USER'S EXPECTATIONS AND PERCEIVED BENEFITS REALISATION OF PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS)

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university.

Signed: _____

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Summary:

A national project NIMIS is installing integrated digital imaging solutions into around 35 Irish hospitals and will provide a patient data flow between these systems and existing installations. This integrated PACS/RIS has been implemented in the researcher's hospital since August 2011.

The practical deliveries of PACS benefits in the literature are inconclusive. Since the system users are good indicators for the evaluation, the researcher recruited medical professionals at consultant and SPR/registrar level to examine user's expectations and realisation of PACS benefits. The researcher conducted an extensive literature review to identify PACS benefits and formulated a questionnaire. Out of total 287 questionnaires, 115 participants sent back the completed questionnaires with the overall response rate of 40%. All data was entered and analysed using the Microsoft excel and SPSS. The Wilcoxon Signed Rank Test is used to determine the statistical significance of each respective benefit item.

The researcher noted high user's benefit expectations before implementation of PACS. Although all benefit expectations level scores were higher than benefit realised, the benefits which were not achieved and statistically significant include: *'saves staff time', 'increases clinical efficiency', 'less time finding images/reports', 'user-friendly', 'reliable', 'increased confidence in patient diagnosis',* and *'cost efficient'.* The participants especially the clinicians expressed much dissatisfaction with PACS.

Based on the study results, the researcher considers PACS hasn't completely revolutionised the clinical practice and doubts the justification of money spent. However, the researcher believes that PACS has a potential to revolutionise and users will realise those benefits in near future. In order, the researcher recommends the project team to evaluate the system regularly, resolve the issues identified, and provide support and user training for successful benefit realisation. Also, the study recommends assessing the user's benefit expectations before implementing PACS in other Irish hospitals.

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Glossary

AMU...Acute Medical Unit

BDN...Benefit Dependency Network

BRM...Benefit Realisation Management

CNM...Clinical Nurse Manager

CSF...Critical Success Factors

CT...Computed Tomography

DICOM systems..........................Digital Imaging and Communications systems

EHR...Electronic Health Record

ED...Emergency Department

HIS...Health Information System

HL7...Health Level 7

HSE...Health Service Executive

ICT...Information and Communication Technology

IS/IT...Information System/ Information Technology

KPI...Key Performance Indicators

MICU...Medical Intensive Care Unit

MRI...Medical Resonance Imaging

NIMIS..National Integrated Medical Imaging System

NPV...Net Present Value

PACS..Picture Archiving and Communication System

RIS...Radiology Information System

SPR...Specialist registrar

TAT...Turn Around Time

CHAPTER 1

1. INTRODUCTION

1.1. Study Background:

Around the world, health care providers are facing rapidly growing demand for improved patient care and maximised service delivery (van de Wetering et al., 2006). They are looking for ways to meet these demands by re-examining the way clinical practice is carried out. With an intention to provide quality care by controlling costs, the hospitals are implementing new technologies (Helfert, 2009). In health sector, these new Information Communication Technologies (ICT) are playing an important role (Wager et al., 2009). Moving towards digital radiology; Picture Archiving and Communication System (PACS) is one of the most crucial technology changes in the radiology department of a hospital (Parvinen and Tolkki, 2007). It provides a *'centralised repository for all imaging data'* (Faggioni et al., 2011, p. 254).

Many studies have revealed the benefits of PACS and are preferred by majority of users worldwide (Macdonald (2011), Nitrosi et al. (2007), Hood and Scott (2006), Pilling (2003), Twair et al. (2000)). Conversely, many investigators reported that despite PACS requiring a massive capital investment and net running cost, many benefits are not achieved (Bryan et al. (1999a), Lettieri and Masella (2009)). So, Turchetti and Geisler (2009) suggests that health care technology like PACS as both cost factor and as an efficient health care contributor requires systematic assessment to document its contributions.

The researcher works in a 750 bedded large university hospital in Dublin. In the researcher's hospital, as part of National Integrated Medical Imaging System (NIMIS), PACS went live in August 2011. As discussed with PACS manager in the

hospital, a total number of diagnostic tests (such as x-ray, CT and other) performed are between 160, 000 - 180, 000 per annum.

In this sluggish economic climate, the resources available are very limited to maintain present technologies and/or to implement modern technologies (Top, 2012). In addition, governments are challenged to find more efficient and effective methods of delivering services (Helfert, 2009). Therefore, the health sector is under immense pressure to find a way to measure the investments contributions to business performance (Jajroudi and Azizian, 2010). This is forcing health care services providers and regulators to be responsible and also accountable for the technologies to be implemented (Lettieri and Masella, 2009). Consequently, the heath care providers are looking for more reliable ways to achieve the benefits from their investments.

Therefore, given the current ubiquitous nature of PACS, the present study examines PACS expectations and the benefits realised by its users in the hospital. This evaluation of PACS will provide evidence to ensure adequate information about the future planning and a fuller appreciation of potential outcomes and impact.

1.2.   Research questions:

In the present study, the researcher aims to answer the following questions:

1. What was the level of user's benefit expectations before the implementation of PACS in the hospital?
2. Do the levels of radiologist's and clinician's PACS benefit expectations differ?
3. What is the level of user's perceived benefits while using PACS?
4. Do the levels of radiologist's and clinician's realisation of PACS benefits differ?

5. Is there a difference between the radiologist's PACS benefit expectations and subsequent benefit realisation after its usage?

6. Is there a difference between the clinician's PACS benefit expectations and subsequent benefit realisation after its usage?

7. Is there a difference between PACS user's benefit expectations before its implementation and subsequent benefit realisation level after PACS usage?

   Null hypothesis: There is no significant difference in the benefit expectations and subsequent benefit realisation of PACS.

1.3. Study Rationale:

The Irish government have invested millions of Euros in NIMIS project to introduce the digital imaging system for better radiological services (Garvan, 2011). For health care projects to run efficiently and effectively the benefit realisation is important. The user expectations and perceptions of the impact of a technology on work and outcomes are suggested as possible means of assessing the achievement of benefits of a project (Szajna and Scamell, 1993, Wakefield et al., 2007). The benefit realisation process evaluates if the planned benefits have been realised and continued after the project finished (Farbey et al., 1999). The practical ability of PACS to deliver a real service to health care and the ability to support the users in their work and goals are influential in analysis of its success. With this in mind, the researcher aims to find out the user's benefit expectations and realisation of PACS.

The majority of the hospitals in many developed countries like USA, Canada, UK, Australia, and other have implemented PACS. Despite the widespread use and advanced technology, many researchers question whether PACS revolutionised the clinical practice or is it simply an automated process in health sector? (Westbrook and Braithwaite, 2010). Though there are studies about PACS, the results still remain inconclusive about complete benefit realisation and research into actual

benefits gained are urgently needed. So, the researcher believes it's an ideal time to evaluate the system before its complete implementation in Ireland and provide feedback to make essential changes to realise the maximum benefits.

1.4. Dissertation outline:

The study evaluates user's benefits expectations and benefit realised of PACS. The dissertation is divided in to five chapters.

Chapter 1 introduces the research topic by providing a brief background and rationale for choosing the topic. This chapter also contains the research questions to be answered in this study.

Chapter 2 is a literature review. In this chapter, the researcher aims to analyse the literature in relation to digital imaging system and benefit realisation of information system or information technology.

Chapter 3 is a research methodology. In this chapter, the researcher provides information about the methodology design and the data collection methods. The rationale for chosen research methods is also discussed.

Chapter 4 is the analysis of the results. In this chapter, the researcher discusses the results of data collection. The researcher also explains the descriptive statistics and conducts hypothesis testing.

Chapter 5 contains summary and recommendations. This chapter summarises research findings and provides answers to the research questions.

CHAPTER 2

2. LITERATURE REVIEW

2.1. Introduction:

In this chapter, the researcher analyses the literature about PACS. The literature includes its user's expectations and perceived benefits, and cost of PACS. The researcher also analyses literature about the importance of benefit realisation, benefit realisation management process and discusses the benefits realisation framework.

The foundation and inspiration for useful research is a well sophisticated literature review (Boote and Beile, 2005). According to Garrard (2010, p. 5) the literature review is defined as "*an analysis of scientific materials about a specific topic that requires the reviewer to carefully read each of the studies to evaluate the study purpose, determine the appropriateness and quality of the scientific methods, examine the analysis of questions and answers posed by the authors, summarize the findings across the studies, and write an objective synthesis of the findings*". A good understanding of the literature in the field helps the researcher to perform a significant research. Authors Boote and Beile (2005) suggests that the researcher needs to understand what has already been done and the strengths and weaknesses of existing studies to advance the collective understanding for good research.

The researcher analysed the literature by accessing online databases mainly through *Google Scholar, Science Direct, Ebscohost* and *Pubmed*. The main key words used in search of literature are *'PACS', 'PACS expecations and perceived benefits', 'benefit realisation', 'cost analysis', 'benefit realisation management'*. In addition, the researcher searched the articles using the reviewed articles references list. The literature review

period limited from 1990- 2013 and the language is limited to only English by the researcher.

2.2. National Integrated Medical Imaging System (NIMIS) Project in Ireland:

In August 2007, the Health Service Executive (HSE) initiated the NIMIS project with the primary objective to implement PACS/RIS solutions into all publicly funded acute hospitals and primary care facilities where radiological imaging is performed in Ireland (O'Hare, 2008).

The use of X-ray film represents one of the largest risk factors and bottlenecks to service delivery within the medical imaging arena in the health services (McGuinness, 2009). According to Dr. Niall Sheahy (consultant radiologist in St. James Hospital and Lead Radiologist for the NIMIS project), the inability of the conventional radiology systems to cope with the modern complex diagnostic imaging lead to NIMIS implementation (Health Matters, 2010).

As per HSE, NIMIS will make Irish hospitals filmless and provide a seamless data flow of patient images between hospitals (Health Service Executive, 2012). The HSE is investing over 40 million Euros in providing the state of the art for 35 Irish hospitals in 3 years from 2010 (See appendix 1). So far, 25 hospitals have fully implemented the digital imaging system (See figure 2- 1).

The goals of the NIMIS project are:
• "Become paperless within Radiology;

• Become filmless within Radiology;

• Implement Speech Recognition technology for rapid reporting of procedures;

• Support the HSE Transformation Process, specifically the reconfiguration of the Hospital and Community Care services, and to provide a system for the integration of image data between these services" (O'Hare, 2008, p. 38).

Figure 2- 1 NIMIS project

There are number of similar projects initiated internationally with similar objectives; Canadian 'InfoWay' project, National Programme for IT (UK), Northern Ireland PACS, NHS Scottish PACS project, Finnish HUSPACS and others (O'Hare, 2008).

2.3. Picture Archiving and Communication System (PACS)

In the past, hard copies were used to capture, store and retrieve to view the radiology images. Though these conventional methods of imaging systems are still widely used around the world, it is dwindling quickly because of digital imaging systems (Bansal, 2006).

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The concept of PACS was developed in Europe during the later part of the 1970's and the first implementation took place in the United States in the early 1980's (Lemke, 2011). In Ireland, the Adelaide & Meath hospital, incorporating the National Children's hospital (AMNCH) was the first to install and operate a complete PACS in their radiology department (Twair et al., 2000). Other successful installations have taken place in St. Vincent's Hospital, University Hospital Galway, Limerick Regional Hospital, and St. James's Hospital (O'Hare, 2008).

According to Hood and Scott (2006, p. 69), PACS are *"comprehensive networks of digital devices designed for acquisition, transmission, storage, display, and management of diagnostic imaging studies"*. PACS interacts with the Radiology Information System (RIS) and Hospital Information System (HIS) in the hospital to support an end to end workflow (See figure 2- 2) (Hecht, 2008). The RIS are designed to store, manipulate and to communicate information associated with the provision and utilisation of radiology services and facilities (Ayal and Seidmann, 2009).
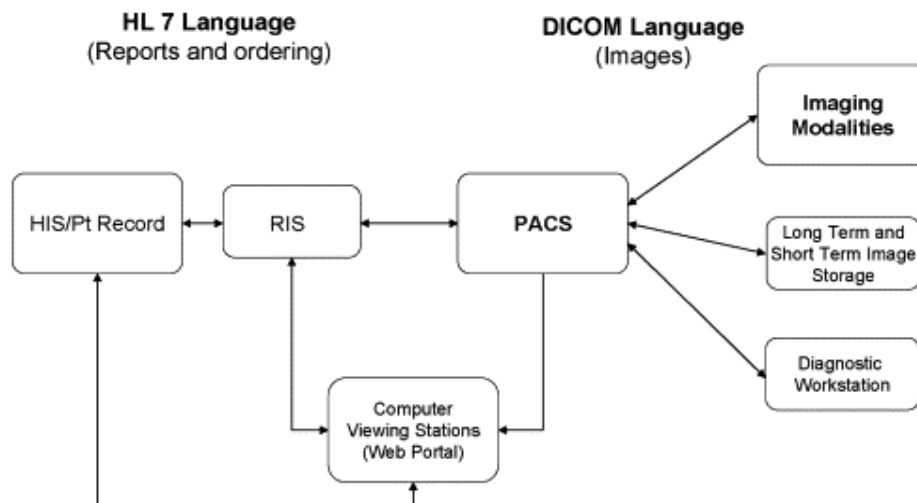
Figure 2- 2 PACS Workflow

(Retrieved from Hood and Scott (2006, p. 71))

Medical imaging instruments like plain x-rays, Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scans, ultrasounds and other are electronically managed by PACS. It consists of image acquisition components, a controller, a database server, an archiving system and an underlying network to connect to them (Hecht, 2008).

PACS has evolved to an advanced platform. According to Faggioni et al. (2011, p. 254), now PACS has integrated both vertically i.e. *'integration at the hospital level across specialties'* and horizontally i.e. *'integration at the territorial level across healthcare services, including affiliated standalone clinics, referring physician offices, and other structures of the National Health System'* (See figure 2- 3). This advent of PACS constitutes a major change of work patterns for radiologists and other hospital physicians.
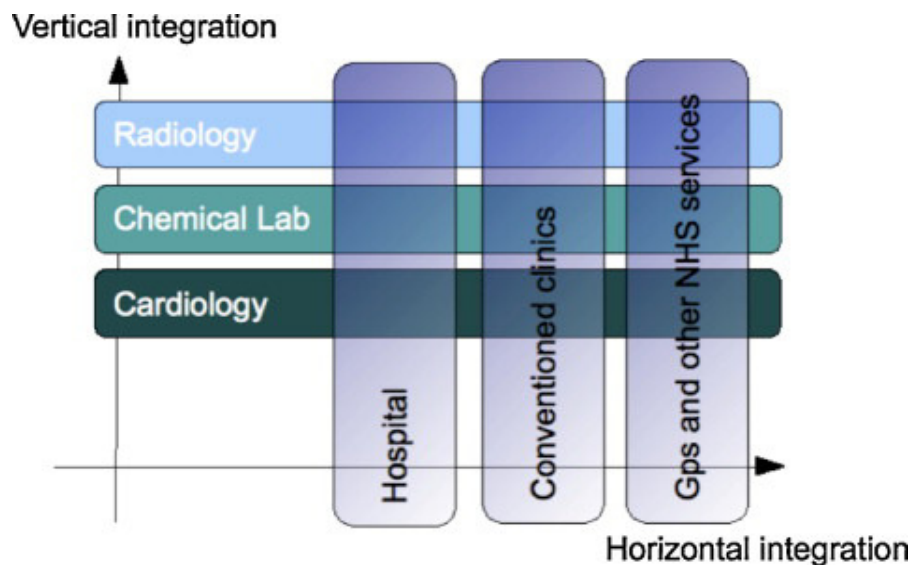
Figure 2- 3 PACS integration with healthcare systems

Retrieved from Faggioni et al. (2011, p. 254)

2.4. Potential PACS benefits and disadvantages:

Many studies have revealed the potential benefits of PACS and it has been preferred by many users worldwide (Macdonald (2011), Nitrosi et al. (2007), Hood and Scott (2006), Pilling (2003), Twair et al. (2000)). The main goal of PACS is to deliver effective and efficient healthcare (Hood and Scott, 2006). It facilitates all health care professionals in the hospital to retrieve and view a radiology image at computer workstations (Twair et al., 2000). This timely and reliable ability to communicate the radiological images and reports to multidisciplinary system is a major benefit of PACS (Ratib et al., 2000).

The IS/IT benefits are often described as either tangible or intangible benefits (Ward and Daniel, 2006). The tangible benefits are measurable by using an objective, quantitative and often financial measure. Some of the potential tangible benefits of PACS are as follows:

- o Availability of images simultaneously in different places,
- o No loss of image or report and improved patient safety
- o Fast reporting time and improved clinical process/workflow (See figure 2- 6) in comparison to conventional method (See figure 2- 5 and See appendix 2)
- o Image manipulation and comparison with old images
- o Improved medical and radiographers work efficiency
- o Decreased length of stay of patients
- o Improved image accuracy
- o Economical benefits
- o Film free radiology department
- o Attaching scans to patients electronic health records
- o Facilitating long distance consultations.

The intangible or qualitative benefits are hard to recognise and measure in terms of money. Some of the intangible benefits of PACS include: increased satisfaction of radiology staff and referring physicians with the radiological services, and increased satisfaction of patients with radiological services (Ayal and Seidmann, 2009).
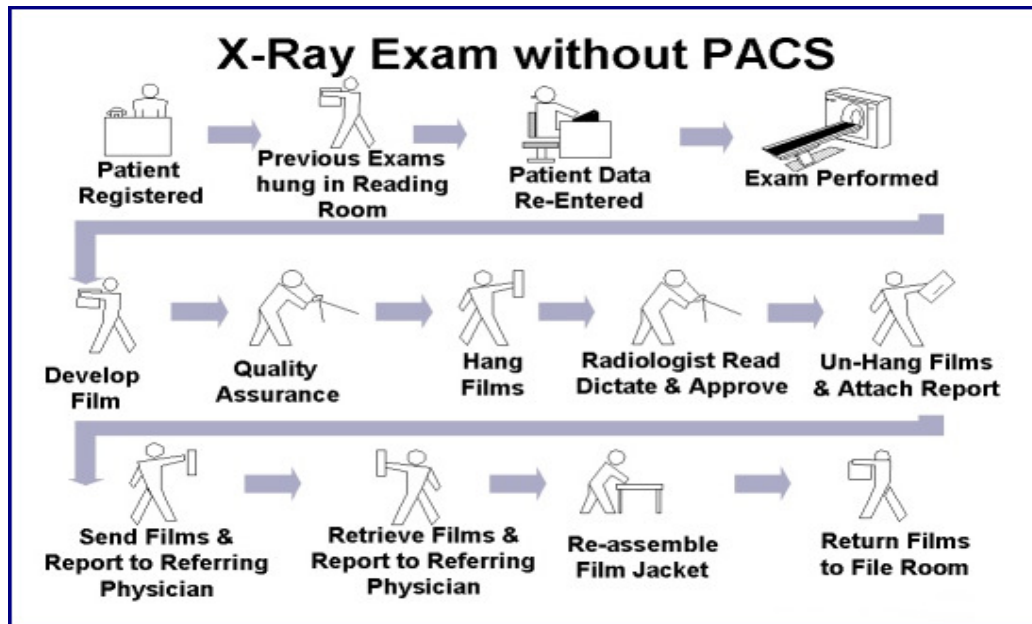
Figure 2- 4 Workflow of an X-Ray exam in conventional method

(Retrieved from McGuinness (2009, p. 5))
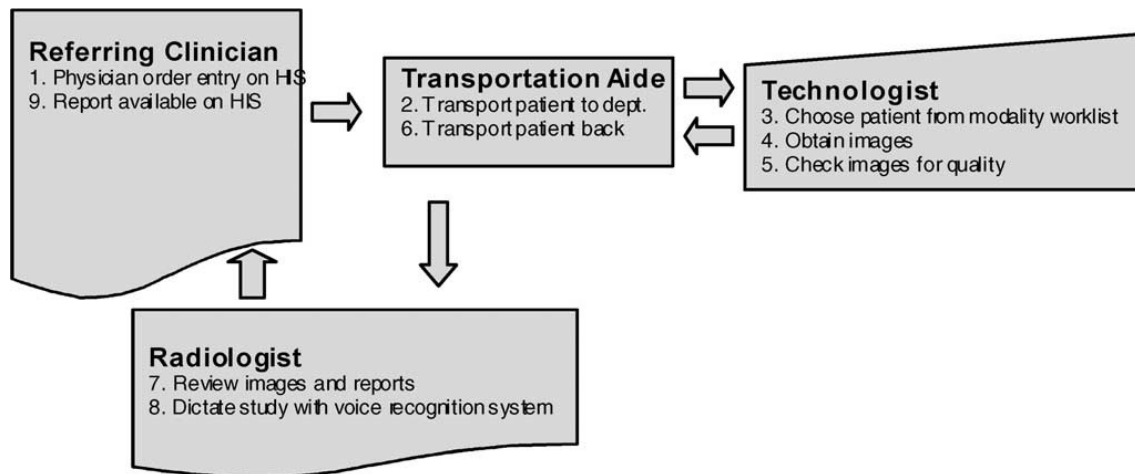
Figure 2- 5 Radiology workflow post PACS implementation

(Retrieved from Siegel and Reiner (2003, p. 104))

Many authors have identified several disadvantages associated with PACS implementation. Authors Jajroudi and Azizian (2010), Reddy et al. (2006) criticises PACS that the requirement of heavy financial support for PACS installation, supply, processing, storage, salary, and maintenance are worrying reasons. Further, the physicians use of this new technology requires continuous training and as they are used to old conventional imaging system without training it can make the system unfriendly (Reddy et al., 2006). Furthermore, MacDonald and Neville (2010) raise concerns such as quality and capacity of image storage, the systems sustainability in long term and the systems disaster recovery capabilities where organisations requires all time dedicated support team.

