various learning sources before, during and after undertaking the fieldwork research.

Further, by undertaking fieldwork, the researcher was able to engage in numerous conversations with the users of technologies (radiographers, radiologists, and MO radiologists) to gain understanding about their occupational roles and social relationships, the radiology work activities and how they use radiology modalities and PACS in their work practices. Also, frequent conversations with other participants at the sites such as clerical staff, nurses, clinicians and medical assistants enhanced the researcher's understanding about the fragmented nature of the work practices in these hospitals, and why effective coordination and communication are crucial to facilitate day-to-day activities and in certain situations, save a patient's life. The opportunities to learn through their points of view and their understanding about their

work have brought the researcher closer to understanding the internal and external elements that influence the way they do things every day.

3.2.5 Semi-structured Interview

Whilst interview method has been widely suggested as a common, useful and important research technique, Myers and Newman (2007) argued that the method has been taken for granted in the information systems research. Explicitly, there have been inadequate reporting practices in the literature because of a lack of proper framework for carrying out an interview. Myers and Newman (2007:16-17) proposed the following guidelines to guide the semi-structured and unstructured interview methods.

1. *Situating the researcher.* The researcher should understand their relationship to the subject and the organisation, and also their role and demographic attributes such as background, age, experience, gender and nationality. These are important information that can be useful for reporting purposes.
2. *Minimise social dissonance.* The researcher should make efforts to make the interviewee to feel comfortable and minimise the social distance.
3. *Represent various voices.* "Triangulation of subjects" and avoiding "elite bias" can increase the quality of the interview data. A variety of voices represented in research can increase the validity of the qualitative research.
4. *Everyone is an interpreter.* The researcher must recognise that subjects are also interpreters, and the interview is 'usually an artificial/rare event' for them. The researcher is also an interpreter, because they will interpret the interview transcripts or texts.
5. *Use mirroring in questions and answers.* The researcher should take the words and phrases that the subjects use in developing a subsequent comment or question. This will allow the subjects to talk more about their world using their own words.
6. *Flexibility.* The researcher must remain flexible in doing semi-structured and un-structured interviews.
7. *Confidentiality of disclosures.* The researcher should know that confidentiality, security and feedback are important aspects of doing qualitative interview. These aspects should be discusses in report writing.

Phase 1: Semi-structured Interviews

Semi-structured interviews focused on obtaining data about: (1) the extent of electronic medical record application and the implementation status of Total Hospital Information System (THIS) in the Malaysian context, and (2) the perception of the senior hospital management and senior officers with regard to deploying information systems and technologies in the hospital work environment. The following figure illustrates the content of the interviews.

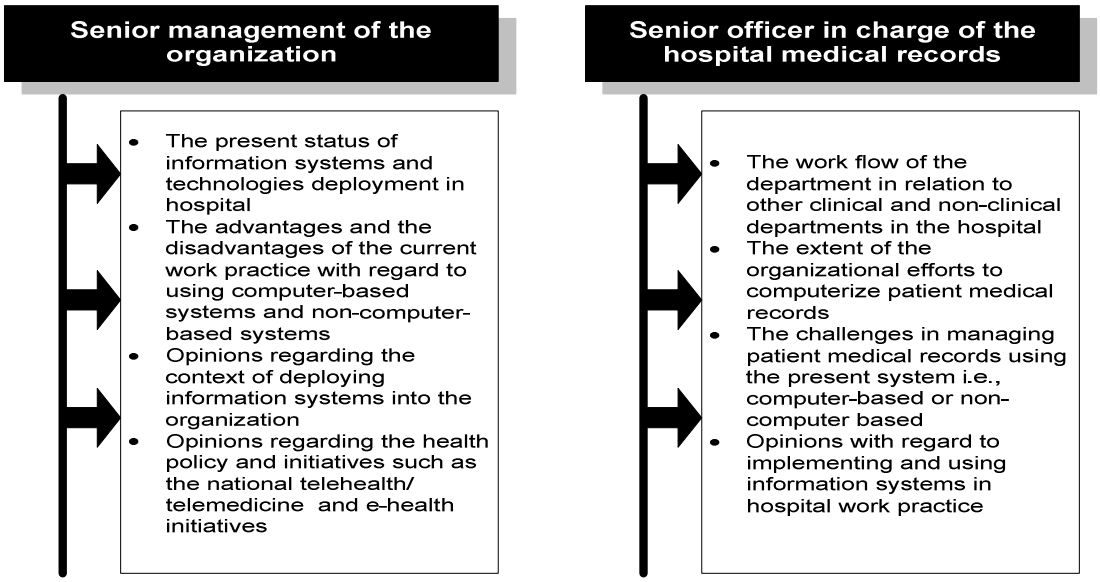


Figure 3.4: Phase 1 Semi-structured Interview Questions

Initially, the researcher sent a formal letter together with two sets of interview questions to 18 hospitals in early July 2006. A follow-up series of telephone calls was made to all the targeted hospitals to obtain confirmation about the interview sessions with the representatives of the hospital. Out of the 18 hospitals, only 11 hospitals agreed to participate in the research. The following table provides brief descriptions of these organizations.

Table 3.5: The Organizations that Participated in Phase 1 Data Collection

Organization	Brief description
PACS-DPMT Hospital	The hospital was established in 1999. It is an IT-based hospital and has more than 950 in-patient beds. It provides secondary and a selected tertiary care services.
COV-DPMT Hospital	The hospital was established in 1880s during the colonial era in Malaya. It has more than 2300 in-patient beds and offers secondary and tertiary services.
ALPHA G-1	The hospital offers secondary and tertiary services. It has about 800 in-patient beds.
ALPHA G-2	The hospital was relocated to a new site in mid 2007. It now functions as

	an IT-based hospital. It offers secondary and tertiary services and has more than 700 in-patient beds.
ALPHA G-3	The hospital was established in 1930. It offers secondary and tertiary services, and has more than 830 in-patient beds.
ALPHA D-1	The hospital was established in 1992 and offers secondary services. It has about 200 in-patient beds.
ALPHA D-2	This hospital was relocated to a new site in early 2007. It now operates as an-IT based hospital. It provides secondary services and has more than 490 in-patient beds.
ALPHA D-3	This is a small-district hospital.
ALPHA D-4	The hospital was established in 2000. It is an IT-based hospital and has more than 250 in-patient beds. It provides secondary and a selected tertiary care services.
ALPHA I-1	The hospital was established in 1992 and provides a specialized healthcare service and treatment.
ALPHA U-1	This is a university-teaching hospital and was established in 1997.

Subsequently, the interviews were scheduled beginning of August 2006 until September 2006. The following is the list of the interviewed participants from 11 hospitals (10 government-owned hospitals and 1 is a university teaching hospital) that participated in the study.

Table 3.6: List of the Interview Participants in Phase 1 Data Collection

Organization	Interviewed participants	No. Of Interviews
PACS-DPMT Hospital	Hospital Director Manager of the Medical Record Department	2
COV-DPMT Hospital	Officer of the Medical Record Department	1
ALPHA G-1	Officer of the Medical Record Department	1
ALPHA G-2	Officer of the Medical Record Department	1
ALPHA G-3	Officer of the Medical Record Department	1
ALPHA D-1	Hospital Director	1
ALPHA D-2	Hospital Director Officer of the Medical Record Department Hospital medical doctor	3
ALPHA D-3	Officer of the Medical Record Department	1
ALPHA D-4	Hospital medical specialist	1
ALPHA I-1	Manager of the Medical Record Department	1
ALPHA U-1	Hospital Deputy Director Manager of the Medical Record Department Hospital medical doctor cum a manager of the hospital IT department	3

All the interviews except one (with Alpha G-3 officer) were recorded on tape. The average time for an interview session with the representative of the hospital medical record department was about one hour and 30 minutes (the shortest interview session was around 20 minutes while the longest was around 3 hours). The average

time for each interview session with the rest of the interview respondents (hospital top managements and medical doctors) was about 50 minutes.

Phase 2: Semi-structured Interviews

Semi-structured interviews were conducted with the Head of the Department and the chief of radiographers of each site. In addition, several interviews were also conducted with the clinicians and the senior of medical record departments from each site.

3.2.6 Survey

This study also deployed the survey method. This method as a research instrument can contribute to higher confidence in the generalizability of results (Jick, 1979). A questionnaire survey is appropriate to obtain data related to self-reported beliefs or behaviours (Neuman, 2000).

The survey instrument was used in this study primarily to obtain the radiographers' socio-demographic information, to validate some observational findings and to gain understanding about their attitudes, beliefs and perceptions on certain issues related to their work practice. Since it is impossible for the researcher, under the limited time frame, to observe all the radiology subunits of the department and also to interact with all the radiographer personnel, the researcher decided to deploy a survey method to address this limitation. The following presents the components of the survey. A sample of the survey in the original language is attached in Appendix A.

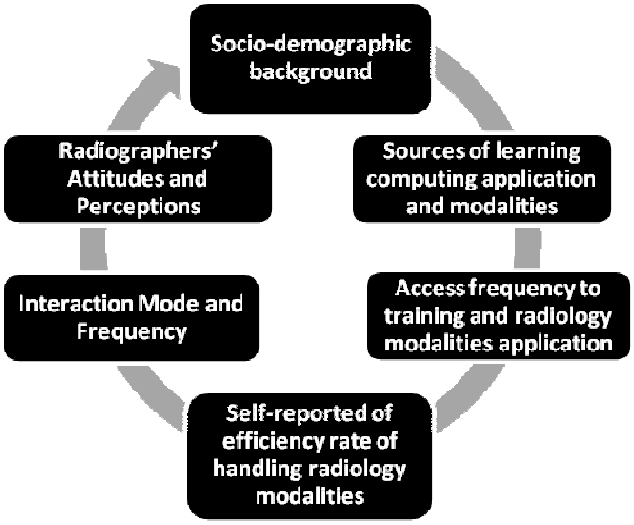


Figure 3.5: Components in Survey

3.2.7 Documentary Evidence from Secondary Resources

This study also used internal and external documentary evidence from secondary resources particularly from (1) the organizations' annual reports, bulletins, seminal/journal articles and websites, (2) the local newspapers and, (3) the Malaysian government websites.

3.3 DATA ANALYSIS STRATEGIES

Miles (1979) used the term 'attractive nuisance' to describe the attractive nature of the qualitative data and the challenging and laborious tasks to perform data analysis. In a nutshell, there are two tasks involved in doing data analysis. First is concerning the analysis of 'process data'; and second is doing data interpretation. Langley (1999:962) described process data as the data that 'consist largely of stories about what happened and who did what, when – that is, events, activities, and choices ordered overtime'. Process data is messy and confusing, particularly with regard to identify boundaries in the data to represent what levels and units of analysis (Langley, 1999). The fluid nature of process data means that such data deals with sequences of events, multiple levels and units of analysis, variation of temporal embeddedness and the eclectic tendency such as 'changing relationships, thoughts, feelings, and interpretations' (Langley, 1999:692). As for data interpretation, it comes from the efforts at sensemaking (Wolcott, 2001). According to Corbin and Strauss (2008:48), interpretation implies 'a researcher's understanding of the events as related by participants'.

This study in general adopted approaches recommended by Strauss and Corbin (1990), Miles and Huberman (1994), Wolcott (2001) and Corbin and Strauss (2008) in doing systematic data analysis, data interpretation as well as presenting research findings. Strauss and Corbin (1990) and Corbin and Strauss' (2008) suggested techniques particularly were used to deal with the 'process data' obtained from the fieldwork and from the interviews. The following Multilevel Data Analysis Framework demonstrates how this study derived the research outcomes from the data using analytical techniques recommended by these authors. The units of analysis for the research are the individual's ways of using radiological work artefacts and the group social interaction.

The Multilevel Data Analysis Framework consists of two levels of data analysis, namely, First Level Analysis and Second Level Analysis. The First Level Analysis concerns with analyzing the data obtained from the fieldwork sites (Phase 2) and also from the interview data. This level of analysis emphasizes on the physical view of data elements, in this case the data that is relevant to 'what', 'where', 'when', 'how' and 'why' questions to provide answers to the research inquiries. The Second Level Analysis focuses upon interpreting and making sense of the data, where systems theory and other selected theoretical concepts has been deployed as a sensitizing device to make sense of the data. The research conceptual framework (presented in the previous chapter) was used to guide the overall data analysis and interpretation for this study.

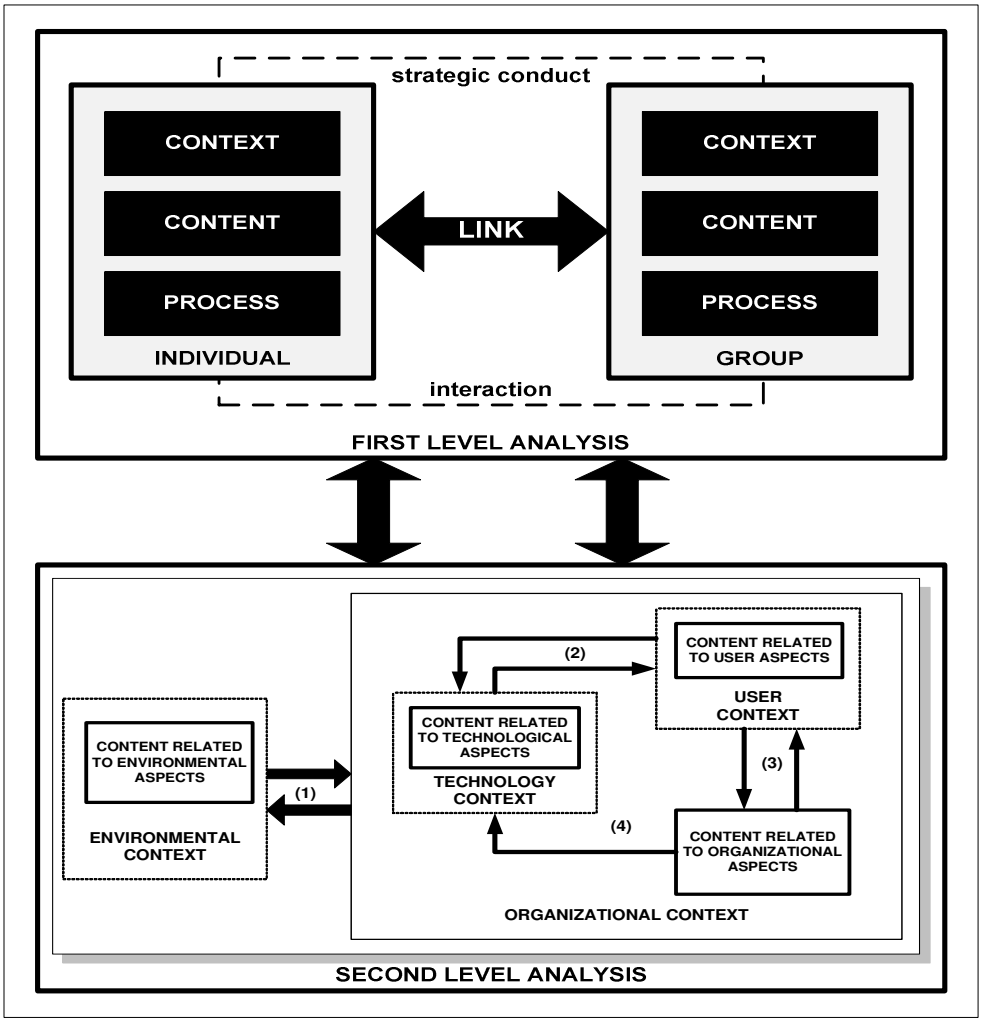


Figure 3.6: Multilevel Data Analysis Framework

The following further demonstrated the process of doing data analysis and interpretation based on the above framework.

3.3.1 First Level Analysis

In general, there are three steps involved in this level. First is related to the process of transcribing and reading data; second is about categorizing data (data coding); and third is presenting the identified categories or coding as research findings. The following describes the three tasks that were undertaken to analyze the process data.

Step 1: Transcribing and Reading Data

All the qualitative data were first transcribed. Then, this study utilized the Audacity (http://audacity.sourceforge.net), a freeware to further process the audio-supported data. The researcher used the software functions such as cut, copy and export to WAV files to perform audio clippings. These audio clippings were linked to the relevant data transcripts using the Microsoft Word Hyperlink tool. The purpose of doing that is to increase the quality of reading and interpreting. Next, using NVivo Version 7 software, the researcher performed data reading. NVivo is a common software tool like ATLAS that has been used to facilitate the data analysis process in the qualitative research. These software merely help the qualitative researcher 'to manage, sort and organize large volumes of qualitative data, store, annotate and retrieve text, locate words, phrases and segments of data, prepare diagrams and extract quotes' (Seale, 2000 cited from Burnard et al., 2008). In this research, three forms of data reading were used, namely literal, interpretive and reflexive readings. According to Mason (2002):

- In the literal reading, the primary focus is on the 'literal aspects such as form, content, structure, style, layout and so on'
- In the interpretive reading, the researcher involves 'constructing or documenting a version of what the data mean or represent, or what the researcher thinks they can infer from them'
- In the reflexive reading, the process 'will locate the researcher as part of the data they have generated, and will seek to explore their role and perspective in the process of generation and interpretation of data'

In doing interpretive and reflexive data reading, the researcher made use of NVivo tools such as Memo and Links, and the audio clippings.

Step 2: Categorizing Data (Open, Axial and Selective Coding)

The researcher adopted three coding techniques (open, axial and selective coding) suggested by Strauss and Corbin (1990).

Open Coding: According to Strauss and Corbin (1990), the open coding process is the initial step in the data analysis where the data will be categorized or labelled accordingly. One of the advantages of doing open coding is that it allows the researcher to generate as many relevant categories or codes as depicted by the data. For this research, instead of using line-by-line analysis, the researcher analyzed paragraph-by-paragraph to understand the context or phenomena before assigning a category or a code. The researcher first performed open coding on the COV-DPMT data, and then followed by the PACS-DPMT data.

Axial Coding: The outcomes of the open coding process are the input for doing axial coding. Axial coding is the coding stage where the outcomes of the open coding will be grouped into categories and sub-categories, and the relationships between these categories supposedly emerge (Strauss and Corbin, 1990). To achieve this, the axial coding process focuses on examining data 'for conditions, interactions among the actors, strategies and tactics, and consequences' (Strauss, 1987). Later, the outcomes of doing axial coding will be reviewed and revised before proceeding to do selective coding.

Selective Coding: The selective coding is the process where the core categories (or themes) will be developed based on the refine codes or categories in the axial coding. In this study, the refined categories were generated from doing constant comparison between categories developed for COV-DPMT's data and categories developed for PACS-DPMT data. According to Corbin and Strauss (2008), the core category (theme) represents the concept that all other concepts will be linked to, and it has analytic power to theoretically explain the phenomenon under investigation. They recommended (2008:104) that the researcher choose 'the category that appears to have the greatest explanatory relevance and highest potential for linking all of other categories together'.

Step 3: Presenting the Coding Findings

The following tables present the core categories that emerged from the fieldwork data and the interview data.

Table 3.7: Categories/Themes derived from COV-DPMT

THEMES	REFINE CATEGORIES	EXAMPLES OF INITIAL CODING	SAMPLE DATA
Work artefact	• Modalities and other healthcare technologies • Information communication and technologies support • Radiographic film • Patient medical records • Other support artefacts	Examination approval, despatch film, patient scheduling, patient issue, tracking patient old films, review examination request, performing diagnostic report, diagnostic discussion, space issue, shortage of film, machine breakdown	***[patient issue] [patient scheduling]*** '...The counter personnel were talking about a cancer patient from KAY's (staff nurse) department who had not arrived yet. KAY made a telephone call to her department to enquire about the patient. After the phone conversation ended, she informed the counter staff that the patient CT exam would need to be rescheduled to another day...' ***[tracking patient old films]*** '...ARN contacted the ward to speak to the patient's clinician about the old patient films. She requested the nurse to check on the patient's old films in their clinic. She provided them the patient's IC (identity card) number to locate the films...'
User	• Work activity • Perception • Attitude	Work authority, interruption at work, radiologist-radiographer, department nurse - radiographer, radiographer-MO radiologist, radiographer-clinician, patient issue, radiologist-counter staff	***[Attitude] [radiologist-clinician][A&E Unit]*** '...A houseman officer came into the panel room with x-ray films and talked with Dr. SH (a radiologist). Dr. SH asked him to explain about the urgent request. The trainee doctor explained to her about the patient sickness. Dr. SH asked whether he has the allergy form with him. The trainee doctor gave some excuses about why he did not have the patient allergy form with him. Dr. SH said: '...you need the allergy form…it is medical legal thing…' The doctor asked 'where to get the form' and he sounded quite rude. Dr SH replied: 'I don't have the allergy form, ask the receptionist to give it to you..'. Few seconds later, the doctor leaved the panel room...'

Organization	• Working culture • Decision making	sharing resources, negotiation, interruption at work, staffing issue, authority, doing research, purchase material, subdivision meeting, ambiguity in work , work space constraint	***[staffing issues][reject rate]*** '...we did notice after the person got transfer to another place, then some of the problems were gone together with that person...when errors happened, always put the blame on the machine. Actually, human factor contributes largely on the error. That's why I said...When the staff was on duty at a particular room, the following week when we performed the analysis, the same problem occurred again. In the meeting, I asked the staff to bring the duty roaster together, so we can understand the problem …'
Environment	• Ministry of Health • Contractor • Patient • Public expectation • Other healthcare organization	Health policy, authority, resource deployment, resource constraint, awarding contract, contractor performance, decision making, in-patient issue, out-patient issue	***[authority] [staffing issue]*** '...I'd like to have the authority to hire and fire...But in the Ministry of Health, my role does not have such authority. If I have the authority to hire and fire, I can be selective. ...don't have to just accept all given to us...I wish I have that authority of hiring and firing...'

Table 3.8: Categories/Themes derived from PACS-DPMT

THEMES	REFINE CATEGORIES	EXAMPLES OF INITIAL CODING	SAMPLE DATA
Technology Design Feature	• Online image retrieval, viewing and storage • Online patient data • Online reporting • Extensive work automation [scheduling] • Various types of digital modalities • Extensive internal networking system • Ubiquitous computing environment	Tracking patient medical history, PACS tools, tracking old images/films, tracking diagnostic reports, performing diagnostic report, image review, patient scheduling, despatch film, request film printing, review radiology request, obtaining images for research, systematic diagnostic reporting, communication, flexibility in work, facilitate radiology request, order entry issue, in-patient issue, out-patient issue, machine breakdown, EMR access issue, interruption at work	***[tracking old images]*** '...In between of my conversation with SL (a radiographer), a surgeon came to seek his help to locate a particular patient's old radiographic images. The surgeon mentioned the images were taken somewhere in year 2003. SL searched the server to locate for the images...He found the images and waited for few minutes to upload them from the server... The surgeon viewed the image using SL's workstation. He was concerned about the patient's last surgery operation (i.e. issues about left or right). He asked SL for opinion regarding the image... The surgeon said thank you and left... SL told me that it is quite common for doctors to come directly to him to ask for assistance to locate some patient old images. Usually, when the images cannot be obtained online, there is high possibility that the images are being kept offline, in this case stored using optical disks....'
User	• Work activity • Trust issue • Perception • Attitude	radiology tasks, additional work activities, work authority, modes of communication, interruption at work, communication barrier, decision making, contractor, IT Department, dependency upon others, in-patient issue, out-patient issue, order entry issue, dependency upon technology	***[in-patient issue]*** '...TL (a radiographer) used PC Compaq to obtain the patient exams list for today. He searched for a specific in-patient's MRN. Then he called another radiographer, CH to confirm whether this is the right patient. After confirming the patient identity, CH made a phone call to the patient's ward. He asked why the patient did not come for CT examination...'
Organization	• Working culture • IT Department • Other departments • Decision making	sharing resources, negotiation, interruption at work, staffing issue, authority, doing research, subdivision meeting, co-operation, contractor performance	***[authority][working culture]*** '...Dr. DD (a medical officer) briefed the radiographers about the patient illness and allergy... She was quite furious when she got information from AR (a radiographer) that her patient will be given contrast. She

			kept mentioning about her illness, and slightly concern about the contrast procedure on the patient... She then obtained confirmation from the radiologist on duty. ...Then, she made a telephone call to the main clinician... She said to the radiographer, since 'the big boss' has given the permission then they can proceed with the contrast procedure...'
Environment	• Ministry of Health • Contractors • Patient • Public expectation • Other healthcare organizations	Health policy, authority, deploying resources, resource constraint, contractor appointment, decision making, in-patient issue, out-patient issue	***[authority][contractor]*** '...in the case of outsourcing, still we have to through the usual government tender...for contractor, we need to have smart partnership with them...because if you can work with them...bring them along, you can expect their commitment to perform is better... contractor has reputation to maintain...

Table 3.9: Categories/Themes derived from Phase 1 Data Collection
[Other Organizations]

THEMES	REFINE CATEGORIES	EXAMPLES OF INITIAL CODING	SAMPLE DATA
Environment	• Ministry of Health • Contractors • Other healthcare organizations	Health policy, authority, deploying resources, resource constraint, contractor performance, decision making, PACS-DPMT Hospital, training, perception, hospital senior management, senior personnel handling medical record, IT impact, implementation strategy	***[medical record management][resource constraint]*** '...if we want to convert the existing system [manual] to electronic, it will be a great burden for the unit [Medical Record Department] because we don't have enough manpower to do that...we need additional staff...we usually don't get what we ask for [additional staff]...last year, we engaged with a daily-paid personnel...we also need to obtain approval from the Ministry of Health... every year, their yearly attachment with us will be reviewed by the ministry...' ***[hospital senior management] [implementation strategy]*** '...we have to negotiate with doctors and initially we started with two doctors who used the EMR...they showed the example...key-in the information themselves [computerizing discharge summary]...Everyone [doctors] knows they are doing it...we approached all the doctors, and they agreed to use EMR...but at this stage, they need an assistance to key-in the information...we agreed, and we trained their secretary...' ***[hospital senior management] [perception][IT impact]*** '...[cost saving] difficult to say...we cannot see the effect immediately...but definitely [technology] will improve efficiency from the aspect of management, billing ... especially when a patient is discharged...they already get their bill. So, this [computerized billing] can improve our collection...also for us, with multidiscipline clinical specialization and with a large number of clinics ... [technology] can improve our patient management...'

3.3.2 Second Level Analysis

The Second Level Analysis is focused upon doing data interpretation. Langley (1999) suggested seven strategies for sensemaking to interpret process data, namely narrative strategy, quantification strategy, alternate templates strategy, grounded theory strategy, visual mapping strategy, temporal bracketing strategy, and synthetic strategy. Each of the strategies tends 'to overcome the overwhelming nature of boundaryless, dynamic, and multilevel process data by fixing attention on some anchor point that helps in structuring the material but that also determines which elements receive less attention' (Langley, 1999:694). Overall, this study adopted a combination of narrative, alternate templates and visual mapping strategies in doing the sensemaking. For this study, alternate template strategy particularly had been useful in dealing with the complexity of the process data. According to Langley (Langley, 1999:696): the alternative template strategy uses theories as key anchor points, and 'adaptable to various kinds of complexity'; the narrative strategy uses time as key anchor point, and 'fits with ambiguous boundaries, variable temporal embeddedness, and eclecticism'; the visual mapping strategy uses events and orderings, and 'deals well with time, relationship but less good for emotions and interpretations'.

In doing sensemaking, this study also made use of several techniques for data display suggested by Miles and Huberman (1994). Data display is 'an organized, compressed assembly of information that permits conclusion drawing and action' (Miles and Huberman, 1994: 11). The following two figures are the examples of data display to present the findings generated from the First Level Analysis. The coding findings have been further organized following the conceptual framework that guided this research. These two figures are the general reference to structure the presentation and discussion of research findings in the subsequent chapters.

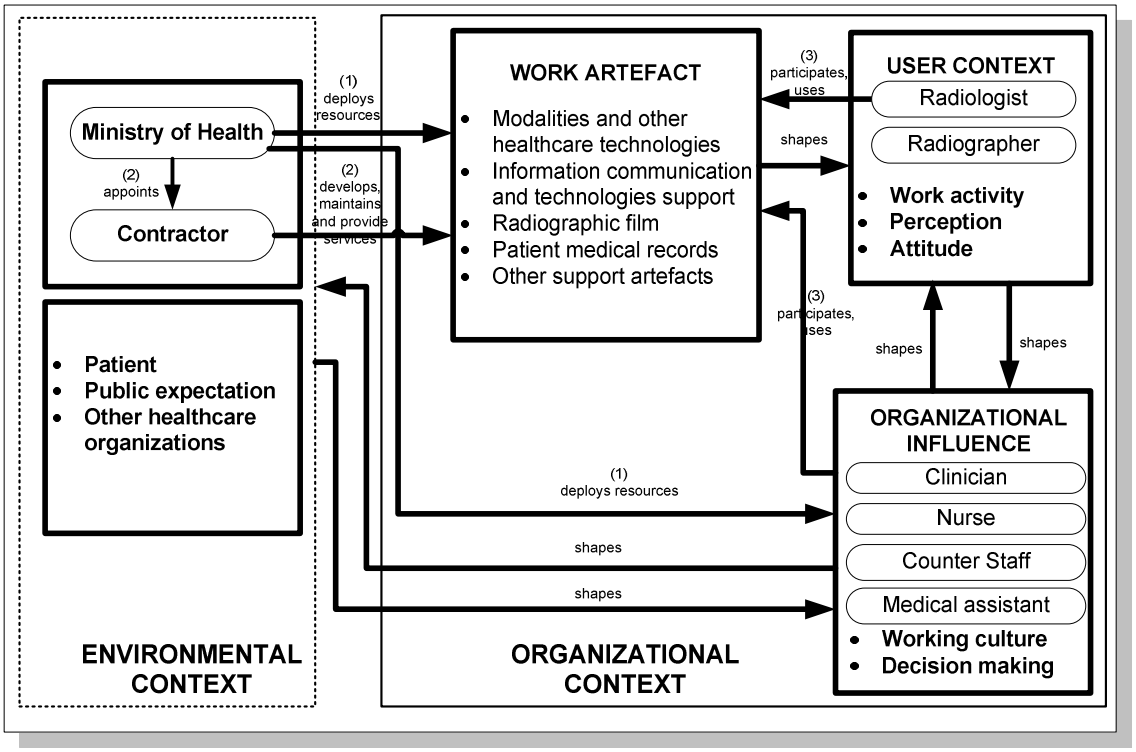


Figure 3.7: Main Research Findings – COV-DPMT

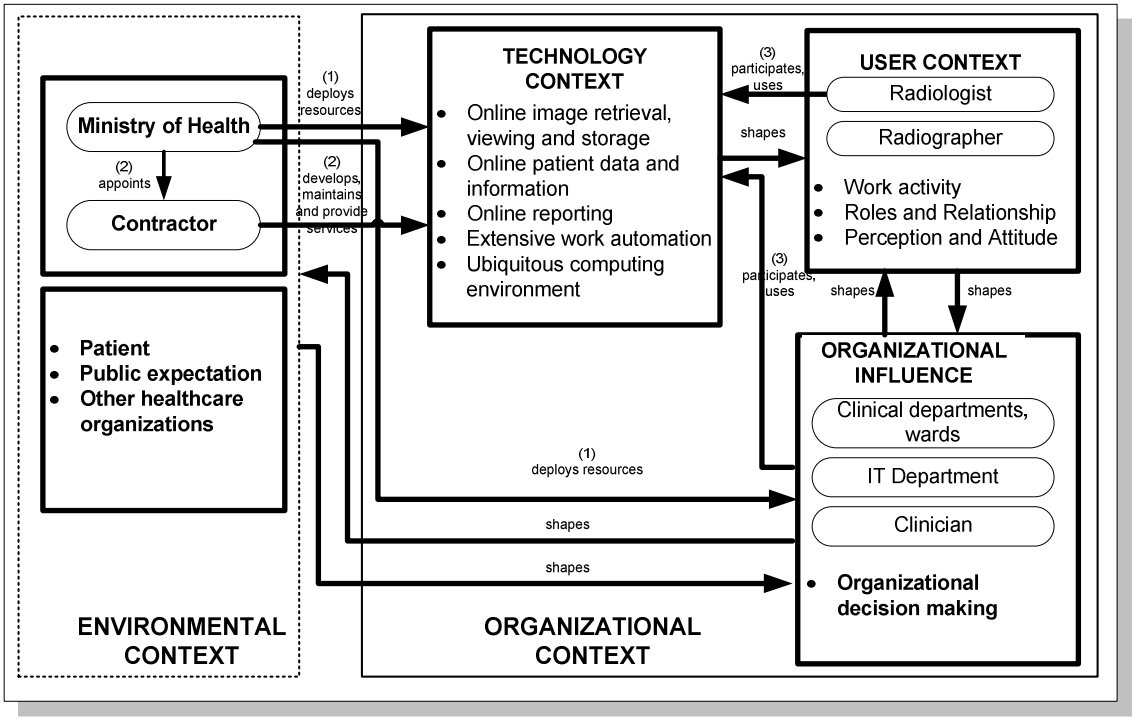


Figure 3.8: Main Research Findings – PACS-DPMT

3.4 CASE SETTING

3.4.1 COV-DPMT

COV-DPMT is a hospital-based radiology department which belongs to one of the largest hospitals in Malaysia, and also in South East Asia. The hospital was formed in the 1880s, during the colonial era in Malaya. The department was established in the early 1900s when the hospital received its first x-ray machine. At that time, the department was known as the X-Ray Department. During the period after Malaya gaining independence from Britain in 1957 and Malaysia was formed in 1963, there were initiatives to upgrade the healthcare infrastructures and services by the government. In the First Malaysia Plan (1966-1970) for example, the government directed its health initiatives towards increasing healthcare access among the rural populations, and also on improving public healthcare services[47]. Significant transformation of the COV-DPMT's hospital's physical infrastructures took place around this period. The hospital was also relocated within the city area. Massive construction of the new hospital building began and took place in several phases. The last phase of the project was completed in the late 1970s.

At present, the hospital has more than 25 clinical departments, and also several clinical support and non-clinical support departments. Currently, the hospital is equipped with more than 80 wards with around 2300 patient beds. As of 2007, the number of medical specialists working in the hospital is close to 300. The hospital also has more than 500 medical officers and about 2,500 staff nurses. Since 2003, the hospital has had an average of more than 6,500 staff per year. Although the hospital mainly offers secondary and tertiary healthcare services, it also provides out-patient care service. The service is managed by the Out-Patient Department. In between 2006 and 2007, the hospital received an average of 989, 254 outpatients annually. For in-patient admission, from 2003 to 2007, the hospital recorded an average of 123,214 patients per year. In Malaysia, the hospital is known as one of the busiest general hospital.

[47] Source: http://www.MOH.gov.my

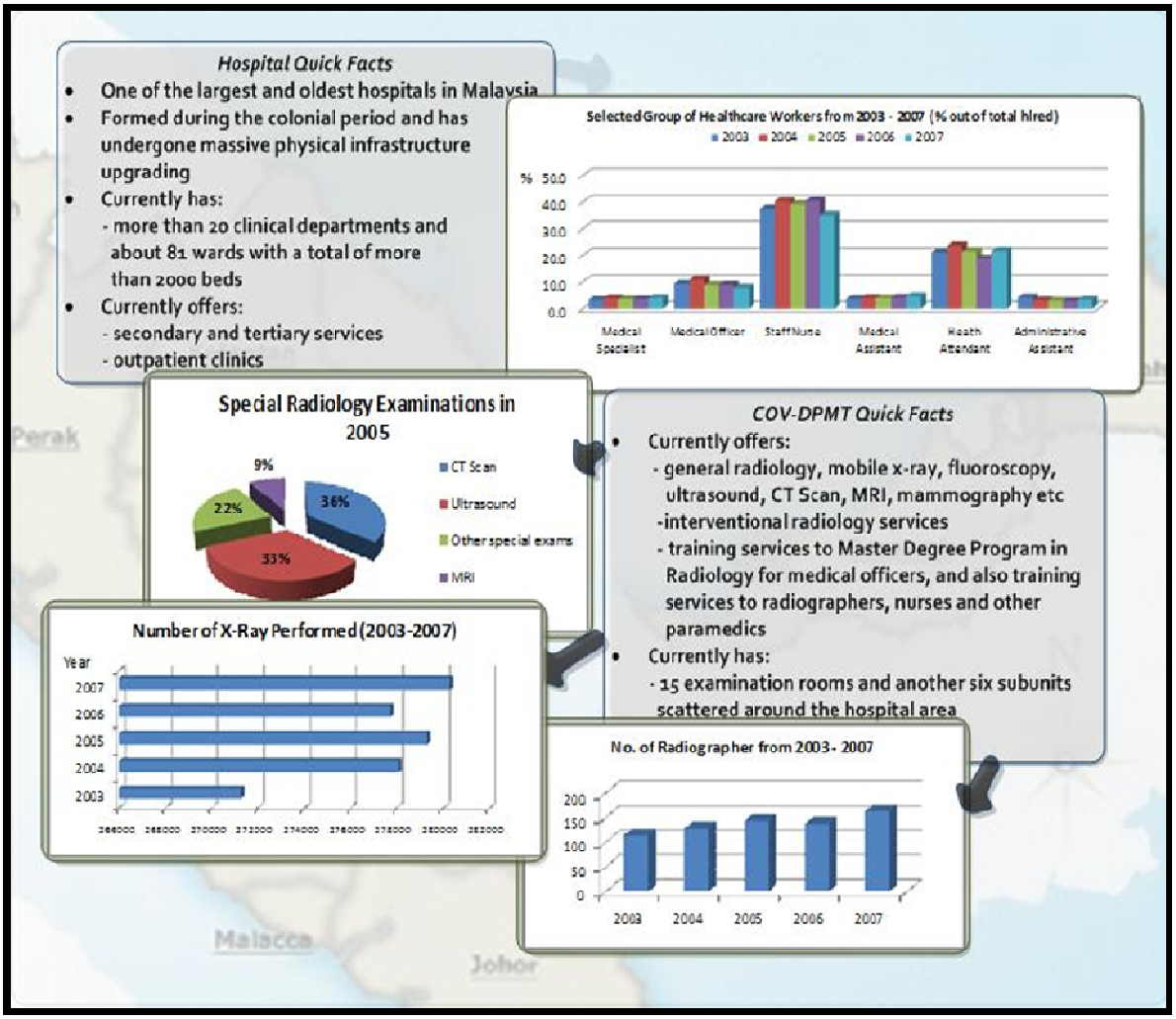


Figure 3.9: COV-DPMT (Selected Facts)

The COV-DPMT has grown at similar pace to the hospital. Since its inception, many important historical events in Malaysia radiology history are linked with the department and the hospital in general. For example, in the colonial era, COV-DPMT was the first to have a dark room to process x-ray films. The department also under the supervision of a British radiologist had trained selected local assistants to become 'dressers' to assist the department's operations. In the late 1940s, some of these assistants were selected to go to the United Kingdom to be trained as radiographers. Also, COV-DPMT is always among the first batch of radiology departments in the country to receive and use the latest radiology modalities available in the market. It was recorded that mammography service (early 1970s) and CT machines (late 1970s) were first introduced in the hospital. Then in early 1990s, the department was among the first to implement MRI modalities. In

Malaysia, ultrasound was only introduced around 1974[48]. The department's work environment continues to develop and is being shaped by the progress of radiological knowledge and medical breakthrough, as well as the advancement in medical imaging techniques and technologies. The department's name has been changed twice, from its original name to Radiology Department in early 1970s, and then to Diagnostic Imaging Department in early 1990s.

Today, COV-DPMT offers radiology services such as general x-ray, mobile x-ray, fluoroscopy, CT, MRI, Ultrasound, mammography and interventional radiology to in-patients and outpatients (referral patients). It also provides training services to the Master Degree Program in Radiology for medical officers (MO) in addition to other training services for radiographers, nurses and paramedics. In term of its physical infrastructure, the department has 15 examination rooms in the main department building and another six subunits scattered around the hospital's clinical departments and institutes. In between 2004 and 2005, the department saw more than 240,000 patients. There was a slight increase in terms of patient numbers in 2005 as compared to 2004. Also in 2005, 36% of its special examinations were from CT, followed by Ultrasound (33%), Other Special Examinations (22%) and MRI (9%).

As of October 2007, COV-DPMT had about 157 staffs. Out of this, about 12 were radiologists (excluding those who were on study-leave), 93 were radiographers, and around 15 were staff nurses[49]. The rest consisted of medical assistants (including two dark room staffs), administration and clerical staff. The Head of Department who is also a radiologist was appointed in 2006; the Chief Radiographer assumed the position in COV-DPMT in 2005. He has more than 30 years experience servicing various community hospitals as a radiographer, and as a Chief Radiographer. In the department's main building, some of the radiology technologies and machines that COV-DPMT uses are: 2 units of CT Scan, 2 units of MRI, 11 X-Ray units, 4 laser printers, 3 film processors, viewing/light boxes, bone densitometer etc. The subsequent diagram illustrates the role mapping based on the day-to-day activities as observed in the fieldwork data.

[48] http://www.radiologymalaysia.org/
[49] The number is based on the interviews conducted with the Head of Department and the Chief Radiographer in September 2007.

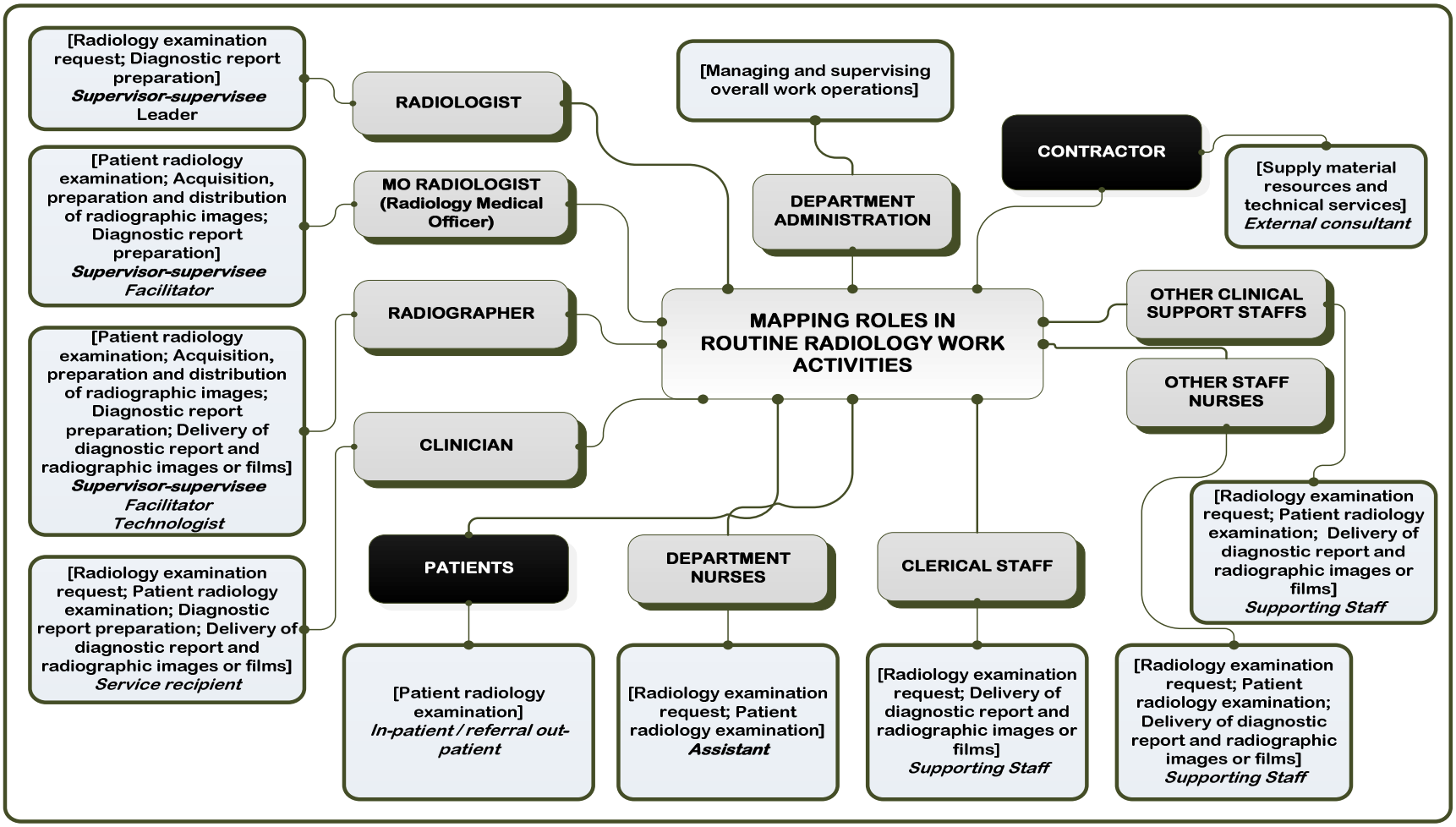


Figure 3.10: Mapping Roles in Routine Radiology Work Activities - COV-DPMT

3.4.2 PACS-DPMT

PACS-DPMT is a hospital-based radiology department which belongs to a community hospital in Malaysia. The hospital building was constructed in the mid 1990s and it took three years to complete. The building was delivered to the Ministry of Health by the appointed turnkey contractor in early 1999. The completed building was installed with hardware and software infrastructures to support the concept of Total Hospital Information System (THIS). In terms of information systems and technologies, it was mentioned that the hospital was equipped with about 1,200 computers, 300 printers, 66 mobile computers, 77 servers and 150 bar-code readers. The hospital commenced its operation in August 1999.

The hospital offers secondary and tertiary healthcare services. It has 20 clinical departments, about 22 operating theatres, close to 30 wards with more than 950 in-patient beds. The hospital also serves as a national referral centre for a number of clinical specialties. In 2007, the hospital was among the selected hospitals to adopt the 'full-paying patient' concept. This concept is devised by the Ministry of Health to provide additional monetary incentive to the government healthcare professionals, particularly the medical specialists. The scheme mainly aims to curb the problem of government doctors migrating to private healthcare institutions due to better remuneration package. The scheme provides an option to the patient who can afford to pay to choose their own preferred specialist. The 'full-paying patient' scheme now has been implemented in all public hospitals since January 2008.

In the context of THIS implementation at the hospital, the Ministry of Health was involved directly in the aspects of planning, monitoring as well as making decisions with regard to the project implementation since the commencement of the project. The THIS concept was originally devised at the ministerial level as part of the efforts to improve the healthcare facilities and infrastructures. THIS in general integrates three important components of hospital work activities, namely clinical, administrative and finance. The hospital information systems that make up the THIS include applications such as EMR, HIS, PACS, RIS, Laboratory Information System (LIS), Pharmacy Information System (PIS), document management and others. Contracts were awarded by the Ministry of Health to several prominent technology vendors to develop and install the THIS infrastructure in the hospital. During the project

implementation, representatives from the key user groups were engaged in the process of implementing the technology.

In the early years of the THIS deployment, especially between 2001 and 2002, a number of human and technical issues linked to the use of THIS had occurred. There were reports that mentioned resistance to use, slow system response and computer system breakdown. Inadequate server and CPU storage capacity were mentioned as factors that triggered the problem of slow system. As for the EMR application, although it was installed in 2001, there had been several on-going works to resolve issues related to the integration of data, particularly concerning the Critical Care System module. On top of that, the poor performance from an appointed contractor that was supposed to overlook the THIS project had also affected the overall performance of the THIS application around this period of time.

To date, THIS has been running smoothly as the backbone of the work activities of the hospital.

Medical Imaging Implementation at PACS-DPMT

PACS-DPMT offers intervention and non-intervention radiology services such as general x-ray, fluoroscopy, Intravenous Urography (IVU), mammography, ultrasound, MRI, CT, angiography, mobile x-ray and interventional diagnostic and therapeutic services. In addition to hospital inpatients and referral outpatients, the department also offers radiology services to the community hospitals and clinics around the area. As of 2007, there were nine radiologists, two full-time medical officers, 22 radiographers and 1 clerical staff, in addition to few nurses.

PACS-DPMT implemented medical imaging system since the inception of the department. Medical imaging, i.e., PACS and RIS as mentioned before is part of the critical components of the THIS concept implemented in the hospital. In the PACS Server Room, there are about 14 servers to cater for the storage capacity of the radiology images so far[50]. The client-server architecture network is fundamental in the medical imaging design. Here, the PACS servers have been linked with about 23 dedicated machines (clients) located at the IT department[51]. As PACS has been fully integrated with all the digital imaging modalities, RIS and other hospital information

[50] The information was derived from the interview conducted with the senior radiographer who was in charge of the PACS Server Room.
[51] The information was derived from the interview with the Chief Radiographer.

systems, substantial radiology work activities in PACS-DPMT are performed online. The hospital is equipped with a substantial number of viewing and diagnostic workstations. These workstations are installed with Siemens MagicView software, an application that enables users to retrieve and view patient images online. The advanced version of this software contains more features to assist the users, particularly the radiologists and medical officers (MOs) in doing image interpretation and diagnostic report. Table 3.10 provides a brief explanation about the medical imaging's technological components and the EMR application in PACS-DPMT.

Table 3.10: Medical Imaging in PACS-DPMT

Artefacts	Computing applications in work practice
Modality workstation	A modality workstation is a gateway to obtain radiology images for PACS. Radiographers use this workstation in their works.
Diagnostic workstation	A diagnostic workstation is used by radiologists and radiology MOs to perform clinical diagnostic of patient images. The workstation is linked with a network and therefore images can be retrieved from the PACS servers or can be received directly from the modality workstations. Using viewing software such as the MagicView application, these images then can be viewed and manipulated to enable the radiologist to perform high quality of diagnostic image review.
Viewing workstation	A viewing workstation is equipped with a MagicView application and linked through a network. This workstation however does not have abilities to perform advanced image manipulation, and usually its usage is restricted only for PACS image retrieval and viewing.
PC workstation	A PC workstation dedicated for doing online reporting is placed next to the radiologist Diagnostic Workstation. Radiographers also use a PC workstation to access the RIS, EMR, other HIS applications and email while performing their duties. Most of the PCs around the department have internet and intranet links.
RIS	The RIS application automates many radiology work processes. Some important functions of this application include patient order list (online order entry), Work List and Exam Management (for radiographer's works) and Transcribing Radiology Report (for doing radiology reporting).
EMR	The EMR application is central to the work activities of the hospital. Radiologists and radiology MOs use this application to obtain patient sickness history when doing radiology diagnostic reports. This application is accessed through the PC workstation which is also installed with RIS. The EMR system can only be accessed by medical doctors. Password is used as a mechanism to protect patient data and privacy.

The subsequent diagram illustrates the role mapping based on the day-to-day activities as observed in the fieldwork data.

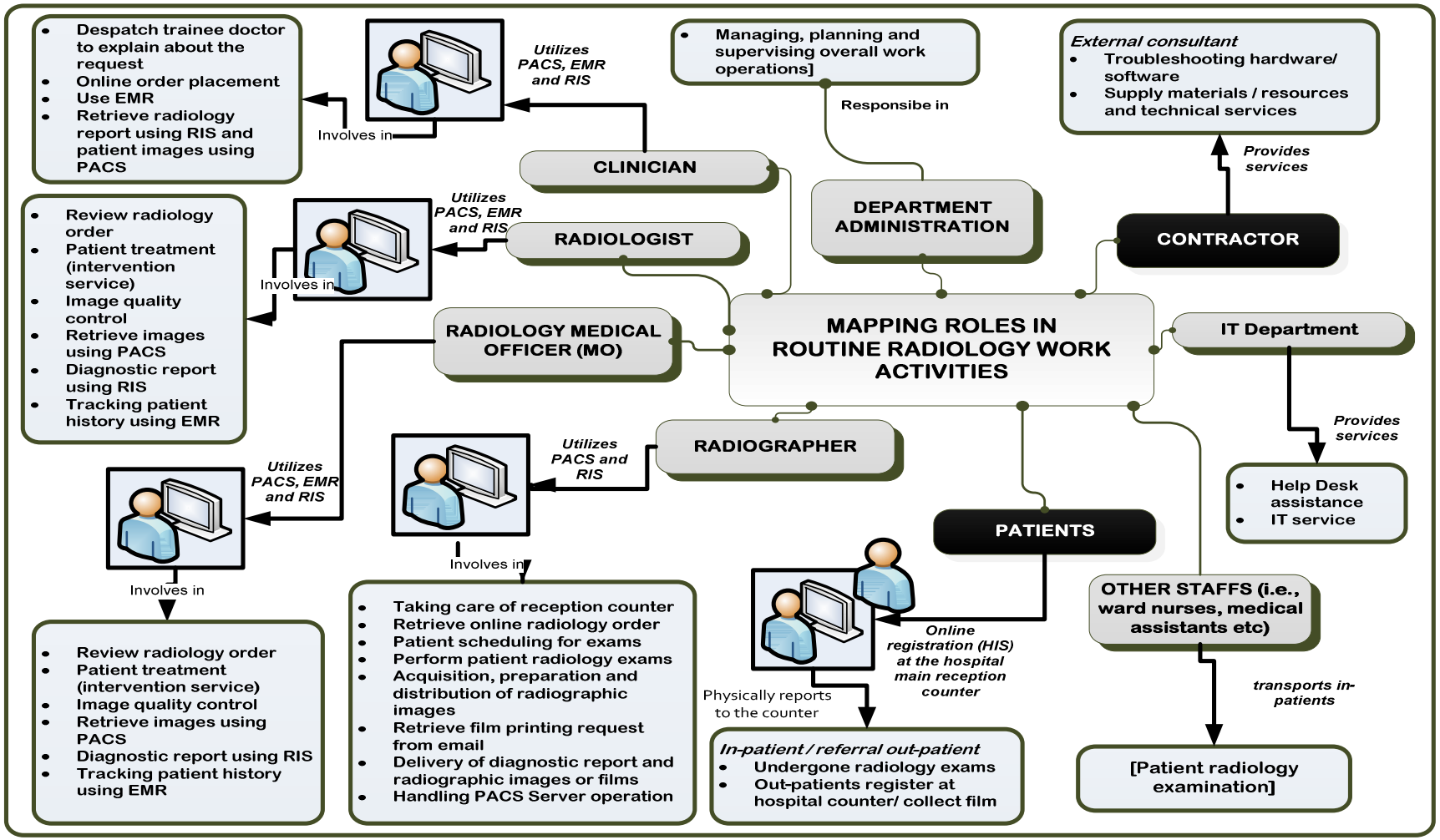


Figure 3.11: Mapping Roles in Routine Radiology Work Activities - PACS-DPMT

3.5 CONCLUSION

This chapter has presented in what ways the research design and choice of methods to obtain data had permitted this study to capture the intricate relationships between the internal and the external contexts and how they affected the implementation and use of medical imaging in organization. These approaches also enabled the research to account for important actors at various levels that influenced medical imaging implementation and were affected by using the application.

In constructing the research design, this study also acknowledged the viewpoints of several prominent qualitative researchers (i.e. Strauss and Corbin (1990), Miles and Huberman (1994), Wolcott (2001), Corbin and Strauss (2008) and others) that maintained the validity concept in qualitative research should be viewed differently from quantitative research. Corbin and Strauss (2008) for example argued that the aspects of validity and quality in doing qualitative research are very subjective and must also emphasize upon the criteria such as being innovative, thoughtful and creative in doing research. Wolcott (2001:93) advised that in the context of doing fieldwork study, 'the unique combination of your field setting and you in it will never be replicated, but discussing how you analyzed your data can be a great help to other researchers with comparable field notes, experiences and data sets of their own'. Overall, this study embraced the views of these studies in an attempt to increase the quality aspects of the research

Using the Multilevel Data Analysis Framework, this chapter further demonstrated how this study dealt with the qualitative data to derive the findings for the research. The subsequent two chapters present the detailed results and analytical interpretation and discussion with regards to the research findings.

Chapter 4

Results

Introduction

This chapter reports the research findings. The findings are framed around two related perspectives, namely medical imaging implementation and medical imaging application. The findings obtained from COV-DPMT provide the conclusions and explanations with regard to the outcomes of implementing and using medical imaging in PACS-DPMT.

This chapter is organized as follows. It begins with a description of how the implementation of medical imaging at PACS-DPMT was initiated. It highlights the ways in which the Ministry of Health, COV-DPMT and other external actors had a direct or indirect involvement in the implementation of medical imaging in the organization. It further reports how the implementation of medical imaging at PACS-DPMT affected the implementation of the technology in several hospitals in Malaysia and discusses how institutional influences shape organizational decision making.

This chapter highlights the context of users and how the dynamics of the work environment shape the utilization of the technology and its consequences in PACS-DPMT. The findings are structured according to the following categories - work activities and users' roles, perception, attitude and social relationships. The survey results are used to support the qualitative findings.

This chapter conclude with a summary of the consequences of deploying medical imaging in PACS-DPMT focusing upon roles, social relationships and networks.

4.1 MEDICAL IMAGING IMPLEMENTATION

This study identified three external influences that affected and are affected by imaging implementation at PACS-DPMT, namely the Ministry of Health, other healthcare organizations and technology contractors or vendors. It also found that the present roles and functions of the Ministry of Health have a strong influence in the organizational decision making process of Malaysian community hospitals.

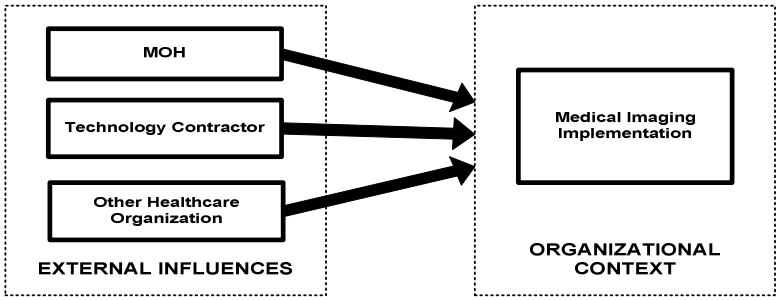


Figure 4.1: External Influences that Affect Medical Imaging Implementation at PACS-DPMT

The following presents the findings.

4.1.1 The Ministry of Health (MOH)

(a) Roles and Functions

In the context of Malaysian community hospitals, the MOH through its present roles and functions appears to substantially influence the administration and operation of community hospitals. This research further identified four areas where the MOH has a direct influence on shaping the organizational context of community hospitals. They are: (1) formulating policies, standards and regulatory frameworks; (2) allocating financial resources; (3) managing manpower resources; and (4) assuming high levels of authority in making strategic decisions. Figure 4.2 (next page) depicts the general roles of MOH in planning, controlling, managing and distributing resources as reflected in the data.

In deploying healthcare information systems and technologies in hospital, the Director of the ALPHA D-1 Hospital made the following comment:

> '...we have to understand the extent of the policies by Ministry [MOH]...our authority, actually we don't have much authority...everything has to be asked from the Ministry...Even, when we have our own initiatives, we still need to obtain consent from the Ministry before we can initiate our plan...in the end, it's about money...funding...'