Fang et al. (2006) identified some risk factors associated with the implementation of PACS, such as user's acceptance of the system, integration of the information systems of the hospital and PACS. In addition, according to Shuen (2010) some clinicians have pointed out the potential disadvantages of PACS such as system crashes, cost of implementation, screen quality, lack of user consultation prior to the implementation.

Reddy et al. (2006) claims that hidden, surprise costs or unanticipated costs such as costs of temporary workers, information system support, other supplies, training and conferences, printing and forms, CD-ROMS etc delay achieving more savings. Also, there are other concerns that the implementation of the system may not yield return profit for the expenses spent and to achieve the profit continuous organisations commitment is essential to manage PACS.

2.5. PACS Cost analysis:

The health care systems accept the new technologies like PACS to improve the service quality and to minimise the expenses (Jajroudi and Azizian, 2010). But, Hood and Scott (2006) argues that PACS are expensive to install like any other

electronic hospital information systems and the initial cost of PACS are difficult to justify by the health care facilities. This is a view supported by Faggioni et al. (2011) who suggests that the system cost has always been a traditional PACS implementation barrier.

Many authors reports that the initial cost of PACS systems were multimillion dollars and the high cost is mainly due to the system cost and size of the individual imaging systems requiring larger storage sets (Reddy et al. (2006), Faggioni et al. (2011)). Further, as per Siegel and Reiner (2003) system depreciation and service contract with the vendors are major contributors of the system cost. Conversely, Chen et al. (2011) argues that in recent years due to multiple vendors competitiveness, PACS has evolved into a cheaper and more advance system making all its benefits accessible to customers.

The financial impact of PACS is categorised as cost saving or increased profit (MacDonald and Neville, 2010). The film and film related cost savings with the implementation of PACS are from the eliminations of film library, processors used for the film, human resources and darkroom, and film costs for the specialities (Ayal and Seidmann (2009), Mansoori et al. (2012)). Studies by Ayal and Seidmann (2009) and Siegel and Reiner (2003) showed 80% and 95% of reduction in the film usage after implementation of PACS respectively. According to Colin et al. (1998), there was an additional annual cost in digital imaging despite the amount spent on film reduced. In contrast, the study by Bauman and Gell (2000) reports that about 65% of organisations declared their systems were cost effective.

According to a Ayal and Seidman (2009) study, the cost analysis performance of PACS kept increasing at the rate of 63% for the first year. The study by Fang et al. (2006) reports that if PACS implemented in the hospital is properly designed then it yields cost savings in comparison to film based system, but the positive net present value yielded only after four years of implementing PACS. Conversely, Gell (2006)

claims that these points of cost effectiveness of PACS are not proven convincingly in a general way.

McGuinness (2009) reports that PACS is ultimately more cost effective over time when a significant increase in workload and volume of examinations occur, without a corresponding increase in the number of radiologists and technologists. However, Colin et al. (1998) suggests to increase the number of department examinations by 15 times to counterbalance the additional cost. In addition, the study by MacDonald and Neville (2010) in Canadian Western Health Authority found that the cost per radiological system in digital imaging system is $11.8 in comparison to $9.5 in conventional film system. He concludes in the study that the implementation and maintenance of PACS was very expensive and it is difficult to justify the system.

The study by Reddy et al. (2006) in a major academic medical centre in US, reports that every year from 1999-2003, the organisation saved an average of $214,460 with a total savings of $1,072,300. However, the savings were significantly less than the $2,943,750 projected savings. However, MacDonald and Neville (2010) have pointed out inconsistencies in the cost evaluation such as; over expenditure, insufficient cost savings, unanticipated costs, and project management issues.

2.6. Barriers to the implementation of IS/It project:

To the successful implementation of any IS/IT project in health care system, some barriers need to be overcome (Duyck et al., 2010). These barriers arise from the time the project initiation phase commences until the project is established. Paré and Trudel (2007) identified four distinctive barriers for the successful implementation of a project. The following are the barriers with some examples (Duyck et al., 2010):

i. Project/economic barrier: Funding issues, timeframe adherence, involvement of the end-user, choice of vendor.

ii. Technical barriers: Operating system compliance, server and storage space, network capability

iii. Organizational: Training issues, end-user equipment availability.

iv. Behavioural/human: Acceptance and use of the IS by the end-user.

2.7.   IT Value:

Goh and Kauffman (2006, p. 1) defines the IT value as "*the impact of IT on organizational performance*". And, he defines potential value as "*the maximum feasible payoff of an IT investment under efficient production conditions*".

The potential value is a justification for the delivery of large investments. Therefore, it should be measurable (Smith et al., 2008). The IT value is measured using the quantitative metrics such as financial metrics, system performance metrics, end user metrics (Lee, 2004). However, these quantitative metrics do not measure the intangible benefits of IT (Sircar et al., 2000). Value conversion effects, such as managerial intervention and environmental influences, play a key role in shaping the outcome of any IT investment, leading to realized value of the IT investment.

Goh and Kauffman (2006) conducted a study in the US which examined the IT investments in industries. They adopted the Malmquist productivity index to model the potential and realized value of IT and apply data envelopment analysis (DEA) techniques to solve the model. The main findings noted from the study showed less than half of the industries realized more than 70% of their potential value.

Reiss (2006, p. 12) describes the value path (See figure 2- 6) and it shows how "projects create deliverables that, when combined into a programme, deliver the capability to change. Only when this capability is used by the organization, a benefit actually realized".
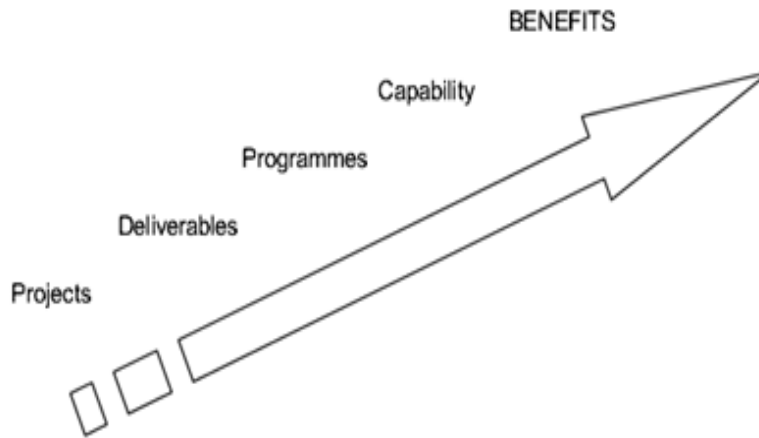
Figure 2- 6 The IT value path

(Retrieved from Reiss (2006, p. 12))

According to Delone and McLean (2002), the measurement of success or effectiveness of the information system is critical for the understanding of the value and efficacy of management actions and investments of information system. The model has six dimensions; information quality, system quality, service quality, usage, user satisfaction and net benefits (See figure 2- 7).
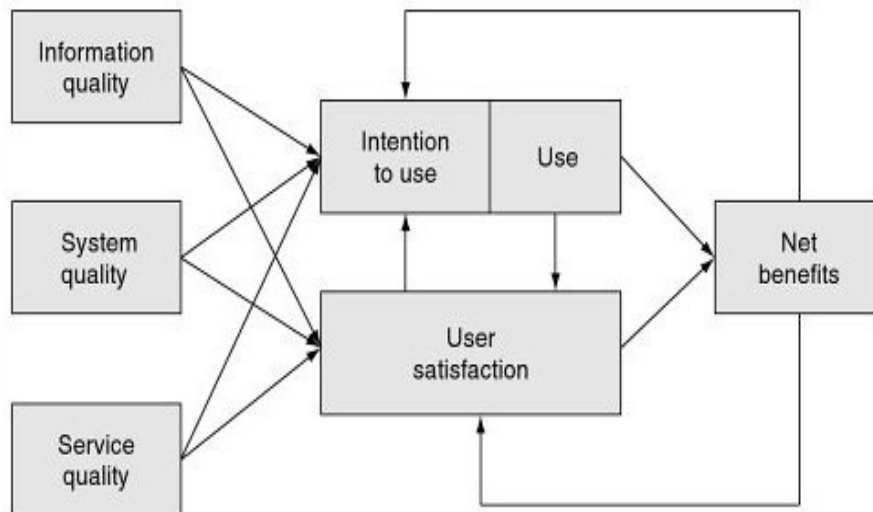
Figure 2- 7 Delone and McLean success model

Retrieved from Delone and McLean (2002, p. 24)

Smith et al. (2008) believes that for the success of any project Critical Success Factors (CSFs) are essential. Peppard et al. (2007) identified three CSFs; on time delivery, within budget and in accordance with user requirements to the success of an IT project. These CSFs are used based on the relevance of the project stages to measure the success and may not use all at once (Smith et al., 2008).

2.8. User's expectations and perceived benefits:

The investments of health care organisations in IT are continued with varying level of user acceptance (Wakefield et al., 2007). Ward et al. (2008, p. 93) point out "*as ever greater financial and other resources are allocated to IT systems in health care, the factors which influence staff attitudes towards them become increasingly significant if the investment is to be worthwhile*". Supporting, Aldosari (2012) states that user's acceptance of PACS implementation is very important to realise maximum amount of benefits from the system.

There are different models developed to explain the user acceptance of IT system: '*Technology Acceptance Model (TAM)*', the '*Diffusion of Innovation model*', '*Unified Theory of Acceptance and Use of Technology (UTAUT)*', the '*Social Cognitive Theory model*' and others (Aldosari, 2012). Many studies advise to measure the factors that influence the acceptance of PACS and recommend organisations to provide continuous training and support for positive outcome (Duyck et al. (2008), Aldosari (2012)).

In the hospital, the main users of PACS are radiologists. The other users include technologists, physicians /clinicians and nurses. Pynoo et al. (2011) believes that, the radiologists attitudes and expectations towards PACS play an important role in its adoption and efficiency of its use in the organisations. Szajna and Scamell (1993, p. 494) defines user expectation as "*a set of beliefs held by the targeted users of an*

information system associated with the eventual performance of the IS and with their performance using the system".

Many authors have reported the importance of user's expectations. As per Szajna and Scamell (1993), the eventual success of an IS/IT project can be predicted based on the user's expectations. Otherwise, it may be the cause for the failure of the project. In addition, the study by Wakefield et al. (2007) suggests that the user's expectations and experiences offers a valid and reliable tool for assessing the perceived impact of new IT/IS.

There were many benefit expectations as per the business case report prior to implementation of PACS in hospitals under NIMIS project (O'Hare, 2008, p. 5). The following were some of the major benefit expectations:

- Filmless hospital and paperless for all Radiology requests and reports
- Reduction in report "Turn-Around" time
- Improved clinical consultation
- Rapid record retrieval
- Streamlining Radiology work-processes
- Integration with other departments
- Remote/ Outsourced reporting
- Improved access and availability of patient information
- Increased clinical efficiency and accuracy in patient care
- Fewer repeat examinations and reduction in collective radiation dose
- Major reduction in unreported and lost images
- Reduced risk and consequently Medico-Legal exposure / costs
- Images follow patient through Care Pathway
- Patient Data Security
- Reduction in the need for Transcriptionists

The expectations of new technological solutions in health care organisations are very high but the fulfilments of these expectations are not predictable (Parvinen and Tolkki, 2007). For instance, there are high user expectations of PACS due to the perception that without digital systems organisations are not advanced or it is at a competitive disadvantage. This has broadened the expectations gap of the system. The expectations gap is the differences between the user's expectations of the system and their actual performance (Aggarwal and Rezaee, 1996). The perceived gap between PACS expectations and its benefits acts as a main barrier in the adoption of PACS (Geisler and Turchetti, 2011).

Festinger (1957) proposed cognitive dissonance theory as cited by Szajna and Scamell (1993, p. 494). It states that *"when an individual maintains two cognitive structures (ideas) that are inconsistent with one another, a psychological state of dissonance will occur. The individual will attempt to attain a state of consonance by changing one of the two cognitive structures"*. Figure 2- 8 shows a graphical representation of cognitive dissonance theory.
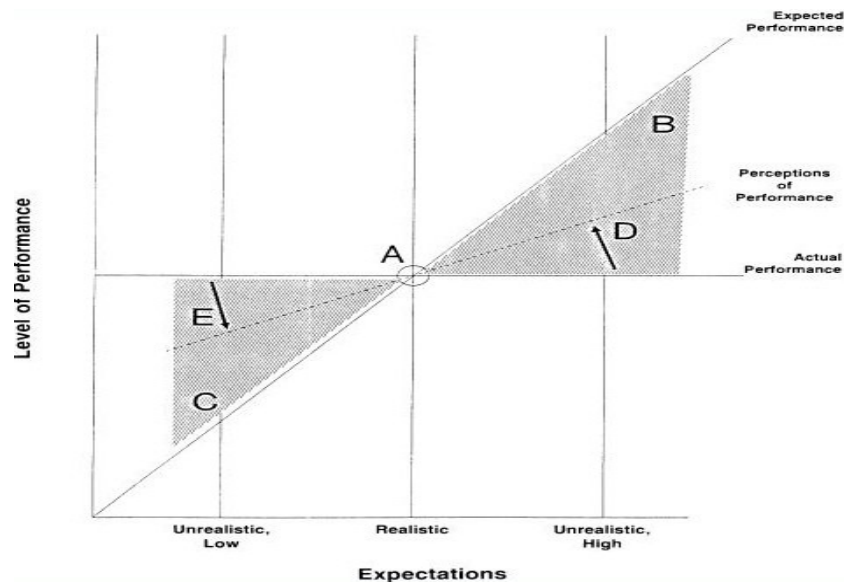
Figure 2- 8 Cognitive Dissonance Theory by Festinger (1957)

(Retrieved from Szajna and Scamell (1993, p. 496))

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In the above figure of cognitive dissonance theory, the point A represents '*a confirmation*' of expectations. It is an intersection of actual performance and realistic expectations. Festinger (1957) explains that, when there is a difference between the expected and actual performance a '*Disconfirmation'* occurs (See B and C in the graph).

The shaded B in the figure represents the '*Negative disconfirmation'*, where actual performance is less than expected performance. In contrary, shaded C explains the '*positive disconfirmation'* which occurs when actual performance exceeds expected performance.

According to Festinger (1957) as cited by Szajna and Scamell (1993, p. 495), Cognitive dissonance theory predicts that "when an individual experiences negative disconfirmation of expectations, perceptions will be assimilated toward expectations, exceeding the perceptions of those with realistic expectations (See arrow D in figure 2- 8)".

The theory also predicts that "those who have experienced positive disconfirmation of their expectations will have perceptions that will be assimilated toward their expectations and will be less than those with realistic expectations" (See arrow E in figure 2- 8).

According to Siegel and Reiner (2003), many authors expected PACS to make efficient radiology departments, economical, and improve the communication between radiologist and referring physician. The study by Bauman and Gell (2000) reports that, in 81% of cases PACS users reported that their expectations had been met. In contrast, the study by the Geisler and Turchetti (2011) found that user's perception of PACS benefits are not adequate with the cost or clinical staff's expectations. Some of the other issues encountered by the users were;

- Staffs felt the adoption can disrupt hospital routine,
- Concern in relation to PACS ease of use,

- Previous negative experiences with the adoption and implementation of IS/IT systems,

- Radiologists reluctance towards learning new systems,

- Organisational infrastructure issues such as storage, connectivity, privacy and confidentiality,

- Issues of standards of different vendors and the lack of trust in the vendors.

Finally, Geisler and Turchetti (2011) recommends that in order to overcome the user's resistance of PACS adoption, organisations need to align user's PACS expectations. Also, it has to be adopted with the criteria they apply in their evaluation of the performance of those who will use PACS.

2.9. Importance of Benefits realisation:

Organisations realisation of both tangible and intangible benefits is the primary purpose of developing and commissioning an information system (Remenyi and Sherwood-Smith, 1998). In addition, Parvinen et al. (2005) recommends that utilisation of PACS must be carefully researched and planned to gain all advantages the system offers. This will have a huge impact on the service evaluation in the health organisation.

Benefit realisation is important in health organisations as the health sector continues to change in its structure, roles and governance. Also, it is an important part of the programme management process (Reiss, 2006). There are a number of reasons why organisations need benefits management. Some authors have recommended commencing the benefits management at the beginning of the project by anticipating project benefits or by reviewing benefits after the project.

According to Lederer and Mirani (1995), most projects anticipate the costs of the IS/IT rather their anticipated benefits. They suggest that, it is important to understand the anticipated benefits for following reasons:

- The understanding of the IS anticipated benefits provide an opportunity for the researchers to characterise IS projects thematically.
- It creates expectations from top management for the project outcomes.
- It provides an opportunity for top management to evaluate the project for the benefits delivered.
- It may help to predict the benefits to be achieved more realistically and thus realise them more often.
- The understanding of benefits may support the management in proposing new projects and recommending their priorities.

Research by Ward and Daniel (2012) shows that, about 90% of organisations reviewed their costs of their projects and only 49% of them reviewed about the benefits realised. They claim that undertaking the benefit reviews directly associated with successful organisations IS/IT projects. They also pointed out a number of reasons for that:

i. The benefit reviews allows organisations to identify unrealised benefits and initiates further actions to realise benefits.
ii. The organisations can impart the knowledge from one project to another through reviews.
iii. Staffs awareness about the benefits review will encourage them to be more realistic and robust in identification of realistic benefits at the start of the project.

According to Goh and Kauffman (2006), due to many hurdles the potential benefits of IT investment do not always translate to the actual benefits. Davern and

Kauffman (2000) argue that, the potential and realised values of IT investments often have a gap and that needs to be defined and measured.

2.10. Benefits realisation:

2.10.1.   Introduction:

In recent years there is a considerable increase in the number of IS/IT projects used around the world. These projects have shown significant increase in complexity, connectivity, scale and strategic focus (Ashurst and Doherty, 2003). Organisations continue to make large investments in these projects for performance improvement, introducing enabling technology, process redesigning and change management. According to Gartner group (2010) report as in Caldeira et al. (2012), a total of 3215.7 billion US$ invested in ICT worldwide in the year 2010. However, Braun et al. (2010) claims that the benefit realisation from these heavily invested projects remains one of the major organisational challenges.

The new technologies are adopted by the health care organisations with a view to minimising the costs and improving the patient quality of service (Helfert, 2009). But, there is a high percentage of failure in ICT projects due to issues in completion time; financial issues; or fulfilment of all business requirements (Caldeira et al., 2012). The final outcome of a newly implemented IS in the healthcare system is unpredictable (Duyck et al., 2010). In many instances, a successful implementation of an IS project in one hospital may easily fail in another hospital. Therefore, Sapountzis et al. (2007) suggests that, at the start of the program the investors and policy makers should have fully defined, understood and agreed expected benefits for the successful realisation of benefits from the investment.

It is important to identify and define the benefits at the early stages of any project or else it can lead to failure of a programme or project (Yates et al., 2009). Research

since 2006 by Ward and Daniel (2012) identified only 30% of total IS/IT projects are completely successful and majority of those projects used the benefit management processes. Hence, it is creating a lot of interest about benefit realisation among the organisations and these organisations are focussing on the ways to measure and realise the benefits from the projects or programmes.

2.10.2.   Benefit Realisation Definitions:

The benefit realisation has been defined in many ways in the literature. The benefit realisation term includes two words, benefit and realisation. According to Yates et al. (2009, p. 224), benefit is defined as "*an outcome whose nature and value are considered advantageous by an organisation*". The realisation is described in Oxford dictionary as a desired or anticipated achievement of something.

Ward and Daniel (2012, p. 8) defines benefits management as "*the process of organizing and managing such that the potential benefits arising from the use of IS/IT are actually realized*".