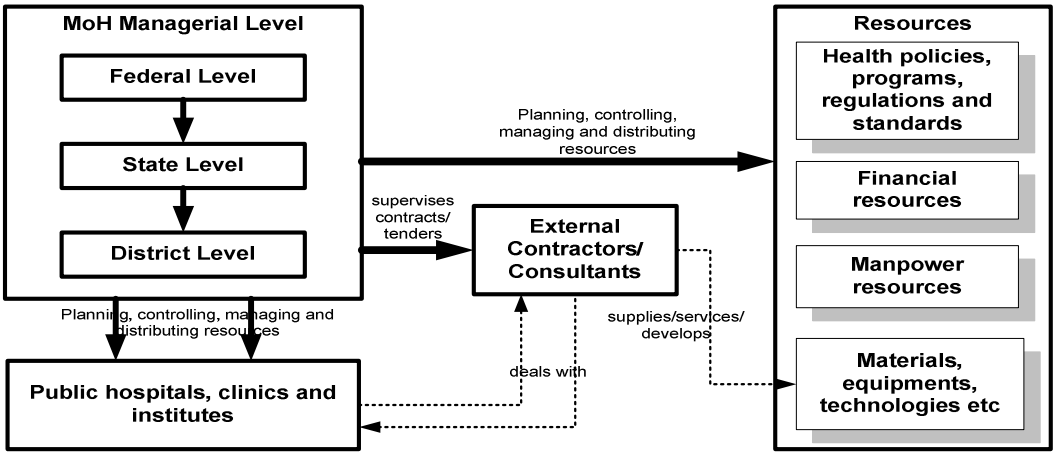


Figure 4.2: The MOH Managerial Hierarchy, Roles and Relationships with Community Healthcare Organizations and External Companies

A senior officer attached to the Medical Record Department from COV-DPMT Hospital commented that:

> '...extensive systems such as EMR [Electronic Medical Record] are decided by the Ministry [MOH]...that's why PACS-DPMT Hospital and ALPHA D-4 Hospital implemented the system first...'

A senior clinician who was also Head of Department from the ALPHA D-4 Hospital (another IT-based hospital) described the MOH involvement in the development of the hospital as follows:

> '...Actually I am one of the members of the Core Team...we were not actually involved in the detailed planning...the planning came from [the unit of MOH]...we were just called in to provide our views ...is it alright for this one...and this one...we did help out in these areas...it was around 1996...'

With regard to the ALPHA D-4 Hospital's administration and management in the early years, she commented that:

> '...[MOH] is not really good at planning...they [MOH] don't know what they want...they cannot foresee the extension that will take place...when the hospital building was done, they [MOH] decided to move in the tertiary services [to the hospital][52]...you know, we are the centre of excellence for endocrinology, breast surgery...on top of everything else, due to the political influence... finally we discovered last year, they [MOH] decided to have the National Breast Cancer Institute moving in to [ALPHA D-4]...they [MOH] have no clear idea ...now, we have space constraints...patients are not happy to travel so far...the public transportation infrastructure is still not fully developed around here...then this year, another unit was shifted to [a new hospital]...with the moving in of the tertiary services, the existing facilities are not adequate ...for my unit, I fought

[52] Originally ALPHA D-4 was built to offer only secondary services.

> hard to get my equipments...but still space constraints like the dimension of the building cannot fully meet our current needs...'

It is very challenging and costly to manage and maintain an IT-based hospital, the Director of PACS-DPMT explained that *'...as a government hospital, we operate following the government's [MOH] directive'.* Hence the charging rate for patients who receive the hospital services is similar to other conventional hospitals. She further commented that *'...yes, it [charging rate] is very cheap. For maternity services for example, delivery service is charged only for RM10 [£1.72] and RM3 [£0.52][53] per day for ward...'* With regard to the cost aspect of maintaining the hardware and software infrastructure, she commented that:

> '...the IT aspects, we have to invest a lot of money especially on equipments such as computer servers, personal computers, software...really product-driven... everywhere money...Ministry [MOH] is very supportive. I am getting the funding resources continuously for maintenance and upgrading...'

(b) <u>Involvement in the Medical Imaging Implementation at PACS-DPMT</u>

As explained before, medical imaging that consists of an integration of modalities with PACS, RIS and HIS is part of THIS infrastructure. The initial idea of introducing medical imaging in PACS-DPMT and within the Malaysian community hospitals was triggered by the MOH.

The Head of Department of PACS-DPMT described the following:

> '...the Ministry of Health [MOH] at that time initiated the efforts and was in charge of the planning...Under MOH direction, we visited Danube Hospital in Vienna...our model hospital. We also visited a number of hospitals in other places. For models of PACS implementation, we observed in Europe only...the Danube Hospital...'

The Chief Radiographer of PACS-DPMT further explained that:

> '...in the initial phase of the implementation [THIS], they [MOH] created Core Team for each department. I was instructed to join the radiology department's Core Team. I and [the Head of Department] at that time were still attached to COV-DPMT. They [MOH] wanted seniors...they [MOH] felt that it's better for the seniors to be involved in the project since the beginning and then continued to serve here [PACS-DPMT Hospital]...I like new things...Initially, we started with several meetings for doing strategic planning...then we worked together with the appointed contractor...our plan is to adapt the model of Danube Hospital...'

According to the hospital's annual report, each core team consisted of four members, who were chosen by the MOH from the selected government hospital

[53] At exchange rate of £1 = MYR 5.83.

staff. They monitored the progress of the project and played key roles in ensuring the continuity of efforts to integrate applications in the hospital department or unit's work operations. The Head of Department of PACS-DPMT for example was initially attached to COV-DPMT before assuming her position in PACS-DPMT.

4.1.2 The Technology Consultant and Vendor

(a) <u>PACS-DPMT's Relationship with Technology Consultants and Vendors</u>

The relationship and interaction between PACS-DPMT and technology consultants and vendors can be visualized as follows:

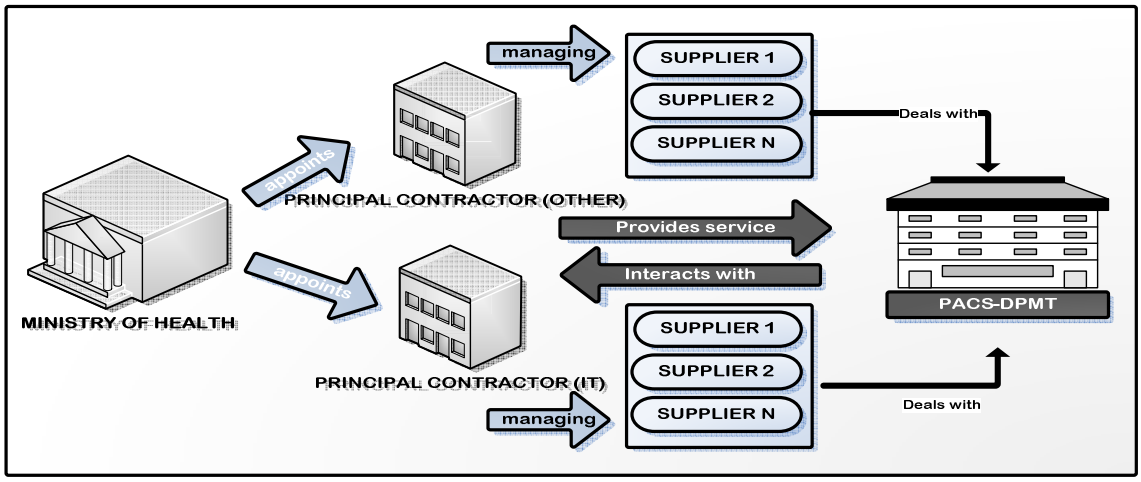


Figure 4.3: Illustration of PACS-DPMT's Relationship and Interaction with Technology Consultant or Vendor

In the initial implementation of medical imaging, the Head of Department recalled the following:

> '...at that time, CERNER was responsible for RIS. For PACS, based on the model of Danube Hospital...we chose SIEMENS. So at that time, SIEMENS was chosen for the project...For the IT Contractor, the one that coordinated everything is TeamVantage, a subsidiary of Radicare...'

She further added that the whole process of appointing and awarding contracts to the technology consultants and vendors *'was monitored and planned at the Ministry level...'*

The Chief Radiographer described their relationship and interaction as follows:

> '...We reviewed the plan until the end...The contractor asked us to evaluate all the medical equipments, PACS components and all those machineries. ...We always gave them input and feedback...we always gave reasons why we agreed or disagreed with their suggestions...Then they decided what and how to develop the system...

With regard to the complexities in medical imaging implementation, the Head of Department responded that:

> '...PACS is there. The activities that had taken longer time to prepare were building Total Hospital Information System. We had to put in a lot of input to build THIS and to integrate PACS into THIS...From our side, THIS needed to be customized according to our specification... so the bulk of the work was mainly on building RIS and HIS... and then training...'

In the context of the day-to-day work at PACS-DPMT, the Chief Radiographer played a key role in facilitating the relationships and interactions between the department and the technology contractors or consultants, the internal IT Department, and the MOH.

He described the existing interactions and relationships with the contractors and vendors as follows:

> '...the flow is like this. For government hospitals, the maintenance is outsourced to a third party...here Radicare maintains the equipment, [ABC Contractor] maintains the IT parts. So if you have problems with the equipment, you will report to Radicare, and if with the IT problems, you report to [ABC Contractor]. The government pays these companies for doing the operational maintenance here...The problem here, we only interact with the general contractor, not the actual suppliers...So far, we found that Radicare did contact the original supplier. So no problem here...But with the ABC contractor[54], we don't know yet. This company is still new to us. Since the government pays directly to these companies, they are responsible for taking actions to deal with PACS problems etc. We [PACS-DPMT] are not supposed to deal directly with the supplier because we're not the one who pays them [the supplier]...'

He further added that from time to time in handling the technology issues at the department:

> '...if we find that this person [contractor] did not come, I would call that person. For example, if the ordered stock has been delayed for two weeks, we would call them [supplier] to confirm that what person [the contractor] was telling us was true...who knows, they [contractor] did not pay the supplier...there are many possible reasons...'

In response to the issue of deploying radiology modalities from different vendors, he remarked that:

> '...we don't experience so many problems. In the case of Siemens specifications and the Angio Philips machine, for example, they [contractor] said the angio images can be sent to here [PACS server]. Actually, they're only photofiles...the machine can obtain images, but these images cannot be manipulated. So now, we

[54] At the end of August 2007, MOH had awarded a contract for doing IT maintenance at the hospital to ABC Contractor.

> learned...if they [contractor] said they can do it, we asked them [contractor] to detail the proposal...'

The following is an excerpt from the observational data that demonstrates the interaction between the Chief Radiographer and the representatives from one of the General Contractors. The representatives from the General Contractor were called earlier on to troubleshoot the Digiscan machine and the printers.

> '...two male staffs wearing their company uniform came in. I was told by the staffs that they were the representatives from the contractor to troubleshoot the machine... The Chief Radiographer came to meet them...
> Chief: 'You already changed the monitor, right?
> Rep 1: 'Before it was flat screen, but they did not want it'.
> Chief: 'Who did not want it?
> Rep 1: [could not recall the name] '...a week or two weeks...'
> Chief: 'Who did not want it? [pressed hard]
> Rep 1: 'That person [still could not recall the name] complained to me...this one [showed the monitor next to the Digiscan machine] is the same quality as this reporting...'
> Chief: 'Where is the flat screen?'
> Rep 1: 'taken back...That person complained the image is not the same'
> Chief: 'Next time, you tell me first. This is important'...

In response to the change of contractor by the MOH, the Chief Radiographer remarked that:

> '...they [MOH] are revising the contract...a new contractor for doing IT maintenance. As of yesterday [31st August], this company [old contractor] has been with us for more than three years...now we have to start all over again to work with this new contractor [ABC Company]...'

(b) <u>COV-DPMT's Relationship with Technology Consultants and Vendors</u>

In COV-DPMT, the Chief Radiographer explained that the established relationships and interactions between the organization and the contractors or vendors are as follows:

> '...big and expensive modalities, we let the contractor handles them...if the contractor cannot do it, they will give the contract to a 3rd party such as Siemen... we don't want any disruptions in our service...Although there is a 3rd party contractor, but we have a minor agreement... we have a designated staff responsible to contact the 3rd party directly ...we will also send a letter to the General Contractor regarding the transaction...we set and follow certain conditions and priorities...we don't want problems such as when the bill arrives, we don't know who should be paying the cost...it is practical for us to do it this way...'

It was also interesting to learn that COV-DPMT had provided a small space in the department's main building to place two employees from the General Contractor. When asked about the presence of the contractor's representatives in the department, the Head of Department explained that:

> '...They asked [for the space] to facilitate their works. To me, it is their initiatives...so although we have limited space, we provided it for them...both parties including us have to negotiate...'

When asked about the future planning including the expansion of the current technological infrastructures, she responded:

> '...We requested certain modalities because we have adequate space. Right now, we're unable to expand further. If we can replace whatever machines... that's good enough for us...we optimize what we have... The management doesn't allow us to do any physical extension...whatever is within the department, we can only renovate. But no more sideways, outwards etc...'

4.1. 3 Other Healthcare Organizations

Based on the data, this study identified three ways how other healthcare organizations affected and are also being affected by the implementation of medical imaging.

(a) <u>Using the Danube Hospital as a Reference Model</u>

In the initial planning for deploying medical imaging, the Danube Hospital was used as a reference model to design the medical imaging infrastructure and to initially organize the work flow at PACS-DPMT[55]. The Head of Department mentioned that during her visits to Europe and US Hospitals, there were many variations in how work is organized around the use of the technology. The *'...PACS-DPMT followed Danube Hospital'*.

The Chief Radiographer explained that:

> '...our model was the Danube Hospital. They [contractor] planned and proposed the infrastructure based on the model from there [Danube Hospital]...they presented us with the plan. I and [the Head of Department] inspected the room, which one is smaller, and which one is bigger...when we disagreed with the plan, we told them [the contractor]... we also evaluated the medical equipments and technologies...'

[55] According to Siemens' website (http://www.siemens.de/shs), the collaboration with Danube hospital to design a filmless radiology department began in 1988. The hospital was completed in April, 1992.

(b) PACS-DPMT Hospital as a Prototype of an IT-based Hospital

In all the interviews conducted in Phase 1, almost all the participants made direct reference to PACS-DPMT Hospital in response to the questions about their hospital's initiatives and their perceptions with regard to deploying hospital-wide information systems and technologies such as EMR, HIS and PACS.

For example, the ALPHA D-2[56] Hospital Director stated that in implementing THIS which includes the clinical and non-clinical modules, the hospital followed the decisions made by the MOH. When asked about the organization's preparation to adapt to a new working environment, the Director explained that:

> '...preparation has been done since early this year...first, we sent our team to visit two hospitals [IT-based hospitals]...we learned about their preparations, how they adapted to the new environment. From there, we developed ideas...we learned about their problems...we used their experience as lessons to be included in the relocation plan...we also learned from PACS-DPMT Hospital's experience...'

The ALPHA G-1 Senior Medical Record Officer in response to a question about online medical records responded that:

> '...in term of physical space, even for the hospitals that implement EMR such as [PACS-DPMT Hospital], although most of the information, yes ...they are being stored in the database...but certain things like ECG for example....cannot be stored online and therefore is still available as hardcopy. [PACS-DPMT Hospital] still needs to have a few shelves to keep these documents...'

When asked about her anticipation when implementing new information systems applications into the department, she explained that: '*we depend on the Ministry of Health to upgrade our current computing facilities'.*

The ALPHA U-1[57] Senior Medical Record Officer remarked that:

> '...our systems are currently being developed using our own technical manpower and specialists...In the meantime, we also learn from the existing hospitals that have implemented electronic medical record such as the PACS-DPMT hospital and others... we used their experience as an input to improvise our systems...'

As a pioneer of an IT-based hospital, the Director of PACS-DPMT Hospital described the experience as follows:

> '...[PACS-DPMT Hospital] is the pioneer...We really feel the pressure. The government has entrusted us, put so much money. We feel that the government is depending on us to try new things...the challenge is always there... A number of

[56] At the time of the interview, ALPHA D-2 was preparing to move to a new hospital building that equipped with THIS.
[57] ALPHA-U1 is a university hospital.

> us, the pioneers, are still here...We worked very hard. In the first three years, we experienced a lot of problems...it took many days to manage the problems and to find the solutions. These initial years, sometimes we quarrelled...but in the end, we managed to solve the issues...'

The Head of Department of PACS-DPMT highlighted that she is constantly invited to give input to the newer hospitals with regard to implementing medical imaging. The Chief Radiographer recalled the experience of providing input to the Siemens User Group as follows:

> '...they asked questions, and we found that most of the answers have been implemented in [PACS-DPMT]...in a way, we are the reference point for Siemens...we have received many visitors to see our system...'

(c) <u>Initiatives in Teleradiology</u>

According to the hospital Director, the PACS-DPMT Hospital is equipped with a teleradiology infrastructure linking the hospital with the COV-DPMT Hospital. Specifically, two connections exist. The first is between the hospital's emergency department and the Call Centre of the COV-DPMT Hospital; and the second is between PACS-DPMT and COV-DPMT. The researcher however was not equipped with sufficient information to determine the present status of teleradiology service between PACS-DPMT and COV-DPMT.

In the context of COV-DPMT, the Chief Radiographer described the department's experience of participating in teleradiology as follows:

> '...We had an experience of linking with an IT hospital [teleradiology]. At that time, there were large numbers of neuro [neurological] cases, until we were [COV-DPMT and Neurology Department[58]] unable to cater...We managed to convince the Ministry that we needed to have a link between this IT hospital and our neurosurgeons here. And we succeeded...We did not have to send the patients [to the other hospital]. They could review the images from there, and make decision whether it's really necessary for the patient to be sent there...save cost and also save patient live...'

[58] COV-DPMT has a dedicated CT unit located at the Neurology Department building to provide radiology services to the Neurology Department.

4.1.4 Organizational Decision Making

With regard to routine organizational decision making, this study found that both organizations – PACS-DPMT and COV-DPMT – have a similar decision making pattern. Typically, the department administrators will obtain feedback or input from the appointed committees or directly from a staff meeting. In COV-DPMT for example, with regard to the department's relationship and interaction with the general contractors, the Chief Radiographer commented that:

> '...When we want something...there is a committee responsible for this...We obtained the technology specifications. The committee members are very experienced...we do not directly consult the appointed company [main contractor]...'

The Chief Radiographer of PACS-DPMT in response to the issue of the uncollected patient hardcopy films stated: *'...for that, we have a meeting to discuss about why patients failed to collect their films...'*

This study also found that the department's Continuous Medical Education (CME) seminars in particular are an avenue where the department administrators and the staff regardless of their level will share and exchange ideas or opinions.

> *Example#1 - COV-DPMT*
> '...He informed me about the outcomes of the previous meeting [CME seminar], particularly about the issue of rejected films. He argued that the blame should not be directed only to the radiographers. According to him, in the meeting, he had suggested that the radiologists and the MO radiologists should learn to perform minor image editing themselves so that they can prepare the films according to their specification. He noticed that a few doctors disagreed and they argued that such tasks are the responsibilities of the radiographers...'

> *Example#2 - COV-DPMT*
> '...His presentation was about the appropriate method in handling chemicals...He utilized a lot of photos to explain what happens in the dark room. He mentioned two names of the dark room staffs...He highlighted a few safety issues related to the dark room staffs and the risks related to their works...he talked about ammonium gas...Then, asked one of the staffs who frequently handles the chemical whether he has been experiencing all the described symptoms...The staff informed the audience that he experiences all those symptoms... There was an issue about the safety standard of the appointed company that is responsible in transporting the chemical... At the end of the presentation, few issues concerning the department safety were brought up by a senior radiologist and several radiographers...The Chief Radiographer who chaired the seminar explained about the two companies that are responsible in handling the chemical. He also talked about the issue of sub-contracting the work...'

Example#3 - PACS-DPMT

'...After Radiographer SH finished the short presentation, Senior NG initiated a discussion about how to improve the service quality of the reception counter. They discussed about the important values in serving patients at the counter... Senior NG reminded the staff about treating the patients well, and not to easily get angry with the patients. If there is a problem, he urged the radiographers to let the seniors or the available doctors to assist with the situation...One of the radiographers complained about the tidiness of the counter...'

With regard to strategic decisions related to manpower resources and reconfiguration or expansion of the existing technologies and systems, decisions made by the administrators of the organizations are handled and finalized by the Ministry of Health.

COV-DPMT's Chief Radiographer stated:

'...I'd like to have the authority to hire and fire...But in the Ministry of Health, my role does not have such authority. If I have the authority to hire and fire, I can be selective. ...don't have to just accept all given to us...I wish I have that authority of hiring and firing...'

With regard to the facilities' upgrading, he commented that:

'...in between 1997 and 2005, from the aspect of building facelift we made some changes...in term of spaces. Before, we didn't have the budget for that. Government policies have now enabled many new developments...Like us, we have been allocated RM200,000 annually to manage the facelift aspect. So when that funding accumulates, in 10 years' time it will be about RM 2 million...it's a lot of funding. Before, we didn't have that much. Usually, if we had funds, they were for purchasing radiology equipment...'

With regard to issues related to funding, the Head of Department of COV-DPMT explained:

'...I don't think we're [COV-DPMT hospital] given a priority as compared to other places. But, you must understand that this hospital is called the main referral centre. In Ipoh for example, the general hospital is responsible for the whole state. But if you compare in term of the workload, certain services that we provide actually have more workloads than others...the funding as you see is to cater for one whole hospital...this hospital has a wider scope...

In the context of managing PACS-DPMT, the Head of Department stated that *'...obtaining budget is a real issue because the hospital is a government hospital...'*

Furthermore, this study found that input via networking can facilitate the decision making process between the organizations and the representatives of the Ministry of Health. The following highlights the example of how PACS-DPMT obtained CT64 modality. According to PACS-DPMT's Chief Radiographer, the CT64 modality was

supposed to be sent to another hospital. However, the decision was finalized at the Ministry level, and hence the modality was sent to them. He explained:

> '...purchasing radiology modalities are within [MOH's] authority. We just do the proposal and give feedback and justify about what we want...We were quite lucky at that time. We asked for a CT slice only, yet we received CT64...the modality was supposed to be for [another hospital]...the higher decision authority [MOH] said that [the other hospital] does not really need this sophisticated equipment yet. So, they decided to look for the hospital that is really in need of the facility. Fortunately, [COV-DPMT] had just gotten their CT16 slices...they [COV-DPMT] gave us the alternative...so we decided to bring in the machine...'

The Chief Radiographer of COV-DPMT explained the reason why the department had to reject the offer by the MOH to bring in CT 64 as follows:

> '...anything new should be here. It is a referral centre. We obtained CT16 using the funding from IDP [Islamic Development Bank]. Then at the same time, after successfully installing the modality, [MOH] acquired two new CT64 slices. They asked us if we wanted the machine to be sent here. But due to physical constraints...we lost the machine although we have been offered first. I called [PACS-DPMT's Chief Radiographer], and asked whether they wanted the machine...I said you have the room. You take it...'

Overall, this study concludes that there can be four levels in the decision making process depending on the nature of the issues or problems at PACS-DPMT and COV-DPMT. Top-down decision making via the roles and functions of the Ministry of Health has shaped the organizational decision making process. Also, this study found certain decision processes that involved the organizations and the Ministry of Health were facilitated via intra-organization networking. Figure 4.4 is a visualization of the organizational decision making pattern practices at both COV-DPMT and PAC-DPMT.

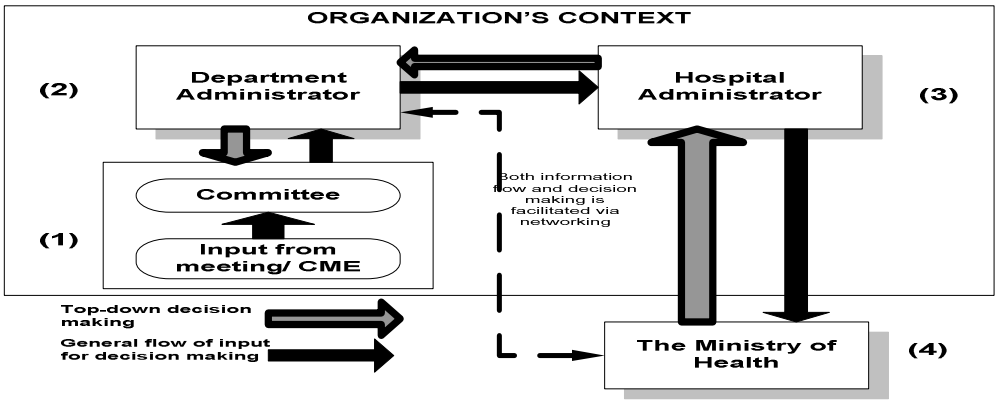


Figure 4.4: Organizational Decision Making Pattern (COV-DPMT and PACS-DPMT)

4.2 MEDICAL IMAGING APPLICATION

Here, the contexts of technology, user, organization and environment were engaged in the analytical analysis of the data (sense-making process) to clearly articulate how the internal and external dynamics of a hospital together influenced the implementation and use of medical imaging, and how this in turn shaped organizational roles and relationships within the hospital. This study compared the research findings obtained from PACS-DPMT with COV-DPMT to derive the conclusions about the impact of medical imaging on work practices, roles, social relationships and networks. The following presents the findings.

4.2.1 Work Activity

For clarity purposes, the following two figures are presented to briefly illustrate the similarities and differences between the work activities at PACS-DPMT and COV-DPMT as illustrated in the CT Unit. A detailed description of these work activities can be found in Appendix A.

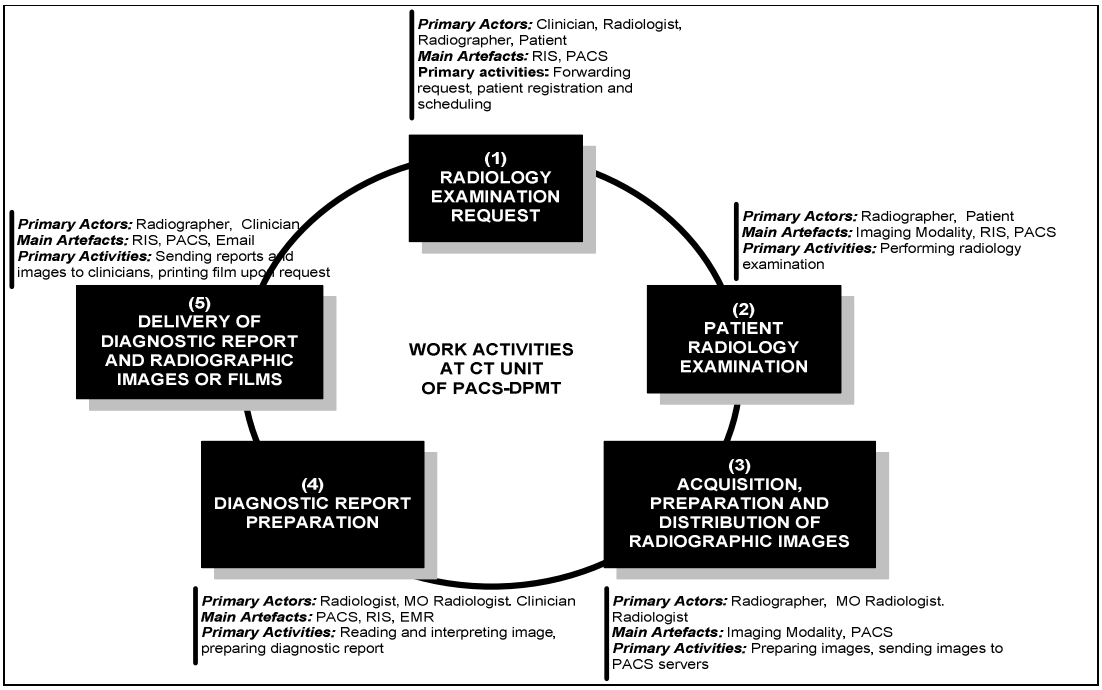


Figure 4.5: Illustration of Work Activities of CT Unit at PACS-DPMT

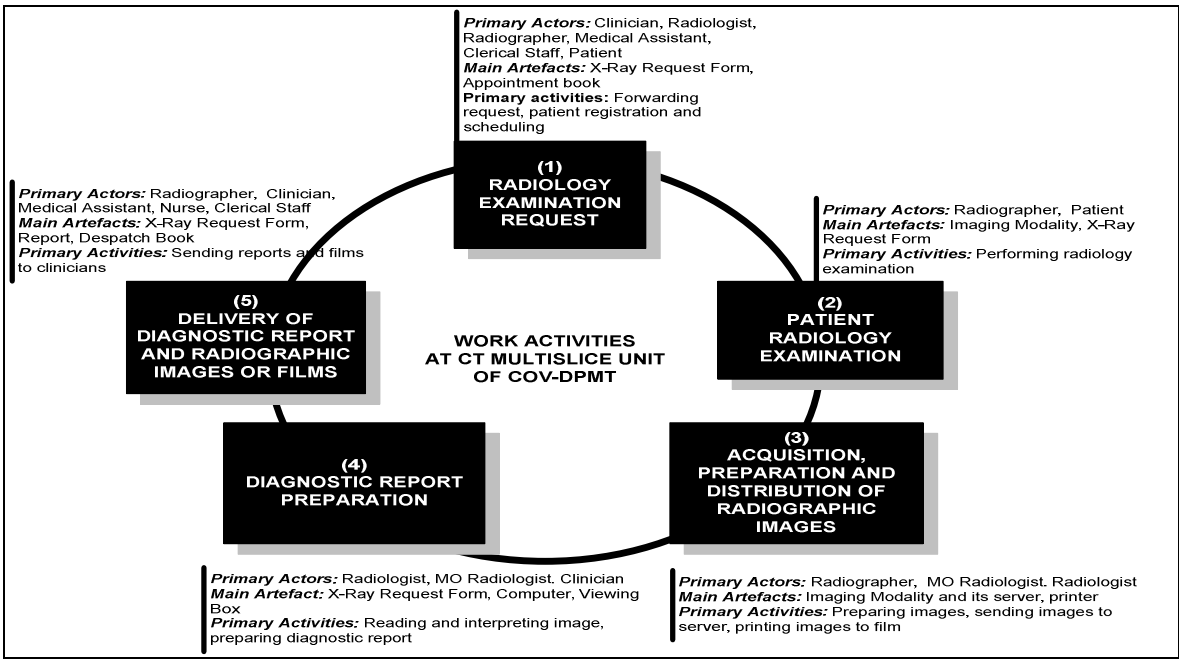


Figure 4.6: Illustration of Work Activities of CT Multislice Unit at COV-DPMT

Overall, this research identified five features of medical imaging infrastructure in PACS-DPMT that have affected, reconfigured and transformed many aspects of traditional radiology work activities and practices. The following elaborates the impact of these technological features upon radiology work practices in PACS-DPMT.