According to Farbey et al. (1999, p. 239) the benefits realisation is "*the process whereby organisations attempt to predict, plan for, achieve and appropriate benefits which flow from new technology and systems*".

There are many classifications of benefits (See appendix 3). According to Caldeira et al. (2012), benefits are classified as: observable, measurable, quantifiable or financial. Sapountzis et al. (2009) classifies benefits as: Tangible (hard/Direct), Intangible (soft/indirect), by organisational or business impact, by stakeholder or actor-oriented, Unplanned/Emergent.

The benefit management approach is an inherent interdependency of benefit realisation and change management (Ward and Daniel, 2012). So, the researcher

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interchangeably uses benefits realisation and benefits management as meaning of both are similar.

2.10.3.　　Reasons for failure to realise the benefits:

In recent years, organisations have noted about 30% - 70% of high level of system failures (Ward and Daniel, 2012). Dhillon (2005) claims that, a huge amount of money is lost due to the organisations inability to realise the benefits of the IS/IT investments. Furthermore, the failure of IT to deliver *"value for money"* made the organisations IT less reputable (Peppard et al., 2007). A survey of 625 chief financial officers by CSC (2008) as in Schubert and Williams (2009, p. 355) reports that *"achieving the expected benefits from IT investments"* ranked as the second most critical issue overall for organisations of all sizes and was the most critical issue for large organisations (greater than $1 billion in revenue).

When the IS/IT are implemented in an organisation, it impacts upon the business design, economic performance and the working conditions of members of staff (Ashurst and Doherty, 2003). These impacts are classified as planned outcomes, and either positive or negative incidental side effects (Doherty and King, 2003). There are a number of reasons why organisations have failed to realise the benefits from their investments. According to Peppard et al. (2007), the methods and tools that emphasize improving the supply side of IT delivery including the use of out sourcing are the primary reasons.

In many cases, the IS projects complete with the functioning of the technology being the paramount objective (Remenyi and Sherwood-Smith, 1998) than the realisation of expected benefits (Peppard et al., 2007). This notion has existed for many years. In addition, according to Eason (1988, p. 44) as cited by Ashurst and Doherty (2003, p. 1) *"traditional approaches to the development of information systems have concentrated on*

the delivery of the technology, rather than emphasising the human and organisational changes that are required in order to ensure that the system delivers meaningful benefits". In these strategies, system failures can be increased due to unforeseen and unresolved negative impacts, and may not fully realise the potential beneficial impacts. Thorp (2002) summarises that, IT function is not accountable for the delivery of benefits but it is accountable for the delivery of technology capability.

The pre investment assessment of the IS/IT projects and review after implementation are insufficient in many cases (Lin and Pervan, 2003). Therefore, overall evaluation of the benefits of projects implementations is difficult. Also, in many cases the methods used to justify projects overstated the benefits to get expenditure approval (Ward et al., 1996). Once the project is approved less attention is given to benefits and most of the effort is expended on technical implementation.

Furthermore, Ward and Daniel (2012) states that, the organisations often believe that the product features from the vendors equate to the list of benefits. The installation of such products may not be needed or are too complex for the organisation. This leads to under utilisation of such products and failure to realise the benefits. Also, unclear benefits statement can lead to uncertain allocations of responsibility for their delivery (Lin and Pervan, 2003). Reddy et al. (2006) believes that product vendors have influence on the financial planning and implementation. He also suggests that the vendors need to estimate the project accurately or otherwise face financial penalties.

An organisation's key stakeholders are central to the successful delivery of benefits (Peppard et al., 2007). Non-involvement or having vastly different stakeholders in the development and execution of plan are also reasons for the failure to realise the benefits. Health care investments are complex due to the involvement of a huge diversity of stakeholders in the hospitals (Sapountzis et al., 2007). Also, these programmes go through different levels of decision making and activities prior to its

completion (Yates et al. (2009), Sapountzis et al. (2007)). It is very important that all stakeholders have a common understanding about the change needed and the approach to achieve necessary changes. It results in a loss of time and resources, eventually leading to difficulty in realising the expected benefits (Ward and Daniel, 2012).

2.10.4.   Benefit Realisation Management (BRM):

In recent years, there is increased interest in benefit realisation due to an increased number of IS/IT projects and its complexity, competitiveness among the organisations for the success and profit. According to Ashurst and Doherty (2011, p. 9), benefit management provides *"a coherent frameworks and common language for business staff, managers and IT professionals to work together effectively to make change happen and to realise the benefits"*. These approaches are to clearly identify the expected benefits and plan how the benefits of the projects will be realised by guiding actions throughout the project implementation.

The Benefit Realisation Management (BRM) process manages an IT investment from pre-project evaluation through to post project evaluation (Smith et al., 2008). Bennington and Baccarini (2004) analysed many project benefits management methodologies and recommended 4 step model of BRM. Ashurst and Doherty (2003) added one more step into BRM as the post implementation evaluation. The modified BRM process by Smith et al. (2008) and the steps are discussed as below:

A. **Pre-project evaluation**:

This is the first step of the benefit realisation process. During the pre-project implementation evaluation, the project needs to be evaluated and objectives have to be identified by an organisation. It is also essential to justify the need for the proposed investment in an organisation. In addition, Shtub et al. (2005) recommend to consider the

factors such as the size of the project, predictable risk in the project and resources required for the project.

B. Benefits Identification:

In this stage, organisations use a variety of techniques to identify and to document the potential benefits from an IT investment (Bennington and Baccarini, 2004). Both tangible and intangible benefits should be identified. However, Bennington and Baccarini (2004) reports the difficulty in identifying benefits by many authors due to intangible benefits that are hard to identify, complex IT projects and therefore hard to document, benefits can change and evolve over time.

Benefits delivery is defined as "*the execution of the set of actions necessary to realise all of the benefits specified in the benefits plan*" (Ashurst and Doherty, 2003, p. 3). The benefits from IS/IT project are wide-ranging rendering it difficult to estimate those benefit accurately. Benefits are uncertain, intangible and may require a long time to achieve. Therefore, Galliers et al., (1998) as cited by Lin and Pervan (2003) proposes projects to evaluate with financial context and benefits from related initiatives. The evaluation and measurement of benefits from the projects should be done post project (Ward et al., 1996).

C. Benefits Planning:

It is defined as "*the process of identifying and enumerating the planned outcomes of an IS development project and explicitly stipulating the means by which they will be achieved*" (Ashurst and Doherty, 2003, p. 3). Developing a business case for the IT investment is the main purpose of this process (Bennington and Baccarini, 2004).

Benefit planning includes a detailed plan of how the organisation can successfully implement the IT investment and realise the potential

benefits (Ashurst and Doherty, 2003). Bennington and Baccarini (2004) proposes to identify the potential beneficiaries of the project and practical ways to achieve identified benefits in the benefit plan.

The benefit planning also involves identifying the responsible person for the delivery of benefits. It is the responsibility of that person of an organisation to identify new benefits by revising the benefit realisation plan regularly (Bennington and Baccarini, 2004).

D. Measuring the planned benefits:

The benefit management requires relevant, accurate and consistent measurement of project performance and of the projects within them (Thorp, 2002). According to Sakar and Widestadth, (2005) as cited by Smith et al. (2008), Key Performance Indicators (KPI) are the means of measuring the project benefits. There are a number of advantages of KPIs in a project; it allows stakeholders to assess the benefits outcome of an investment, identifies the benefits of a project and when to measure them; it enables action based on the KPI measurement; accountability for the benefits measured; and they assist in the project being funded (Bennington and Baccarini, 2004).

E. Benefits monitoring:

According to Bennington and Baccarini (2004, p. 22) it is defined as "*a process that compares project results with the benefits realisation plan during the project and assesses if internal and external changes have occurred that will affect the delivery of planned benefits*". The benefit monitoring is a continuous process and facilitates monitoring and feedback to the objectives of the project.

F. Benefits realisation:

This involves the comparison of benefits identified and the benefits actually achieved (Bennington and Baccarini, 2004). Many authors have noted that organisations fail to review realised benefits of the project delivery (Helfert (2009), Lin and Pervan (2003)). The reasons for the failure to monitor benefits being realised by the organisation are: the expensive post implementation reviews on benefits, time pressure, little attention towards the intangible benefits when the decisions are made, organisations poor IS/IT adoption practices, variation in hospital processes, lack of resources, some organisational culture against to act as both watchdog and implementer for benefits delivery (Helfert (2009)), Lin and Pervan (2003)).

G. Post project evaluation:

The post project evaluation is conducted after completion of the project and assists in determining the actual benefits realised. Benefits review is defined as the *"process by which; the success of the project in terms of benefit delivery is assessed; opportunities for the realisation of further benefits are identified; and lessons learned and opportunities for improvement in future projects are identified"* (Ashurst and Doherty, 2003, p. 3).

H. Assigning accountability for benefits realisation:

Accountability is about ownership. According to Thorp (2002, p. 90) there must be a clear and active accountability to realise the benefits. He further states that effective accountability can be achieved by the following conditions; a clear mandate and scope for the project; clear lines of accountability; relevant performance measures; and alignment with the reward system.

2.10.5.   *Benefit realisation management frameworks:*

To successfully realise the benefits from the project, an organisation requires certain approaches or tools. Many researchers have developed frameworks and models. The organisations have used many socio-technical and benefit driven approaches for over a decade (Ashurst and Doherty, 2011). Some of the approaches or models (See appendix 4) are:

- The Cranfield process model of Benefits Management (Ward et al., 1996)
- Active Benefit Realisation (ABR) by (Remenyi and Sherwood-Smith, 1998)
- Towards best practice to Benefit Management (Ashurst and Doherty, 2003)
- Benefit Dependency Network (BDN) (Peppard et al., 2007) and
- BeReal Framework (Yates et al., 2009).

Peppard et al. (2007, p. 5) suggests that any organisations benefits realisation from the investments must be able to address the following principles. The principles are:

(a) IT has no inherent value

(b) Benefits arise when IT enables people do things differently

(c) Only business managers and users can release business benefits

(d) All IT projects have outcomes but not all outcomes are benefits

(e) Benefits must be actively managed

Sapountzis et al. (2007) discuss the need for an appropriate model or approach integrated into business planning in the health sector. He also recommends that the approach should be easy to implement, capable to withstand change, cost effective and user friendly.

A. Benefit Dependency Network (BDN)

Peppard et al. (2007) developed a tool- Benefit Dependency Network (BDN), for the construction of the benefit realisation plan. He claims that BDN is simple to use and

flexible where two different investments can be started from different starting points. It provides a framework to link the investment objectives and the benefits expected of a project. Also, it brings business changes necessary for delivering the business benefits and the essential IT functionality. The figure 2- 9 illustrates a partial BDN for European paper manufacturer's new customer relationship management system (CRM).

The study by Caldeira et al. (2012) shows the success of application of BDN in systems and technology investments which was useful in implementation of a complete hospital clinical information system-Alert®pfh software in the Espírito Santo hospital. The study concludes that, in addition to financial benefits, the system contributed in improvement of patient service quality, positive impact on and streamlining the tasks for health care professionals and other benefits.
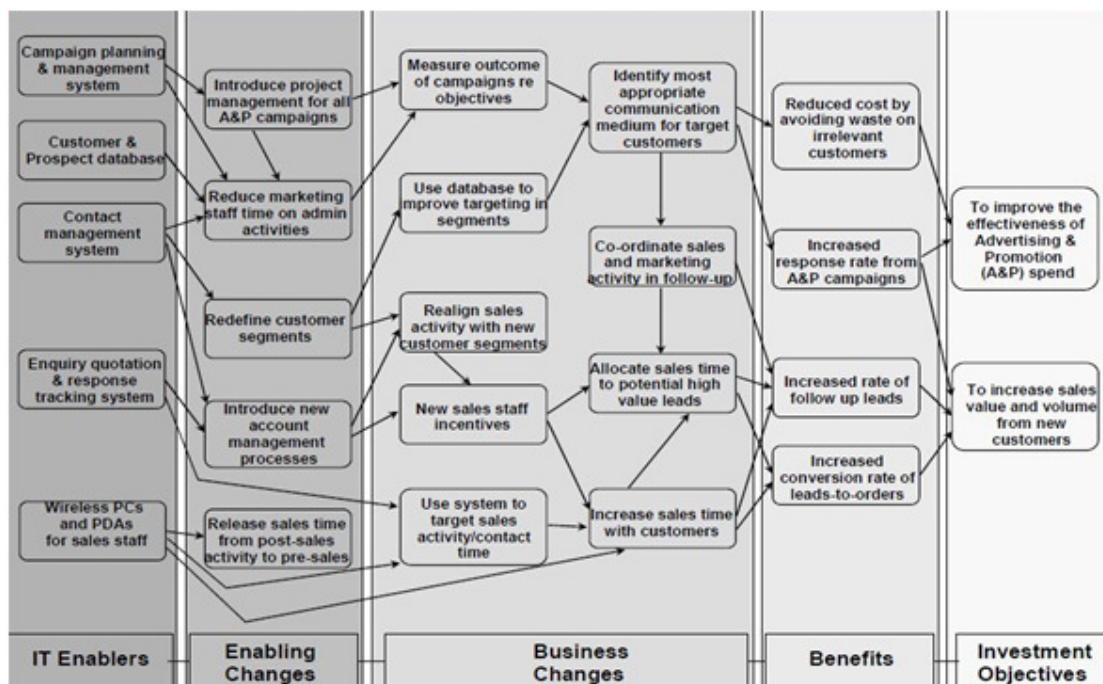
Figure 2- 9 An example of partial benefits- dependency network

(Retrieved from Peppard et al. (2007, p. 12)).

According to O'Hare (2008) in the NIMIS business case report, benefits realisation will be an essential component of the roll-out strategy that individual hospitals sign up to the realisation of the objectives & benefits (and the delivery of the associated metrics) prior to the implementation of the system. The objectives and the benefit realisation time table plan for the NIMIS is shown as in the Appendix 5.

2.10.6. *Change management:*

The relationship between the project, programme, change and benefit management is described by Reiss (2006) as in figure 2- 10. He explains that projects do not deliver benefits directly while programmes rarely do so. The programmes create capabilities by combining projects and their deliverables and will facilitate to achieve the desired benefits. The benefit management processes utilises these capabilities and delivers the anticipated business benefits (Sapountzis et al., 2007).

Implementation of any health care IT projects represents a major health care organisations change and PACS is not exceptional (Aldosari, 2012). There are many barriers to the implementation of health care technology; technological, financial and human. According to van Rensburg, (1998) as mentioned in Helfert (2009, p. 940), a critical success factor for implementing business processes is *the ability to understand change and its effect across all dimensions of an organization (e.g. the people, resources, processes, and patient/customers)*.
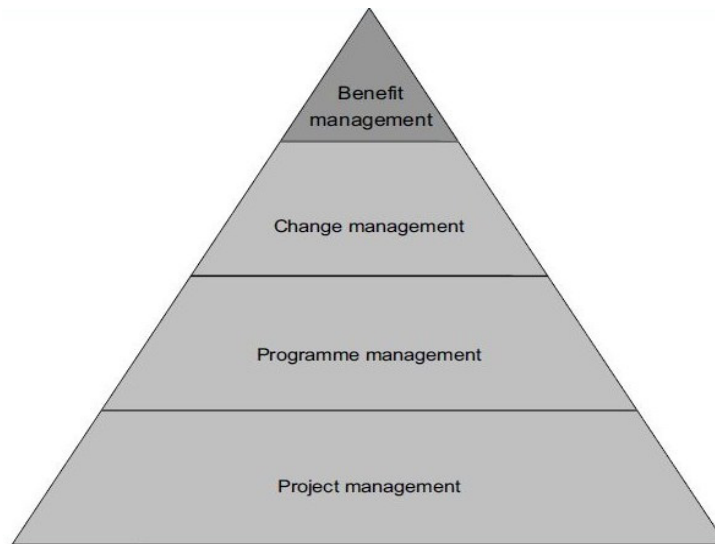
Figure 2- 10 Relating benefit, change, programme and project management

(Retrieved from Reiss (2006, p. 18).

According to Ashurst and Hodges (2010), the organisational success and its survival depend on an ability to adapt and transform. The change management is important for project management in order to achieve organisational benefits (Caldeira et al., 2012). Supporting, Helfert (2009) believes that the project and change management issues of an organisation are one of the reasons for project failures.

The importance of change management is growing rapidly. For instance, in United Kingdom around £100 billion is spent alone on change programmes every year (Sapountzis et al., 2007). However, the successful change management continues to be a major issue for organisations (Ashurst and Hodges, 2010) and the effect of change having on organisations performance (Sapountzis et al., 2007).

The implementation of any IT/IS project involves significant resistance of change (Caldeira et al., 2012). Sapountzis et al. (2007) recommend organisations to effectively adapt to both internal and external changes for their continuous improvement and to achieve goals. Furthermore, Ward and Daniel (2012) suggests that business benefits from an IS/IT depends mainly on the changing organisational

processes and its relationships and roles. It also depends on employees working practices both inside and outside the organisation.

In 1995, Leyton developed a framework to look at the relationship of benefits management in context with the business change framework (Sapountzis et al., 2007). The framework provides a clear view of a continuous relationship and flow between change and benefit (See figure 2- 11).
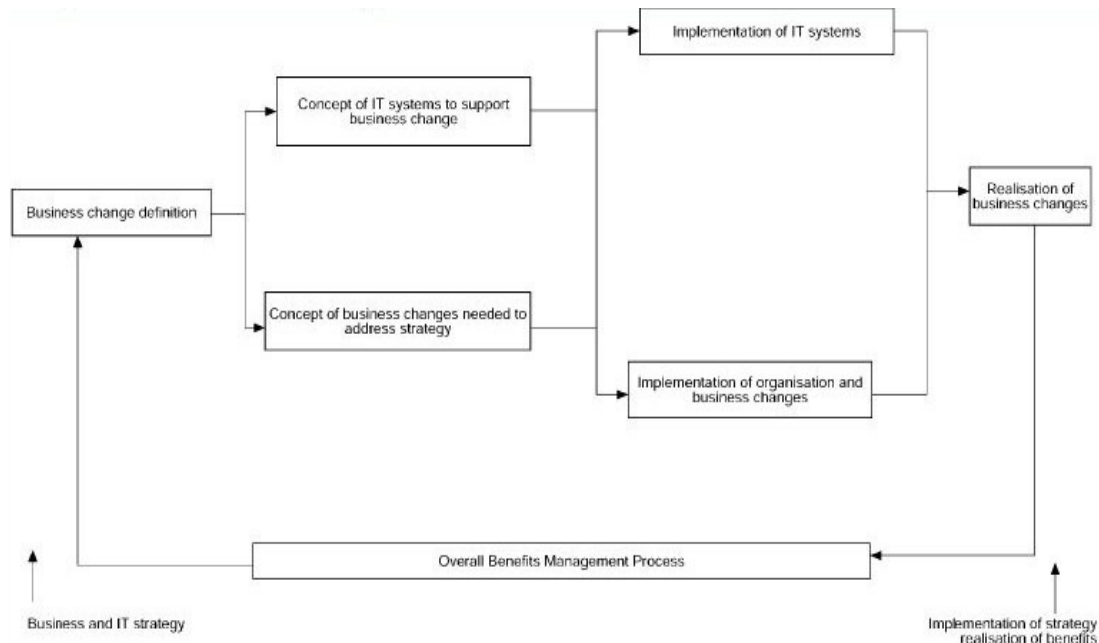
Figure 2- 11 Continuous flow between change and benefits by Leyton (1995)

(Retrieved from Sapountzis et al. (2007, p. 9))

2.10.7. Importance of stakeholders:

An early part of any change is identification of potential stakeholders. Consideration and active involvement of wide set of stakeholders from the project perspective is an important part of benefit management (Ward and Daniel, 2012). This is particularly important in health care which is more specialised and complex in nature (Helfert, 2009). The resistance by users can make the best and most expensive IT system like PACS ineffective (Aldosari, 2012). Stakeholders are

constituted as individuals, groups or organisations which have a stake and can attempt to influence the organisations decisions and actions (Freeman, 1999). Further, stakeholders are the *'benefit owners'* of the project, who are responsible to take actions to realise the benefits needed. However, Bradley (2010) reports that stakeholders are less valued and not recognised at all but they are extremely valuable for their experience and their creativity.

Stakeholders should be involved throughout the project. They can contribute to the following areas: creating the vision, agreement to the objectives, identifying the benefits, determining the dependencies, selecting from solutions options, business case development, acceptance of testing new capabilities, implementing the changes, determining the measures and tracking the benefits (Bradley, 2010, p. 11).

Parvinen et al. (2005) conducted a study on stakeholder analysis in the adoption of PACS in healthcare and proposed a tentative schedule for the different governance, process and stakeholder management activities (See figure 2- 12). His study concludes that technology adoption and stakeholder governance are two parallel processes which are important for new health technology.
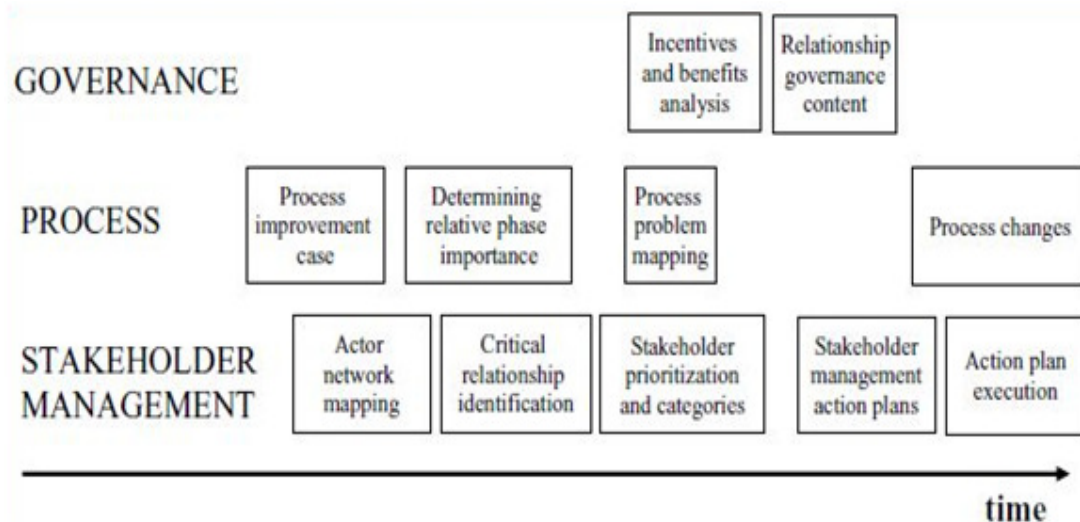
Figure 2- 12 A tentative schedule for governance, stakeholder management and process management tasks along with adoption process

(Retrieved from Parvinen et al. (2005, p. 246))

2.11. Literature review conclusion:

The literature review began with a review of secondary data such as published or syndicated data, or trade literature that discusses similar cases. Keeping the importance of the literature review in my mind, the researcher reviewed academic journals, books, conference proceedings related to research problem. It fills the gaps and extends prior studies and also provides a framework for establishing the importance of the study (Creswell, 1994).

In the last decade, the PACS have been used widely by the hospitals worldwide. Also, the technological advancements and both private and public health sector initiatives are boosting the adoption of PACS.

Various authors have documented potential benefits resulting from the proper installation of PACS for multiple users. In contrast, numerous studies have reported that the benefits of PACS in terms of cost are not immediately achieved but took a few years. Many authors have reported disadvantages and risks of implementing the PACS such as the cost, user resistance. The literature is inconclusive regarding the cost and benefits of PACS.

Before implementation of PACS numerous issues should be considered. Organisations consider the delivering the project as only technology implementation and less attention is given towards the benefits realisation. The literature has showed the importance of benefit realisation management for the organisation to achieve the expected benefits from a project. There are numerous frameworks or models available and have showed positive results by realising the projects benefits.

In the next chapter, the researcher discusses about the research methodology used in the present study.

CHAPTER 3

3. RESEARCH METHODLOGY

3.1. Introduction:

In the present study, the researcher examines the user's expectations and benefits realisation of PACS system. This chapter describes the methodology used in the present study. Research methodology is a systematic way to solve the problems identified in the research study (Kumar, 2011). Also, it explains the rationale for the methods used in the research study (Jankowicz, 2005).

In this chapter, the researcher begins with the research philosophy. The researcher describes and justifies their research design and methodology techniques. Also, the researcher explains about the study setting population and the purposes of sampling choices for the study. Furthermore, the researcher will precede to addresses the data collection methods, research question interpretation and the issues of ethical principles. The researcher concludes this chapter by conducting hypothesis test and describes the results.

3.2. Research philosophy:

There are number of research philosophies. However, the most important philosophies are '*positivism*' i.e scientific method and '*phenomenology*'. *'Positivism'* has captured the imagination of many scholars and continues to motivate due to the idea that scientific methods is the surest way to produce the knowledge about the natural world, scientific knowledge is effective and this knowledge can be used to

improve the natural habits (Bernard, 2011). The researcher's careful observation and measurement of objective reality that exists around that is the foundation of knowledge in positivism. In this method, the researcher begins with a theory, collects data that either supports or refutes the theory, and then makes necessary revisions before additional tests are conducted (Creswell, 1994).

According to Bernard (2011, p. 18), Phenomenology is *"a branch of philosophy that emphasizes the direct experience of phenomena to determine their essences, the things that make them what they are"*. The present study evaluates the user's expectations and realisation of PACS in the researcher's hospital by collecting the data. The data will be recorded and analysed in statistical form. These statistics are used to answer the research questions. Consequently, the researcher decided to use the positivism philosophy in the present study as it was deemed more appropriate.

3.3. Research approach:

The next important step after deciding the research philosophy was finding the suitable research approach to conduct a study. *'Paradigm'* is a set of philosophical underpinning from which research approaches (Morse and Field, 1995). He also mentioned that constructing a solid theory is the main aim of paradigm but the accomplishment of this differs according to the philosophy underpinning each of them.

The research approach is mainly classified as; qualitative, quantitative and mixed. The three important contributors to the research approach are the knowledge claims, the strategies, and the methods (Creswell, 1994). In quantitative approach, the investigator uses primarily postpositive claims for developing the knowledge. Whereas, in qualitative approach the investigator makes knowledge claims based primarily on constructivist perspectives. Also, qualitative approach is a systematic,

interactive, subjective approach (Burns & Grove, 2005). In mixed methods approach, the researcher tends to base knowledge claims on pragmatic ground such as problem centred, consequence oriented. This involves the data collection either simultaneous or sequential gathering of both numeric as well as text information.

It is important to decide about the choice of research approach used in the research study. The researcher should understand the factors which affects in selecting the approach. The quantitative approach is used if the research problem is identifying the factors that influence an outcome, the utility of an intervention, or understanding the best predictors in outcomes. Whereas, the qualitative approach is used in a concept or phenomenon needs to be done because the topic is new and not much research done on it. The mixed approach is beneficial to capture the best of both qualitative and quantitative approaches.

As the present study is evaluating the benefit expectations and benefit realisation of PACS system, a quantitative approach is more suitable. The quantitative data provides an explanation or prediction about the relationship among the benefit expectations of PACS system to the benefit realised.

3.4. Research method:

Once the research approach is decided, the method required needs to be finalised. There are different methods in quantitative research such as experiments and surveys. The researcher decided to use the survey research method for the present study.

Survey method include studies for collection of data with the intent of generalizing from a sample to a population (Babbie, 1990). However, there is a concern related to the reliability of information obtained from the small portion representing the whole population (Rea and Parker, 2012). The researcher used the survey method as this

method generates a standardised data that are quantifiable and can be analysed statistically to compare the benefits expectations and benefits realisation of PACS.

3.5.   Research process:

According to Kothari (2009), research process *'consists of the series of actions or steps needed to carry out research and the desired sequencing of these steps'*. Further, Loiselle et al. (2004) states that, it is a systematic which uses disciplined methods to answer questions and solve problems with ultimate goal to develop and expand a base of knowledge.   It consists of various steps and all the steps are interdependent. The researcher discusses the steps followed in the research study as below:

3.5.1. Formulating a research problem:

The first step of the researcher in the research process was to define the problem that has to be solved (Churchill and Iacobucci, 2009). This requires the researcher to understand the problem thoroughly and rephrase the same into meaningful terms from an analytical point of view (Kothari, 2009).

In this study, the researcher defined the research question about PACS carefully and precisely after examining the available research literature and similar previous studies to get acquainted with the selected problem. Also, the researcher specified research questions that related to the research problem.

3.5.2. Extensive literature review:

Once the research problem was formulated, it was important to find the source of information for the study. According to Boote and Beile (2005, p. 3) "*a thorough, sophisticated literature review is the foundation and inspiration for substantial, useful*

research". There are many purposes of literature review. The literature review shares about the other similar studies results to the researcher. It is important that the researcher understands the history of the topic. The literature review therefore provides the researcher a detailed description of topic history and sources related to the literature, illustrate the issues and refine the focus of the research, which ultimately lead to research problems questions (Gray, 2009).

In qualitative study, the study literature review is exploratory, where the research has not been done much. Here, the researcher listens to participants and based on their ideas a conclusion is drawn. In quantitative study, the literature is often used at the beginning of the study to introduce research problem and the results will be compared with the existing literature at the end.

The researcher uses either a qualitative or quantitative approach to the literature depending on the type of research design being used in the study. The researcher Creswell (1994) suggests to use the literature in qualitative research inductively whereas in quantitative deductively.

3.5.3. Developing a working hypothesis:

Based on the extensive literature review in the chapter 2, PACS have shown that users have realised many benefits. Therefore, it is assumed that these benefits are also apparent in the Irish hospitals. To test this, the researcher formulated a working hypothesis. Hypothesis is a *'tentative assumption made in order to draw out and test its logical or empirical consequences'* (Kothari, 2009). The benefits of developing a working hypothesis are important in research as they provide a focal point for research and affect the manner of data analysis.

The research hypothesis is the basis for the research project. It is directly dependent on previously known facts, potential solutions, and results expected from the

variable analysed. Hypothesis testing is a systematic way to test claims or ideas about a group or population. There are different varieties of hypothesis testing: Inductive (based on observation) or deductive (originating from theory), the directional (expected direction) or non-directional (relation exists), and the null (no significant relation) and alternative (significant relation) hypotheses (Alexander H. Toledo et al., 2011). In this study, the researcher used the null hypothesis and alternative hypothesis to measure the difference. The *Null hypothesis* is shown as H o, which predicts no significant difference. The *alternative hypothesis* is shown as H_A, demonstrates the significant difference in the study.

The researcher formulated a working hypothesis as below:

Null hypothesis Ho: *"there is no significant difference in the user's benefit expectations and subsequent benefit realisation of PACS".*

Alternative Hypothesis H_A: *"there is a significant difference in the user's benefits expectations and subsequent benefit realisation of PACS."*

There are different steps in the hypothesis resting (See figure 3- 1).
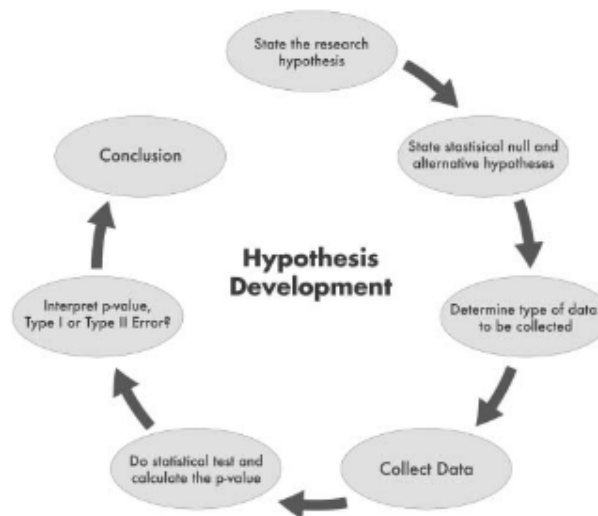
Figure 3- 1. Hypothesis Development

(Retrieved from Alexander H. Toledo et al. (2011, p. 193)

3.5.4. Designing survey questionnaire:

The researcher's aim of the study was to assess the clinician's and radiologist's PACS expectations prior to its implementation and benefits realised after. The researcher used the Information Systems Expectations and Experiences (I-SEE) survey design (Wakefield et al., 2007) to assess the impact of PACS on clinical work processes and outcomes. Since PACS in the researcher's hospital has been already implemented (since August 2011), the researcher used '*one group both before and after*' for data collection. In this, the researcher recruited one group to measure participant's expectation level and their subsequent realisation level. This would provide more accurate results and eliminates variations as same individuals provided their opinions before and after implementation of PACS.

The development of a questionnaire was a continuous and repetitive process. Before developing a questionnaire, the researcher searched many articles and identified specific PACS benefits. Those benefits were formulated into question form for both before and after PACS implementation. The initial questionnaire was reviewed by both radiologists and clinicians (1 radiologist and 3 clinicians) working in the hospital with PACS experience. The questionnaire was then modified accordingly.

The survey questionnaire was divided into four parts. The questionnaire began with probing questions (Part A) related to the general demographic information which includes gender, professional qualification, speciality, personal experience and duration of use film system and PACS system.

The second section (Part B) was an actual questionnaire and focused mainly on expected benefits of PACS. In this part, the participants were requested to cast their mind back to the time before PACS was implemented in the hospital to answer the questions. The questions in this section were phrased in the future tense.

The third section (Part C) was also an actual questionnaire and was more focused about the realised benefits of PACS. The questions were similar to part B expected benefits questions. But these questions were phrased in past tense.

Both part B and part C contained 17 questions each. The respondents were asked to rate a score for questions on a 5 point '*Likert scale*' ranging from 1 to 5. If they thought they strongly disagreed with a question then they instructed to score 1. If the respondent was non decisive or neutral, they were instructed to score 3 while they strongly agreed, they were instructed to score 5. All the participants were requested to choose and circle the appropriate answer to each question. The questionnaires focused on all the benefits identified by the researcher and were as follows;

- *Benefit item 1- Rapid access to images*
- *Benefit item 2 -Rapid access to reports*
- *Benefit item 3- Improves continuity of patient care*
- *Benefit item 4- Saves staff time*
- *Benefit item 5- Minimises loss of data/ films*
- *Benefit item 6- Increased efficiency of clinical practice*
- *Benefit item 7- Delivery of quality patient health care*
- *Benefit item 8- Quality of images are diagnostic*
- *Benefit item 9- Less time in finding the images / reports*
- *Benefit item 10- Less complicated radiology workflow/ ordering*
- *Benefit item 11- Simultaneous review of images in more than location*
- *Benefit item 12- User friendliness*
- *Benefit item 13- Reliability*
- *Benefit item 14- Increases confidence in patient diagnosis*
- *Benefit item 15- Full satisfaction with the system*
- *Benefit item 16- Cost efficient*
- *Benefit item 17- Enables effective communication among clinical members*

There are different aims of PACS and different stakeholders with many expectations and conflicting interests to find out the success of the system. So, the researcher identified the general aims of PACS as above to evaluate the success of PACS.

The last section, Part D is about general comments. In this part, questions were asked about how PACS can be improved and how the participants utilise the time saved by PACS.

3.5.5. Determining the sample design:

After the final design of the questionnaire the next step was to find out the appropriate sample for the study. According to Brink & Wood, (1998), *'population is everyone in the world who meets the criteria for the people who interact with the study'*. PACS is a hospital wide system and it has been used by all medical professionals from various departments. For the present study, the target population were medical professionals at consultant and SPR/ registrar level. In the hospital intranet, the list comprising of 330 consultants and SPR/ registrars from all the specialities were noted and included in the survey group. The researcher formed an inclusion and exclusion criteria for this study. This was to ensure an easy access to the target population to achieve the study aims. Inclusion criteria:

- A medical professional either consultant or registrar currently working in the hospital
- Must have experience in using PACS

Exclusion criteria:

- Non medical professional
- Other than consultant or registrar
- No experience of using PACS

Since the researcher works in the same hospital where this descriptive quantitative study is conducted, the researcher chose convenience sampling. Convenience sampling is the *'population elements selected for inclusion in the sample based on ease of access'* (Kothari, 2009).

3.5.6. Ethical approval:

The legal or ethical requirements for the study were very important. Once the questionnaire designed and target population for the study were finalised, the researcher applied for the ethical approval from both the ethics committee in the researcher's hospital and the Trinity College Dublin.

Since the present study is evaluating the service in the hospital, the ethics committee chairperson informed the researcher that ethical approval was not deemed necessary but to inform the *'Quality and Standards department'* in the hospital. The researcher sent an e-mail to inform the department in charge of 'Quality and Standards' in the hospital about the purpose of the study and study design. The researcher also applied for the ethical approval from the Trinity College Dublin Ethics committee. The researcher received an e-mail confirming about the ethics approval from the college (See appendix 6).

3.5.7. Pilot study:

Once the legal requirements of the study were completed, the questionnaire was piloted by sending questionnaires to 10 different department consultants and registrars in the researcher's hospital. They were asked to complete the pilot version of questionnaire and requested to provide feedback about how the questionnaire might be improved. The researcher received responses from 8 with feedbacks. This feedback was further discussed with the radiologist consultant. This discussion

allowed us to revise the contents of questionnaire before it was finalised for the actual study.

3.5.8. Collecting the data:

Once the pilot study was complete, the researcher distributed survey questionnaires to collect data. There are various ways available to collect survey information such as mail-out, web based, telephone, in-person interviews (Rea and Parker, 2012). The researcher sent out questionnaires to all the radiologists and clinicians in the hospital through the hospital internal mail facility. Although there are disadvantages of sending questionnaire by post as noted by Rea and Parker, (2012) such as longer time, lack of researcher involvement, incomplete open ended questions, the researcher felt mail out questionnaire will be useful as it's simple, convenient, easy to maintain anonymity, and potential cost savings.

The researcher sent an email to all the clinical directors in the hospital to inform them about the study undertaken and requested to encourage their team members to participate in this study to gain more responses. The researcher sent 330 survey questionnaire packs to all consultants and registrars of all departments with their names and department address. The survey pack included the study information sheet (See appendix 7), 2 consent forms (one copy for participants to retain and other one to return back to the researcher) (See appendix 8), questionnaire (See appendix 9) and 2 self addressed envelopes. The participants were instructed to send a copy of signed consent form and questionnaire separately in the self addressed envelopes provided to maintain the anonymity of participants.

All the participants were informed that the participation was voluntary and confidential. The participants required 10- 15 minutes to complete the questionnaire. The last date for returning the completed questionnaire was notified on the information sheet.

The hospital postal department was informed about the study. A collection box with the researcher's name was kept in the researcher's work place to receive the entire incoming completed questionnaire. The researcher work place Clinical Nurse Manager s (CNM) and ward clerks were informed about the study and instructed to keep all the posts in the collection box while the researcher was not working.

The initial response rate was low and only 35 responses were received after the first 10 days. An explanation for this low response rate was discovered by the researcher, many department secretaries had not distributed the questionnaire package correctly meaning many of the target population were still unaware of the research. The researcher approached the consultant radiologists and other departments to inform their team members about the study conducted in the hospital and about the questionnaire.

The researcher received 18 questionnaires back from different departments due to unavailability of participants. Also, the researcher was informed by some of the departments such as the psychiatry, palliative care departments were not using PACS. In total, the researcher sent 25 questionnaires to the above mentioned departments. So, the researcher reduced 43 from 330 and considered 287 as the final sample size.

In the literature, the satisfactory response rate chosen was 50% reflecting the average respondents response in surveys (Lindsay et al., 2011). In this study, the researcher received 115 responses from the participants out of 287 with the response percentage of 40%. 2 respondents did not fill out the questionnaire as the respondent was not working in the hospital prior to PACS implementation and another respondent; a psychiatrist clinician mentioned that they won't use the PACS to view images or reports. 1 respondent did not come under inclusion criteria. So, 4 responses were not included in the study. In total, 111 responses from the participants were used to analyse the data.

3.5.9. Analysis of data:

Once the data was collected from the questionnaire, it was time to analyse the data. The researcher entered all the data in Microsoft excel 2007 and SPSS. The analysis involved a comparison of PACS expectations and realisation data. The internal consistencies of the questionnaire were performed using the Cronbach's alpha analysis. A descriptive analysis of both the benefits expectations and perceived/ realised benefits of PACS performed. The analysis of continuous data was undertaken using the Wilcoxon Signed Rank tests.

3.5.10. Hypothesis testing:

The researcher followed the steps for the hypothesis testing as shown in the figure 3-1. The statistical significance of the results was demonstrated by using the Wilcoxon Signed Ranks Test. In this test, the researcher calculated Z score and the null hypothesis rejected if Z score was < -1.96 or >1.96.

3.5.11. Interpretation of results and preparation of report:

The researcher analysed the complete data and descriptive statistics for both the benefits expectations and realisation performed. The mean score of benefits realised were compared with the user's expectations. Also, the difference between radiologists and clinicians were compared. The researcher conducted a hypothesis testing on each individual PACS benefit item to measure the statistical significance of the results. The researcher discussed in detail about the findings from the study. These study findings were further related and compared to other previous PACS benefits studies and conclusion drawn up. The researcher concluded the study in the last chapter providing present study limitations and recommendations for the future studies about PACS.