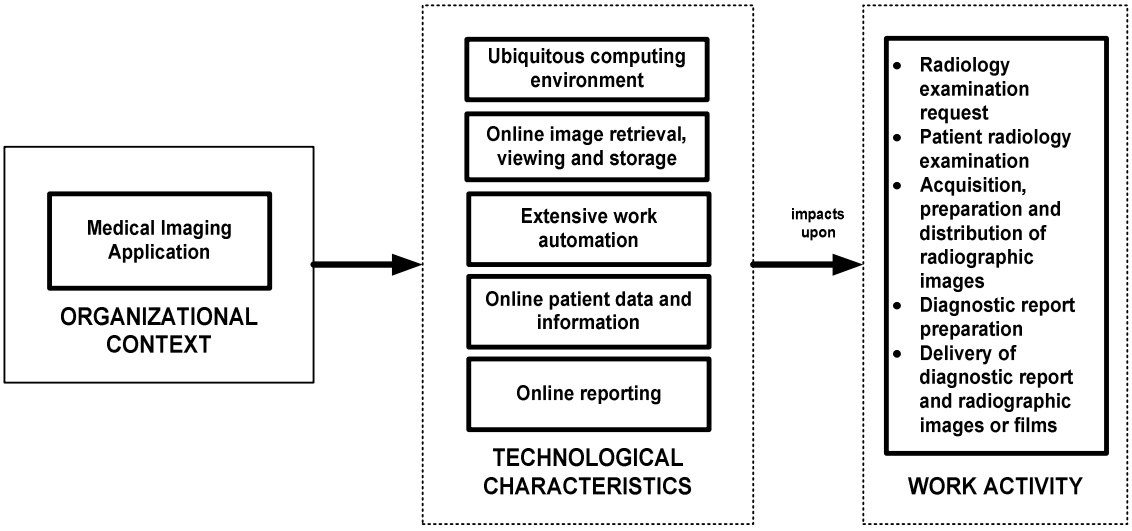


Figure 4.7: Medical Imaging Technological Characteristics Shape Work Activity

(a) Ubiquitous Computing Environment

In the ubiquitous computing environment, many computers are made available throughout the physical environment to encourage users to use the computer (Weiser, 1993). Also, substantial organizational processes and work activities are 'mediated through embedded computing devices that form part of the physical environment or move around with the workers, physical objects and products' (Editorial, 2005).

The PACS-DPMT Hospital has been equipped with adequate computing infrastructures including wireless mobile computers to enable the extensive integration of computing used in performing routine hospital work activities. The hospital has about 1200 personal computers and about 22 wireless mobile computers. Roughly, 5 to 6 personal computers are available in each ward. As for medical imaging applications, there is a significant number of PACS viewing workstations located across hospital wards and clinics. In PACS-DPMT alone, in addition to PACS viewing workstations, there is also a number of PACS diagnostic workstations and personal computers available in each of the department's sub-units. Personal computers are installed with RIS and EMR applications.

Based on the observation, this study found that the ubiquitous computing environment created more systematic and organized radiology work activities in the department. Unlike COV-DPMT, the radiology personnel in PACS-DPMT enjoyed ease of access to the computing facilities and used them to obtain quick up-to-date information and status pertaining to patients via RIS and PACS. For example, radiologists and radiographers could immediately obtain the status of a patient's radiology examination by simply logging into the RIS and searching for the patient's medical registration number (MRN).

> '...Dr HH wanted to confirm if the patient's clinician has ordered a CT scan through the system. He logged onto the PC Compaq using his user name and password, and then opened the RIS application. He obtained the patient's MRN from the list of patient from the system. He jotted down the patient's MRN. Then, he asked his colleague to make a phone call to the ward regarding the patient's status of the CT scan...'

In PACS-DPMT, the ubiquitous computing environment also offers radiologists some flexibility in doing online reporting. Explicitly, the PACS and the availability of viewing

and diagnostic workstations in a number of reporting rooms permit them to choose where they prefer to do their work.

> '...Two doctors were still discussing about the images. A few minutes later, Dr. SH (senior radiologist) asked the radiographer to send all the patients' images for today to the MRI Room. In the MRI Room, there are four viewing monitors to enable the radiologist to read images...'

In COV-DPMT, obtaining up-to-date patient information depends on the radiology personnel contacting the relevant clinician or ward via telephone or to search for the information through conventional artefacts such as the patient's X-Ray Request Form, the appointment booking or the film despatch book. The following is an instance of a typical activity where a radiologist has to take the initiative to contact the patient's clinician to obtain more information about the patient.

> '...Dr. SF asked the radiographer whether the patient brought notes. The radiographer said there was no note with the patient...Then, Dr. SF made a telephone call to inquire about the patient's note. She requested to speak to the patient's clinician. She waited a couple of minutes...Someone entertained her call. She repeated again that she wanted to know some details about the patient...Then she waited again. A few seconds later, someone entertained her call. She said the following: 'about what kind of the patient's operation', she repeated the patient's name, and even spelled the last name... Then she asked to speak to a specific clinician, and then waited again. Then someone entertained the call and she repeated again about her request for information. Parts of her telephone conversation with the clinician: 'what they do...what you know about...expecting to pee... something has been done before...So you are talking about ... bowel...' Then, the conversation ended...'

The lack of computing resources has been acknowledged by the Head of Department. She explained that:

> '...the computing resources are very limited. Every year, we forwarded a request to have more computers...this year we're supposed to get 5 units, but we heard the KSU did not approved... Not just us … computing resources are under the hospital package...'

With limited computing facilities, MO radiologists and radiologists sometimes experience difficulties in performing their day-to-day tasks. In COV-DPMT, it is common to see doctors bringing their own mobile computer to type the diagnostic report.

> *Example #1*
> '...Dr. FZ (MO) asked her colleagues if there was an available computer that she could use to do the report typing. She brought a stack of patient forms with her, and went out. A few minutes later, she came back and asked whether the

> particular patient films were ready. After collecting the films from the radiographer, she informed them that she would be using a computer in one of the radiologists' room to do the report writing...'
>
> *Example #2*
> '...Dr. ZH told me that she preferred to work in an IT-based radiology department where PACS is used...She mentioned the difficulty in tracking patients' old films in the conventional work practice such as here. She also complained about the tedious task of manually doing diagnostic reports. That's why today she brought her own laptop...'

As for PACS-DPMT radiographers, working in the ubiquitous computing environment has had a direct impact upon their non-relational roles, particularly in the area related to using computing knowledge and skills. The survey results indicate that the majority of PACS-DPMT's radiographers gained their computing knowledge and skills through their own initiative (61%) and also through colleagues' assistance (61%). A majority (61%) rated themselves as above average (good or very good) with regard to using computers in doing minor image editing. As for COV-DPMT's radiographers, the results indicate that most of them (56%) gained their computing knowledge and skills through formal education. About half of them (50%), rated themselves as below average (poor or don't know) in using computers to perform minor image editing.

(b) <u>Online Image Retrieval, Viewing and Storage (PACS application)</u>

This study found that PACS which enables online image retrieval, viewing and storage has generated substantial benefits to the MO radiologists and radiologists in PACS-DPMT. Explicitly, these professions gained advantages from using the application not just in the context of doing diagnostic reporting, but also in reviewing radiology examination requests. Here, the application has indirectly facilitated communication between them and the clinicians.

In forwarding a radiology examination request, the researcher observed that prior to online ordering, a clinician would usually despatch a trainee/junior clinician to brief the MO radiologist or the radiologist (whoever is in attendance at the panel room) about the request. This study found that immediate access to online images through PACS led to better communication quality in reviewing the request between these professions. Specifically, in this process, the radiologist or the MO radiologist would retrieve and review the patient's previous images together with the trainee clinician or junior clinician. In the interaction process, there was a discussion about the

previous radiology diagnostic finding, in addition to the usual explanation about the clinical indications provided by the clinician. One clinician viewed the interaction as follows:

> '...sometimes, when we do the ordering, the radiologist gives advice to us to do other types of scan. We generally follow their advice because they are the experts...'

The following are two sample events derived from the observational data.

> *Example #1*
> '...a trainee doctor came to request MRI brain scan for his patient. Dr. SN (a senior radiologist) asked him about the patient's old images...Dr. SN attempted to locate the patient's images through the diagnostic workstation...She mentioned to the trainee doctor that the images were probably kept offline. In reviewing the request, she also gave some advice regarding the request, and then asked the trainee doctor to follow up with the clinician who was in-charge of the patient. After arranging the MRI appointment with Dr. SN, the trainee doctor left the MRI Room...'
>
> *Example #2*
> '...Dr. KH (MO) retrieved the patient's old images from PACS. The trainee doctor was standing next to her. She asked him if they have done the test tube. She studied the image and made a few comments regarding hemothorax. Then, she asked the trainee doctor for the patient's latest exam result. The trainee doctor was unsure. She probed further about the patient's condition, i.e., asked about the patient's urine whether it wasclear or not etc. She showed the hemothorax area in the screen...The trainee doctor tried to justify again about the request...Dr. KH mentioned the indication given was not clear. The trainee doctor told her that this request was instructed by the main clinician...After a few minutes discussing about the image, Dr KH asked the trainee doctor to let the main clinician provides a better indication, i.e. stating clearly what the clinician wanted...The trainee doctor decided to refer back to the main clinician...'

In COV-DPMT, the examination request is forwarded using the X-Ray Request Form. The responsible radiologist must authorize the request (exception in the cases of walk-in emergency patients) before an appointment for a patient to undergo a radiology examination can be booked. Usually, difficulties in reviewing the radiology request may occur due to the incomplete information provided by the clinician in the request form and when there is no previous patient film attached with the request for reference. It was apparent in the data that the process of obtaining patient's old films may take a longer time even for the purpose of doing diagnostic report.

> '...The patient (a prisoner) was escorted by a few policemen into the examination room. In the panel room, Dr JC asked the Senior Radiographer about his old films. They were discussing where they should obtain the films. Then, I saw a counter staff, YN, coming in with the dispatch book. YN told the doctor that the last

> radiology examination was performed in June as recorded in the despatch book. Dr. JC then recalled that probably she was the one who handled the patient case...'

Also sometimes, there is a conflict where the responsible radiologist requests the counter staff to forward the X-Ray Request Forms to other similar sub-units. For example:

> '...The counter staffs – NN, YY and an on-call nurse - were discussing about what to do with a stack of patient x-ray request forms. I was told by YY that the radiologist on duty asked the forms to be transferred to other CT Units (i.e. other CT radiologist to authorize the examination requests). NN suggested to YY to approach the head of department directly to obtain her feedback about the exam requests...'

In doing diagnostic reporting, although this study is unable to determine whether PACS has led to faster completion of diagnostic report, but as mentioned by a senior radiologist of PACS-DPMT, *"all the important tools are available"* and the application has been viewed as necessary, practical and *"a very useful tool"* for them to perform their tasks. Through simultaneous online access to patient images and medical records, and using RIS to do reporting, the work process has been structured in such a way that these professions can do the reporting task straight away. With PACS, many miscellaneous time-consuming tasks have been eliminated from the work process. These miscellaneous tasks such as taking longer time to obtain old films, reprinting films, making frequent contact with the patient's clinician to obtain more clinical information, were part of the routine work processes of COV-DPMT. A few of the clinicians also gave positive feedback with regard to PACS application. One clinician described PACS advantages as follows:

> '...PACS is really easy to use...it saves a lot of time. We can view the image from our workplace. It [PACS] also makes the interaction easier with radiologists ... we can see the image together with the report...the MagicView software is easy to use and useful...'

(c) <u>Extensive Work Automation (PACS, RIS/HIS applications)</u>

The following two tables present a comparison of some details of work activities of PACS-DPMT and COV-DPMT.

Table 4.1: PACS-DPMT - The Use of Work Artefacts by Users

Work Areas	PACS-DPMT
Radiology examination	***Artefact:*** RIS/HIS ***Related Activities:*** Key-in data and retrieve information

request	***Primary Users:*** Clinicians, radiologists/MO radiology and radiographers ***Special Note:*** A clinician is required to input relevant data while doing the online ordering.
Patient radiology examination	***Artefact:*** HIS/RIS/PACS ***Related Activities:*** Key-in, retrieve, send data and information ***Primary Users:*** Clinicians, radiologists/MO radiology, radiographers, Nurses, ***Special Note:*** The radiology examination is conducted under strict clinical procedures and guidelines.
Acquisition, preparation and distribution of radiographic images	***Artefact:*** Modality, modality workstation, PACS/RIS/HIS, film processor and laser printers ***Related Activities:*** Physically handles the modality; key-in, retrieve , manipulate and send data and information; print film (on request) ***Primary Users:*** radiologists/MO radiology, radiographers ***Special Note:*** For advanced modalities such as CT and MRI, clinical image review will be performed by an MO radiologist or a radiologist.
Diagnostic report preparation	***Artefact:*** PACS/RIS/HIS and EMR; diagnostic workstation ***Related Activities:*** Retrieve data and information, type and send reports ***Primary Users:*** radiologists/MO radiology ***Special Note:*** Consultation between a radiologist and a patient's clinician may take place.
Delivery of diagnostic report and radiographic images/ films	***Artefact:*** PACS/RIS/HIS; PACS viewing workstation ***Related Activities:*** Retrieve reports and view images online ***Primary Users:*** Radiologists/Clinicians/Radiographers ***Special Note:*** Further consultation between a radiologist and a patient's clinician may take place

Table 4.2: COV-DPMT - The Use of Work Artefacts by Users

Work Areas	COV-DPMT
Radiology examination request	***Artefact:*** A standard X-ray form; Appointment book ***Related Activities:*** Write and read information; stamp authority ***Primary Users:*** Clinicians, radiologists/MO radiology and radiographers ***Special Note:*** A clinician is required to give information about the patient including medical information such as patient sickness indication, allergy and the type of radiology examination request.
Patient radiology examination	***Artefact:*** X-Ray form ***Related Activities:*** Read and stamp authority ***Primary Users:*** Radiologists/MO radiology and radiographers ***Special Note:*** The radiology examination is conducted under strict clinical procedures and guidelines.
Acquisition, preparation and distribution of radiographic images	***Artefact:*** Modality, modality workstation, film processor and laser printers, viewing box (light box) ***Related Activities:*** Physically handles the modality; key-in, retrieve , manipulate and send data and information (for CT and MRI), print films, review films ***Primary Users:*** radiologists/MO radiology, radiographers ***Special Note:*** Clinical image review will be performed by MO or radiologists for advanced modalities such as CT and MRI.
Diagnostic report preparation	***Artefact:*** X-Ray Form, Films and diagnostic work stations (for CT and MRI), viewing box (light box) ***Related Activities:*** Retrieve image/ review films; using personal computer to type report or manually writing down report ***Primary Users:*** radiologists/MO radiology

	Special Note: Consultation between a radiologist and a patient's clinician may take place in complicated clinical cases. The process to obtain old films and medical records from the Medical Record Department can take some time.
Delivery of diagnostic report and radiographic images/ films	***Artefact:*** X-Ray Form and additional supplement for report, and films will be placed in a film jacket ***Related Activities:*** Sort films and reports; despatch and collection ***Primary Users:*** Clinicians, radiologists/MO radiology, radiographers, nurses, clerical staffs and porters. ***Special Note:*** Further consultation between a radiologist and a patient's clinician may take place.

In PACS-DPMT, much of the routine activities, apart from obtaining images from modalities, and performing minor editing on these images, have been automated using RIS/HIS. Although appointment record book is still maintained for the purpose of practicality, the major routine of work activities such as handling examination request, doing patient scheduling and despatching images are all being done online. PACS-DPMT also utilizes email to entertain the request for film printing. For the purpose of clarification, film printing is still required especially when involving out-patients, where their GPs or hospitals are not an IT-based organization. In the survey data, the majority of PACS-DPMT's radiographers reported that: the use of the present systems had made their jobs easier (89%); they were very comfortable in using the technologies (95%); and they were satisfied with the current work environment and conditions (94%). As for COV-DPMT's radiographers, a majority of them (77%) were satisfied with the work conditions. About 85% of them would prefer to utilize computer-based systems such as in the case of IT-based hospitals.

Extensive work automation via PACS and RIS hence has reorganized many aspects of the traditional work activities of radiographers. This research finding supports many similar observations reported in the literature such as by Larsson et al. (2007) and Fridell et al. (2008) with regard to radiographer's work practice and roles transformation. Comparing with COV-DPMT's findings, this study specifically found that the radiographer's roles in PACS-DPMT have been expanded in three ways, namely: (1) becoming more independent and structured, (2) demanding sufficient knowledge of ICT to facilitate the routine work processes, and (3) extending the radiographer's professional autonomy in in ensuring that the patient radiographic images are successfully sent through network and stored in the PACS server.

(d) Online Patient Data and Information

This study found the following benefits of having online access to patient data and information via RIS/HIS applications (for radiographers) and EMR application (for radiologists).

First, online access to patient information was found to be useful when doing immediate patient rearrangement for radiology examination. In the research, patient-related factors were found to be one of the frequent causes that affects the routine radiology work processes at both organizations, especially in cases where out-patients failed to show up for their radiology examination appointment. Pertinent issues related to patients are discussed in the subsequent chapter. This study found that with an immediate access to up-to-date online patient data via RIS/HIS applications, PACS-DPMT's personnel can immediately perform a radiology examination to optimize the use of time and resources. Explicitly, the online patient information permits the radiographers to rearrange the patients' schedule to fill-in the vacant slot. In performing day-to-day tasks, one radiographer explained that the *"Online Work List"* and the *"Dept Order Entry"* functions of RIS are very important to them to obtain up-to-date patient information. In the case of COV-DPMT, because there was no immediate information available to them (unless a patient had contacted the department earlier on to cancel the appointment), it was difficult for the radiographers on duty to perform immediate patient arrangement to fill-in the available time-slot.

Second, online access to patient medical history via the EMR application has greatly facilitated radiologists and MO radiologists of PACS-DPMT in doing diagnostic reporting. Explicitly, the parallel access to EMR, PACS and RIS applications has made their jobs easier and most of them viewed these applications as strategic and important. In the COV-DPMT context, the diagnostic reporting process can take longer time if the important information pertaining to a patient has not been provided in the X-Ray Request Form by the patient's clinician. A senior radiologist of COV-DPMT described one of the difficulties in doing diagnostic reporting as follows:

> '...in our case, we depend on whatever information that is given to us in the form [X-Ray Request Form]. Sometimes, we have to do some extra works such as looking for the specialist to find out more information. It is ok if you know the specialist...in the worst case scenario, sometimes, only the specialist name is stated, but no other contact details... especially for the out-patient cases. In this

> scenario, we can only report based on the information given in the form...that's why we're quite differential in our way of doing reporting...depending on cases...'

(e) Online Reporting

Generally, for radiologists, delivering radiology diagnostic reports to clinicians serves as a final task in their work processes.

In PACS-DPMT, MO radiologists and radiologists will perform clinical image reviews immediately after obtaining the patient radiology images via PACS. Typically, the radiologist will interpret the image using PACS diagnostic workstation and the MO radiologist will transcribe the discussion using RIS reporting module installed in the personal computer (Compaq PC) located next to the PACS diagnostic workstation. In doing diagnostic report, details about patient's clinical history will be obtained using the EMR application. Sometimes medical books and website resources will be utilized as references in the discussion. Also, if there is further information needed, the radiologist or the MO will make a telephone call to consult the patient's clinician. A senior radiologist mentioned that with PACS and RIS, *'we can do our work straight away'*.

In the COV-DPMT context, the difficulties in doing diagnostic reporting usually arise from issues such as locating the patient's previous films, obtaining details about the scan request in the X-Ray request form, and locating the patient's previous medical records. The Head of Department elaborated:

> 'If [the department] is fully computerized, it will make our life, our work lighter...sometimes when we do reporting, we have to use reference books, Internet and so on. With a computerized system, we can just access patients' files, get whatever information we want. It makes the reporting faster and [for us] also easier to monitor the deadline [for submitting the report]. With the hardcopy report, you cannot see the performance of the individual radiologist like how many cases and so on…'

This study found that performing online diagnostic reporting has generated two advantages to PACS-DPMT and the hospital. Explicitly, online reporting via RIS has led to more systematic work processes for radiologists and MO radiologists in doing diagnostic reporting, and has promoted transparency at work. The following sample data illustrates the routine of diagnostic reporting work processes at PACS-DPMT and depicts the ways the application has led to more transparency at work.

> '...Dr. KH [MO] briefly explained to Dr. BT [radiologist] about the patient's medical history using her notes. I observed that she took some notes from the PowerChart [EMR] application earlier on. She studied the images...Dr. BT reviewed the image. Dr. KH mentioned: 'weird...MRI?' They discussed again about the images. Then, they attempted to find the history of the patient's radiology exams. Dr. BT mentioned:'...the patient only did an ultrasound exam...' Dr. K further read the patient's history of radiology exam using PowerChart from the PC Compaq...She was reading the previous radiology diagnostic report and attempted to determine who wrote the report. Dr. BT mentioned one name [a senior radiologist] and few seconds later, was confirmed by Dr. KH. They studied the content of the previous report...'

A senior clinician in an informal conversation described the advantages of having online access to reports and images as follows:

> '...everything is in the computer. At least we don't have to call and say 'have you completed' [referring to the radiologist]. The system is making the works more transparent...we're also able to track the patient's examination progress. I know only by tracking [the progress] through the system... Then, when the system shows that the examination is complete, then I can view and retrieve the images and the diagnostic report for my work...'

4.2.2 Users' Roles, Social Relationships, Perception and Attitude

It is apparent from the data that medical imaging application has not just substantially reorganized users' work activities at PACS-DPMT, but has also affected their traditional roles and social relationships with other professions. For radiographers, in addition to introducing a number of new responsibilities in their work, the use of medical imaging also affects social relationships between them and other professions particularly clinicians. This study found no evidence to suggest that the use of medical imaging changes social relationships between radiographers and radiologists or MO radiologists at PACS-DPMT. Furthermore, this study found that day-to-day interruptions to work procedures result from both human and technical factors, whether a medical imaging system is present or not.

(a) <u>Additional Work Responsibilities</u>

The deployment of medical imaging at PACS-DPMT has resulted in radiographers' assuming a number of new responsibilities. In contrast to COV-DPMT, this study found additional radiographers' work responsibilities in areas related to the management of PACS servers and the department's reception counter. These additional responsibilities have a direct impact upon their non-relational roles.

First, the department assumes a responsibility in handling and managing PACS servers because the servers are placed under the authority of PACS-DPMT. To date, the PACS Server Unit is located in PACS-DPMT. According to the Head of Department:

> '...it is much easier for PACS servers to be managed by the radiology department. The knowledge can be passed to the radiographers. If the servers are placed under the IT Department, you know...it [IT Department] has broad responsibilities, everywhere, so, the priority can be overlooked. We are also afraid the knowledge pertaining to managing PACS will be lost...'

The Chief of Radiographer explained that:

> '...If you observe the newer hospitals, PACS [servers] is not placed in the radiology department. They [the hospitals] put them [the servers] at the IT Department. In my opinion, it is better to have the servers here, the ownership will be here. We own the equipment. If an image is lost or something, we can deal with the issue immediately... '

The department has appointed a senior radiographer to assume a role in supervising work activities related to PACS Server Unit.

Example #1

'...My conversation with Radiographer SH was interrupted by a surgeon. The surgeon came to seek Radiographer SH's assistance to look for a patient's old images. Radiographer SH began to locate the images directly from the server. Later, he searched the images through the server's archived data. He found the images, and started to retrieve them. He and the surgeon observed the images together. The surgeon wanted to be certain about some issues (i.e., left or right) before performing a surgery operation on the patient. He asked Radiographer SH's opinion about the images. Radiographer SH gave a brief comment. After being satisfied with the finding, the surgeon said thank you and went out from the office. Radiographer SH explained to me that it is quite common for clinicians and surgeons to come directly to him to locate certain patient's images. He elaborated further that if the images could not be viewed online, then there would be a high possibility that the images are stored offline via optical media...'

Example #2

'...Radiographer SH who is in charge of PACS Server Unit was asking Radiographer MH about the images of a patient. He mentioned that the images have not yet been stored in the server... Radiographer MH kept repeating her words that she had already sent all the images earlier on...'

In addition, the department has also identified a number of individual radiographers who can assist the senior radiographer to manage the PACS Server Unit. These individual radiographers have to go through the on-going department training to obtain basic understanding pertaining to computing-related matters such as networks and servers.

Second, the radiographers at PACS-DPMT are also responsible for supervising the department's reception counter. In conventional radiology departments such as COV-DPMT, clerical staff or medical assistants are usually responsible for handling the reception counter. In the case of PACS-DPMT, the Chief Radiographer explained that their request for clerical staff to handle the reception counter has not been approved by the MOH.

'...We are supposed to have clerical staff to handle the reception counter. We asked for it but our request had not been granted...'

(b) Attitude and Perception towards Other Group of Users (Clinicians)

In the survey, whilst a majority of the radiographers viewed the use of technology positively, yet about 56% of them felt that they did not receive full support from other departments. Lack of cooperation and the clinicians' failure to place an order into the system were further mentioned in the survey as factors that interrupt their work activities. These survey findings supported the observational findings that the attitude of a certain group of users in using medical imaging particularly RIS/HIS application has had a direct impact upon radiographers' work activities and also affecting other users such as radiologists and MO radiologists. Explicitly, the clinicians' failure in performing online ordering but directly sending their patient to undergo radiology examination has affected radiographers in doing patient scheduling and also has an impact on radiologists/ MO radiologists in performing diagnostic reporting tasks. Although sending a trainee/junior clinician to brief the radiologist or the MO on duty, and then making a booking appointment are part of the work processes, however it is imperative for the clinician to place an order online using the RIS/HIS application. Without an order being placed in the system, MO radiologists or radiologists cannot perform online reporting via RIS. The following are three examples to illustrate the event.

Example #1

'...Dr. KH [MO radiologist] was complaining to Dr. AN [senior clinician] about the number of patients who did not have order in the system. Dr. KH: '[AN], I want to make a complaint... really gave a headache to us', then she began reading the patient names from the list... Dr. AN asked: 'from clinic? Who? Dr K: '...doesn't matter'. Dr. AN probed further about the issue...'

Example #2

'…Dr. HL [senior radiologist] was discussing with Dr. KH [MO radiologist] about a patient on whom a CT scan was performed on last night. He informed her that he could not do reporting using RIS because there was no order. Dr. KH suggested him to make a telephone call to ask the clinician about that... Then she showed Dr. HL about the RIS Order Entry module...Dr. HL took a few minutes to check on the system, and mentioned again that there was no order...'

Example #3

'…The patient came in and asked the radiographer why was his name has not being called yet, while a few others who came after him had done their scan. He was told by the radiographer that they were waiting for the clinician to place an order in the system. The radiographer asked him to be patient and to wait outside for his name to be called…'

One of the radiographers commented that:

> '...doctors sometimes do not follow our procedure...they booked the appointment but they did not place an order in the system. If their patients come, we could not do anything. So, we had to call them to remind them to place an order into the system...really pity the patients...they were furious sometimes...they did not know the process...'

(c) Radiographers' Perception of Their Capability in Using Computers

The outcomes of the survey also reveal that PACS-DPMT's radiographers were more self-confident in rating themselves as either good or very good in handling advanced imaging modalities such as CT and MRI, and computers for doing minor image editing as compared to COV-DPMT's radiographers. When the responses with regard to using computers for doing minor image editing were cross tabulated with respondents' gender (see Table 4.4), the study found about 60% of female radiographers' of COV-DPMT rated themselves as below average (poor or don't know how to use) and 70% of the male radiographers rated themselves either average, good or very good in using computers for doing minor image editing. As for PACS-DPMT, there was no significant difference between male and female radiographers.

Table 4.3: Using Computers for Doing Minor Image Editing (By Gender)

PACS-DPMT – BY GENDER		
Efficiency rate in editing image	**MALE (%)**	**FEMALE (%)**
Very Good		**3 (27)**
Good	**4 (57)**	**4 (36)**
Average	**2 (29)**	**4 (36)**
Poor	**1 (14)**	
Grand Total	**7 (100)**	**11 (100)**
COV-DPMT – BY GENDER		
Efficiency rate in editing image	**MALE (%)**	**FEMALE (%)**
Very Good	**1 (6)**	
Good	**6 (35)**	**7 (20)**
Average	**5 (29)**	**7 (20)**
Poor	**1 (6)**	**3 (9)**
Don't know how to use	**4 (24)**	**18 (51)**
Grand Total	**17 (100)**	**35 (100)**

When cross tabulated with the respondents' age, all the respondents at PACS-DPMT that are between the ages of 26 and 35 rated their capability as either average, good or very good. In contrast, a majority of COV-DPMT's respondents (59%) who belong in the same age category rated themselves below average.

Table 4.4: Using Computers for Doing Minor Image Editing (By Age)

PACS-DPMT – BY AGE				
Efficiency rate in editing image	**18-25(%)**	**26-35(%)**	**36-45(%)**	**46-55(%)**
Very Good	**1 (50)**	**2 (13)**		
Good		**8 (53)**		
Average	**1 (50)**	**5 (33)**		
Poor			**1 (100)**	
Grand Total	**2 (100)**	**15 (100)**	**1 (100)**	**0**
COV-DPMT – BY AGE				
Efficiency rate in editing image	**18-25(%)**	**26-35(%)**	**36-45(%)**	**46-55(%)**
Very Good		**1 (4)**		
Good	**6 (26)**	**6 (25)**	**1 (33)**	
Average	**7 (30)**	**3 (13)**	**1 (33)**	**1 (50)**
Poor		**3 (13)**	**1 (33)**	
Don't know how to use	**10 (43)**	**11 (46)**		**1 (50)**
Grand Total	**23 (100)**	**24 (100)**	**3 (100)**	**2 (100)**

With regard to the duration of working with the organization, unlike PACS-DPMT, the study found that about 23% of the respondents of COV-DPMT who have been working for more than three years with the organization rated themselves as below average.

Table 4.5: Using Computers for Doing Minor Image Editing (By Duration of Working with the Organization)

PACS-DPMT – BY DURATION OF WORKING					
Efficiency rate in editing image	**<12 mth (%)**	**1-3 yrs (%)**	**3-5 yrs (%)**	**5-10 yrs (%)**	**>10yrs (%)**
Very Good		**3 (43)**			
Good	**1 (50)**	**1 (14)**	**2 (40)**	**4 (100)**	
Average		**3 (43)**	**3 (60)**		
Poor	**1 (50)**				
Grand Total	**2 (100)**	**7 (100)**	**5 (100)**	**4 (100)**	**0**
COV-DPMT – BY DURATION OF WORKING					
Efficiency rate in editing image	**<12 mth (%)**	**1-3 yrs (%)**	**3-5 yrs (%)**	**5-10 yrs (%)**	**>10yrs (%)**
Very Good	**1 (6)**				
Good	**6 (35)**	**4 (25)**	**2 (20)**	**1 (14)**	
Average	**3 (18)**	**5 (31)**	**2 (20)**	**2 (29)**	
Poor			**2 (20)**	**1 (14)**	**1 (50)**
Don't know how to use	**7 (41)**	**7 (44)**	**4 (40)**	**3 (43)**	**1 (50)**
Grand Total	**17 (100)**	**16 (100)**	**10 (100)**	**7 (100)**	**2 (100)**

In the PACS-DPMT context, with regard to the mechanisms to increase computing and technical knowledge and skills, a majority of them mentioned department

training (95%), own initiatives (94%), formal education (67%) and assistance from colleagues (67%).

(d) Interaction Pattern between Radiographers and Clinicians

In PACS-DPMT, interactions via face-to-face, telephone and email are the preferred modes of the day-to-day communication. There was no evidence to suggest that medical imaging use has affected the traditional interaction pattern between radiologists/MO radiologists and radiographers.

> *Example#1 – PACS-DPMT*
> '...Dr. K was checking the image displayed at the modality workstation. She asked about the patient sickness. Dr. K reviewed the images on the screen, and briefed the radiographer about the images. She also entertained the radiographer's curiosity about the image. She then made a brief comment that the patient should do an ultrasound first rather than doing the CT scan straight away...'
>
> *Example#2 – PACS-DPMT*
> '...Radiographer FZ called Dr. K to review the images. Dr. K said: 'wow...the bladder is big'. FZ mentioned something about mesh to Dr. K... The radiologist on duty, Dr. B looked at the images on the screen and commented further about the mesh...'
>
> *Example#3 – COV-DPMT*
> '...Dr. NN (MO) sat next to MZ (radiographer). Dr. NN pointed to the image on the screen and said: 'this one is ok'. Then MZ asked her: 'Do you want this one also?' They were discussing about which images should be sent for printing. Then MZ said to Dr. NN: 'This patient, she hasn't had an operation yet, but, she has been ill for quite sometimes...'
>
> *Example#4 – COV-DPMT*
> '...FZ (radiographer) asked Dr. RN about the images on the screen, whether he should adjust the image quality. FZ said: 'Adjust?' At first, Dr. RN was sort of agreed with the decision, but few seconds later, she said: 'No'. She explained to FZ that the images were like that because: '...this is the frontier... this has been like this for a long time...' FZ asked: '...why didn't they put...' Dr RN responded: 'Exactly…whether they have light or what... ' Then she explained some details regarding the images on the screen to FZ...'

However, this study found that the clinicians in general showed a tendency to contact the radiographer on duty via the telephone to inquire about the status of their patients' images, e.g., when the images will be ready for viewing or whether the hardcopy films are ready to be collected. In the COV-DPMT context, usually the reception counter staff will entertain clinicians' inquiries about the status of patients'

hardcopy films. In the survey, about 61% of the respondents of PACS-DPMT perceived that they have a frequent interaction with clinicians. On the other hand, about 60% of COV-DPMT's respondents mentioned that they seldom interact with the clinicians.

(e) The Nature of Work Interruptions

In the survey, a majority of the radiographers perceived that the existing systems are user-friendly and the performance of the computing infrastructure and network is good. In the daily working context, this study found both technical and human-related factors could cause occasional interruptions to work procedures. In the survey, 17 out of 18 of radiographers who responded to the open-ended question that asked them to list the difficulties that they frequently experience in their work mentioned the following technical and human-related factors depicted in Figure 4.8 and Figure 4.9, respectively.

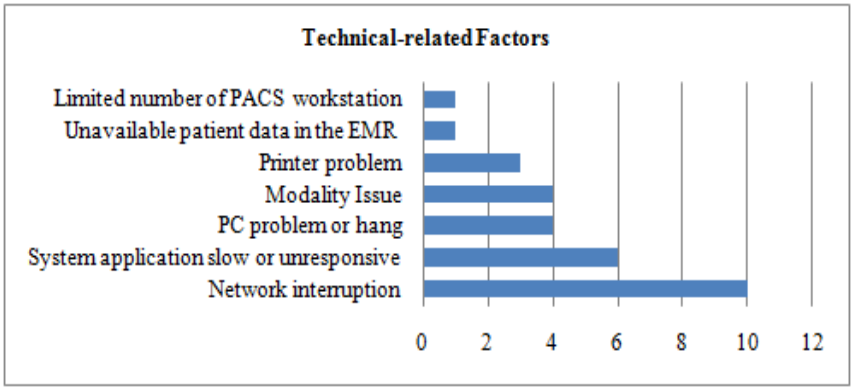


Figure 4.8: Technical-related Factors as Causes of Work Interruptions (PACS-DPMT)

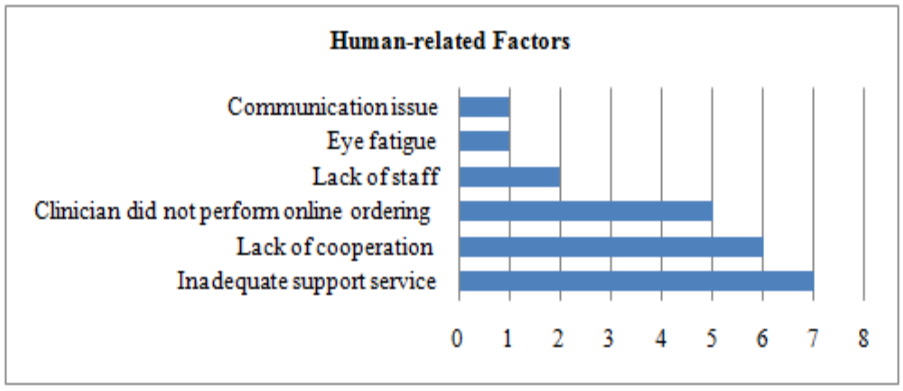


Figure 4.9: Human-related Factors as Causes of Work Interruptions (PACS-DPMT)

The survey results have confirmed some of the findings derived from the observational data with regard to the nature of interruptions in radiographers' work activities.

> Example #1 – Machine
> '…I was told by Radiographer MLH and Radiographer CG that they were experiencing problems with two DigiScan machines...CG told me that the patient has been lying there (on the x-ray bed in the examination room) for almost 20 minutes…Radiographer NZ complained to me that she could not do her work (entertaining hardcopy request and printing films) because both printers were not working properly …'

> Example #2 – Computer
> "…Dr RT [MO radiologist] was still unable to access the Powerchart. Dr Shay [senior radiologist] was waiting for her to obtain the patients' medical history from the system. Dr RT asked my advice what to do with the problem. I asked her to reset the computer. Dr. Shay also suggested her to reset the computer. I noticed that the PC Compaq was so slow… Dr. RT was quite frustrated with the problem…She complained to me that in here [PACS-DPMT], the system and network problems are really a hassle...'

> Example #3 – System
> '...Radiographer CH reported the PowerChart's access problem to the senior radiologist. Immediately she asked him to call the IT department. She said: 'I cannot do my work without the PowerChart...'

In the observation, network breakdowns were found to cause work interruptions in the radiology work procedures that could involve patients, radiologists, MO radiologists, radiographers, and clinicians. A clinician from the Emergency Department mentioned:

> '...network problems like now...I don't feel it because I can walk to the ED X-Ray and view the images there. But for the staffs that have their work area located slightly far away, then they have to walk to the ED X-Ray Unit to view the images...'

Based on the feedback from the interviews and from the informal conversations with PACS-DPMT staffs and hospital clinicians, the occurrence of network problem however is less frequent, unlike in the early years of medical imaging implementation. Furthermore, in addition to the online ordering issue, several users also mentioned about the inadequate support service particularly from the hospital's ICT internal support. A clinician complained that:

> '...when we called the IT Department and asked them to come, they would say they would come in a short time...but they did not come...we're doctors, the computer problems need to be solved quickly, so that we can work...'

4.2.3 SURVEY RESULTS

The outcomes of the survey method are used to support the major findings of this research. As indicated in the previous chapter, the survey was mainly a research instrument to obtain data about the radiographers' socio-demographic background, their self-rated skills and knowledge in using computers and handling certain types of modalities, their frequency of access to certain radiology sub-units as well as to triangulate certain findings based on the observational data.

The total number of respondents from PACS-DPMT and COV-DPMT is 18 and 52, respectively, providing 82% response rate for PACS-DPMT and 71% for COV-DPMT. The response rate is higher for PACS-DPMT because the number of radiographers is relatively small as compared to COV-DPMT. COV-DPMT, as mentioned before, has several radiology sub-units scattered across few hospital buildings in the area. Due to this factor, the researcher had to rely on the helper, who is also a radiographer to administer the questionnaire. As for PACS-DPMT, the researcher had personally administered the survey.

Table 4.6: Survey Response Rate

	PACS-DPMT	COV-DPMT
Number of radiographers (excluding senior management)	22	73
Number of questionnaires distributed	22	73
Number of questionnaires returned	18	52
Response rate	**81.8%**	**71.2%**

(1) Socio-demographic Background

For both sites, the data in Table 4.7 shows that the majority of respondents was female. Male respondents were 39% and 33%, respectively for PACS-DPMT and COV-DPMT. For PACS- DPMT, a majority (83%) of the respondents were between age 26-35, whereas for COV-DPMT, about 46% were belong to the 26-35 age category and 44% were between the ages 18-25. In terms of educational level, all the respondents in COV-DPMT were diploma holders. As for PACS-DPMT, 2 (11%) radiographers had obtained a first degree, while the rest (89%) was diploma holders. In term of years of working with the department, about 50% of the respondents of PACS-DPMT have been attached with the department for more than 3 years. As for

COV-DPMT, about 67% of the respondents have been working for more than 3 years with the department. Half of the respondents from PACS-DPMT had some experience working with a conventional hospital, whilst for COV-DPMT about 14% of the respondents had some experience working with an IT-based hospital.

Table 4.7: Socio-demographic Background

	PACS-DPMT (%)	COV-DPMT (%)
Gender		
Male	7 (38.9)	17 (32.7)
Female	11 (61.1)	35 (67.3)
Age		
18-25	2 (11.1)	23 (44.2)
26-35	15 (83.3)	24 (46.2)
36-45	1 (5.6)	3 (5.8)
46-55	0	2 (3.8)
Educational level		
Diploma	16 (88.9)	52 (100)
First Degree	2 (11.1)	0
Duration of work at the department		
1-6 month	2 (11.1)	7 (13.5)
6-12 month	0	10 (19.2)
1 -3 years	7 (38.9)	16 (30.8)
3-5 years	5 (27.8)	10 (19.2)
5-10 years	4 (22.2)	7 (13.5)
10-15 years	0	1 (1.9)
>15 years	0	1 (1.9)
Experience Working With Other Hospitals		
	With Conventional Hospital	**With IT-Based Hospital**
Yes	9 (50)	7 (13.5)
No	9 (50)	45 (86.5)

(2) <u>Obtaining Knowledge and Skills related to Computing and Modalities</u>

Table 4.8: Preferred Methods in Obtaining Technical Skills and Knowledge

	PACS-DPMT (%)	COV-DPMT (%)
Computing knowledge and skills		
Formal education	8 (44.4)	29 (55.8)
Internal department training	9 (50)	21 (40.4)
Training from IT vendors	0	14 (26.9)
Previous working experience	5 (27.8)	14 (26.9)
Colleagues	11 (61.1)	20 (38.5)
Close family	4 (22.2)	11(21.2)
Self-motivation	11 (61.1)	11 (21.2)
Knowledge and skills to handle modalities such as CT Scan and MRI		
Formal education	4 (22.2)	31 (59.6)
Internal department training	13 (72.2)	12 (23.1)
Training from vendors	3 (16.7)	12 (23.1)
Previous working experience	3 (16.7)	16 (30.8)
Colleagues	13 (72.2)	18 (34.6)
Self-motivation	8 (44.4)	31(59.6)
On-the job training	9 (50)	8 (15.4)

Note: The respondent can choose more than one option

For the computing knowledge and skills, a majority of the respondents of PACS-DPMT selected internal department training (50%), colleagues (61%) and self-motivation (61%) as methods for obtaining computing knowledge and skills. Whilst for COV-DPMT, the top three selections by the respondents were as the following: (1) formal education (56%), (2) internal department training (40%), and (3) colleagues (39%). As for obtaining knowledge and skills to operate advance modalities such as CT Scan and MRI, internal department training (72%), colleagues (72%) and on-the job training (50%) were selected by the majority of the respondents of PACS-DPMT. For COV-DPMT, formal education (60%) and self-motivation (60%) were chosen by the majority of the respondents.

(3) Work Access Frequency to Handling CT /MRI and Training

In COV-DPMT, the survey asked the radiographers to rate their frequency of access to 3 CT Single slice Units (CT AE, CT Somatom, CT Neuro), 1 CT Multi slice Unit (CT16) and 2 MRI Units (MRI 1 and MRI 2). Whereas in PACS-DPMT, the survey asked the radiographers to rate their work access frequency to the CT Single Slice Unit, the CT Multi Slice Unit and the MRI unit.

Table 4.9: Access to CT and MRI (PACS-DPMT)

Access Frequency	CT Single Slice	CT Multi Slice	MRI
Never	4 (22.2)	9 (50.0)	10 (55.6)
Few times a year	2 (11.1)	1 (5.6)	5 (27.8)
Few times a month	9 (50.0)	5 (27.8)	1 (5.6)
Few times a week	1 (5.6)	2 (11.1)	2 (11.1)
Everyday	2 (11.1)	1 (5.6)	0

Table 4.10: Access to CT Multi Slice and MRI (COV-DPMT)

Access Frequency	CT Multi slice	MRI 1	MRI 2
Never	41 (78.8)	47 (90.4)	48 (92.3)
Few times a year	4 (7.7)	3 (5.8)	3 (5.8)
Few times a month	6 (11.5)	0	0
Few times a week	1 (1.9)	1 (1.9)	1 (1.9)
Everyday	0	1 (1.9)	0

Table 4.11: Access to CT Single Slice (COV-DPMT)

Access Frequency	CT AE	CT Somatom	CT Neuro
Never	41 (78.8)	39 (75.0)	40 (76.9)
Few times a year	5 (9.6)	5 (9.6)	6 (11.5)
Few times a month	5 (9.6)	7 (13.5)	4 (7.7)
Few times a week	1 (1.9)	1 (1.9)	1 (1.9)
Everyday	0	0	1 (1.9)

For PACS-DPMT, a majority (78%) has handled the CT Single Slice modality. However for CT Multi Slice and MRI units, almost half of them have not been given an opportunity yet to hande these advanced modalities. For COV-DPMT, a majority of them has yet to be given responsibility to manage the CT and MRI modalities.

Table 4.12: Estimated Frequency of Training

Training frequency	PACS-DPMT (%)	COV-DPMT (%)
Never	2 (11.1)*	0
Few times a year	13 (72.2)	46 (88.5)
Few times a month	3 (16.7)	3 (5.8)
Few times a week	0	3 (3.8)

Note: There were two respondents who have been working with PACS-DPMT for less than 6 months.

In terms of frequency of training received, a majority of the respondents from the two case studies have undergone training at least a few times a year.

(4) Self-reported Efficiency Rate of Handling Modalities and Computers

The questionnaire had been designed with a four-point Likert scale – very good, good, poor and don't know – to assess the efficiency rate concerning the handling of CT Single Slice, CT Multi Slice, MRI, General X-Ray and using computers to perform minor image editing.

Table 4.13: Self Reported Efficiency Rate (PACS-DPMT)

	CT Single slice	CT Multi slice	MRI	General X-Ray
Very good	3 (16.7)	2 (11.1)	1 (5.6)	11 (61.1)
Good	12 (66.7)	7 (38.9)	7 (38.9)	7 (38.9)
Poor	3 (16.7)	2 (11.1)	1 (5.6)	0
Don't know	0	7 (38.9)	9 (50.0)	0

Table 4.14: Self Reported Efficiency Rate (COV-DPMT)

	CT Single slice	CT Multi slice	MRI	General X-Ray
Very good	0	0	0.0	16 (30.8)
Good	14 (26.9)	10 (19.2)	3 (5.8)	46 (88.5)
Poor	2 (3.8)	1 (1.9)	0.0	0.0
Don't know	36 (69.2)	41 (78.8)	49 (94.2)	0.0

Table 4.15: Self Reported Efficiency Rate Using Computers for Minor Image Editing

	PACS-DPMT	COV-DPMT
Very good	3 (16.7)	1 (1.9)
Good	8 (44.4)	13 (25.0)
Average	6 (33.3)	12 (23.1)
Poor	1 (5.6)	4 (7.7)
Don't know	0.0	22 (42.3)

For PACS-DPMT, a majority of the respondents rated themselves as 'Good' in handling CT Single Slice (67%) and 'Very Good' in handling General X-Ray (61%). Whereas for CT Multi Slice, about half of them were either 'Poor'/ 'Don't know' or 'Good'/'Very Good'. The pattern was almost consistent in the case of handling MRI modality. In term of using computers to perform minor image editing, about 61% rated themselves as above average.

For COV-DPMT, none of the respondents rated themselves as 'Very Good' for handling CT Single Slice, CT Multi Slice and MRI. A majority of respondents rated themselves as 'Don't Know' pertaining to handling CT Single Slice (69%), CT Multi Slice (79%) and MRI (94%).

(5) Means of Communication and Frequency Interaction

Table 4.16: Email and Internet Application

	PACS-DPMT		COV-DPMT	
	Yes	**No**	**Yes**	**No**
Using email for work	16 (88.9)	2 (11.1)	7 (13.5)	45 (86.5)
Using Internet for work	4 (22.2)	14 (77.8)	9 (17.3)	43 (82.7)

Table 4.17: Means of communication with other departments

	PACS-DPMT	COV-DPMT
Telephone	17 (94.4)	48 (92.3)
Face-to-face	9 (50.0)	29 (55.8)
Email	11 (61.1)	5 (9.6)
Fax	1 (5.6)	7 (13.5)
Others	0.0	19 (36.5)

About 89% of the respondents of PACS-DPMT use email for work. The email application also ranked second (61%) after telephone (94%) as mediums to communicate with other departments.

For COV-DPMT, 87% of the respondents did not use email for work. The popular means of communication with other departments are telephone (92%) and face-to-face (56%).

Table 4.18: Interaction Frequency for Radiographers with Other Professionals

	PACS-DPMT			COV-DPMT		
	Radiologist	MO Radiologist	Clinician	Radiologist	MO Radiologist	Clinician
Frequently	10 (55.6)	4 (22.2)	9 (50.0)	7 (13.5)	16 (30.8)	3 (5.8)
Very frequently	4 (22.2)	13 (72.2)	2 (11.1)	24 (46.2)	23 (44.2)	18 (34.6)
Rarely	4 (22.2)	1 (5.6)	7 (38.9)	21 (40.4)	12 (23.1)	31 (59.6)

For PACS-DPMT, the respondents mentioned a higher frequency of interactions with radiologists, MO radiologists and clinicians in comparison to respondents from COV-DPMT. Also in PACS-DPMT, about 61% of the respondents viewed their interactions with clinicians as frequent, unlike the majority of respondents from COV-DPMT where 60% of them rated 'Rarely'.

(6) Radiographers' perceptions and attitudes concerning their work routines

This section emphasizes on three main areas – (1) radiographers' perceptions on what contributes to the efforts to improve their ways of using technology/ modality/ system, (2) their attitudes and beliefs towards using technology/modality/system and its impacts on their work, and (3) their perceptions and beliefs on certain issues concerning their work environment. 13 statements were designed for the respondents of PACS-DPMT; 11 statements for the respondents of COV-DPMT. Using a five-point Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree, Not Relevant), the respondents were asked to respond to these statements.

In constructing the statements, the researcher used certain terms to suit the context of radiographers' understanding of their work practices. In COV-DPMT for example, since the use of computers, or to be specific, the modality workstations only occurs in the handling of digital modalities such as CT, MR and digital X-Ray, most of the radiographers that the researcher had come across, tend to refer to the modality workstations as 'computer'/ 'system'/'technology'. So in order to minimize the confusion, the researcher decided to use the term 'modality/technology' to refer to the use of modality workstations to handle digital modalities. As for PACS-DPMT, a similar term was also being used in the questionnaire, and the term is a reference to a large scale PACS application that includes RIS and the handling of modality workstations in their context of work practices. The researcher had also intentionally used the term 'computerized systems' to emphasize on the feature of PACS-driven work environment – i.e., information can be exchanged online using e-mail or through computer systems due to the wide installation of computer network infrastructure. Also, in the prepared statements, the term 'new technology/modality' refers to the modality/technology/system that is new to the radiographers (i.e., first time user).

The following tables are the outcome of the survey for this section for PACS-DPMT and COV-DPMT.

Table 4.19: Radiographers' Perceptions and Attitudes (PACS-DPMT)

	1	2	3	4	5
1. Training that was given in the department helps to increase my efficiency in using new modality/technology	38.9	55.6	0	0	5.6
2. I always depend on my colleagues to help me to increase my efficiency in using new modality/technology	5.6	55.6	33.3	5.6	0
3. My own motivation to try help to increase my efficiency in using new modality/technology	44.4	50.0	5.6	0	0
4. Skills that I learned from college/university have assisted me in using new modality/technology	22.2	44.4	27.8	0	5.6
5. I can do my job better because the network and computing systems are always good	16.7	55.6	22.2	5.6	0
6. The usage of computerized systems requires frequent interactions between me and radiologists	5.6	33.3	61.1	0	0
7. The usage of computerized systems requires frequent interactions between me and doctors from other departments	5.6	38.9	50.0	5.6	0
8. The used of computerized system makes my job more easier	16.7	72.2	5.6	5.6	0
9. The current system is user-friendly	5.6	77.8	16.7	0	0
10. I have received full cooperation from other departments in order to complete my daily routine	0	44.4	50.0	5.6	0
11. The arrival of the new machine/system/modality has increased my workload	0	5.6	77.8	16.7	0
12. If I had a choice, I feel more comfortable using the conventional system (using films and paper-based patient forms)	5.6	0	72.2	22.2	0
13. I am satisfied with my workplace and surrounding	44.4	50.0	5.6	0	0

Note: 1=Strongly Agree; 2=Agree; 3=Disagree; 4=Strongly Disagree; 5=Not Relevant

Table 4.20: Radiographers' Perceptions and Attitudes (COV-DPMT)

	1	2	3	4	5
1. Trainings that was given in the department helps to increase my efficiency in using new modality/technology	19.2	44.2	1.9	1.9	32.7
2. I always depend on my colleagues to help me to increase my efficiency in using new modality/technology	7.7	44.2	32.7	1.9	13.5
3. My own motivation to try help to increase my efficiency in using new modality/technology	21.2	59.6	1.9	0.0	17.3
4. Skills that I learned from college/university have assisted me in using new modality/technology	7.7	51.9	23.1	0.0	17.3
5. The usage of new modality requires frequent interactions between me and radiologists	15.4	57.7	5.8	1.9	19.2
6. The usage of new modality/technology requires	7.7	61.5	11.5	1.9	17.3

frequent interactions between me and doctors from other departments					
7. The arrival of the new modality/technology makes my job more easier	17.3	67.3	3.8	1.9	9.6
8. I have received full cooperation from other departments in order to complete my daily routine	3.8	51.9	30.8	1.9	11.5
9. The arrival of the new machine/system/modality has increased my workload	5.8	11.5	57.7	13.5	11.5
10. If I had a choice, I would feel more comfortable to use the computerized system such as in IT hospital	19.2	65.4	13.5	0.0	1.9
11. I am satisfied with my workplace and surrounding	11.5	65.4	17.3	5.8	0.0

Note: 1=Strongly Agree; 2=Agree; 3=Disagree; 4=Strongly Disagree; 5=Not Relevant

Statements 1, 2, 3 and 4 are concerned with four factors – department training, colleagues, self-motivation and formal education from college/university - to facilitate the radiographers in handling new technology/modality. Based on the result, a majority of respondents of PACS-DPMT agreed that department training (95%), assistance from colleagues (61%), self-motivation (94%) and formal education (67%), have helped them to improve their efficiency in using new modality/technology. Also, 39% of the respondents mentioned that they did not always rely on colleagues to help them improve their ability in using new modality/technology. There was also a similar pattern in the case of COV-DPMT - i.e. department training (63%), assistance from colleagues (52%), self-motivation (83%) and formal education (60%).

Statement 5, 6, 7, 8 and 9 are related to the respondents' perceptions of PACS-DPMT in terms of computing infrastructure, and its application and impacts on their work. When asked about the performance of computing infrastructure and network, 72% of the respondents viewed that the present computing infrastructure is good. Also, about 83% agreed that the current system is user-friendly. About 89% mentioned the use of computerized systems has made their job easier. With regard to the impact on communication with others, a majority of them disagreed that the use of computerized system requires them to interact frequently with the professionals such as radiologists and clinicians.

In the context of COV-DPMT work practice, statements 5, 6 and 7 relate to the radiographers' perceptions on the handling of new modalities. About 73% felt that they need to interact more with the radiologists and clinicians (69%). A majority of the respondents (85%) agreed that the use of new modality/technology has made their job easier.

Finally, statements 10, 11, 12 and 13 for PACS-DPMT and statements 8,9, 10 and 11 for COV-DPMT are concerned about their attitudes and beliefs about general issues related to their work environment. In the context of PACS-DPMT work practice, interestingly, 56% of the respondents mentioned that they did not receive full cooperation from other departments. A majority (95%) of the respondents also disagreed that the arrival of new machine/system/modality has increased their workload. 94% of the respondents also mentioned satisfaction with the current workplace and surrounding, and the similar number of respondents have strongly mentioned about feeling comfortable with the present radiology work practice.

For COV-DPMT, a majority (56%) of the respondents agreed with the statement that they have received full cooperation from other departments to complete their work routine. A majority of the respondents (71%) disagreed that the use of new modality/technology has increased their workload. Despite the fact that about 77% of the respondents mentioned satisfaction with the current work environment and surrounding, a large number of the respondents (85%) also would also like to use computerized systems such as in the IT-based hospital work practice.

4.3 CONCLUSION

The findings reported in this study are summarized as follows:

Medical imaging implementation perspectives:

- The implementation of medical imaging in PACS-DPMT was institutionally triggered
- PACS-DPMT has become a reference point for other community hospitals in implementing medical imaging
- PACS-DPMT's organizational context is structured by the external influence, i.e., via the roles and functions of the Ministry of Health

Medical imaging application perspectives:

- Medical imaging has structured and systemized several aspects of radiology work processes in PACS-DPMT
- PACS-DPMT's staff have gained several advantages in using the technology
- The use of the technology has substantially affected the radiographers' relational and non-relational roles, and shaped their perception and attitude
- The use of the technology did not change the traditional interaction pattern between the radiologist/MO radiologist and the radiographer
- The use of the technology has affected the interaction pattern between radiographers and clinicians
- Occasional interruptions to work procedures occurred whether a medical imaging system is present or not, which could result from both human and technical factors

The subsequent chapter discusses the findings further.

Chapter 5

Discussion

Introduction

In the preceding chapter, the research findings were framed in two perspectives - medical imaging implementation and medical imaging application. With regard to medical imaging implementation, the implementation of the technology at PACS-DPMT was institutionally initiated and their experience with the technology has been used as a frame of reference by other organizations. In terms of medical imaging application, it was found that utilization of the technology has generated a number of benefits to PACS-DPMT and to the hospital in general. The use of medical imaging also caused to day-to-day interruptions to work procedures. With regard to the impact on roles and relationships, this study found that the application of medical imaging has substantially affected radiographers' non-relational roles, perceptions, attitudes and also their interaction patterns with clinicians. The use of the technology however did not change the traditional interaction pattern between the radiographers and the radiologists or MO radiologists.

As explained in Chapter 2, this study draws upon systems theory and relevant theoretical concepts to provide a plausible theoretical explanation of how the internal and external contexts of an organization, together, influenced the implementation of medical imaging, and how this in turn shaped the organizational roles, relationships and networks. Using these theoretical approaches, this chapter discusses the

research findings. Further, the discussion is structured under three main headings: (1) the relationship between the internal and the external contexts; (2) the relationship between the technology and the organizational contexts; and (3) the relationship between the technology and the user contexts.

5.1 The Relationship between the External and the Internal Contexts

5.1.1 The MOH Shapes the Organizational Context of Community Hospitals

Resource Allocation

The outcomes of this research have suggested that in the context of Malaysian community hospitals, the MOH has applied direct control and supervision in allocating resources to the organizations. Particularly, in the aspects of formulating rules and policies, and controlling financial and manpower resources, the MOH has shaped the internal context of these organizations. Hence, it is not surprising to find that in the case of COV-DPMT and PACS-DPMT, the MOH also acts as an important decision maker in relation to the department's planning and expansion of its present resources (service, manpower, machineries, technologies, buildings etc). The MOH, following Scott (2001), practices centralized power and authority to exert its control on the organizations. As a powerful agent, the MOH's roles are affecting the community hospitals in deploying and managing information systems such as medical imaging.