3.6.   Research methodology conclusion:

In this chapter, the researcher described the research methodology used to conduct a study to evaluate the users' benefits expectations and realisation of PACS.   The chapter commenced with the selection of research philosophy for the study.   In research philosophy, the researcher described the importance of different research philosophies and rationale for selection of positivism philosophy to conduct the study.

The researcher explained about different types of research approaches such as qualitative, quantitative and mixed.   The researcher also rationalises use of the quantitative approach for the current study.   Further, the research methods and research process are explained.   The researcher explained the step by step research process used in the present study.   Legal requirements to conduct a study are also discussed in the chapter.

In the next chapter, the researcher provides detailed data analysis of the survey conducted to evaluate the PACS.

CHAPTER 4

4. RESULTS AND DISCUSSION

4.1. Introduction:

This chapter includes the results obtained from the analysis of data. The researcher begins the chapter by describing the reliability and validity of the results. This is followed by the general demographic details of the participants. Furthermore, a descriptive analysis of user's level of benefit expectations and realisation of PACS are described. The mean and median scores of benefits expectations and realised benefits of PACS are explained using tables and/or figures. The comparison of benefit expectations and realisation by the users are explained. Also, the expectations and realisations of PACS by the radiologists and clinicians are compared separately. The difference in the radiologists and clinicians level of expectations and benefits realised are also described in the chapter. This chapter concludes with the hypothesis testing for each benefit item and the discussion of results.

4.2. Reliability and validity:

The researcher used a statistical quantity *Cronbach's alpha* to assess the degree of internal consistency. *'It is an average of all correlations among the different questions in the scale used for the study'* (Peacock and Peacock, 2010). The Cronbach's alpha value of 0.925 found in a scale used to measure the expected benefits of PACS (See table 4-1). The Cronbach's value of 0.945 found in realised benefits of PACS scale (See table 4- 2). According to Peacock and Peacock (2010), the values between 0.70 to 1.0 are

acceptable. So, the results obtained show that the scale used in this present study was reliable and internally consistent.

Case Processing Summary

		N	%
Cases	Valid	111	100.0
	Excluded	0	.0
	Total	111	100.0

a. List wise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.926	17

Table 4- 1 Cronbach's Alpha for users PACS expectations

Case Processing Summary

		N	%
Cases	Valid	111	100.0
	Excluded	0	.0
	Total	111	100.0

a. List wise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.946	17

Table 4- 2 Cronbach's Alpha for users PACS benefits realised

4.3. General Information/ Demographics:

General information about the participants is described in this section. The general demographics include participant's gender, professional qualification, and professional speciality. In addition, the research finds out information about user's personal use and experience with both the conventional (film) and PACS. This information will provide a good understanding to the researcher about participants' types and their relationship with the study conducted. These details are helpful to know whether they affected the study results or not; such as the different gender, educational status, professional speciality. Also, this information will help other researchers to identify the gaps in the study and conduct more studies in future.

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4.3.1. Gender:

Out of total participants (n= 111) majority were male participants (n=78) in comparison to female participants (n=33) (See table 4- 3). The percentages of distribution of participants based on gender are shown in the figure 4- 1.

Gender distribution
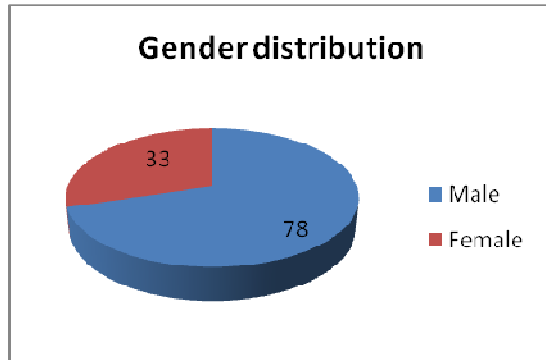
Distribution of participants based on Gender	
Gender	Total
Male	78
Female	33
Grand Total	111

Table 4- 3 Participants distribution based on gender

Figure 4- 1 Distribution of participants based on gender

4.3.2. Professional qualification:

The researcher recruited mainly the consultants and Specialist Registrar (SPR)/ registrars in the hospital. The main reasons in recruiting them were that both consultants and registrars served the hospital for many years. This increased the probability of the respondents having experience with both conventional and PACS. Also, PACS went live in August 2011 in the researcher's hospital and the researcher needed participants who worked in the hospital.

Out of total respondents (n=111), 39% were the consultants (n=43) and the remaining 61% participants were SPR/ registrars (n=68) (See table 4- 4). The distribution of participants' professional qualification is shown in the figure 4- 2.
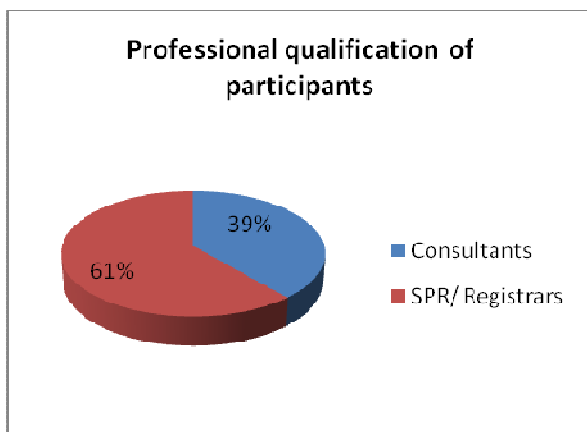
Figure 4- 2 Professional qualifications of participants

Professional Qualification of Participants	
Professional Qualification	Total
Consultants	43
SPR/ Registrars	68
Grand Total	111

Table 4- 4 Participants' professional qualification

4.3.3. Speciality:

The researcher categorised the professional speciality into two groups: the radiologists and all other departments' clinicians. The other department includes all multi speciality departments other than radiology in the hospital. The radiologists are directly involved with the radiological services in the hospital. They review and provide report to the radiological images. On the other hand clinicians utilise the radiological services to order tests or images and to view images/reports for their patients. Initially, the researcher wanted to recruit only radiologists but later it was deemed necessary to know if there's any difference in the views of radiologists and other clinicians about PACS benefits expectations and benefits realised.

The hospital radiology department has 28 radiology consultants and SPR/ registrars. The researcher received total of n=13 questionnaires back from the radiology department with 46% return rate. In the category of other clinicians, the researcher received in total 98 questionnaires back. The distribution of participants based on their professional speciality is shown in the figure 4- 3.
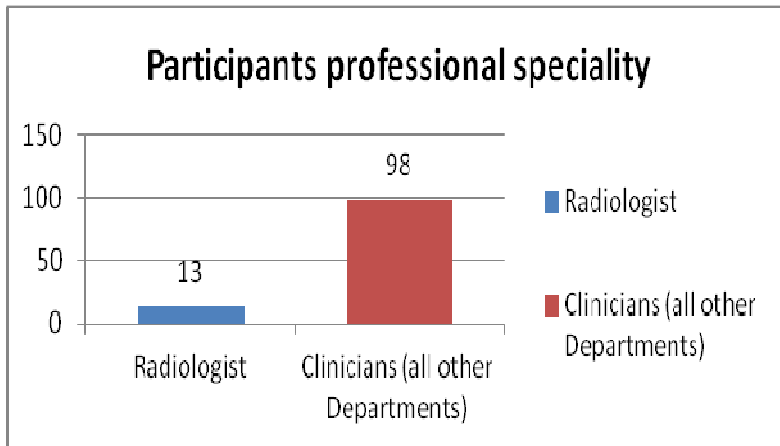
Figure 4- 3 Participants' professional speciality

4.3.4. *Use of both conventional (film) and digital imaging system:*

Users were asked to state whether they used or using both conventional and digital imaging system (PACS). Of the total 111 respondents, the majority of the participants were using or used both conventional and PACS. About 99% (n=110) participants responded 'Yes' and only 1% (n=1) participant responded 'No' (See figure 4- 4) to use of both systems. This shows that the present participants were able to answer the study questions accurately as they are experienced in both the imaging systems.
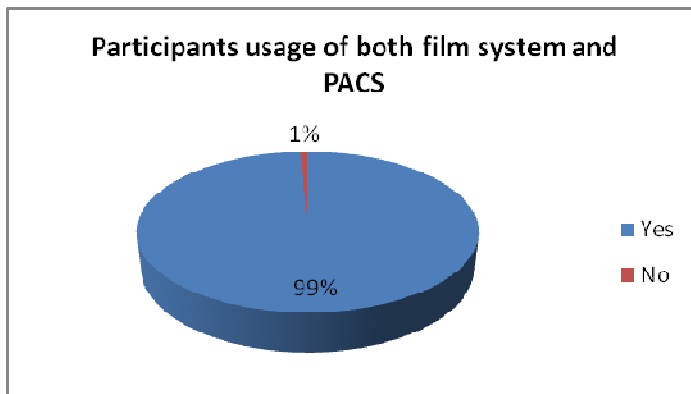
Figure 4- 4 Participants usage of both the film system and PACS

4.3.5. Experience using PACS:

The participants in the study were asked since how long they have been using PACS. Figure 4- 5 describes that more than half of the participants (n=65) have experience of 1 to 5 years of using PACS. Of the remaining participants, about n=24 participants have experience of less than 1 year while n=22 participants have experience of more than 5 years.

Although PACS went live only since August 2011 in the researcher's hospital and very few Irish hospitals have PACS, many participants have more than 5 years of PACS experience. This clearly shows the wide implementation of PACS all over the world where participants are exposed to the same.
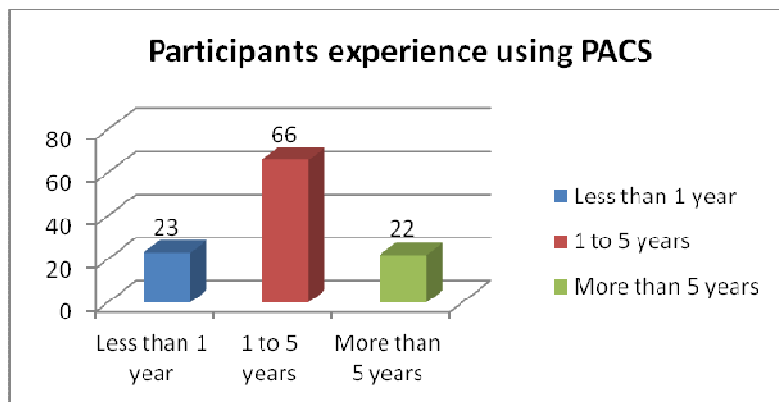
Figure 4- 5 Participants experience using PACS

4.3.6. Use of conventional (film) system:

Users were asked the number of years they used the conventional system in their profession. Figure 4- 6 shows the distribution of participants experience using the conventional system. Of the 111 participants, majority (n=59) of them used conventional method for more than 5 years in their career. 38 participants used

between 1 to 5 years of conventional system. The interesting point noted in this distribution was that there's one participant who hasn't used the conventional system and a small group of participants (n=13) used for less than 1 year. This shows that PACS has been widely introduced in throughout the health care system by replacing the conventional imaging system.
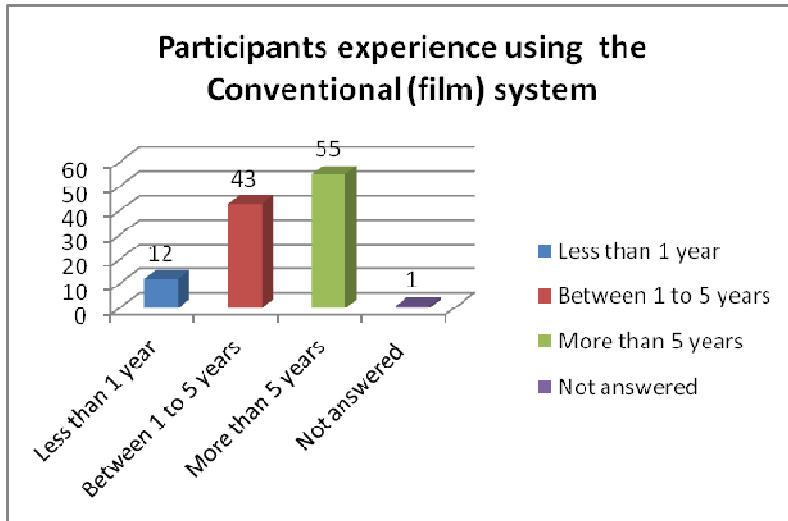
Figure 4- 6 Participants experience using the conventional system

4.3.7. Personally uses PACS to view the images and reports:

Participants were asked to state whether they personally used/uses PACS to order and view images/ reports. Figure 4- 7 describes the distribution of a participant's personal use of PACS. About 97% of the participants (n=108) response was that they used PACS to order and view the images/reports and only 3% (n=3) of the participants didn't personally use PACS. This information is important as it measures accuracy in PACS assessment by the participants
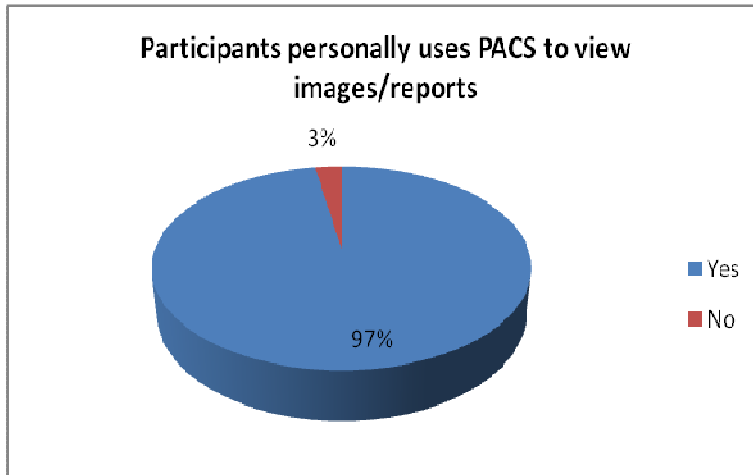
Figure 4- 7 Participants personally uses PACS to view images and report

4.4. Descriptive statistics:

4.4.1. Descriptive statistics results for the participant's level of benefit expectations prior to implementation of PACS.

The descriptive statistics for benefit expectations based on the responses from the participants are shown as in the table 4- 5. The descriptive analysis includes mean, median and standard deviation with 95% confidence interval for sample proportion.

The expectations scale scores tended to be skewed negatively. This is due to a high number of higher scores which suggests that the participants had high levels of expectations from the PACS before its implementation in the hospital. The negative skewness also shows normal distribution of responses from the participants.

The mean scores of level of PACS users expectations are shown in the figure 4- 8. The mean value is the sum of all values divided by the number of values (Peacock and Peacock, 2010).

Descriptive Statistics

EXPECTATIONS	N	Mean		Std. Deviation	Variance	Skewness	
	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
Rapid access to formal images	111	4.67	.067	.705	.497	-3.071	.229
Rapid access to formal reports	**111**	**4.43**	**.077**	**.816**	**.666**	**-1.874**	**.229**
Improves continuity of patient care	111	4.40	.075	.789	.623	-1.288	.229
Saves staff time	**111**	**4.50**	**.074**	**.785**	**.616**	**-1.709**	**.229**
Minimises loss of data/ films	111	4.69	.061	.644	.414	-2.739	.229
Increased efficiency of clinical practice	**111**	**4.50**	**.071**	**.749**	**.561**	**-1.899**	**.229**
Delivery of quality health care	111	4.35	.072	.759	.575	-1.326	.229
Quality of images diagnostic	**111**	**4.18**	**.076**	**.800**	**.640**	**-.772**	**.229**
Less time in finding the images and reports	111	4.65	.064	.669	.448	-2.599	.229
Less complicated radiology workflow/ ordering	**111**	**3.95**	**.106**	**1.115**	**1.243**	**-.711**	**.229**
Simultaneous review of images in many locations	111	4.55	.072	.760	.577	-2.325	.229
User friendly	**111**	**4.64**	**.066**	**.698**	**.487**	**-2.474**	**.229**
Reliability	111	4.62	.067	.701	.492	-2.377	.229
Full satisfaction of the system	**111**	**4.06**	**.078**	**.823**	**.678**	**-.616**	**.229**
Increases confidence in patient diagnosis	111	4.26	.076	.806	.649	-.619	.229
Cost efficient	**111**	**4.18**	**.078**	**.822**	**.676**	**-.547**	**.229**
Enables effective communication of among clinical members	111	4.16	.081	.859	.737	-1.023	.229

Table 4- 5 Descriptive statistics- Users level of PACS benefits expectations
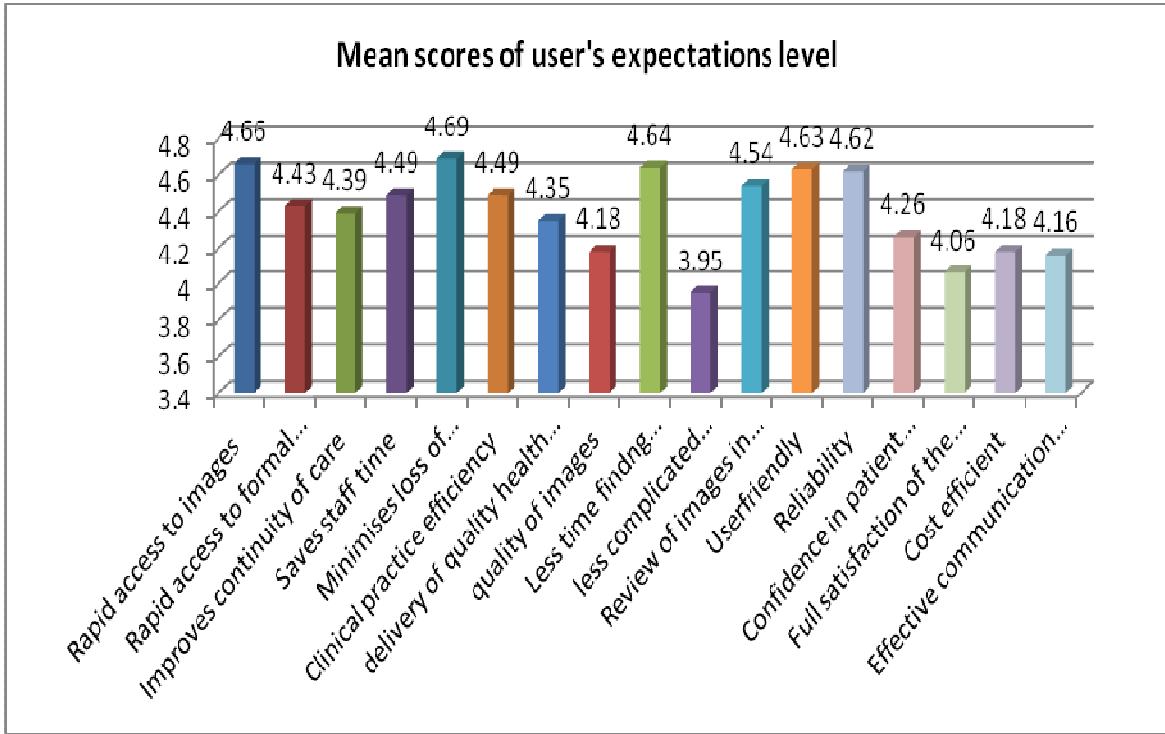
Figure 4- 8 Mean scores of level of user's expectations
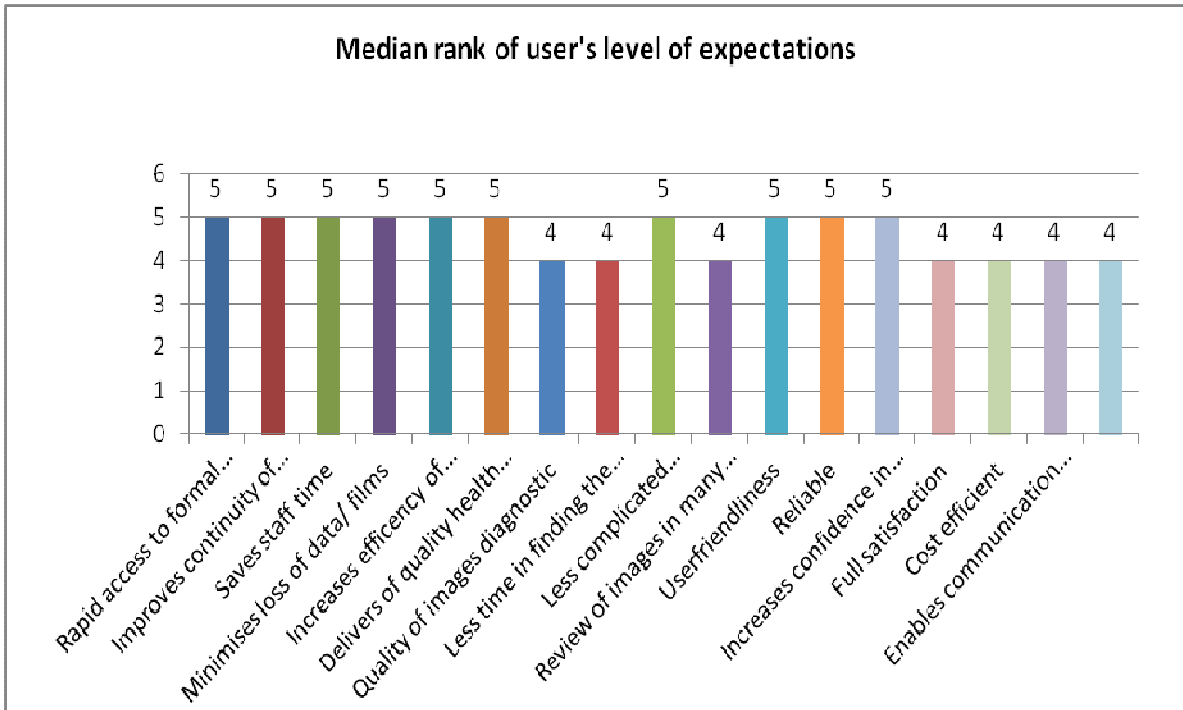
Figure 4- 9 Median ranks of users' level of expectations

The median ranks of users' level of benefit expectations are shown in the figure 4- 9. Median is the middle value when the data are arranged in the ascending order of size (Peacock and Peacock, 2010). The median values for benefit items noted are 4 and 5.