It is also important to clarify here that, at present, the strategic decision to allocate and distribute radiology manpower such as radiologists and radiographers lies within the authority of the MOH. With regard to junior radiographers, their work placement after successfully obtaining a diploma from the government's college of radiography will be decided by the MOH. Due to this practice, the senior management of the organizations studied were critical of the impact of such practices on their organization. The Chief Radiographer of COV-DPMT for example, commented that the lack of authority within his role on this issue is counterproductive and has created unnecessary challenges to developing competent radiographers who are loyal to the organization. In the case of PACS-DPMT, such an issue has implications for the radiographer's organizational roles. Explicitly, due to the shortage of radiology personnel and the restriction of local authority to recruit more of these personnel, the

department has to utilize the current radiographers to fill in the staffing gaps, requiring them to fulfil such duties as in handling the reception counter or managing the PACS server room.

In the Malaysian context, the MOH undeniably, through its present roles and functions, plays an important role in shaping community hospitals. The subsequent discussions elaborate on the implications of the MOH's roles from the standpoint of community hospitals.

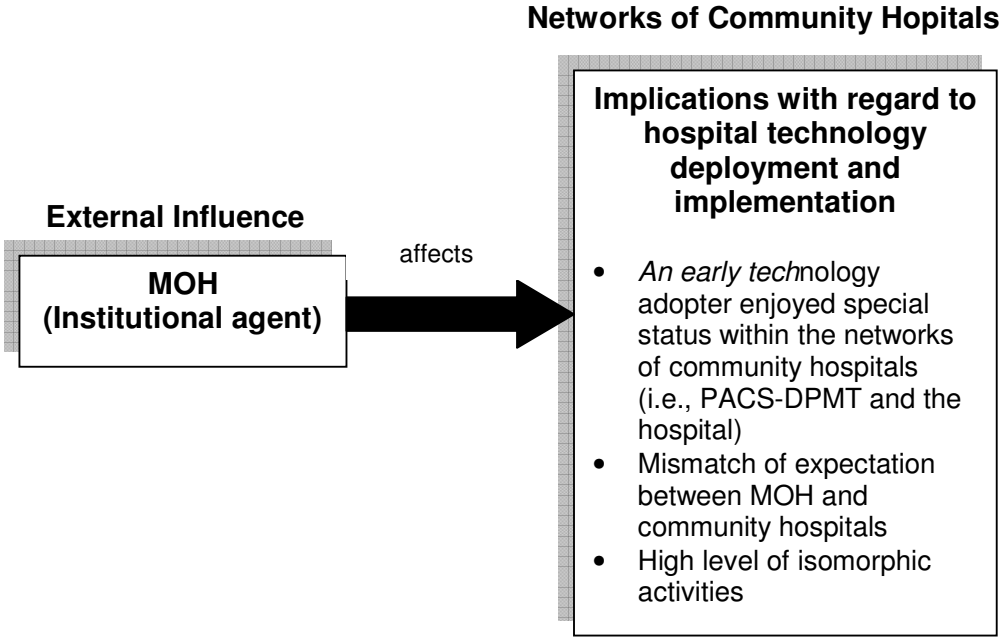


Figure 5.1: The MOH's Roles and Functions, and Their Impact on the Networks of Community Hospitals

Technology Implementation: The Perspective of Community Hospitals

As discussed in the previous chapter, this study found that the initiatives to implement hospital-wide information systems and technologies, i.e., THIS and medical imaging were institutionally triggered via the roles and functions of the MOH. The technologies were implemented at the PACS-DPMT Hospital first,followed by the ALPHA D-4 Hospital.

Briefly three categories of organizations related to the implementation of THIS and medical imaging, can be identified from the networks of the Malaysian community hospitals, namely an early technology adopter (PACS-DPMT Hospital and ALPHA D-4 Hospital), a relatively new technology adopter (ALPHA D-2 Hospital, ALPHA D-8 and others) and a potential technology adopter (non-IT based hospitals such as

COV-DPMT and others). The early technology adopter, via key people selected to participate in the development of THIS and medical imaging in PACS-DPMT Hospital, had used and adapted practices of several healthcare organizations from developed nations. PACS-DPMT specifically learned from the implementation of medical imaging at the Danube Hospital, Austria. Later, after successfully implementing the technologies, the relatively new technology adopters referred to the practice of PACS-DPMT Hospital as a frame of reference to guide them in the implementation processes. Within the planning of the MOH, the benefits of deploying THIS and medical imaging at PACS-DPMT Hospital and ALPHA D-4 Hospital, i.e., teleradiology and teleconsultation, can also be extended to include other potential technology adopters such as COV-DPMT and other conventional hospitals. Because of the failure of the appointed contractor to deliver the infrastructures, the project has been put on hold for several years. And recently, the MOH used PACS-DPMT Hospital's performance as a benchmark to assess whether to expand or to limit the resources allocated to diffusing THIS and medical imaging into the community healthcare organizations.

One of the implications of the organizations' interaction in the organizational field is that PACS-DPMT Hospital and ALPHA D-4 Hospital as the early technology adopters have enjoyed special status within the networks of the community hospitals in Malaysia.

However, in terms of managing and integrating the applications to transform the conventional work practices of hospitals' organizational members, both hospitals experienced a number of challenges and problems. The Director of PACS-DPMT Hospital, for example, highlighted the legal aspects and the staff's attitude and mindset as factors that obstruct the ideal of achieving a truly paperless and filmless hospital environment in the Malaysian context. In the early years of THIS implementation, several of the emerging challenges mentioned in the organization's annual report and covered in the news include issues such as users' resistance to change, frequent failures of computers and networks, poor performance of system applications and poor performance of the appointed contractor. As for the ALPHA D-4 Hospital, a senior specialist cum Head of Department highlighted factors such as leadership issues at the ministry and the hospital level, lack of strategic focus, and

resource constraints as major road blocks to the effective integration and use of new technologies with the hospital's work system.

Network Interactions: A Discourse

Learning from the implementation and use of THIS and medical imaging in PACS-DPMT Hospital and ALPHA-D4 Hospital as well as the progress of the telehealth project, there are two implications contained in the research findings concerning the network interactions of community hospitals.

First, there was an apparent mismatch between the MOH's expectations and the reality of implementing, managing and working with the technologies under restricted organizational authority and resources. In 2004 for example, the MOH restructured the telehealth project and admitted that:

> '...the initial [telehealth] project was too ambitious as it planned to link all the hospitals and polyclinics in the country. Now, the government has agreed for the project to be in stages and has approved RM60 million for that...Not all disciplines are suitable for Telehealth. We have identified four important components namely teleconsultation, continuous professional development, mass health educational programmes and personalized health record. We scaled it down only to these four components', (Bernama, 2004)...'

Then in 2007, the MOH admitted that implementing THIS was complicated and further mentioned that human factors in addition to technical ones contributed to this complication.

However, in the context of the organizations that participated in this research, this study found that that the present bureaucratic nature of the MOH and the total dependency of community hospitals on it to obtain strategic resources (i.e., manpower, technologies, and machinery) offer little space for organizational innovation through the implementation and use of information systems and technologies. Also, with a restriction in organizational authority with regard to staffing issues, i.e. retaining, hiring and firing, it is difficult for these organizations to effectively capitalize its manpower resources as an agent of change to disseminate technical skills and knowledge to others, and to further sustain and expand the benefits of deploying the technology to the organization and the public, i.e., patients. In the PACS-DPMT context for example, the frequent transfer of staff particularly from the organization back to another conventional hospital is a worrying trend because it can contribute to de-skilling and loss of knowledge.

This mismatch of expectations in the long run can be counterproductive to Malaysia as a nation that attempts to reform the present status of its healthcare system and practices via the use of advanced technologies such as medical imaging. The MOH acknowledged in the Health 2005 Report that its present weaknesses caused difficulties to Malaysian community hospitals - particularly the IT-based hospitals. The report mentioned issues such as its bureaucracy, slow decision-making processes, a lack of manpower resources and an increasing number of patients using community health facilities. However, the MOH has yet to take a proactive role to reform its present weaknesses.

In the literature, a study by Southern et al. (1997) is particularly pertinent to this scenario. The research examined a case study of the state public health system in New South Wales (NSW), Australia in implementing a packaged clinical information system from the United States. Adopting the concepts of IT-organization fit theory, Southern et al. (1997) explored the problems and the challenges that led to the failure of the project. Overall, the study concluded that the lack of organizational fit in the NSW healthcare organizations contributed to the difficulties in successfully transferring the packaged clinical systems. The study also highlighted that the lack of fit between the formulated strategies at the federal level and the organizational structures (headquarters and local organizations) posed several problems in managing and diffusing the implementation of the technology into the local environment. This mismatch also caused the organizations to experience role ambiguity and uncertainty. Specifically, whilst the technology was implemented and used locally, i.e., in the organization's specific setting, confusions about roles and responsibilities arose because the policy formulation and system selection were conducted centrally. Southern et al. (1997:123) emphasized that in the context of the case study, 'the depth and complexities of the issues that surround the transfer of large-scale technology from another environment, and its diffusion throughout a large federally structured health service have been underestimated'.

Finally, because of the total dependency on the MOH to obtain strategic resources, a high level of isomorphism with regard to implementing information systems and technologies into the organization is anticipated. Explicitly, when vital resources are centralized, organizations face comparable pressures from the resource suppliers, and 'interacts with uncertainty and goal ambiguity' (Dimaggio and Powell, 1983:155).

To respond to the uncertainties surrounding the implementation of new technologies into the organization, these organizations will imitate other organizations that they perceive to be more legitimate and successful (Dimaggio and Powell, 1983). Hence, in the case of other hospitals, they perceived PACS-DPMT Hospital and PACS-DPMT as an ideal frame of reference to develop ideas and plans in the process of implementing and adapting THIS and medical imaging.

5.1.2 The Roles and Performance of Technology Contractors and Consultants

The relationships and the interactions between an organization and technology consultants (contractors) and vendors play a vital role in hospital technology implementation and adoption. In medical imaging a number of studies have discussed how the on-going support from suppliers and vendors can contribute to the success rate of implementing and using the technology (Pilling, 1999; Kinnunen and Pohjonen, 2001; Pilling, 2002; Huang, 2003; Pare and Trudel, 2006).

In the context of community hospitals, it was further revealed that their primary concerns are mostly related to establishing good relationships with the contractors, and having high expectations of their performance. Two of the hospitals' top management referred to the inadequate performance of the local contractors as a challenge that they had to deal with. One of them - the Deputy Director of the university hospital - remarked as follows:

> '...In Japan for example, they have many reliable consultants. We thought we could just follow the Japanese model. So, initially we engaged the local companies to help us with the plan. But later, we felt that they are not serious and also have problems like not enough technical people... I said, maybe it is better to use our own staff, build the system internally...'

The failure of the contractors or consultants to deliver an IT project as agreed, undoubtedly will negatively impact the success of hospital technology implementation and adoption. In the case of Medical Online, for example, their failure to deliver the agreed telehealth projects had greatly affected the progress and the overall status of the national telehealth agenda. Explicitly because of this contractor's failure, the initial plan to integrate the THIS application in PACS-DPMT Hospital and Alpha-D4 Hospital with the telehealth application had been affected.

In addition, in 2005 the National Audit Report[59] on the projects that involved several new hospitals highlighted that there was a conflict between the MOH and another government agency (the Ministry of Works) with regard to the development of Hospital Information System (HIS). According to the report, HIS was not in operation yet and had to be withdrawn from the initial design and build package which had been agreed initially between the Ministry of Works and the appointed contractor. The report further commented that: the scope of the contract should be discussed with the MOH in the project planning stage; issues such as HIS, if uncertain about the implementation, should be withdrawn from the contract and a separate tender could be initiated to call for the implementation.

In the context of COV-DPMT and PACS-DPMT, the top management of the organizations maintained that, in addition to negotiation, good monitoring and supervision are also important to facilitate the relationships between them and the appointed contractors. In dealing with the MOH and the contractors' procedures, both organizations have their own systems for handling aspects related to the procurement proposal, supply, maintenance and upgrading of machineries and technology infrastructures.

5.1.3 The Public and the Patients

The findings of the research suggest that patient factors can influence the efficiency of PACS-DPMT and COV-DPMT's day-to-day work operations. This study – based on the fieldwork findings - specifically identified two areas related to patients (particularly outpatients) based on the fieldwork findings that can impact on the radiology operations. The first of these is concerned with their attitude to meeting their radiology appointment; and the second is related to their behaviour in receiving radiology services.

This study particularly found that the on-going issue with patients' failure to comply with their radiology appointment has consistently interrupted the radiology personnel - particularly radiographers - in performing effective patient scheduling at both organizations. However, unlike COV-DPMT, PACS-DPMT's radiographers can tackle this issue immediately via the use of medical imaging. Explicitly, the availability of online patient data via the use of medical imaging has enabled the

[59] Laporan Audit oleh Ketua Audit Negara bagi Tahun 2005, Bil 27/2005.

radiographers to make an immediate arrangement to fill-in an empty slot in the radiology examination room. Hence, this can contribute to the optimal use of radiology personnel time and modalities. With regard to patient behaviour in receiving radiology services, PACS-DPMT at present has to deal with the issue of patient failure to collect their x-ray films. COV-DPMT does not experience this problem because the patient x-ray films are kept and handled by the hospital Medical Record Department.

In addition, other issues such as the patients' fear of undergoing radiology examination and the language barrier between the radiology staff and the patients were some common scenarios and challenges facing the radiology personnel at COV-DPMT and PACS-DPMT in fulfilling their duties. This study also found that the VIPs as patients were handled differently from the other patients. For example, in the context of COV-DPMT's operational service such as MRI, it is a common practice to reschedule other patients' appointment to accommodate the VIPs and their close relatives (usually ministers' immediate family and other relatives, and high-profile civil servants) in undergoing the radiology examination.

With regard to hospital technology implementation such as medical imaging in community hospitals, such implementation has created awareness among both public and patients. Since the opening of PACS-DPMT Hospital and ALPHA D-4 Hospital's services for example, these two hospitals have gained wide public attention and scrutiny, as well as received on-going exposure and publicity through the media[60]. In the early years of THIS and medical imaging at PACS-DPMT Hospital for example, it was reported in the newspaper (The Star Online, 2003):

> '...The hospital information system was supposed to speed up processes and shorten patients' waiting time. However, a recent visit to the hospital showed that the waiting time was just as long as in other public hospitals. Coincidentally, the computer system was down. Patients said it was a quite common occurrence.
> Said one woman who had taken her mother to the hospital: "It's a matter of luck. There were times we were in the hospital for four hours when the system was slow or down." Another patient said she had waited for almost two hours and was told

[60] In the 2001 Parliamentary Budget, one of the MPs from the opposition parties debated the implementation of an IT-based hospital such as PACS-DPMT Hospital. The MP raised concerns about: 50% use of the hospital capacity; the growing dissatisfaction by the hospital medical specialists because of the working condition, the workload and the poor salary scale; the issue whether THIS can increase the quality of patient treatment and cure, as well as can cut patient waiting time; and the issue of expensive investment to deploy the technology and whether the decision is for the benefits of people or the cronies.

> that the computer system was down. “Now, I have difficulty getting a medical certificate because they could not retrieve my medical records,” said the patient who was suffering from severe rheumatoid arthritis...

The Deputy Director-General of Health responded on the issues as follows:

> ‘...When we mooted this idea of a paperless hospital, it was to provide greater efficiency of services to the public as well as health care providers. It saves time and is user-friendly. It is supposed to be based on high-tech and high-touch philosophy,” he said. “The systems were disturbed (sic) and patients have to wait for long hours, but to be fair to us, it was the first time for us to have THIS in government hospitals and when we say THIS, we are talking about the total system framework in which clinical, imaging and administrative functions are being linked in one function...’

In early 2006, the Health Minister complained that ALPHA D-4 Hospital was abused by “people claiming to be Very Important Persons (VIPs)” that demanded special treatment when they seeking clinical consultation (out-patient treatment). He criticized these irresponsible VIPs who disregard the proper procedure such as registering first and then waiting for their turn. In late 2007, there was another complaint published in the local news by a doctor who claimed that the hospital at present caters to needs of elite people and civil servants more than the average non-elite and non-civil servant income earners.

Also at present, despite the increased availability of online patient data in community hospitals via the application of EMR, HIS, RIS and PACS (as a standalone or integrated system), the public and patients’ awareness with regard to the issue of data confidentiality and privacy is unknown.

5.2 The Relationship between the Technology and the Organizational Contexts

5.2.1 Integrating Medical Imaging in Hospital Work System

Medical imaging was deployed into PACS-DPMT Hospital as a solution to improve the quality of providing radiology service, access and delivery to the public. In the context of PACS-DPMT, according to the Head of Department and the Chief Radiographer, the initial integration of medical imaging application into the department's work system had received less resistance from the radiology staff. It was simply because the use of PACS and RIS had systematized and simplified the radiology work flows, and hence the radiologists, the MO radiologists and the radiographers had enjoyed the benefits from using the technology since the beginning. However, in the initial years of using the technology, resistance to change did exist among other groups of users, particularly the clinicians. For example in the case of the hospital's operating theatre (OT), whilst it is within the hospital's policy to have filmless work practice, yet the OT's personnel still preferred the conventional method. The Chief Radiographer observed, however, that throughout the years the OT personnel had changed their perceptions and forwarded a request to have PACS viewing workstation placed in the theatre room.

Also, after 3 years of using THIS and medical imaging at PACS-DPMT Hospital, an internal study that conducted the user satisfaction survey reported about 93% of the respondents preferred THIS environment, and about 64% to 71% of the users rated the IT work processes as being very good to excellent. In another study that compared the results of using THIS application with another conventional hospital, it was reported that PACS-DPMT Hospital had: 11% reduction time in patient registration; 37% in time reduction in admission procedures; 73% time reduction following portable x-ray reporting; 80% reduction in time to view the patient's medical records; and 52% efficiency gain in scheduling patients.

Whilst PACS-DPMT and the hospital in general have benefited from integrating medical imaging into the work system, yet related organizational issues can pose great challenges in managing the technology and sustaining the efficiency and benefits gained from using the application. In addition to obtaining budget, this study found that aspects related to the restriction of organizational authority and norms

with regard to dealing with staff transfer could have a counterproductive effect on the organization in the long run. Explicitly,

- Limited funding obstructs the organization to promote innovation activities through the implementation and use of technology
- Restriction in the organizational authority particularly in the decision area related to the appointment of the technology consultants or contractors for providing on-going services in maintaining the technology can create dissatisfaction and is counterproductive to the efforts of the organization in establishing good relationship with the preferred technology consultant
- Restriction in the organizational authority in selecting and retaining valuable manpower can affect the long-term objectives of building specialized, technical-oriented and expertise in the related work area

5.2.2 Medical Imaging Benefits

As reported in the previous chapter, the use of medical imaging has generated a number of benefits for the staff of PACS-DPMT and the hospital in general. Focusing on five generic areas of radiology work activities, overall this study found the following advantages of using medical imaging as summarized in the subsequent page (see Table 5.1).

Medical imaging as a configurable type of technology offers potential to be further reconfigured to support teleradiology activities, in which the benefits of the application can be extended beyond a single organization. In a nutshell, the MOH initial planning to further integrate the infrastructure of medical imaging in community hospitals such as PACS-DPMT Hospital to implement teleradiology applications undeniably was a strategic move to cater for the increasing demand of radiology service and access by the Malaysian population. This study further contends that without MOH's long-term commitment to address these issues (funding, staffing and organizational authority), the Malaysian community healthcare organizations such as PACS-DPMT Hospital, COV-DPMT Hospital and others will not be able to play active roles to effectively induce changes within the organizational context and further to shape the consequences of deploying healthcare information systems and technologies such as medical imaging and the telehealth applications to benefit the patients and the public.

Table 5.1: Medical Imaging Innovative Features – The Benefits Gained by PACS-DPMT and the Hospital

Features	Conditions	Benefits
Online image retrieval, viewing and storage (PACS Application)	• Immediate access and view of patient images • Immediate retrieval of patient old images	• Instigate action for radiologists and MOs to initiate diagnostic reporting tasks • Greatly facilitate the examination review request, particularly in providing advice to the clinicians about which kind of radiology examination is suitable or recommended for the patient
	• Parallel access to patient images and reports	• Enhance the quality of interaction between radiologists, MO radiologists and clinicians
	• Patient images can be easily copied and stored using off-line optical disks	• Extend the benefit of storing radiographic image data for doing research; such benefits also have been extended to other external professional groups such as academic researchers.
	• Digital storage	• Save physical space • Simplified the radiographers' work activities
Online patient data and information (PACS/RIS/HIS and EMR)	• Immediate access to patient clinical information • Immediate access to patient demographic information	• Enhance the quality of diagnostic reporting discussion • Permit immediate patient arrangement to deal with the unexpected situation, i.e., patients' failure to meet the schedule appointment
Online radiology reporting (RIS)	• Structure the task of preparing diagnostic report	• Lead to systematic radiology diagnostic reporting • Promote transparency in works
Extensive Work Automation (PACS/RIS/HIS, email)	• Immediate access to up-to-date information • Systematize the radiographer's tasks in handling patient radiology examination • Systematize the department's radiology workflows	• Lead to systematic work processes • Enable initiatives to optimize time usage, machineries and manpower resources • Contribute to radiographers becoming more independent in work
Ubiquitous computing environment	• Wide availability of computing resources • Online patient data (clinical information and radiographic image) can be accessed across hospital wards, clinics and departments	• Encourage extensive integration in hospital work activities • Offer some flexibility in doing work and enhanced the quality of work environment • Increased the user's (radiographers) confidence level in using computers

5.3 The Relationship between the Technology and the User Contexts

This study found that, in addition to transforming many aspects of conventional radiology work practice, the application also has the organizational roles and social relationships of the users in PACS-DPMT and the hospital in general. This study however found no evidence of change with regard to the interaction patterns between the radiographers and the radiologists and MO radiologists.

5.3.1 Radiographer

In the context of a radiographer's works, the findings of this research confirmed the results of several prior studies showing that in medical imaging particularly, the use of PACS had structured and systematized the work practices, and hence leading the radiographers to become more independent in performing their duties. Larsson et al. (2007) further reported in their study that PACS utilization has led the radiographer's work to become more highly scientific and the radiographers enjoyed a higher level of prestige. Fridell et al. (2008), based on a longitudinal qualitative study, reported that the use of PACS has expanded the radiographer's skills and responsibilities.

The findings of this research also further indicated that the radiographers of PACS-DPMT had more self-confidence than those in COV-DPMT with regard to rating their ability in using computers for doing minor image editing. Unlike COV-DPMT, PACS-DPMT has a ubiquitous work environment, and hence it permits the radiographers to use computers everyday for their work. One of the advantages of this as revealed in the findings is that the availability of the computing resources has encouraged the radiographers to have own initiatives or to obtain assistance from colleagues to increase their computing knowledge and technical skills.

Furthermore, in addition to radiographer's non-relational roles, this study also found that the deployment of medical imaging in PACS-DPMT has also affected their relational roles. First, due to a shortage of staff, the junior radiographers have to take turns to take care of the reception counter. The Chief Radiographer noted that while this additional responsibility could present advantages in facilitating the reception counter's service, it does not add value to the radiographer's technical skills. Finally, due to the fact that the PACS Server Room is within the domain of PACS-DPMT, it requires them to train their selected radiographers in areas related to PACS servers and computer networks in handling daily matters related to the activities of the unit.

From the standpoint of the radiographers who were selected to undergo the required training, they are the point of reference in the department to refer to whenever problems related to the use of PACS application arise. They are being perceived as more knowledgeable and skilful in handling information systems and technologies' issues and are also shown more respect not just by other radiographers but also radiologists and MO radiologists. These current approaches practised by PACS-DPMT somehow focus the radiographer's roles in becoming more multi-tasking rather than being technically specialized. In the developed countries such as in the UK and the US, with regard to handling a PACS system, a PACS administrator, manager or technologist normally assumes this role. See for example studies by Cabrera (2002) and Nagy et al. (2005).

5.3.2 Radiologist - Radiographer

Barley (1986) reported that the introduction of the CT scanner had transformed the interaction patterns and roles between the radiologists and the radiographers in his case studies. This study however found no significant change in the interaction patterns and roles between the radiologists, the MO radiologists and the radiographers of PACS-DPMT as a result of deploying medical imaging. Whilst Barley (1986) performed within case comparative analysis in examining changes related to the CT scanner use, this study focused on cross case comparative analysis, i.e., comparing between the work practice context of PACS-DPMT and the work practice context of COV-DPMT, in examining the organizational changes related to the implementation and use of medical imaging.

In the case of PACS-DPMT, despite the extensive use of medical imaging, yet educational background and language barrier are the apparent causes that contribute to the division of roles between the doctors (radiologists and the MO radiologists) and the radiographers. As found in the survey, 89% of the radiographers (16 out of 18) at PACS-DPMT and 100% (52) of the radiographers of COV-DPMT who participated in the survey are diploma holders. Also based on the observations at both sites, a majority of the radiographers could not communicate in English. On the other hand, radiologists and medical officers usually use the English language among themselves when discussing issues related to their tasks and responsibilities. This language barrier undeniably limits the interactions between the

radiographers and the doctors (radiologists and MO radiologists). Due to the language barrier, radiologists and MO radiologists typically use the national official language, i.e., Bahasa Malaysia to communicate and to converse with the radiographers in day-to-day work practices.

The Chief Radiographer of COV-DPMT who is also the President of the Malaysian Society of Radiographers remarked the following when asked about the interaction level between the radiographers and the doctors:

> '...I think the radiographer themselves have to show confidence in speaking out their feeling. They cannot just wait until someone asks them, then they talk...being confident is important...Maybe their confidence level is related with to knowledge, or maybe the environment has suppressed them...doctor autonomy...maybe, I am not sure. But, there are no two-ways interactions between radiographers and doctors...'

In PACS-DPMT and COV-DPMT's workplace contexts, it is not that surprising to learn that there is a lack of two-way interaction between radiographers and radiologists. The Malaysian society in general is known as a highly hierarchical society and places considerable importance upon status differences, and shows a high level of gender inequality in many aspects of their life (Kennedy, 2002). In the context of the organizations being studied, these cultural values are part of their organizational culture. Hence, it is not common in the context of radiology tasks to find a radiographer regardless of their seniority level, to personally confront face-to-face the decisions or actions taken by the radiologists or medical officers.

Furthermore, within the Malaysian community healthcare institutions, the following applly to the radiographer[61]:

- the junior radiographers who graduated with a diploma, hold GRED U29
- only the radiographers who hold GRED U32 and above can provide image and radiograph assessment that produced from the imaging modalities
- only the radiographers who hold GRED U41/U42 and above can further provide image and radiograph assessment in the aspects of abnormal anatomic and structure
- only the radiographers who hold GRED U44 and U48 together with the x-ray specialists (i.e., doctors) can further provide suggestion for further radiology examination

Therefore, although a particular radiographer has attained the highest seniority role, he or she cannot provide suggestion for further radiology examination without the

[61] http://www.jpa.gov.my/pekeliling/pp05/bil10/pp1005.pdf

advice of doctors, i.e., radiologists or medical officers. In the UK, a study reports that radiology reporting by radiographers had increased since year 2000 (Price and Masurier, 2007). Unlike the UK, Malaysia has yet to take advantage of these advanced technologies and to explore the available alternatives to empower users in their workplace. Radiographers in the UK for example were found to have an increased in performing reporting in areas such as ultrasound, appendicular skeleton, barium meals, mammography, chest radiography and paediatric (Price and Masurier, 2007). It was further noted that technologies such as PACS contribute to the rapid development in radiographer role extension in the UK (Larsson et al., 2007).

5.3.3 Radiographer - Clinician

As reported in the previous chapter, unlike COV-DPMT, the majority of PACS-DPMT's radiographers perceived that they have had frequent interactions with the hospital clinicians. Also, based on the survey results and the observational findings, the use of medical imaging whilst enabling work transparency and permitting immediate access to up-to-date information, surprisingly did not really have an obvious impact on the use of the traditional mode of communication i.e., using telephone to obtain information. In day-to-day work practice, PACS-DPMT's personnel, particularly the radiographers interacted frequently with the hospital clinicians via the telephone. The clinicians' sense of urgency can contribute to what Reiner et al. (1998) described as increasing 'miscellaneous and delay' times in completing the radiographer's work task. In the context of CT scan work activities for example, the clinicians make a telephone call to obtain information such as when the images are ready to be viewed or whether the images have been printed on film and ready to be collected.

5.4 Conclusion

This chapter has discussed in detail the relationship between the external and the internal contexts in which have shaped the overall aspects of implementing and using medical imaging in the context of Malaysian community hospitals. The findings of this research suggest that the roles and the functions of the MOH shape the organizational context of community hospitals, and thus also affecting the organizational implication of implementing medical imaging.

With regard to using medical imaging to support day-to-day hospital work activities, this chapter has elaborated in detail how and to what extent the use of the application has affected the radiology work practice, social relationships and organizational roles.

Chapter 6

Conclusion

Introduction

This research set out to investigate the implementation and use of medical imaging in the Malaysian context. It specifically aimed to examine how the internal context of a hospital and its external context together influenced the implementation of medical imaging, and how this in turn shaped organizational roles and relationships within the hospital. It also sought to understand how the implementation of the technology in one hospital affected the implementation of the technology in another hospital.

Guided by the emergent perspective and the systems theory approach, this research has empirically shown that the organizational context of Malaysian community hospitals is shaped by the dynamics of the external environment particularly by the role and function of the MOH. The outcomes of this research further indicate that influences from both internal and external contexts have had a substantial impact upon the progress of the technology implementation and the extent of the benefits that the organization can gain from implementing the technology. In the context of roles and social relationships, the findings revealed that the routine use of the technology has substantially affected the organizational roles and social relationships of the radiographers, the radiologists, the MO radiologists and the clinicians. Also, the implementation of THIS and medical imaging in PACS-DPMT Hospital was found

to influence the approaches taken by a number of new IT-based hospitals in implementing the technology.