- **Research question 1: What is the level of user's benefit expectations before implementation of PACS in the hospital?**

As noted in the figure 4- 8, among expected benefits, 16 out of 17 benefit mean scores are at higher levels which are more than 4. This shows that user's benefit expectations of PACS were very high before its implementation. The participants highly expected that PACS *'minimises loss of data/films' (mean score 4.69out of 5)*, provides *'rapid access to images' (4.66 out of 5)*, consumes *'less time finding the images/reports' (4.64 out of 5)*, will be *'user friendly'* (4.63 out of 5) and will be *'reliable' (4.62 out of 5)*.

The participants expected less from PACS that it will have *'less complicated workflow/ ordering' (3.95 out of 5)* and they will be *'fully satisfied with PACS' (4.06 out of 5)*.

- **Research question 2: Do the levels of radiologist's and clinician's PACS benefit expectation differ?**

The figure 4- 10 shows the differences in the level of expectations of PACS benefits among the radiologists and clinicians. PACS expectations level by the hospital clinicians were more than the radiologists in the number of benefit items. The reason for this may be unrealistic expectations by clinicians. It could be argued that this is because clinicians have less exposure to radiology services compared to radiologists.

The clinicians expected highly that PACS provides *'rapid access to images'* and will be *'user friendly' (mean score 4.66 out of 5 each).* Whereas, radiologists highest level of expectations were that PACS *'reduces time required to find the images and reports'* *(4.61 out of 5),* *'improves clinical efficiency' (4.61 out of 5)* and *'minimises loss of images and reports' (4.61 out of 5).* It is interesting to note that both clinicians *(4 out of 5)* and radiologists *(3.69 out of 5)* had low expectations level towards *'less complicated workflow/ ordering'* benefit.
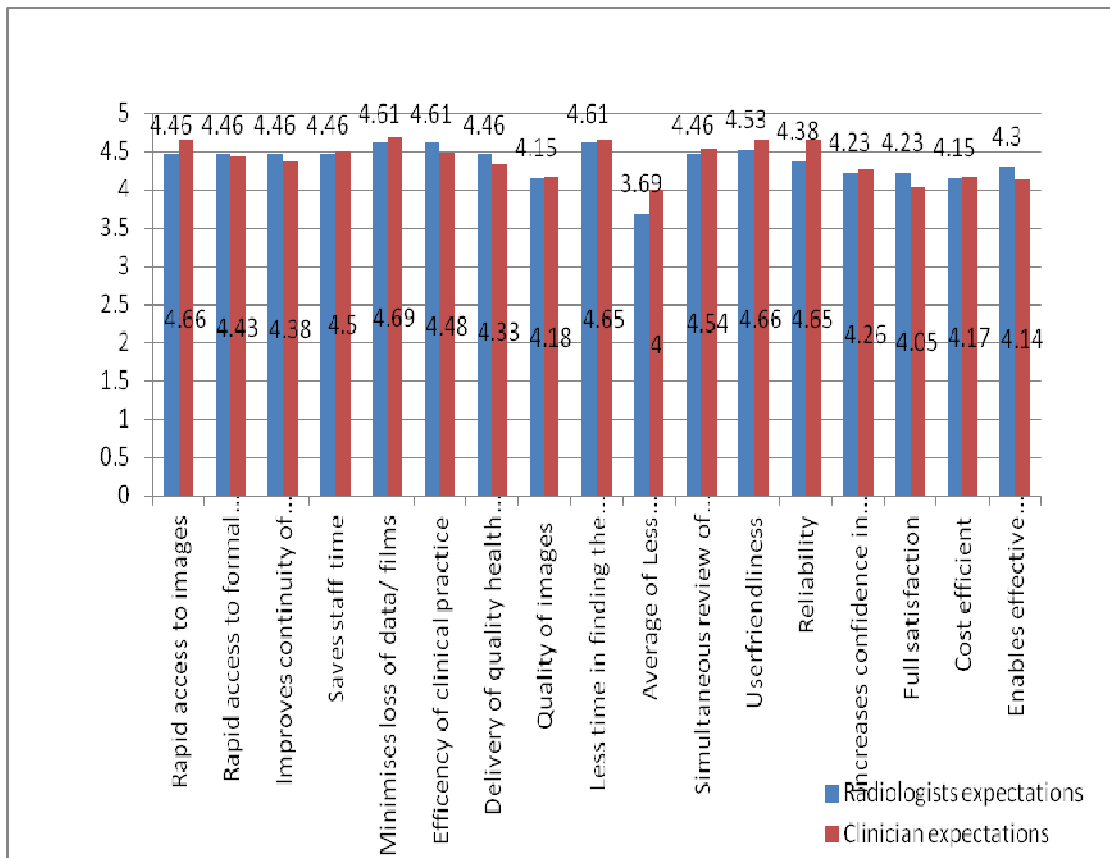
Figure 4- 10 Comparison of level of benefit expectations between radiologists and clinicians

4.4.2. Descriptive statistics results for the participant's level of benefits realisation after implementation of PACS.

The descriptive statistics of user's level of benefits realisation is shown in the table 4-6. The benefit perceived scale scores shows negative skewness. This suggests that the participants have experienced high levels of realisations from PACS and also shows normal distribution of responses from the participants.

Descriptive Statistics

	N	Mean		Std. Devia	Variance	Skewness	
	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Err
Rapid access to Images	111	4.61	.067	.703	.494	-2.330	.229
Rapid access to formal reports	**111**	**4.41**	**.080**	**.847**	**.718**	**-1.554**	**.229**
Improves continuity of patient care	111	4.36	.074	.784	.614	-.966	.229
Saves staff time	**111**	**4.33**	**.082**	**.867**	**.752**	**-1.560**	**.229**
Minimises loss of data/films	111	4.63	.066	.700	.490	-2.425	.229
Increased efficiency of clinical practice	**111**	**4.38**	**.079**	**.832**	**.692**	**-1.776**	**.229**
improved quality of health care	111	4.30	.078	.827	.684	-1.195	.229
Improved quality of images	**111**	**4.25**	**.077**	**.814**	**.663**	**-1.114**	**.229**
Less time to find images/reports	111	4.52	.072	.761	.579	-2.094	.229
less complicated workflow/ordering	**111**	**3.78**	**.104**	**1.090**	**1.189**	**-.371**	**.229**
Simultaneous review of images in more location	111	4.48	.074	.784	.615	-1.650	.229
User friendly	**111**	**3.93**	**.098**	**1.033**	**1.067**	**-.760**	**.229**
Reliable	111	4.24	.073	.765	.586	-1.066	.229
Increases confidence in patient diagnosis	**111**	**4.05**	**.082**	**.862**	**.743**	**-.279**	**.229**
Full satisfaction	111	3.93	.083	.871	.758	-.616	.229
Cost efficient	**111**	**3.97**	**.081**	**.858**	**.736**	**-.300**	**.229**
Enable effective communication among clinical members	111	4.03	.084	.889	.790	-.449	.229

Table 4- 6 Descriptive statistics- user's benefits realised

- **Research question 3: What is the level of user's perceived benefits while using PACS?**

The benefit realisation levels of PACS users are shown in the figure 4- 11. The majority of realisations scores are more than 4. However, the participants level of benefit perceived was low for the benefit items *'less complicated workflow/ ordering'* *(3.78 out of 5)*, *'user friendly' (3.92 out of 5)*, *'full satisfaction with the system' (3.92 out of 5)* and *'cost efficient' (3.97 out of 5)* of PACS. Participants perceived highly that PACS *'minimises loss of films/ data' (4.63 out of 5)* and *'rapid access to images' (4.61 out of 5)*.
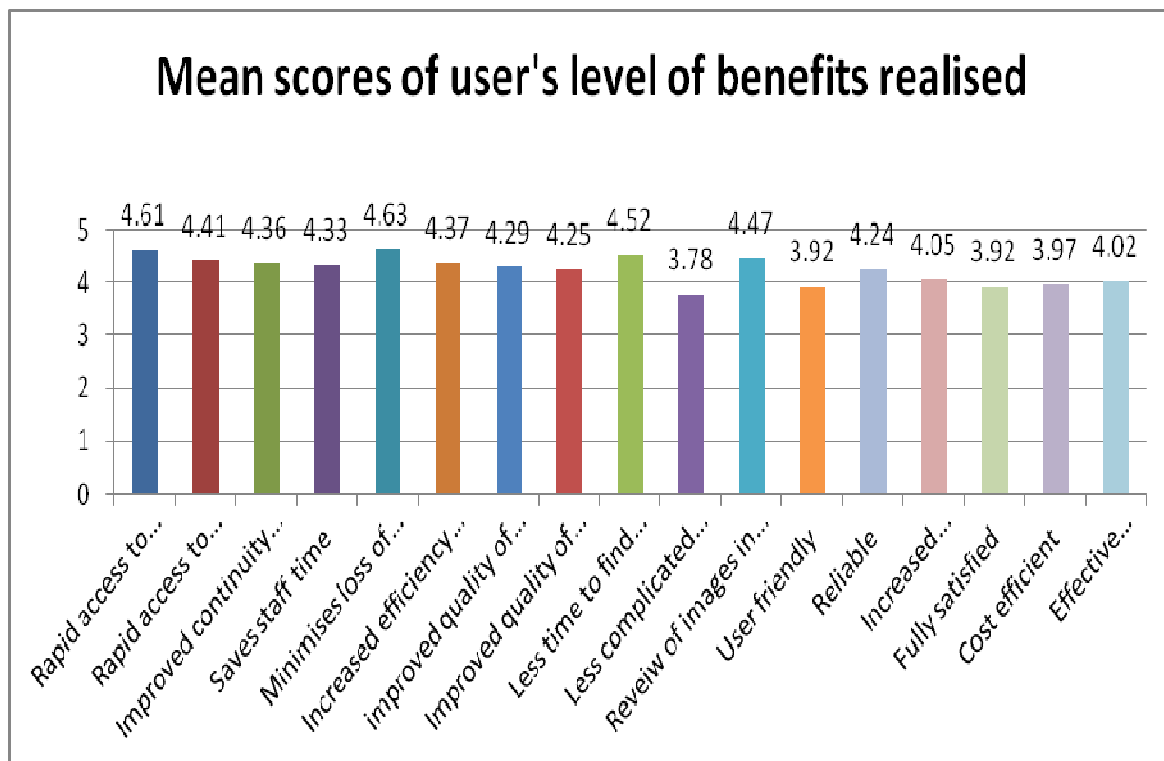
Figure 4- 11 Mean scores of user's level of benefits realised

Figure 4- 12 shows the median ranks of user's level of benefits realised. The median ranks values are 4 and 5.
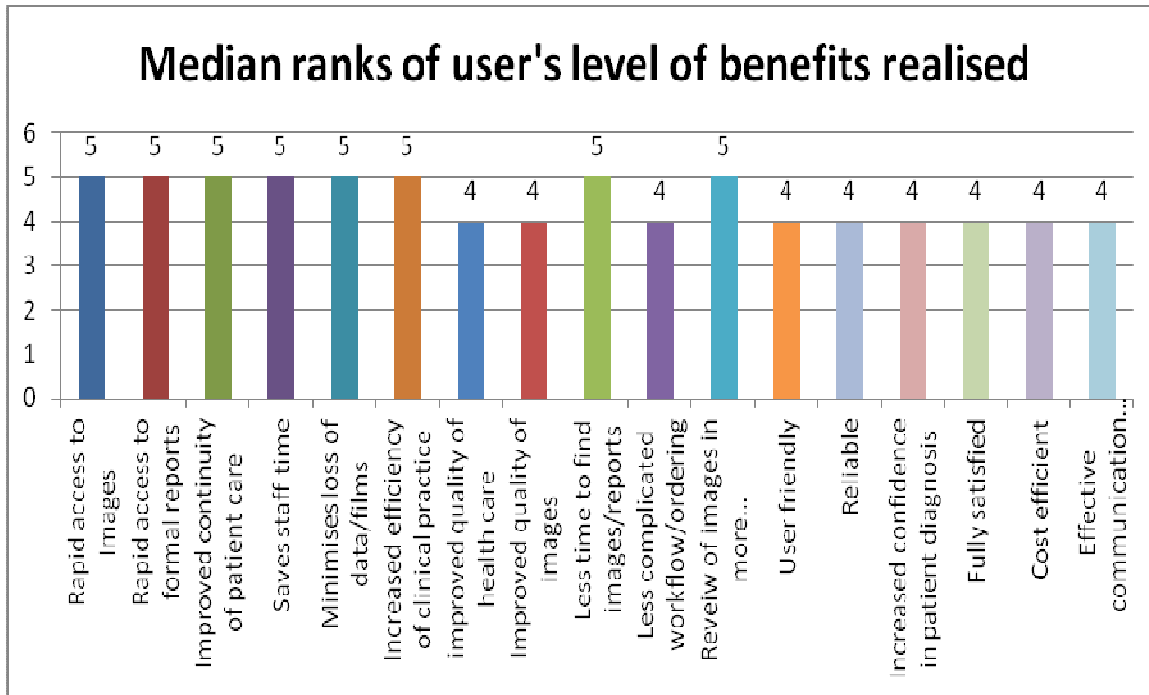
Figure 4- 12 Median ranks of user's level of benefits realised

- **Research question 4- Do the levels of radiologist's and clinician's realisation of PACS benefits differ?**

The figure 4- 13 shows the differences in the level of PACS benefits realisation among radiologists and clinicians. The radiologists scored higher realisation levels for majority of benefit items compare to clinicians.

The radiologist's benefit realisation score was (mean score out of 5) high for the following benefit items: *'improves continuity of patient care' (4.53), 'increases clinical efficiency' (4.53), 'improves quality of health care' (4.61), 'less time finding the images' (4.61), quality of images are diagnostic' (4.38), 'less complicated workflow/ ordering' (4.61), 'simultaneous review of images in more location' (4.53), 'user friendly' (4.15), 'increase confidence in patient diagnosis' (4.61), 'cost efficient' (4.3)* and *'enables communication among clinical members' (4.38).* Radiologists showed a notably higher realisation level *(4.61 out of 5)* in comparison to the clinicians *(3.98 out of 5)*

that PACS *'increases confidence in patient diagnoses'.* The radiologists and clinicians both satisfied highly that PACS provides *'rapid access to images'* and *'minimises loss patient data/ films'* and were less satisfied that PACS results in *'less complicated workflow'* and *'full satisfaction with PACS'* as shown in the figure 4- 13.
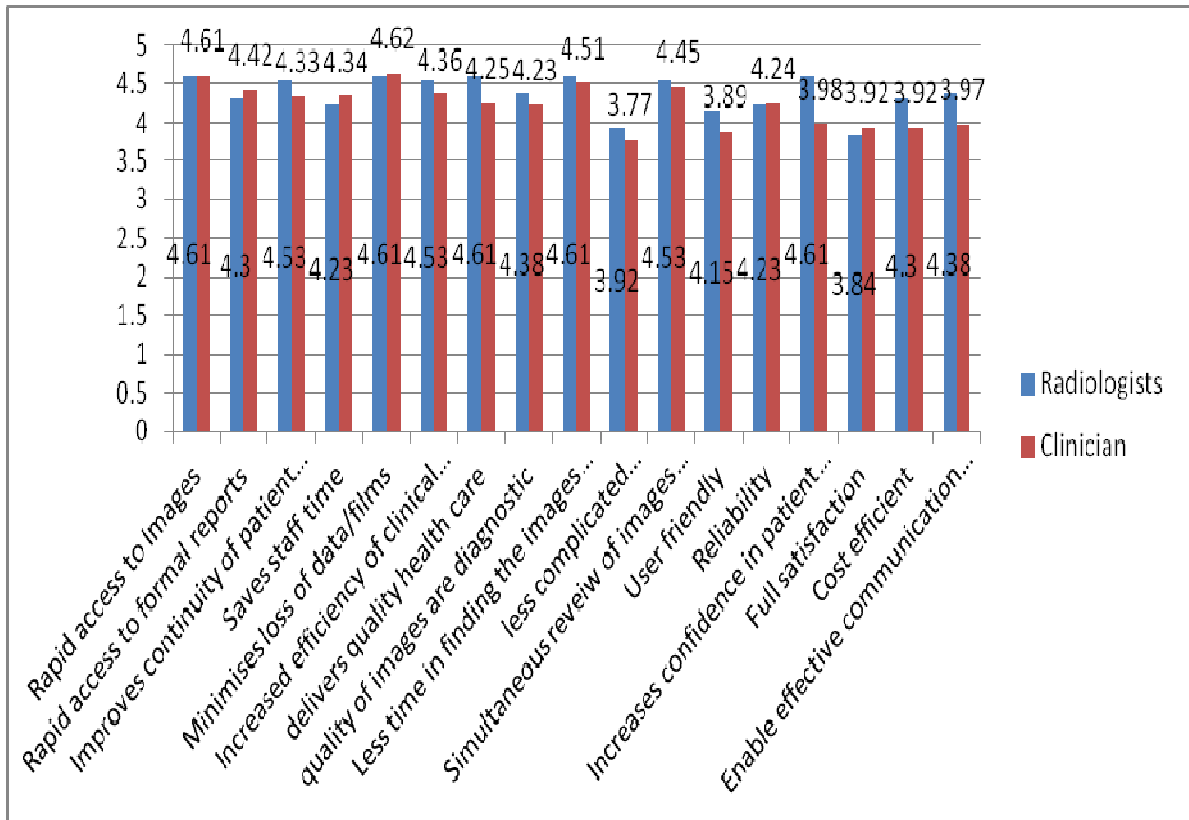
Figure 4- 13 Comparison of level of benefits realised between radiologists and clinicians

4.4.3. Comparison on mean scores of user's level of expectations and realisation of PACS benefits:

The mean scores of PACS user's expectations and perceived benefits are shown in the figure 4- 14. The figure shows that the benefit perceived levels are marginally lower than the expectations. Overall it is noted that PACS expectations level of users are not achieved except benefit item PACS *'quality of images is diagnostic'* where user's

realisation score *4.25* noted in comparison to expectation score *4.18*. Users perceived *(3.92 out of 5)* very low compared to their expectation *(4.63 out of 5)* that PACS is user-friendly. Similarly for the benefit item 'reliability' where the realisation level *(4.24 out of 5)* lower than expectation level *(4.62 out of 5)*. The researcher will conduct the hypothesis testing to measure the statistical significance of the results later in the chapter.
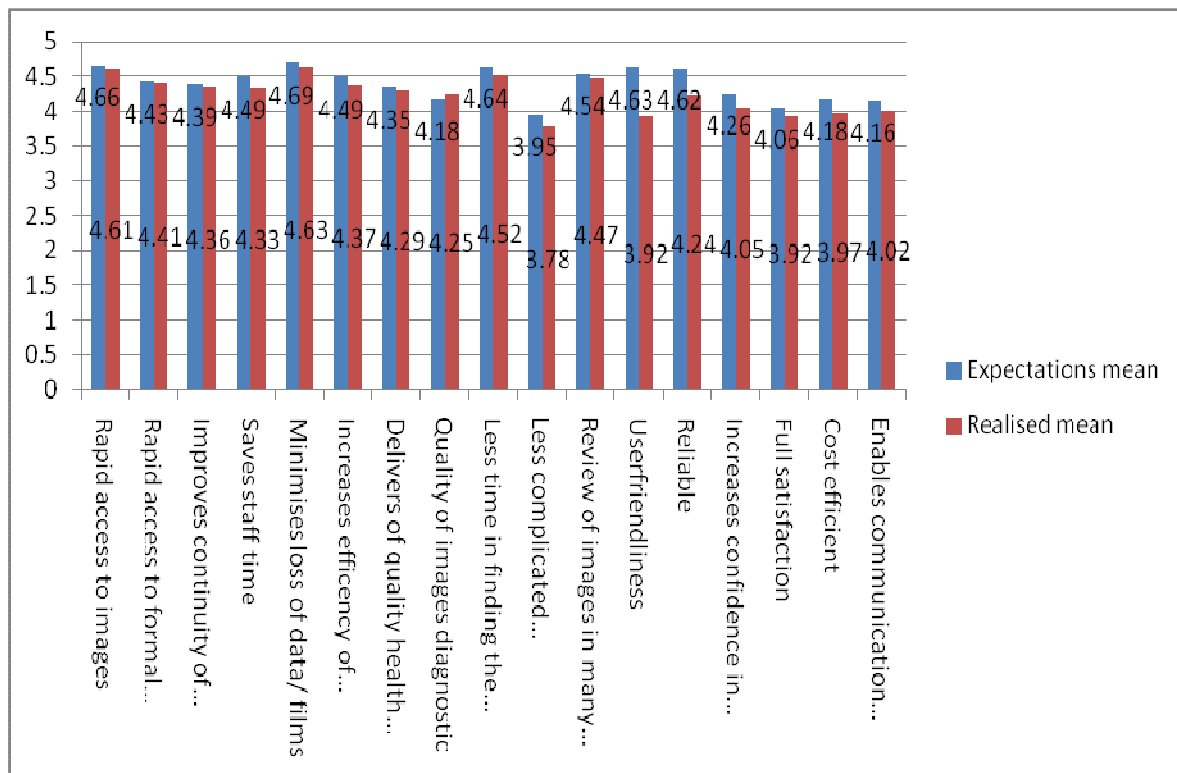
Figure 4- 14 Comparison between mean scores of participant's expectations and benefits realised

The comparison of median ranks between the user's expectations and realised benefits are shown in the figure 4- 15. The median ranks shows uniformity in all the benefit items except *'user friendliness'* and *'reliability'* where the median ranks of benefit realised are lower than the expected.
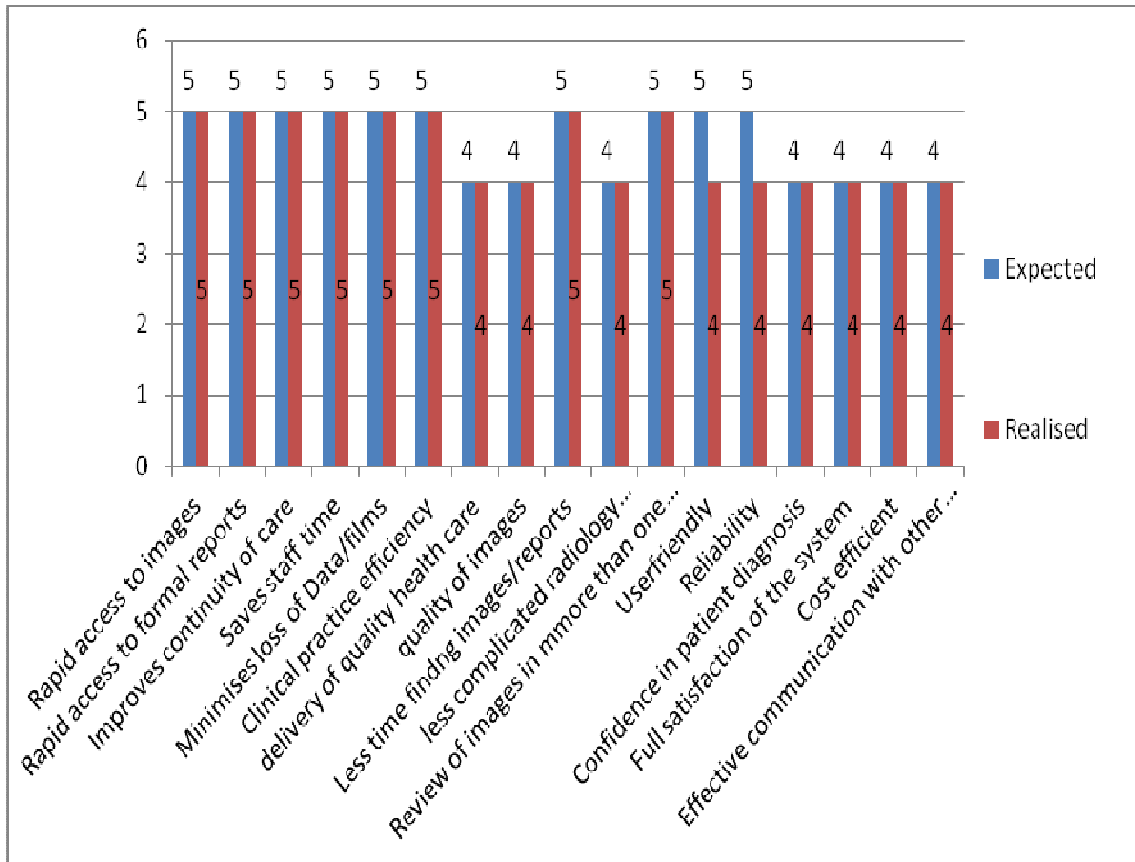
Figure 4- 15 Comparison between the user's median ranks of benefits expectations and realised

- **Research question 5- Is there a difference between the radiologist's PACS benefit expectations and subsequent benefit realisation after its usage?**

The figure 4- 16 compares the difference between the radiologist's expectations and realisation of PACS benefits. Majority of the benefits realisation scores were higher than their expectations by radiologists except benefit items '*rapid access to reports'*, *'saves staff time', 'efficiency of clinical practice', 'user friendliness', 'reliability'* and *'full satisfaction of the system'*.

Radiologists strongly agreed (*4.61 out of 5*) that PACS increased their confidence in patient diagnosis than they expected (*4.23 out of 5*). This result directly reflects on

radiologist's routine work where they review the images and provide diagnostic reports.

Though radiologists had low expectation level *(3.69 out of 5)* that PACS will result in *'less complicated workflow/ ordering'*, the realisation level *(3.92 out of 5)* scored was slightly higher. However, this can be argued that this benefit level is least achieved as their realisation level still low compared to other benefits score. The result shows that radiologists are not satisfied with the current PACS system and it's not user-friendly.
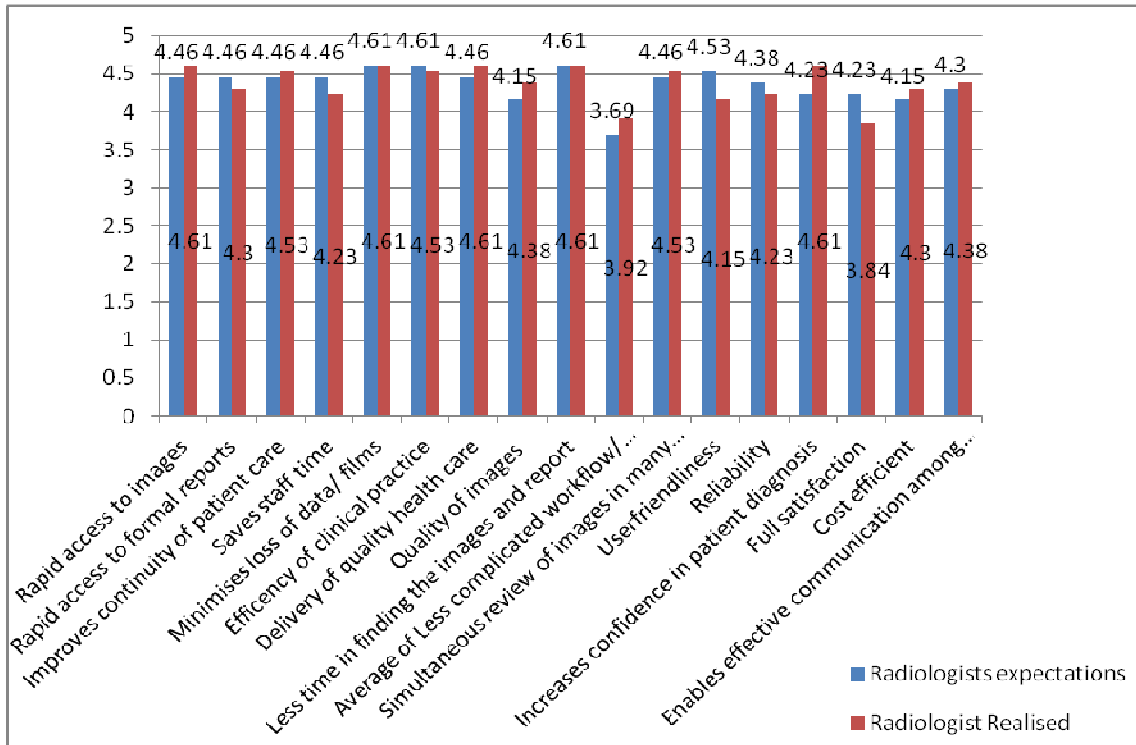
Figure 4- 16 Comparison of Radiologist's benefit expectations and realisation

- **Research question 6 - Is there a difference between the clinician's PACS benefit expectations and subsequent benefit realisation after its usage?**

The figure 4- 17 shows the differences between the clinician's realised benefits against their expectations. All benefit expectations levels were higher than their realisation levels. Similar to radiologists, clinician's disagree that PACS is *'user friendly'* and *'reliable'* as they scored much lower realisation level than their expectations level.
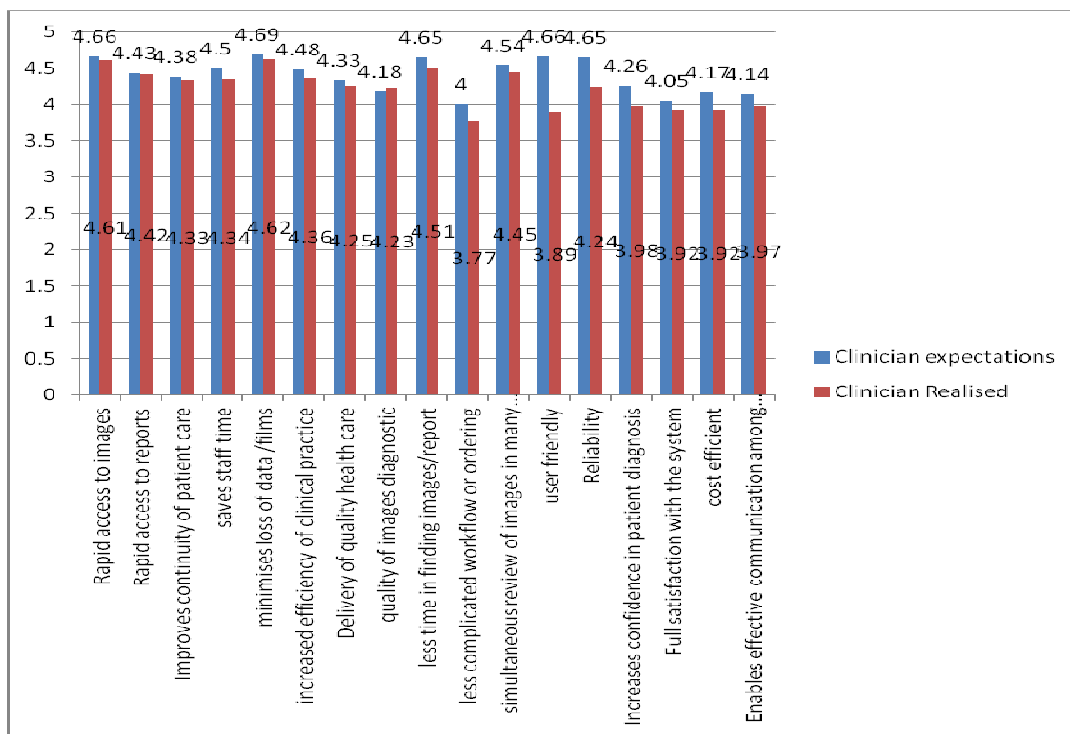
Figure 4- 17 Comparison of Clinician's benefit expectations and realisation

4.5. Hypothesis testing and discussion on the study findings:

Many authors have claimed PACS has shown benefits as discussed in the literature review. The researcher conducted an extensive literature review and all PACS benefits were identified. A survey questionnaire was made based on those

identified PACS benefits. The results were analysed as above. The researcher conducted a hypothesis testing to determine statistical significance between the user's expectations and their perceived realisation using the survey results. The researcher formulated a null hypothesis and alternative hypothesis for the research question as below:

- **Research question 7: Is there a difference between PACS user's benefit expectations before its implementation and subsequent benefit realisation level after the PACS usage?**

Null hypothesis Ho: There is no significant difference among the user's benefit expectations and subsequent benefit realisation of PACS

Alternative hypothesis HA: There is a significant difference among the user's benefit expectations and subsequent benefit realisation of PACS

The researcher performed a comparison of benefit expectations with their subsequent realisation similar to the study by Bryan et al. (1999b). The statistical significance of the results were analysed using the Wilcoxon Signed-Ranks test for each benefit item. This provides the researcher important information regarding the user's views about PACS benefits and helps to identify if the individual benefit is achieved or not. This helps to find out reasons for the failure to achieve individual benefit and will help appropriate personnel to target the issues so that maximum benefits can be achieved.

The Wilcoxon Signed- Ranks Test is a version of the dependent samples t- Test that can be performed on the ordinal data. The *'Z score'* in the test is used for the hypothesis testing. In the Wilcoxon Signed- Ranks test, the null hypothesis will be rejected if *'Z score is less than -1.96 or greater than 1.9 at the alpha value of 0.05'*.

4.5.1. Benefit item - PACS provides rapid access to images:

The user's realisation level *(4.61 out of 5)* for this benefit item remained marginally lower than their expectations *(4.66 out of 5)*. On comparison, the radiologist's realisation level was higher and clinician's realisation level was lower than their subsequent expectations. The Wilcoxon Signed Ranks Test result was *Z score of - 1.215* (See table 4- 7). This Z value confirms that there is no significance difference between the user's expectation and realisation level.

Test Statistics[a]

	Realisation- Rapid access to Images – Expectation- Rapid access to images
Z	-1.215[b]
Asymp. Sig. (2-tailed)	.224

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks

Table 4- 7 Wilcoxon Signed-Ranks test- PACS provides rapid access to images

In the researcher's hospital, approximately 160,000 to 180,000 radiological examinations are performed per annum. The rapid accesses to these images on PACS are important for optimum patient diagnosis, treatment and follow-up. The above results are similar to other studies.

The study by Reiner BI et al. (1998) reported that rapid availability of images in PACS increased clinicians review of images throughout the hospital. In addition, Bryan et al. (1999a) conducted an evaluation by comparing *'before and after'* PACS implementation. There was 97.7% improved image availability in PACS versus 86.9% in conventional method. Conversely, Horii and colleagues measured the time taken from examination requested until its dispatch in Emergency Department (ED) and Medical Intensive Care Unit (MICU). The study reported requiring longer time

after PACS implementation in both ED (20 mins pre and 25 mins post PACS) and MICU (34 mins pre and 42 mins post PACS) (Horii et al., 2000).

Singh and colleagues conducted a survey of 782 members from British Thoracic Society to assess their experience with PACS. About 77% of respondents recorded positive experiences that PACS increases speed of access to stored images and 83% were satisfied with PACS ability to manipulate the images (Singh et al., 2007). In addition, Nitrosi et al. (2007) reported that PACS increased the overall radiology department productivity by 12% and 60% improvement in the turnaround time. In a recent study by Top (2012) in two Turkish hospitals, the majority (74%) of physicians considered rapid availability of images on PACS very useful. In contrast to the above results, the clinicians from the present study scored less realised level than their expectation. They claim that they are not able view images faster due to some of the reasons such as: slow computers, less availability of workstations and system login problems.

4.5.2. Benefit item - PACS provides rapid access to reports:

The participant's expectations *(4.43 out of 5)* for this benefit item remained slightly higher than their realisation level *(4.41 out of 5)*. The clinician's both expectations and realisation were at same level. However, the radiologist's expectation was not met. It could be due to their nature of work. They usually provide reports for the tests performed for patients in the hospital. The Wilcoxon Signed Ranks Test results shows the *Z score of -0.315* (See table 4- 8), which concludes no statistical significant difference.

The above result is similar to the results from previous studies where the investigators reported that PACS improved access to reports (O'Hare (2008), Mackinnon et al. (2008), Pilling (2002), Watkins et al. (2000)). Mehta et al. (2000)

study found out 85% decreased turnaround time from conventional method (3.73 days) to PACS (0.56 days). Supporting, radiologists from the Norfolk and Norwich University Hospital in UK perceived that they reported more examinations after implementation of PACS (Pilling, 2002). In addition, a case study in St. James's hospital showed a majority of cases reported within 48 hours. This is a significant reduction in reporting of radiological examination and all reports with the hospital's emergency department reported by 08.30 the following morning (O'Hare, 2008).

Test Statistics[a]

	Realisation - Rapid access to formal reports - Expectation- Rapid access to formal reports
Z	-.315[b]
Asymp. Sig. (2-tailed)	.753

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 8 Wilcoxon Signed-Ranks Test- PACS provides rapid access to formal reports

An evaluation of an impact of PACS on reporting times and productivity was conducted by Mackinnon et al. (2008) between 2002 – 2006. This 5 year audit (2 years pre- and 3 years post-PACS installation) found a 30% increase in the radiological examinations from 11,531 per month to 15,057 per month. There was 26% reduction in plain radiographs reporting time from 6.8 to 5 days and a decrease in unreported films from 5% to 4%. Around 24% (from 4.1 to 3.1 days) reduction in specialty modalities reporting time and unreported were steady for specialty modalities (< 1%).

In another study conducted by Lindsay et al. (2011), 70% of clinicians felt PACS improved their reporting time. Conversely, some of the participants from the present study claim that reports were not available as they expected. One

participant suggested that *"radiologists should provide a formal report on day of imaging".* Another participant suggested that PACS can be improved by *"shortening time of reports release on system especially for emergency cases"*. The participants of this study concur with research by Bryan et al. where it was found that there were no improvements in PACS quality of reporting services (Bryan et al., 1999a).

4.5.3. Benefit item – PACS improves continuity of patient care:

The mean score of user's expectation level and realisation level for this benefit item difference was insignificant. The statistical significance of this result was clarified (See table 4- 9) and the Z score *(Z=-0.726)* obtained confirms that there is no significant difference between the user's expectation and realisation levels.

The present study result is similar to the study conducted by Mullins et al. (2001), where 75% of the radiology residents agreed that PACS improved patient care. In addition, radiologists from the present study accept that PACS improves the continuity of patient care, but clinicians scored lesser realisation level than their expectation level.

Test Statistics[a]

	Realisation- Improves continuity of patient care - Expectation- Improves continuity of patient care
Z	-.726[b]
Asymp. Sig. (2-tailed)	.468

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 9 Wilcoxon Signed Ranks Test- PACS improves continuity of patient care

4.5.4. Benefit item - PACS saves staff time:

The user's level of expectation *(4.49 out of 5)* remained higher than their realisation *(4.33 out of 5)*. The *Z score (-2.316)* obtained illustrates statistical difference among the results. This confirms user's level of expectations of this benefit item is not achieved and the null hypothesis is rejected. Interesting to note is, both radiologists and clinicians from this study strongly disagreed that PACS saves their time.

This result differs to previous studies. Reiner BI et al. (1998) claimed that the amount of time saved by clinicians due to the use of PACS was 44 minutes and clinicians believe that increased accessibility to images results in improved time management. In addition, the study presented by the Irish Medical Organisation (Hospital Activity Analysis, 2005) reports that in film based method medical professionals spend an average of 1% of their time in finding or chasing x-rays. This can be eliminated using PACS (McGuinness, 2009).

Test Statistics[a]

	Realisation- Saves staff time – Expectation- Saves staffs time
Z	-2.316[b]
Asymp. Sig. (2-tailed)	.021

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 10 Wilcoxon Signed Ranks Test- PACS saves staff time

The researcher queried the participants if they agree that PACS saves staff time, *"how would they utilise the time?"* Many participants (n=61) from the study answered this question and had different views. Some participants agreed that PACS saves time by eliminating the need for tracing and organising images or reports. They had utilised that time in many ways such as : *'report more images', 'more review of patients*

or patient examinations', 'sending referrals', 'early management and treatment of patients', 'able for some more admin work', 'performing procedures', 'attending family meetings', 'able to read more studies or conduct research', 'for personal growth and development', 'less overtime or spending unnecessary hours in hospital', 'finish work on time and go home'. One respondent stated that "*it helps utilising time more effectively as less time wasted on finding films/ sending films/ requesting films. Time saved spent on clinical work and other less efficient part of the health care system*".