Overall, this study makes three important contributions. Firstly, it extends Barley's (1986, 1990) research in three ways, namely: (1) it demonstrates that both internal and external contexts can shape the implementation and use of technology in an organization; (2) it shows in what ways the processes of implementing and using technology in an organization can impact upon roles, relationships and networks; and (3) based on the research findings, it contends that from the perspective of a developing country, it is inadequate to solely rely upon a role-based approach to examine the outcomes of implementing an advanced technology such as medical imaging. Secondly, learning from the Malaysian experience, this study proposes that scaling up an advanced technology such as medical imaging in developing countries is not necessarily a linear process. Thirdly, this study offers practical contributions that can benefit healthcare organizations in the Malaysian context.

This chapter is organized as follows. It begins with a brief summary of the research findings. Then it elaborates further the contributions of this research and highlights the limitations of the study as well as the opportunities for future research.

6.1 Summary of the Findings

This study outlined five guideline questions which have been answered as follows:

Q1: What are the effects of implementing medical imaging on work practices?

It was found that medical imaging has affected, reconfigured and transformed many aspects of traditional radiology work practices. Focusing on five generic areas of work activity, it explicitly reported in what ways the innovative features of the medical imaging infrastructure have systematized and structured radiology work activities in the organizations under study. In addition to bringing new activities and tasks to the organizations, the implementation and use of medical imaging has also substantially affected the traditional relationships and interaction patterns of the users.

Q2: Who are the actors that are affected by the implementation of the technology?

This study identified a wide range of actors that are affected by the implementation of the technology including the MOH, technology contractors, Malaysian community hospitals, technology users (radiologists, MO radiologists, clinicians and radiographers), patients, the hospital medical record department and the IT department.

Q3: Does the implementation and use of the technology impact on roles, relationships and networks, and in what ways?

Medical imaging implementation and use was found to significantly affect radiographers' relational and non-relational roles. The application also has affected the interaction pattern between radiographers and clinicians. There was no evidence that the use of the application has changed the relationships between radiologists/MO radiologists and radiographers. This study found that the PACS-DPMT Hospital as the early technology adopter enjoyed special status within the networks of the community hospitals.

Q4: What are the internal and external influences that affect the implementation and use of the technology and how they are related?

This study reported a number of influences (internal and external) and explained in what ways they are related. With regard to the MOH as a powerful actor, its present

bureaucracy and high level of control of resources has influenced the progress of diffusing medical imaging among community hospitals. It also shapes the organizations' interaction in the organizational field and substantially influences their organizational context.

Q5: How does the external context shape the implementation and use of the technology?

This study particularly found that the external influences via the roles of the MOH and the technology contractors condition the implementation progress of medical imaging and its potential to be reconfigured to teleradiology applications. The MOH roles and existing rules and policies also influenced the decision making pattern within the organization.

6.2 Theoretical Contributions

6.2.1 Extending Barley's (1986, 1990) Research

(a) The Influences of External and Internal Contexts

Barley's (1986, 1990) studies ignored the external context and mainly focused on the internal context of the organization in studying the impact of using CT scanners. Guided by systems theory and the views of the emergent perspective paradigm, this study shows that the dynamics of the internal and external contexts can shape the implementation and use of the technology in community hospitals and can affect roles, relationships and networks. As shown in the research, the use of systems theory particularly Luhmann's views is beneficial to explicitly articulating the role of the external context and influences that can affect the implementation and application of the technology in the organization. Further, this study supports Davidson and Chismar's (2007) contention that 'institutional and technology-change triggers can interact to engender changes in social structure to facilitate effective organizational use of IT'. Based on the research findings, this study further contends that the roles of external factors can greatly influence this interaction and can shape the overall strategic implications of implementing and using the technology in an organization. Moreover, this study asserts that institutional practices can play an important role in moderating the technology-change triggers in the organization's context.

In the Malaysian context, the deployment of medical imaging was institutionally triggered via the roles and functions of the MOH. The research evidence further suggests that the MOH's role in allocating and managing manpower and economic resources, and formulating rules and policies has important implications for the implementation of the technology in the context of community hospitals. Also, although medical imaging offers the potential to be reconfigured and extended to teleradiology applications that can generate benefits to the mass public, the dynamics of the external influences i.e., via the roles of the MOH and the performance of the appointed technology consultants by the MOH condition its implementation progress. Whilst the MOH's decision to invest in innovative technologies such as THIS and medical imaging can transform the healthcare service and delivery standards, its present bureaucracy and highly centralized

decision making can undermine the initiatives of the community hospitals in cultivating change from within.

This study recommends that future work should emphasize the dynamics of the organizational environment (the external and internal contexts) surrounding the implementation of the technology to provide an integrated understanding and a more balanced view of the consequences of implementing technology in organizations.

(b) The Processes of Implementing and Using Technology

Reflecting on the research by Barley (1986, 1990), this study contends that his works, whilst focused, are rather restricted in terms of demonstrating the processes of implementing the technology in the organization.

This study, following Orlikowski's (1992) recommendation, engaged the context of implementing and using the technology in PACS-DPMT Hospital to account for the potential of medical imaging as a reconfigurable type of technology. Hence, it explicitly considers the processes of implementing and using medical imaging and in what ways it can impact upon roles, social relationships and networks in the Malaysian context. Particularly, the processes surrounding implementation in PACS-DPMT Hospital have contributed to: (1) the hospital enjoying a special status within the networks of community hospitals; and (2) the hospital's performance becoming a benchmark in the government's decisions (via the MOH) in diffusing and expanding the technology to other hospitals. The dynamics of these processes in turn can put pressure on the hospital's personnel, particularly the administrators and the users (clinical and non-clinical personnel) to deal with the expectations of the government and the public while simultaneously fulfilling their organizational responsibilities. Further, in the context of Malaysian community hospitals, the evidence also suggests that there was a noticeable mismatch between the MOH's expectations and the reality of implementing and managing healthcare technologies such as medical imaging in the organization.

Hence, a failure to engage the implementation and use contexts and to understand their processes in the study can result in an incomplete understanding of the phenomena.

(c) Engaging a Role-based Approach in Research

Barley (1990:68) maintained that a role-based approach, i.e., the focus on relational and non-relational roles, is pragmatic and 'compatible with an analysis of a technology's immediate material implications'. This study contends that such an approach is inadequate, particularly in the context of developing countries, where economics and socio-political factors are intertwined with initiatives to promote change via the implementation of innovative technologies. In such a context, both the internal and external dynamics of an organization contribute to how the use of a particular technology transforms roles and relationships.

Whilst investigating the impact of using medical imaging on roles and relationships in PACS-DPMT, this study identified different groups of users and found that there were both intended and unintended consequences of utilizing the technology. In the case of radiographers, this study found no change in roles and relationships between the radiographers and the radiologists or MO radiologists. The radiographers' educational background, the scope of their professional roles and functions as well as their level of English proficiency serve to maintain the authority of expertise and the traditional system of professional dominance in radiology work practice.

6.2.2 Scalability of Technology Is Not Necessarily Linear

Sahay and Walsham (2006: 188) defined scaling as follows:

> '...Scaling is not only about numbers and size (although these are important elements of the problem), which can be achieved through network externalities (where as the value of a technology increases, more users will adopt it), but refers to the processes and embedded practices by which heterogeneous networks around the technology are spread, enhanced, scoped and enlarged; scaling concerns aspects of geography, software architecture, people, processes, infrastructure, technical support, and political support...'

In the current literature, there have been many calls for efforts to address theoretically and empirically the scalability aspects of implementing advanced technology from the perspective of developing countries. In a recent publication in the MIS Quarterly Journal – "Special Issue on Information Systems in Developing Countries" - Walsham, Robey and Sahay (2007) call for future research to address the issue of scalability in key sectors including healthcare.

Learning from the Malaysian experience in implementing THIS and medical imaging, this study puts forward an argument that the initiatives to scale up these technologies are not necessarily linear. In addressing the two important questions, namely "what is being scaled" and "how is it being scaled" (Sahay and Walsham, 2006), this study proposes future research to clearly address the reconfigurable features of technology in order to develop an in-depth understanding of the potential complexities and cost to scale up the technology across the country. In the Malaysian context, in addition to the political and institutional influences, it is apparent that the initial failure of the MOH to understand the reconfigurable aspects of medical imaging to be expanded to teleradiology and the complexities of implementing it from the organizational standpoint has proven costly in the long run. As a result, the government now has decided to scale down THIS and medical imaging implementation, and this undoubtedly will have a great impact on efforts to scale up teleradiology applications in Malaysia.

This study further recommends future studies illuminate the influential roles of actors particularly organizations, the MOH and the technology contractors/suppliers, and to use micro and macro-level data in the research. It is pragmatic to consider deploying qualitative research through case studies or using a combination of quantitative and qualitative research design to gain an in-depth understanding of technology scalability in developing countries

6.3 Practical Contributions in the Malaysian Context

6.3.1 Managing Technology (Medical Imaging) in Hospitals

Nowadays, as healthcare technologies are becoming more innovative and complex, hospital administrators have to confront various issues and sometimes conflicts with regard to managing the technologies. In the context of managing THIS and medical imaging, the outcomes of this research suggest that PACS-DPMT and the hospital in general face a number of challenges. In addition to ensuring sufficient funding to maintain and upgrade the technologies, the hospital administrators also have to deal with several fundamental issues such as managing relationships with the technology providers and providing adequate training and assistance to users to ensure that the deployment of technology can generate benefits to the organization and patients.

Learning from the evidence, the following can clarify some issues regarding medical imaging deployment in the context of Malaysian hospitals.

1. The MOH has planned for the implementation of reconfigurable technologies such as THIS and medical imaging to be further extended in the future to include other organizations. This decision undoubtedly will affect the intended objectives and performance of the hospitals in deploying the technologies. The organizations therefore must anticipate that this will also have a great impact on resource planning and training in the future.
2. At the departmental level, the outcomes of this research suggest that managerial decisions pertaining to the ownership of technologies such as PACS will have substantial implications for the department and its members. In the PACS-DPMT context, the department's decisions to assume managerial autonomy in the management of PACS servers have: (1) brought a new set of activities to the radiology department; and (2) affected the non-relational roles of radiographers (i.e., demanding new skills and knowledge). In managing PACS servers, the Chief Radiographer of PACS-DPMT works closely with the hospital IT Department and the appointed technology consultant. The selected radiographers, that obtained some training pertaining to managing PACS servers, are responsible for supervising the related activities pertaining to the PACS Server Unit. They receive requests to retrieve radiographic images from doctors and academic researchers, and perform routine checks on the transfer and storage of images to prevent image loss. In the Malaysian context, their roles in

this sense are quite similar to the personnel in charge of hospital medical records. This study recommends that prior to making such important decisions, an internal study should be conducted first to examine the potential of emerging issues related to the ownership of PACS, and in what ways (pros and cons) such issues can affect the healthcare professional's roles and relationships as well as other departmental resources.

6.3.2 Political Determination to Promote Change

Reflecting on the findings of this research, whilst the Malaysian government, via the roles and functions of the MOH has been proactive in developing policies, strategies and initiatives to diffuse innovative and advanced information systems and technologies, its bureaucracy and lack of pragmatic approaches could become a bottleneck in helping community hospitals to smoothly integrate and adapt to the work practice organized around the use of technology such as medical imaging. In the Health 2005 report, the MOH recognized these issues as contributing factors that create difficulties for new IT-based hospitals in integrating technologies with their work practices. The MOH must determine to address these issues and to reform its present weaknesses.

Also whilst national efforts to build home-grown technology to support the healthcare sector is undoubtedly important (Bulgiba, 2004), the government, via the roles and functions of the MOH must always prioritize resources to provide adequate healthcare service to the poor and has to curb the wastage of resources that results from the appointment of incompetent technology providers to build and maintain the complex healthcare infrastructure.

6.4 Limitations of the research and Opportunities for Future Research

This study focused on the implementation and use of medical imaging in the perspective of Malaysian community hospitals and hospital radiology work practices. It deployed several theoretical concepts and approaches to uncover the intricate issues and relationships surrounding the implementation and use of medical imaging in organizations. The theoretical model that guided the research was further developed using a contextual approach. Whilst this study was able to relate the historical and institutional processes surrounding the implementation and use of medical imaging and how these shaped the overall organizational implications of deploying the technology, the generalization and the application of the research findings are rather limited. Specifically:

1. This study focused upon the understanding of the relationships between the internal and external contexts of medical imaging implementation and use in organizations and how they shaped the organizational consequences of deploying the technology. The research did not particularly focus upon developing a pragmatic model that could directly assist the organization to increase technology acceptance and integration among its organizational members.
2. Whilst this study used multiple methods and systematic data analysis, the researcher as an outside observer, had some restrictions while undertaking the research. Explicitly, due to the present circumstances as well as time and resource constraints, this study was unable to directly engage the perspectives from the representatives of the MOH and the technology contractors. These restrictions may introduce some bias in the sense-making process of doing data analysis and interpretation of data generated from the case studies.

However, it is possible for future research to replicate this study, particularly the conceptual framework and methods, to account for the organizational consequences of implementing medical imaging in a different setting. This study particularly suggests that future studies should consider doing a cross-country comparison to generate a systematic understanding of the impact of implementing and using advanced technologies such as medical imaging from the developing countries perspective.

Appendix A: Supplementary Research Materials

(1) Phase 1: Semi-structured Interview Questions

Interviewee: Hospital Top Management

1. Can you explain the operational background of this hospital?
   Boleh terangkan latar belakang operasi hospital ini?

2. What are the level of ICT (information communication technology) deployment and adoption in this hospital? To what extent the daily hospital transactions (administrative and clinical) are being automated or computerized?
   Apakah tahap penggunaan ICT di hospital ini? Setakat mana sistem pengkomputeran di dalam transaksi harian (pengurusan dan klinikal)?

3. To what extent the patient medical records are being computerized? How the electronic based patient record affects the current referral system?
   Setakat mana rekod kesihatan pesakit di komputerkan? Bagaimana rekod pesakit berdasarkan elektronik mempunyai impak kepada sistem referral sekarang?

4. If the manual system is still in used, what are the advantages/disadvantages of using the paper-based version of patient record?
   Sekiranya sistem manual masih di gunakan, apakah kebaikan dan kelemahan sistem manual yang berdasarkan kertas ini?

5. How the top management formulates plans to deploy ICT and to encourage the use of ICT among staffs? Is there any plan in the future for this hospital to fully computerize patient records?
   Bagaimana pengurusan atasan membuat perancangan mengenai pengaplikasian ICT di hospital dan menggalakkan penggunaannya di kalangan staff? Apakah ada perancangan di masa hadapan untuk mempunyai sistem maklumat pesakit berasaskan elektronik sepenuhnya?

6. In your opinions, what are the factors that hinder/promote effective usage of ICT in hospital?
   Berdasarkan pendapat tuan, apakah faktor-faktor penggalak dan juga yang melemahkan penggunaan ICT secara efektif di hospital?

7. What is your opinion on the progress of ICT in Malaysia health care system such as the telemedicine project and the electronic based patient record? Can the technology implementation improvise the hospital quality of health care service and delivery?
   Apakah pendapat tuan mengenai pembangunan ICT di dalam konteks sistem kesihatan Malaysia seperti projek telemedicine dan rekod pesakit berasaskan elektronik? Bolehkah implementasi technologi membaiki kualiti perkhidmatan kesihatan?

Interviewee: Unit Medical Record Officer

1. Can you describe the work flow of the daily transaction of the units? How the unit is related with other units?
   Boleh terangkan aliran kerja dalam transaksi harian unit ini? Bagaimanakah unit ini berkait dengan unit lain?

2. To what extent the patient medical record is being computerized? What sort of hardware/software systems are currently being utilized? Does the hospital have scanning technologies?
   Setakat manakah rekod kesihatan pesakit di komputerkan? Apakah jenis sistem hardware/software yang di gunakan? Adakah hospital mempunyai scanning technology?

3. What are the difficulties in maintaining the paper based medical records?
   Apakah kesulitan di dalam mengemaskini rekod pesakit berasaskan kertas?

4. Which hospital units/staffs have access to computer networks? Who updates the patient records?
   Hospital unit atau staff manakah yang mempunyai akses kepada rangkaian computer? Pihak manakah yang mengemaskini rekod pesakit?

5. How the referral system relates to your unit? What is the process within this unit if a patient is being referred to another specialist or hospital?
   Bagaimakah sistem referral berkait dengan unit ini? Apakah process yang berlaku di dalam unit ini sekiranya seorang pesakit di pindah ke hospital atau pakar lain?

(2) Phase 2: Survey Questions (Original Language) – Radiographers

PACS-DPMT Radiographers

i. Socio-demographic Background

Sila tandakan kotak yang berkenaan. Anda boleh menandakan lebih dari satu kotak sekiranya berkenaan.

1. Jantina: Lelaki☐ Perempuan☐ ***2. Umur:*** < 18☐ 18-25☐ 26-35☐ 36–45☐ 46-55 ☐ lebih 55 ☐
3. Tahap pendidikan (tanda yang tertinggi): Diploma ☐ Ijazah Pertama ☐ Ijazah Lanjutan ☐
4. Jenis Jawatan: Pengurusan ☐ Biasa ☐ Lain-lain tanggungjawab (nyatakan): _____ ☐

5. Tempoh berkhidmat di Hospital *:* 1- 6 bulan ☐ 6 bulan – 1 tahun ☐ 1 - 3 tahun ☐
3 -5 tahun ☐ 5 - 10 tahun ☐ 10 – 15 tahun ☐ lebih 15 tahun ☐
6. Adakah anda pernah bekerja dengan hospital konvensional? Ya (berapa lama? ____) ☐ Tidak ☐

ii. Obtaining knowledge and skills related to computing and modalities

7. Sumber pembelajaran mesin modality (cth: CT Scan, MRI dll) (boleh tanda lebih dari satu)
Melalui latihan pendidikan formal ☐
Latihan drpd Jabatan (internal training) ☐
Latihan drpd vendor/supplier ☐
Pengalaman kerja dgn organisasi sebelumnya ☐
Kawan satu jabatan ☐
Minat dan motivasi sendiri ☐
Latihan sambil bekerja ☐
Lain (nyatakan): _____ ☐

8. Sumber kemahiran komputer: (boleh tanda lebih dari satu)
Melalui latihan pendidikan formal ☐
Latihan drpd Jabatan (internal training) ☐
Latihan drpd vendor/supplier ☐
Pengalaman kerja dgn organisasi sebelumnya ☐
Kawan satu jabatan ☐
Ahli keluarga terdekat ☐
Minat dan motivasi sendiri ☐
Lain (nyatakan): _____ ☐

iii. Work access frequency to handling CT/MRI and training

9. Apakah tahap kekerapan bekerja anda di unit-unit berikut:
CT Plus 4 Setiap hari☐ Beberapa kali seminggu☐ Beberapa kali sebulan☐ Beberapa kali setahun☐ Tidak pernah ☐
CT 64 Setiap hari☐ Beberapa kali seminggu☐ Beberapa kali sebulan☐ Beberapa kali setahun☐ Tidak pernah ☐
MRI Setiap hari☐ Beberapa kali seminggu☐ Beberapa kali sebulan☐ Beberapa kali setahun☐ Tidak pernah☐

10. Apakah tahap kekerapan latihan formal (cth: latihan dari vendor/kursus formal) yang di sertai sebelum mengendalikan modality baru?
Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐

11. Apakah tahap kekerapan latihan formal (cth: latihan dari vendor/kursus formal) yang di sertai sebelum mengendalikan system perkomputeran baru?
Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐

12. Secara anggaran, berapa kali anda menghadiri kursus/latihan formal yang berkaitan dengan tugas?
Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐

iv. Self-reported efficiency rate of handling modalities and computers

13. Tahap kecekapan pengendalian CT Scan Single slice: Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
14. Tahap kecekapan pengendalian CT Scan multislice : Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
15. Tahap kecekapan pengendalian MRI: Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
16. Tahap kecekapan pengendalian General x-ray: Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
17. Tahap kecekapan penggunaan computer dalam memanipulasi imej (cth: computer untuk CT Scan imej dan menggunakan tetikus dan kemahiran dalam membuat image editing, cut, paste, print dll)
Sangat baik☐ Baik☐ Sederhana ☐ Lemah☐ Tidak pernah guna ☐

v. Communication means and frequency of interaction

18. Adakah anda menggunakan aplikasi email di dalam tugasan harian? Ya ☐ Tidak ☐

19. Adakah anda menggunakan aplikasi Internet di dalam tugasan harian? Ya ☐ Tidak ☐

20. Saya selalu berinteraksi dengan jabatan lain di dalam meyempurnakan tugasan harian dengan menggunakan: (boleh tanda lebih dari satu)

Telefon ☐ Bersemuka ☐ Email ☐ Fax ☐ Perantara,cth porter/nurse dll ☐ Lain-lain _____

***21.* Frekuensi interaksi anda dengan MO (medical officer)?** kerap ☐ sangat kerap☐ Jarang ☐

***22.* Frekuensi interaksi anda dengan radiologi pakar?** kerap ☐ sangat kerap☐ Jarang ☐

23. **Frekuensi interaksi anda dengan doctor di jabatan lain?** kerap ☐ sangat kerap☐ Jarang ☐

vi. Radiographers' perceptions and attitudes concerning their work routines

Latihan yang di sediakan oleh jabatan telah membantu meningkatkan kecekapan saya menggunakan modality/teknologi baru
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya sentiasa bergantung kepada kawan sekerja di dalam meningkat kan kecekapan menggunakan modality/teknologi baru?
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Motivasi saya sendiri untuk mencuba, membantu meningkatkan kecekapan menggunakan modality/teknologi baru
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya dapat melaksanakan kerja dengan baik kerana infrastruktur seperti network dan sistem komputer sentiasa stabil
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Penggunaan sistem berkomputer memerlukan saya berinteraksi secara kerap dengan pakar radiologi?
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Penggunaan sistem berkomputer memerlukan saya berinteraksi secara kerap dengan doktor di unit/jbtn lain?
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Penggunaan sistem berkomputer memudahkan kerja harian saya
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya mendapat kerjasama sepenuhnya dari jabatan/unit lain di hospital untuk menyempurnakan tugasan harian
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Kemahiran yang di pelajari di kolej/universiti banyak membantu saya di dlm mengendalikan modaliti/teknologi baru
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Kehadiran mesin/modality/system berkomputer menambahkan beban kerja saya
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Sistem yang di guna pakai adalah berciri user-friendly
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Sekiranya ada pilihan, saya lebih selesa menggunakan sistem konvensional (penggunaan filem dan borang pesakit)
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya berpuas hati dengan persekitaran dan suasana di tempat kerja
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

1. Senaraikan kesulitan berkenaan penggunaan system berkomputer di dalam tugasan:

2. Senaraikan kesulitan menyediakan imej pesakit untuk di hantar kepada MO/doctor/pakar radi

3. Apakah kesulitan harian yang di hadapi yang menyukarkan penyempurnaan tugasan harian?

TERIMA KASIH

COV-DPMT Radiographers

i. Socio-demographic Background

Sila tandakan kotak yang berkenaan. Anda boleh menandakan lebih dari satu kotak sekiranya berkenaan.

1. Jantina: Lelaki☐ Perempuan☐ ***2. Umur:*** < 18☐ 18-25☐ 26-35☐ 36–45☐ 46-55 ☐ lebih 55 ☐
3. Tahap pendidikan (tanda yang tertinggi): Diploma ☐ Ijazah Pertama ☐ Ijazah Lanjutan ☐
4. Jenis Jawatan: Pengurusan ☐ Biasa ☐ Lain-lain tanggungjawab (nyatakan): _____ ☐

5.Tempoh berkhidmat di HKL*:*
1-6 bulan☐ 6bln–1thn ☐ 1-3thn ☐ 3-5 thn ☐ 5-10 thn ☐ 10–15thn ☐ lebih 15 tahun ☐
6. ***Adakah anda pernah bekerja dengan hospital-IT sebelum ini?*** Ya (berapa lama? ____) ☐ Tidak ☐

ii. Obtaining knowledge and skills related to computing and modalities

7. *Sumber pembelajaran mesin modality (cth: CT Scan, MRI dll)* (*boleh tanda lebih dari satu)*
Melalui latihan pendidikan formal ☐
Latihan drpd Jabatan (internal training) ☐
Latihan drpd vendor/supplier ☐
Pengalaman kerja dgn organisasi sebelumnya ☐
Kawan satu jabatan ☐
Minat dan motivasi sendiri ☐
Latihan sambil bekerja ☐
Lain (nyatakan): _____ ☐

8. *Sumber kemahiran komputer:* (*boleh tanda lebih dari satu)*
Melalui latihan pendidikan formal ☐
Latihan drpd Jabatan (internal training) ☐
Latihan drpd vendor/supplier ☐
Pengalaman kerja dgn organisasi sebelumnya ☐
Kawan satu jabatan ☐
Ahli keluarga terdekat ☐
Minat dan motivasi sendiri ☐
Lain (nyatakan): _____ ☐

iii. Work access frequency to handling CT/MRI and training

8. Apakah tahap kekerapan bekerja anda di unit-unit berikut:
CT Neuro Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐ Tidak pernah ☐
CT A&E Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐ Tidak pernah ☐
CTSomatom Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐ Tidak pernah
CTMultiSlice Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐ Tidak pernah
MRI 1 Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐ Tidak pernah ☐
MRI 2 Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐ Tidak pernah ☐

9. Apakah tahap kekerapan latihan formal (cth: latihan dari vendor/kursus formal) yang di sertai sebelum mengendalikan modality baru?
Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐

10. Apakah tahap kekerapan latihan formal (cth: latihan dari vendor/kursus formal) yang di sertai sebelum mengendalikan system perkomputeran baru?
Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐

11. Secara anggaran, berapa kali anda menghadiri kursus/latihan formal yang berkaitan dengan tugas?
Setiap hari ☐ Beberapa kali seminggu ☐ Beberapa kali sebulan ☐ Beberapa kali setahun ☐

iv. Self-reported efficiency rate of handling modalities and computers

12. Tahap kecekapan pengendalian CT Scan Single slice: Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
13. Tahap kecekapan pengendalian CT Scan multislice : Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
14. Tahap kecekapan pengendalian MRI: Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
15. Tahap kecekapan pengendalian General x-ray: Sangat baik☐ Baik☐ Lemah☐ Tidak tahu ☐
16. Tahap kecekapan penggunaan computer dalam memanipulasi imej (cth: computer untuk CT Scan imej dan menggunakan tetikus dan kemahiran dalam membuat image editing, cut, paste, print dll)
Sangat baik☐ Baik☐ Sederhana ☐ Lemah☐ Tidak pernah guna ☐

v. Communication means and frequency of interaction

17. Adakah anda menggunakan aplikasi email di dalam tugasan harian? Ya ☐ Tidak ☐
18. Adakah anda menggunakan aplikasi Internet di dalam tugasan harian? Ya ☐ Tidak ☐
19. Saya selalu berinteraksi dengan jabatan lain di dalam meyempurnakan tugasan harian dengan menggunakan: (boleh tanda lebih dari satu)
Telefon ☐ Bersemuka ☐ Email ☐ Fax ☐ Perantara,cth porter/nurse dll ☐ Lain-lain _____

***20.* Frekuensi interaksi anda dengan MO (medical officer)?** kerap ☐ sangat kerap☐ Jarang ☐
***21.* Frekuensi interaksi anda dengan radiologi pakar?** kerap ☐ sangat kerap☐ Jarang ☐
22. **Frekuensi interaksi anda dengan doctor di jabatan lain?** kerap ☐ sangat kerap☐ Jarang ☐

vi. Radiographers' perceptions and attitudes concerning their work routines

Latihan yang di sediakan oleh jabatan telah membantu meningkatkan kecekapan saya menggunakan modality baru (cth: CT16)
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya sentiasa bergantung kepada kawan sekerja di dalam meningkat kan kecekapan menggunakan modality baru?
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Motivasi saya sendiri untuk mencuba, membantu meningkatkan kecekapan menggunakan modality baru
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Penggunaan modality baru memerlukan saya berinteraksi secara kerap dengan pakar radiologi?
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Kehadiran modaliti/teknologi baru di dalam bidang kerja telah meningkatkan frekuensi interaksi saya dengan doktor di unit/jbtn lain?
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Kehadiran modaliti/teknologi baru memudahkan kerja harian saya
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya mendapat kerjasama sepenuhnya dari jabatan/unit lain di hospital untuk menyempurnakan tugasan harian
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Kemahiran yang di pelajari di kolej/universiti banyak membantu saya di dlm mengendalikan modaliti baru
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Kehadiran mesin/modality baru menambahkan beban kerja saya
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Sekiranya ada pilihan, saya lebih selesa menggunakan sistem berkomputer seperti hospital berasaskan IT
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

Saya berpuas hati dengan persekitaran dan suasana di tempat kerja
Amat setuju ☐ Setuju ☐ Tidak setuju ☐ Amat tidak setuju ☐ Tidak berkenaan ☐

23. Senaraikan kesulitan berkenaan penggunaan system berkomputer di dalam tugasan:

24. Senaraikan kesulitan menyediakan imej pesakit untuk di hantar kepada MO/doctor/pakar radiologi:

25. Apakah kesulitan harian yang di hadapi yang menyukarkan penyempurnaan tugasan harian?

TERIMA KASIH

(3) Phase 2: Sample of Observational Data (COV-DPMT – CT Neuro Unit)

Time: 2:00 am – 5:00pm
Code: 26 – 040907

2:30pm
Radiographer KR went inside again to calm the patient. From the panel room, I saw him demonstrating to the patient how she was supposed to lie down on the gantry machine bed. KR was very patience in dealing with the patient. All the trainees were also inside to help the patient.

A phone rang but no one was there to entertain the call because everybody inside the operating room.

The mother went inside to help her daughter. The patient was still crying. KR tried very hard to explain to the mother, so that the mother can explain to her daughter in Chinese language. The mother started to shout and become stern with her daughter. The patient was still crying and refused to adjust her body properly on the gantry machine. The mother and the sister tried very hard to persuade her...

KR came out from the exam room and with me in the panel room to observe the situation. He kept saying maybe the patient was scared...

2:40pm
A phone rang again but no one bothered to entertain because everybody inside the exam room. Patient was lying on the gantry bed but still was not at the correct position...

In the panel room, the trainees and the staffs were assessing the situation. KR was thinking to reschedule the appointment since the patient resisted to follow the instruction. He said *'mcm nie pening dah nak buat'* [like this gives him a headache]...

3:30pm
The radiographer was waiting for the patient to be given contrast.
Dr. AZ came into the panel room. She is the MO on duty. I vacated the place to let her seat next to the phone area.
...She went into the exam room to deliver contrast injection to the patient...
Dr. AZ and KR were talking about the previous seminar. I also joined the conversation...

...Dr AZ continued studying the patient film using the viewing box. She was curious about the history of the scan and concerned about the clinician's request to perform contrast on the patient. She spotted something in the film, and said to KR and AZ: 'see...He (the clinician) said no contrast yet...that one is not ours'...Then she made a phone call to the clinician...she did not satisfy with the clinician's reason for the error...She complained to us: '...sending the patient to us...decision said contrast…why not do the checking properly whether contrast or not.' Later, she explained to us about the communication issue during the clinician's work shift...'

(4) Phase 2: Sample of Observational Data (PACS-DPMT – CT Unit)

Time: 10:00 am – 12:30pm
Code: 12-220807

10:15 am
Inside the CT Scan Panel Room.
Dr. KH was using the PC Compaq computer next to the modality workstation. I called this the radiographer work area. Radiographers on duty today were ML, FZ, HZ and Mr A (a new radiographer)...

...In addition to supervise the radiographers' activities in the CT Scan room, HZ also trained Mr A about the CT Scan Plus 4 and CT 64...Few trainee students were also inside the panel room. There was one patient inside the exam room at present...

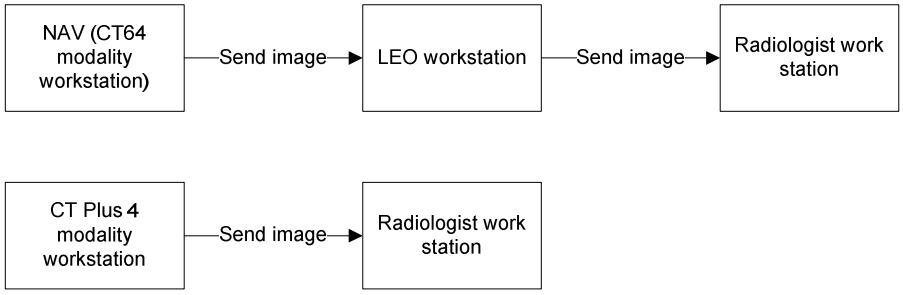
...Dr KH (MO) and Dr BT (radiologist) were discussing some issues. Dr. SH (a senior radiologist) came in and I said "hello" to her...

...Dr. KH asked FZ about the protocol to do certain abdomen scan. FZ was unsure about the steps. She also asked HZ to confirm first the protocol before she initiated the scan. Both FZ and Dr KH listened to HZ's explanation.

10:28am
One patient lady was inside the exam room...
A houseman physician came in to negotiate about the patient scan appointment with the radiologist...

A phone rang and was entertained by HZ. A caller asked about MRN of a patient. HZ went to the PC Compaq to check on the patient MRN. Then he mentioned to the caller: '500714' and after few seconds, the conversation ended. HZ told me that the caller was asked about a patient appointment for CT Scan/MRI. HZ continued to explain to Mr. A about the procedures in CT+4 modality workstation. I observed HZ called Mr. A as *'abang'* [brother]...

I saw an indicator displayed on the modality workstation interface that said the image has been sent successfully to LEO. I asked FZ what is that means. FZ explained to me that their workstation, NAV will send the image to LEO (the work station next to NAV), then the radiographer will send the images to the Radiologist work area. The CT Plus 4 according to Faiz will send images straight away to the workstation at the Radiologist work area...



10:47 am
Another patient was inside the exam room and being asked to take oral contrast. The students assisted the patient on the gantry bed.

In the panel room, FZ referred to the patient slip and began to type in the patient ID. I observed closely on what FZ doing in the screen. I saw her opened the work list update, then she seemed to drag the patient name into the exam management application. Then the system triggers patient details, i.e. which procedure required for patient...
I recalled last time, the radiographers were laughing at the words entered in the procedure for patient. They did not understand what the physician typed. FZ initiated the scan.
....
11:12am
Another patient was inside the exam room.
FZ at LEO, confirmed with HZ that she already sent the image to Doc PC.
I saw doctors were studying medical books...
I chatted for a while with FZ ...and observed her works in initiating CT abdomen...
She mentioned if doctor ordered different part of the abdomen, then they have to enter it separately. The monitor showed patient hand is blocking the scan. The trainee went inside to adjust the patient hand.
...
All the radiographers went inside to see the patient. Both doctors were still talking about the images. FZ came out from the exam room and informed the doctors about the patient feeling pain when the contrast in. She also said the patient hand *'bengkak-bengkak'* [swollen]....

11:50am
One doctor (a houseman) came in with a file to see doctors. For few minutes, the two doctors were still talking, and disregarded his presence.
The radiographer FZ called Dr KH to review images. Dr KH asked the patient name. FZ told her the patient name and described briefly about the patient sickness.
Dr BT entertained the housemen doctor. They discussed about the patient condition, with all the technical jargons...

Dr. KH was reviewing the images and conversing with the radiographers about the images. I noticed that the radiographer sometimes asked Dr. KH about the images. All of the radiographers next to Dr Khairiah were looking at the image.

Dr. BT gave her opinion to the housemen doctor regarding the patient. Few minutes later the houseman doctor leaved the room.

Dr KH mentioned 'hepatitis' to Dr BT while studying the images on the screen at the CT16 workstation. Dr BT came and reviewed the images. She described the images...

HZ checked on LEO if NAV has sent the images successfully...

(5) Phase 2: Sample of Images/Screen - PACS-DPMT Hospital[62]

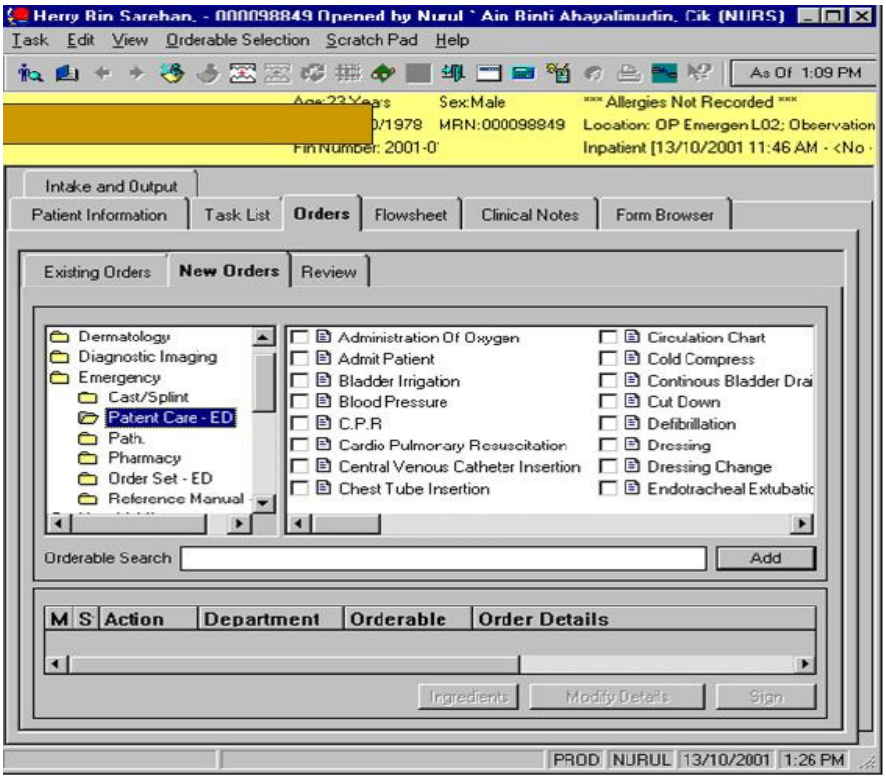


Figure A-1: Sample Screen for Order Entry

Figure A-2: Sample Image for Viewing Workstations

[62] http://www.mmaselangor.org

Figure A-3: Computed Radiography

Figure A-4: General X-Ray

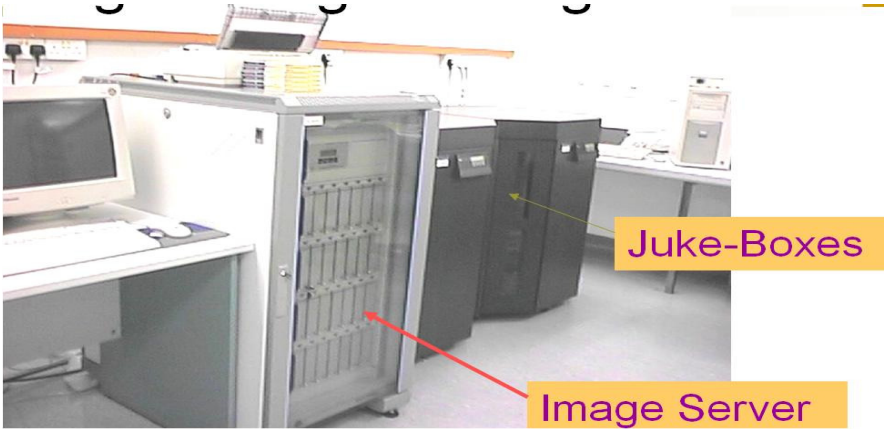


Figure A-5: PACS Server Room

(6) Phase 2: Sample of X-Ray Request Form (COV-DPMT)

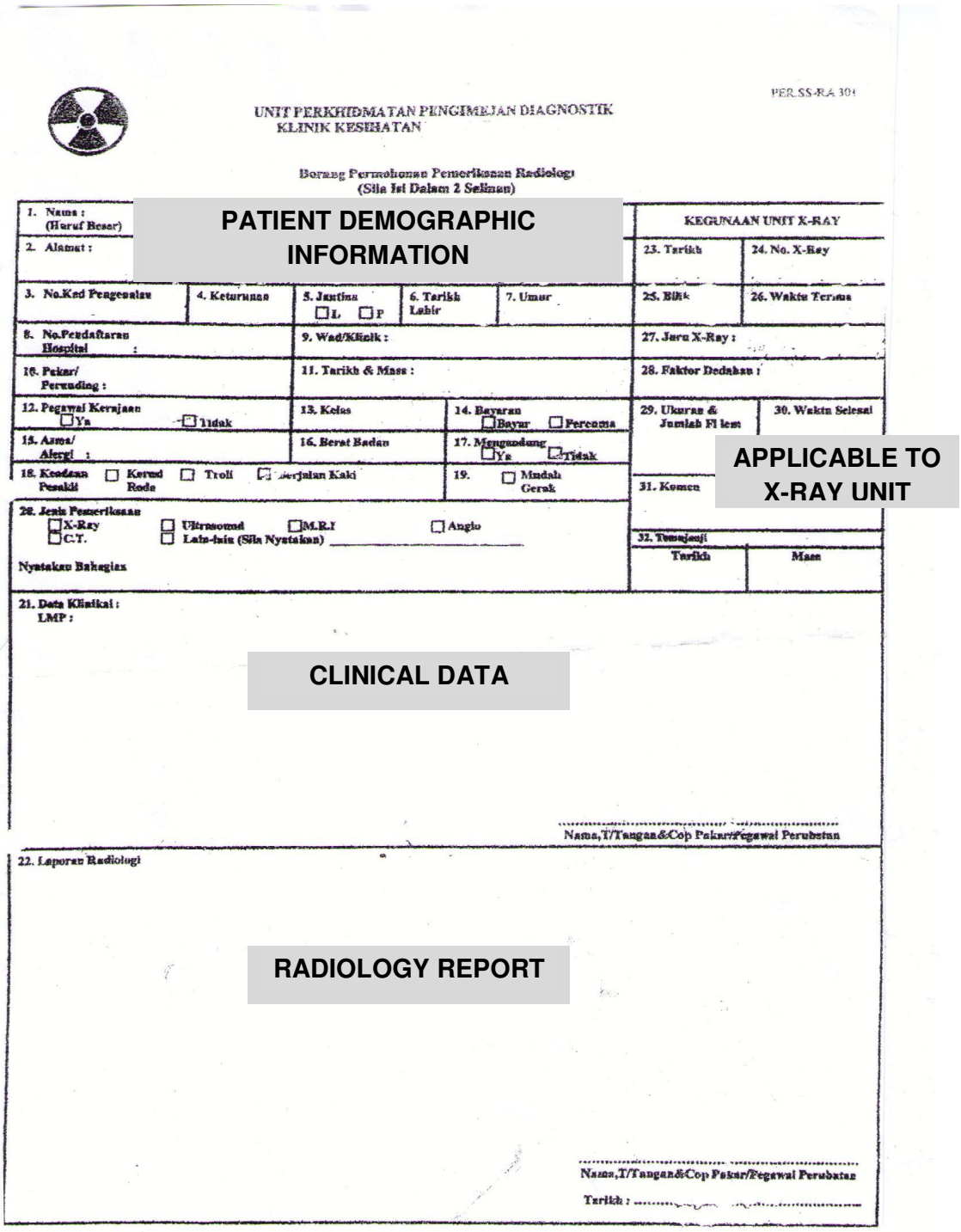


Figure A-6: Sample X-Ray Request Form

(7) Phase 2: An Illustration of CT Multislice Unit's Work Activities - COV-DPMT

There are three main work areas associated with the work activities of CT16 Room as depicted in the following figure.

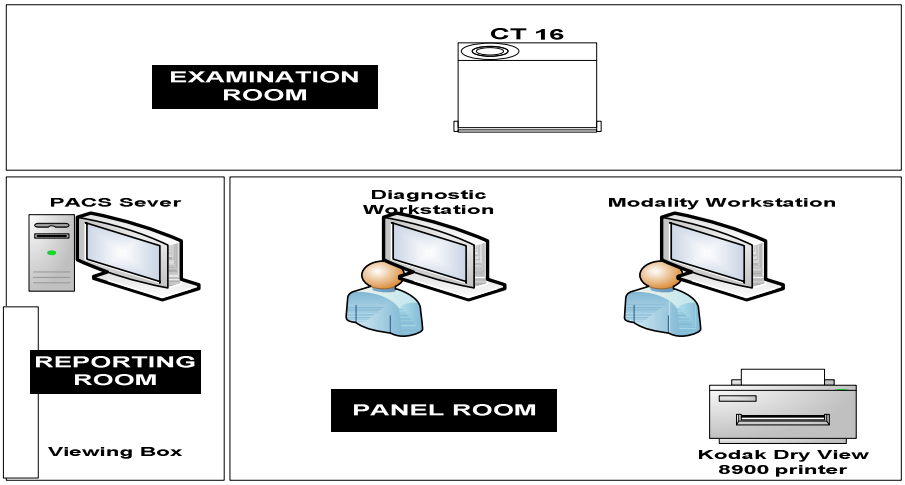


Figure A-7: An Illustration of CT16 Room of COV-DPMT

The panel room work area is the main area where the radiographers, the medical officers (MOs) and the radiologists perform their day-to-day work activities. Besides them, department nurses and sometimes clinicians or trainee radiographers are also present from time to time in the panel room. This room is equipped with a CT16 modality workstation, a diagnostic workstation, a laser printer to print film, a small shelve and a notice board. The panel room is small and usually in the afternoon, where the diagnostic report discussion takes place between radiologists and MOs, the room can be very crowded.

In the examination room area, there is one CT Sensation 16 modality. Till now, this modality is the only multi slice CT version of modality in COV-DPMT hospital. Other existing CT modalities available at the main department and other satellite units are single slice version. The reporting room is the smallest area of CT Unit. The PACS server system is placed in this room. In addition, there is one viewing box to read films available in the room. Occasionally, radiologists and MOs will use the viewing box to review films, but the frequency is quite rare. This is probably because of the small space where it is not conducive to have discussion meeting in the room. The room can barely fit more than four persons.

In the context of CT 16 Unit operation, many aspects of radiology work areas are performed manually. The use of computing applications is limited to CT 16 modality workstation (for radiographers) and the diagnostic workstation (for MOs and radiologists). The PACS server system attached with the modality is primarily utilized for storing and retrieving CT 16 images, and also selected images from different modalities such as MRI. Typically, images that are not from CT 16 modality were copied from the optical disk, and then stored in the server. These tasks are usually

performed by a senior radiographer who is in charge of supervising the day-to-day operation of CT 16 Unit.
Figure 5.1c provides details illustration of the activities in five generic work areas related to CT 16 unit. Generally,

1. ***Radiology examination request:*** A patient radiology examination request is done using a standard patient X-Ray Request Form (see Appendix A). The clinician forwards the request using the form, and later will be reviewed and approved by the responsible radiologist.

2. ***Patient radiology examination:*** A patient physically registers at the counter and waits at the patient waiting area for their turn. In the examination room, usually a department nurse will assist the radiographer on duty in positioning a patient on the CT scanner bed or handling special procedures such as administering contrast injection to the patient. In a complicated case, usually a clinician or a department medical officer (MO) will be there to observe and to administer certain clinical procedures to the patient. Prior to performing the scan examination, the patient or the accompanied nurse/porter will hand in the patient's old films to the responsible staffs. In the case where there is no old films handed to the staff, the radiographer will contact the clinic or the ward to request for the old films.

3. ***Acquisition, preparation and distribution of radiographic images:*** Normally, after settling a patient in the gantry of the CT scanner, a radiographer who handles the modality workstation in the panel room will begin to enter the patient details into the system. Then, the radiographer will confirm with the MO on duty about the type of radiology scan requested by the patient's physician. In the case of a patient requires a specific contrast delivery procedure such as a contrast injection, the radiographer will wait until the contrast flows into the patient body. After setting the required system protocols and selecting an appropriate angle for scan, the radiographer then will initiate the scan. Upon obtaining the patient images, the radiographer will ask the MO to review the images. The radiographer then will perform minor editing such as resizing the images before sending them to the server and to the diagnostic workstation. Few of the selected images will be printed on films according to the specification requested by MOs or radiologists.

4. ***Diagnostic report preparation:*** Normally after the diagnostic workstation has received patient images sent from the modality workstation, the MOs will initiate the discussion about the images. In the panel room, there are two MOs usually present. It is sort of a pattern where the senior MO or the radiologist will sit at the diagnostic workstation, and another MO (usually a junior MO) will do the report typing. Because the computing resources are scarce, the MOs and sometimes the radiologists usually bring their own laptops to do the report writing. The one

with the laptop will usually occupy a small space, next to the diagnostic workstation. The diagnostic discussions between MOs are slightly different if compared to the discussion where the radiologist is present. The discussion between two or more MOs without radiologists is very much like peer discussion. When the radiologist is present to discuss the findings and to finalize the diagnostic report contents, the level of the discussion is more intense. Usually the MOs will present their findings, and then the radiologist will scrutinize and will probe deeper by base on his/her evaluation on the images that are being displayed on the screen. The expert (i.e., the radiologist or the senior MO) will utilize a computer mouse to flip the images or to use the measurement tool to measure certain areas in the images. Sometimes after measuring certain areas in the images, they will type-in small notes and these images will be saved later into the server. If there is additional information needed about the patient while doing diagnostic report, the MO or the radiologist will contact the patient's clinician to ask for details. In complicated cases, a conference that involves a radiologist and a clinician will take place to review the patient's case.

5. ***Delivery of diagnostic report and radiographic images or films:*** Once the films and the report are ready, both will be placed in the film jacket (envelope) that has the patient's name. The film jacket will be sent to the reception counter for collection.

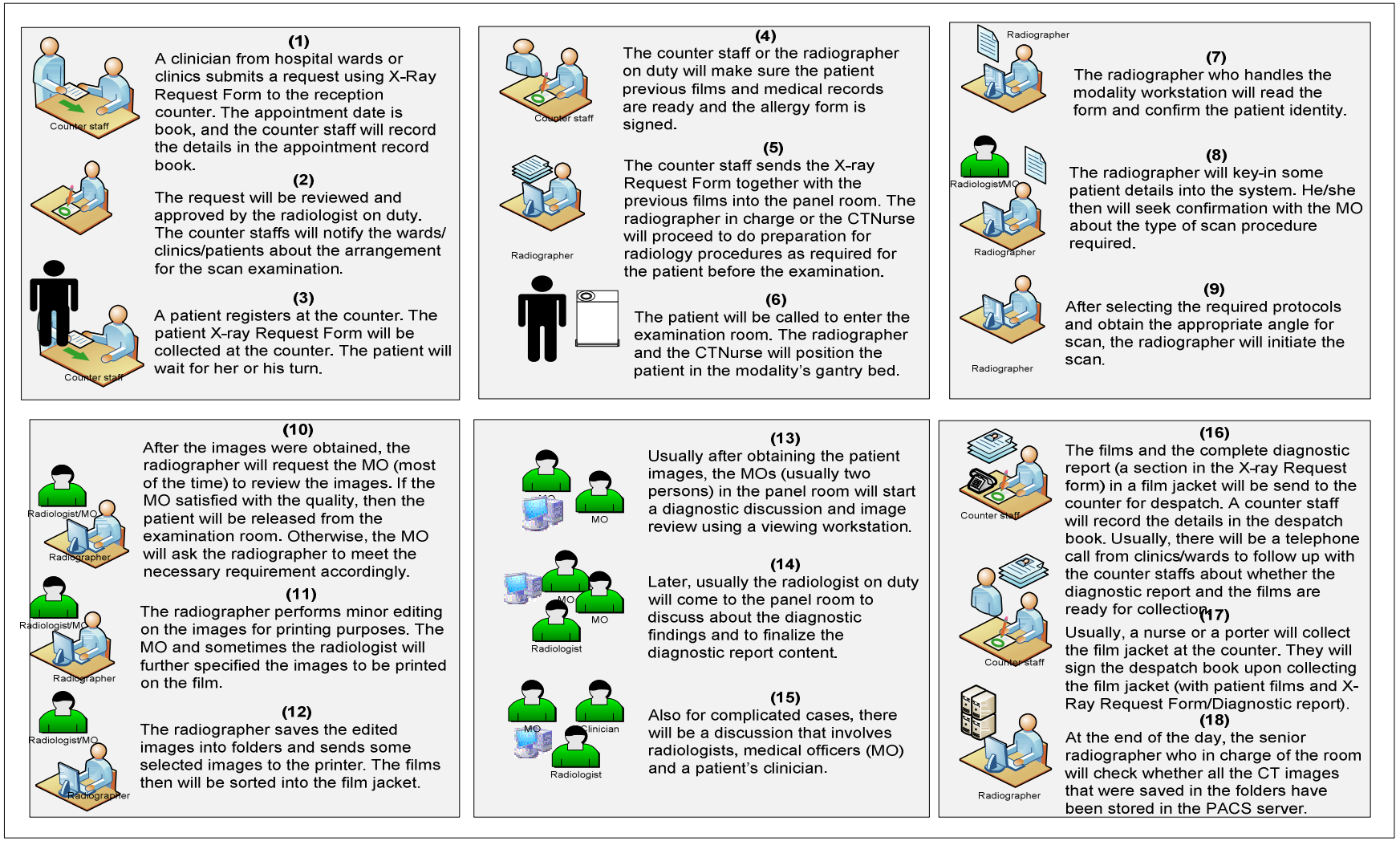


Figure A-8: An Illustration of Work Activities of CT 16 Unit of COV-DPMT

(8) Phase 2: An Illustration of CT Unit's Work Activities - PACS-DPMT

The following figure illustrates the physical layout and the arrangement of work artefacts of the CT Unit.

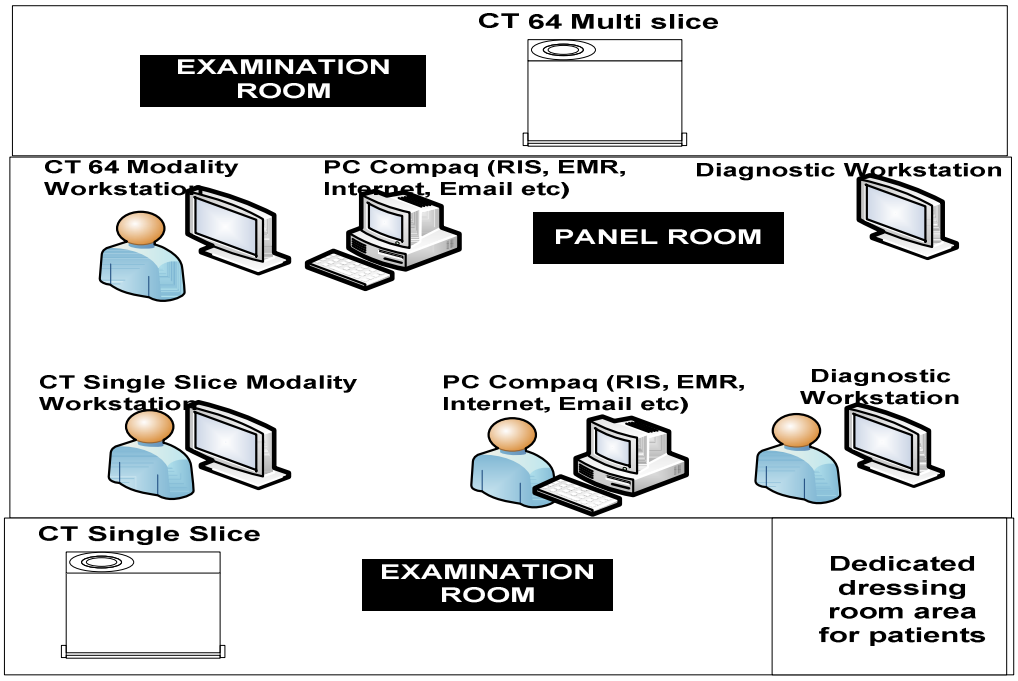


Figure A-9: An Illustration of CT Unit of PACS-DPMT

The CT Unit handles two CT modalities - a Siemens Somatom Plus 4B and a Siemens Sensation 64. Inside the panel room, there are few work artefacts as follows: (1) CT Somatom Plus 4B workstation, (2) CT Sensation 64 workstation, (3) two diagnostic workstations, and (4) two Compaq desktops - one for radiology reporting purposes and another for radiographers' to use. There is also one unit of viewing box in the panel room.

In day-to-day routines, usually two radiographers will be assigned to handle the CT scan examinations in the unit. There is a senior radiographer, who has been appointed to monitor and supervise the day-to-day work activities of the unit. A medical officer (MO) is always present in the room, and she usually occupies the radiologist work area to perform image review and to work on the diagnostic reporting. She also facilitates the patient examination process such as delivering contrast injection and performing image review (i.e., image quality control) after the image acquisition task is done. Radiographers will consult the MO for any issue pertaining to the patient's radiology examination. Typically, a radiologist will also present in the panel room for several hours to prepare for the diagnostic report. The radiologist most of the time will interact with the MO. It is not common for a radiologist to be involved or be consulted by radiographers about issues related to the patient scan examination. However, if the MO is unsure about the quality of the

images obtained from the scan, she will consult the radiologist's opinion. At all time, the radiologist performs clinical image review for diagnostic reporting using the diagnostic workstation. Frequently also, clinicians will come into the panel room to discuss with the radiologist about the image findings.

The following explain details of the related work process in the unit:

1. ***CT examination request –*** The patient examination request is done using RIS application. A clinician will order CT examination for his/her patient using the RIS Order Entry module. Usually before submitting the order, a clinician will despatch a trainee doctor to brief the MO or the radiologist (whoever present in the panel room) about the patient's sickness condition. The MO or the radiologist will then ask further questions about clinical indication to justify if the request for CT examination is appropriate. Depending on the sickness indication explained by the junior doctor, sometimes the MO or the radiologist will give advice for the patient case, for example to use other form of radiology examinations such as MRI (Magnetic Resonance Imaging), Ultrasound etc.

2. ***Patient CT scan examination:*** An out-patient first registers at the hospital main registration counter. After that, then the patient will report to PACS-DPMT counter. He/she has to present a small appointment booklet to the radiographer who is in charge of the department counter. The booklet contains the patient's appointments with the hospital's clinical departments. The radiographer will collect the patient booklets and then will send them to the panel room of the CT Unit. As for the in-patients, usually the radiographer in charge of the CT Scan Unit will make a telephone call to tell the ward to bring down the patient to the CT Unit. Detail about the in-patient is available through the registration system. When the patient is admitted or walks in the examination room, the radiographer will refer to the patient booklet/slip (for in-patient) to obtain the patient MRN (Medical Registration Number). Using the modality workstation such as the CT Sensation 64 system, the radiographer then enters the patient MRN to obtain the patient data in the modality system. He or she will use the RIS application in the Compaq desktop to obtain the work list update. She will drag the patient name into the RIS module called exam management. The module then will display relevant information such as patient demographic data, scan procedure, allergy information and other clinical information provided by the patient's clinician when ordering the radiology examination. The radiographer then will proceed with the necessary procedures to complete the patient's examination process. If the information given by the clinician is not sufficient for the radiographer to determine what sort of abdomen scan type, then the radiographer will consult the radiology MO.

3. ***Acquisition, preparation and distribution of radiographic images:*** After obtaining the images, the radiographer will ask for the MO to review the quality of the clinical images. If the MO satisfies with the quality and there is no additional request for CT exams, then the radiographer will allow the patient to leave the examination room. Subsequently, the radiographer will perform some minor editing such as image resizing before sending the images to the PACS server and to the radiologist's diagnostic workstation.

4. ***Diagnostic report preparation:*** Upon obtaining the patient radiology images in the diagnostic workstation, the radiologist in charge will perform clinical image review. Usually, the radiologist will interpret the image using the diagnostic workstation while the radiology MO will transcribe the discussion using the RIS reporting module available in the personal computer (Compaq PC). In doing diagnostic report, details about patient clinical history will be obtained using the EMR application. Sometimes medical books and internet resources will be utilized as references in the discussion. Also if there is further information required in the process of doing diagnostic report, the radiologist or the MO will make a telephone call to consult the patient's clinician.

5. ***Delivery of diagnostic report and radiographic images or films:*** The patient's clinician obtains the diagnostic report from the RIS application. The clinician also can view the patient images from the clinical viewing workstations placed around wards and clinics.

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