However, some reported that PACS did not save time for them but improved the services. They claimed PACS takes more time to order and view images, slower computers can make outpatient clinics slower, and still they have to discuss all CT results with the radiologists. One participant stated that "*it does not save time for me. It may save time for intern's time but for me it is slower to order and review x rays than the previous system. My OPD time per patient has increased*". Another participant quoted that "*PACS does not save as much time as anticipated. Junior staffs still need to plead to have tests completed and unnecessary delay to patient care*".

4.5.5. Benefit item - PACS minimises loss of data/ films:

The participant's expectation level *(4.69 out of 5)* remained marginally higher than realisation level *(4.62 out of 5)* for this benefit item. There is no statistical significant difference noted in between the expectations and realisation *(Z= -1.301)* (See table 4-11). The radiologists agree that it minimises loss of data/ films. However, the clinician's expectations remained higher than their realisation level.

Many authors reported loss of data and/or images in conventional method. This led to repeat imaging and unnecessary exposure to radiation. Implementation of PACS reduced repeat imaging rate from 9.9% to 7.3% and reduced total radiation doses by 20% for lateral lumbar spine examinations (Bryan et al., 1999a).

In a survey conducted by Singh and colleagues, 71% participants agreed that PACS minimised the loss of images after its implementation (Singh et al., 2007). The St. James hospital case study reports that the loss of film rate decreased from 30-40% to <1% after implementation of PACS (O'Hare, 2008).

Test Statistics^a

	Realisation- Minimises loss of data/films - Expectation- Minimises loss of data/ films
Z	-1.301^b
Asymp. Sig. (2-tailed)	.193

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 11 Wilcoxon Signed Ranks Test- Minimises loss of data/ film

4.5.6. Benefit item - PACS increases efficiency of clinical practice:

The results shows that participant's expectations *(4.49 out of 5)* were not achieved *(4.37 out of 5)* for this benefit item. The *Z score of -2.062* was obtained using the Wilcoxon Signed Ranks Test (See table 4- 12) and it describes statistical significance difference between the expectation and realisation level. The null hypothesis is rejected.

In contrast to the above results, there are number of studies that proved PACS increased their clinical practice efficiency. The participants in a study conducted by Crowe and Sim, reported that PACS surmounted problems of delayed clinical decision making and disruption during their outpatient or inpatient ward rounds (Crowe and Sim, 2005). They also agreed that PACS improved the clinical efficiency in their hospital by assisting in outpatient visits and in demonstrating problems to patients. According to O'Hare, the implementation of PACS has resulted in

increased efficiency of clinical practice. The improvement in ordering and access to images or reports, nil duplicate orders and also the increased number of radiology procedures of 6%, of which 4% is attributed to PACS/RIS (O'Hare, 2008). In another study in NHS UK, Collin et al. (2008) reported the evidence of possible PACS efficiency associated with a increase in number of tests, reduction in repeat plain x ray in outpatient departments and a reduction in inpatient CT.

	Test Statistics[a]
	Realisation- Increased efficiency of clinical practice - Expectation- Increases efficiency of clinical practice
Z	-2.062[b]
Asymp. Sig. (2-tailed)	.039

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 12 Wilcoxon Signed Ranks Test- Increases efficiency of clinical practice

4.5.7. Benefit item - PACS delivers quality patient health care:

The result shows that participant's expectations (*4.35 out of 5)* remained higher than their realisation (*4.29 out of 5)*. The *Z score (-1.055)* signifies no statistical significance of the results. The radiologist's realisation level was higher than their expectation and the clinicians had low realisation level than their expectation level.

The above results concur to other studies. The study conducted by Crowe and Sim (2005) concluded that PACS has facilitated patient management through teaching and the efficient conduct of clinical conferences. In addition, according to Gell (2006), PACS has an influence on the patient quality of care processes such as direct benefit from tele-consultation or the availability of otherwise unavailable images.

The study by Nitrosi et al. (2007) in Reggio Emilia hospital Italy, reports an average of 12% improvement in average patient stay in the Neurology department. The

length of patients stay with imaging procedures decreased from 8.9 to 6.9 in neurology patients, 7.8 to 6.3 in thoracic surgery patients, 13 to 11.7 in general medicine patients. Supporting, the increase in report and image access will result in patients spending less time in hospital as images follow the patient through the "Care Pathway". This will assist in predicting length of stay and the development of care pathways (McGuinness, 2009). Conversely, many studies evaluated the impact of PACS on patient's length of stay and reported that PACS didn't impact on patient length of stay in the hospital (Collin et al. (2008), Crowe and Sim (2004), Bryan et al. (1999a)).

The orthopaedic surgeons reported that PACS has improved their dialogue with the patients in order to explain the details of the disease and treatment options (Fridell et al., 2011). However, one participant from the present study concerned about use of PACS and quoted that "*I think PACS results is a high risk that important clinical results will be overlooked*". Another participant stated, "*maximise technology in health service, but need to aware not to depend too much on it*".

Test Statistics[a]

	Realisation- improved quality of patient health care - Expectation- Improves quality of patient health care
Z	-1.055[b]
Asymp. Sig. (2-tailed)	.291

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 13 Wilcoxon Signed Ranks Test- Improves quality of patient care

4.5.8. Benefit item - PACS quality of image is diagnostic:

The survey result shows that participant's realisation level *(4.25 out of 5)* was higher than their expectations *(4.18 out of 5)*. The Z score *-1.141* obtained from the Wilcoxon

Signed Ranks Test illustrated as in table 4- 14. The result showed no statistical significance in the results. Both radiologists and clinicians accepted that qualities of images were diagnostic and their expectation was achieved.

This result is similar to other study results. The respondents from the Hammersmith hospital showed higher satisfaction with the quality of images available on PACS and a lower rate of diagnostic 'errors' are noted in casualty (0.65% versus 1.51%) (Bryan et al., 1999b). In addition, Reiner and colleagues claims that compared to conventional method PACS offers more accuracy in CT interpretation for radiologists (Reiner et al., 2002).

Furthermore, Gell reports that digital imaging allows the users to explore PACS image content by zooming, windowing, scrolling, overlaying of different information's, 3D reconstructions etc. This has improved the diagnostic efficacy of PACS (Gell, 2006). However, the study by Tan and Lewis (2010) highlighted that the poor quality of images of PACS due to poor monitors as one of the potential problems. Conversely, about 69% of the clinicians rated their ability to interpret the PACS investigations as either good or excellent in the study conducted by the Lindsay and others. Also, the clinicians felt that the reports were either informative or decisive (Lindsay et al., 2011).

Test Statistics[a]

	Realisation- Improved quality of images - Expectation- Improves Quality of images
Z	-1.141[b]
Asymp. Sig. (2-tailed)	.254

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 4- 14 Wilcoxon Signed Rank Test- Improved quality of images

4.5.9. Benefit item -PACS reduces time in finding the images / reports:

This benefit item result shows that participant's expectations *(4.64 out of 5)* remained higher than they realised *(4.52 out of 5)*. The radiologist's both expectations and realisation level were equivalent whereas; the clinician's realisation level was lower than their expectation. The *Z score of -2.182* is significant and the null hypothesis is rejected.

This result is not in favour of other studies. The clinicians from the study conducted by Crowe and Sim (2005) stated that PACS saved minimum of three full time equivalent positions of junior medical staff throughout the hospital. Before PACS they spent more time searching for missing X-ray films and now it had decreased markedly. This result is supported by the report on PACS in St. James hospital. PACS implementation helped to remove their need for doctors to search for radiology films and this reduced interruptions for radiologists during reporting process (O'Hare, 2008).

The results from the present study concur to the study by Fridell and colleagues. In this study, the orthopaedic surgeons at Karolinska Sjukhuset Huddinge and Solna complained that PACS implemented was slow, and took 10 to 15 minutes to retrieve images of a patient. The digital environment appeared more complex for the surgeons as they had to log into and use many different systems (Fridell et al., 2011).

Test Statistics[a]

	Realisation- Less time to find images/reports – Expectation- Less time to find the images and report
Z	-2.182[b]
Asymp. Sig. (2-tailed)	.029

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 15 Wilcoxon Signed Ranks Test- Less time to find the images/reports

In the present study, only clinicians reported that their expectations were not met. The researcher believes this is due to the increased time consumption to view images and reports due to less number of computers, slow computers, and poor network as reported by the participants.

4.5.10. Benefit item - PACS has less complicated radiology workflow/ ordering:

The participant's expectations were higher *(3.95 out of 5)* than their realised level *(3.78 out of 5)*. The Wilcoxon Signed Ranks Test *(Z= -1.715)* shows no statistical significance between the results. The radiologist's realisation score is higher whereas, the clinician's lesser in comparison to their respective expectations. The participants in the present study claimed that the ordering system is very complicated; time consuming due to the use of different episode numbers.

One participant questioned *"Why do we need different episode numbers before ordering for images? We are receiving large number of cancellation from radiology department as the ordering doctor did not select the specific episode. Why it is so complicated? It can be made simpler if we get rid of different episode for each order"*.

The implementation of PACS decreased radiologists workflow (Horii et al., 2000). In conventional method, the workflow has resulted in a bottleneck for the hospital resulting in many consequences affecting both the clinical and administrative staff and patients, give rise to numerous and serious risk management issues in the hospital (McGuinness, 2009). The study conducted by the Lindsay and others reported about 56% of clinicians felt that PACS improved working patterns for medical staff (Lindsay et al., 2011).

Though the radiologist's realisation level was higher than their expectation level, it remains lowest among other PACS benefits. Potential reasons for this include: an

unwillingness to embrace new technology,   technology not being customised to their exact needs (such as episode numbers).

Test Statistics[a]

	Realisation- less complicated workflow/ordering – Expectation- Less complicated workflow/ ordering
Z	-1.715[b]
Asymp. Sig. (2-tailed)	.086

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 16 Wilcoxon Signed Rank Test- Less complicated radiology workflow/ ordering

4.5.11.   *Benefit item - PACS provides* simultaneous review of images in more than location:

The user's expectation level of PACS was slightly higher than their realisation level. The statistical significance of participant's expectation and realisation difference shows the *Z score of -1.417* (See table 4- 17) which is not significant. The radiologists agreed realising this benefit item, whereas clinician's expectations remained high.

Test Statistics[a]

	Realisation- Simultaneous review of images in more than one location - Expectation- Simultaneous review of images in many locations
Z	-1.417[b]
Asymp. Sig. (2-tailed)	.157

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 17 Wilcoxon Signed Rank Test- Simultaneous review of images in more than one location

PACS integrates radiology results and images with patient demographics, laboratory reports, electronic orders, scheduling information, and patient episodic history for the clinicians at any PC throughout the organisation (McGuinness, 2009). Also, PACS enables to view same image by several professionals at different locations (Hood and Scott, 2006).

4.5.12.   Benefit item - PACS is user friendly:

The result shows a wide difference between the participant's realisation level *(3.92 out of 5)* and expectations level *(4.63 out of 5).*   The *Z score -6.080* (See table 4- 18) shows that user's expectation were not achieved and the null hypothesis is rejected. Both the radiologist's and clinician's realisation level were low.

Test Statistics[a]

	Realisation- User friendly – Expectation- User friendly
Z	-6.080[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 18 Wilcoxon Signed Rank Test- PACS system is user-friendly

The result of this study is not exceptional to other studies, where the users have complained that PACS is not user friendly. The main perceived disadvantage of PACS noted are system failures/ can't logon, moving between systems (Top, 2012). The participants in this study have complained that PACS is not user friendly due to many reasons: *'need better access codes', 'more user friendly screens', 'less complicated system to view the images', 'easier navigation' and other.*

One participant claimed *"I think the monitor size could be made larger. Access to PACS is a problem - it should be a card access also PACS access and McKesson Access codes are not identical i e, you are asked to change passwords at different times"*. Another participant claimed *"technical issues eg certain prompts are not user friendly 'this study is being reported by another user' comes up when you try to dictate a study if any of their current or previous imaging is being viewed by another user"*.

4.5.13.   Benefit item - PACS is reliable:

For the benefit item *'Reliability'* of PACS, user expectations level *(4.62 out of 5)* was higher than their realised level *(4.24 out of 5)*. The *Z score -4.551* (See table 4- 19) shows that user expectations are not achieved with PACS *'reliability'* benefit item and the null hypothesis is rejected. Both the radiologists and clinicians realised level mean scores were lower than expectations level.

Pilling (2002) claimed that PACS implemented in the Norfolk and Norwich University Hospital in 2001 showed highly reliable. Conversely, about 20% of the respondents from the study conducted by Tan and Lewis (2010) reported that PACS was not reliable and claimed that they could not use the system at least 1 week in a year.

Test Statistics[a]

	Realisation- Reliable - Expectation- Reliability
Z	-4.551[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 19 Wilcoxon Signed Rank Test- Reliability of PACS

4.5.14. Benefit item - PACS increases confidence in patient diagnosis:

User's expectations *(4.26 out of 5)* were higher than their realised level *(4.05 out of 5)* that PACS increases their confidence in patient diagnosis. The *Z score -2.461* (See table 4- 20) shows that user's expectations were not achieved with this benefit item and null hypothesis is rejected. Though radiologists claim that PACS increased their confidence, the clinician's disagreed. The possible reason may be their professional expertise. Unlike clinicians, radiologists generally review images and provide reports about diagnosis.

Around 94% respondents from the study conducted by Lindsay et al. (2011) in Northern Ireland felt that radiology reports were either *'informative and decisive'* or provided *'a useful list of differentials'*. Supporting, Top (2012) claims that "*PACS is one of the most valuable tools supporting the medical profession both in decision making and during the treatment procedures*".

Test Statistics^a

	Realisation- Increases confidence in patient diagnosis - Expectation- Increases confidence in patient diagnosis
Z	-2.461^b
Asymp. Sig. (2-tailed)	.014

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 20 Wilcoxon Signed Rank Test- PACS increases confidence in patient diagnosis

4.5.15. Benefit item - Full satisfaction with PAC system:

In this benefit item of PACS, the user expectations *(4.06 out of 5)* were higher than their realised level *(3.92 out of 5)*. The *Z score -1.596* (See table 4- 21) shows no statistical significance difference in the results. Interesting point to note was both

radiologist's and clinician's realisation levels were lower than their expectations level. This shows that they were not satisfied with the present PACS in the hospital.

Test Statistics[a]

	Realisation- Full satisfaction – Expectation- Full satisfaction
Z	-1.596[b]
Asymp. Sig. (2-tailed)	.110

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 21 Wilcoxon Signed Rank Test- Full satisfaction with PACS

The result agree to the study conducted by Bryan and colleagues, where both providers and clinical users were highly satisfied PACS (Bryan et al., 1999a). in addition, Wadley and colleagues describes that the implementation of PACS in Santa Barbara, California has shown a high level of satisfaction among its users (Wadley et al., 2002).

In the study conducted by Lindsay and colleagues, clinicians felt that the approachability of radiologists was the key factor significantly associated with the increased satisfaction and this overall satisfaction was not related to their opinion of PACS system (Lindsay et al., 2011). Similarly, one participant from this study complained that *"radiology department is the most difficult department of any hospital. Besides changing PACS system we need to change the attitudes of radiologists and radiographers"*.

About 56% of the physicians preferred PACS and felt less frustrated due to instant availability of images and no physical handling of the films and films jackets in the study by Top (2012). In addition, a participant from this study stated that *"PACS/McKesson is excellent resource for AMU (Acute Medical Unit) as rapid access to*

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results with a great built in governance structure. It improves the rate of patient turnover in our rapid assessment unit as images come through instantly and reports very soon after facilitating earlier discharge of patients and therefore improves patient care flow much more efficient system".

4.5.16. Benefit item - PACS is cost efficient:

The researcher noted that the mean scores of user expectations *(4.18 out of 5)* were higher than user's benefit realisation (*3.97 out of 5).* There is a statistically significant difference *(Z= -2.928)* between the expectations and realisation levels. This clearly indicates that user's expectation of PACS being *'cost efficient'* is not achieved and the null hypothesis is rejected. However, there is a contradictory opinion among the radiologists and clinicians about the cost efficiency of PACS. Radiologists believe PACS is cost efficient and they scored higher realisation level than their expectations. Conversely, the clinicians scored lesser realisation level than their expectations.

PACS study in Austria by Gell (2006) claims that if the aim of PACS is to decrease cost then the success is doubtful. In Reggio Emilia Hospital Santa Maria Nuova, Nitrosi et al. (2007) conducted a study to evaluate PACS. In this study, the investigators noted the decrease in the length of patients stay in different department patients resulted in the economic benefits to the hospital with estimated actual economic benefit of hundreds of thousands of dollars. However, annual financial upsides have exceeded $1.9 million/annum.

A study by Bryan et al. (1999a) reported that PACS increased running costs with the cost of 1.7 million Pounds per annum (annual equivalent replacement cost: 0.8 million Pound). Conversely many researchers perceived the cost benefit from PACS. A study by Mansoori et al. (2012) in Ohio University Hospital Case Medical Center (UHCMC), reported the overall cost reduction due to implementation of PACS was $3.2 million in 5 years. This includes cost saving by reduced purchases of film and

related cost, eliminated lost or unreported and repeat rate of films. The cost saving also included reduction of courier related expenses by 12% in year one and 60% by year five.

PACS eliminates film cost, film processing, and ongoing repair maintenances for equipment, ongoing storage cost, substantial personnel and valuable hospital space costs for a large film library (Fang et al., 2006, Mansoori et al., 2012, Bick and Lenzen, 1999). Fang and colleagues measured PACS and conventional method cash and running costs over an 8-year time horizon. The net present value (NPV) for PACS operation is US $1,598,698, whereas the NPV for film based operation was US $2,083,856, indicating a net saving of US $485,157 (Fang et al., 2006).

In Ireland, St. James hospital reported that after PACS implementation the film cost reduced by approximately 430,000 Euros per annum and staff savings of over 150,000 per annum (O'Hare, 2008). Supporting, many of the risk factors mentioned that PACS can alleviate include: unavailability of patient films, delays in reporting; reporting without access to previous films copies, have the potential expose the hospital to significant medico-legal cases, and consequently, costs (McGuinness, 2009).

After reviewing the above studies, the researcher assumes that the participants especially the clinicians were not aware about possible PACS cost reductions in the hospital as seen in other studies. One participant from this study supported that "*I do not know how much PACS cost but I do believe it is worth any money spent*".

Test Statistics[a]

	Realisation- Cost efficient - Expectation- Cost efficient
Z	-2.928[b]
Asymp. Sig. (2-tailed)	.003

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 22 Wilcoxon Signed Rank Test- PACS is cost efficient

4.5.17. Benefit item - PACS enables effective communication among clinical members:

The participant's expectations *(4.16 out of 5)* were slightly higher than the realisation level *(4.02 out of 5)*. There is no statistical significant difference *(Z= -1.742)* noted and participant's expectations were realised (See table 4- 23). The radiologist's realisation level was slightly higher than their expectations level whereas, clinician's realisation level was lower than their expectations.

The study by Reiner (1998) claims that clinician's access to images and reports decreased the frequency of radiologist consultation. In addition, Naul and Sincleair (2001) reports that PACS has a tendency to decrease the communication between the clinicians and radiologists. Conversely, according to Crowe and Sim (2005), PACS/RIS improved clinical communication by senior clinicians with clinical colleagues. Also, this has led to better scheduling of surgical operations and the communication between the departments improved.

From the study conducted by Aas in Norway, participants reported that PACS reduces the contact between the radiologists and clinicians. Also, the respondents were concerned that medical students may not select radiology as a speciality due to reduced contact between the radiologists and patients (Aas, 2006). Conversely, 61% of survey participants were satisfied with PACS ability to facilitate the communication among clinical members to discuss about an image at different work stations (Singh et al., 2007). In addition, 93% clinicians reported that radiology staff positively expressed interest in discussing clinical cases with referring clinicians (Lindsay et al., 2011).

Fridell and colleagues conducted a qualitative study in Sweden to analyse the effect of PACS on the practice of orthopaedic surgeons in relation to radiologists. They analysed professional role category before and after digitisation. The study reported that PACS has created new possibilities for orthopaedic surgeons and radiologists to

work more closely together in different teams (Fridell et al., 2011). Also, the working trend changed to multidisciplinary way of working. Supporting, Lindsay and colleagues states that the traditional relationship between referring clinicians and the radiology departments in the hospitals are markedly changed by the introduction of PACS and tele-radiology systems (Lindsay et al., 2011).

Test Statistics[a]

	Realisation- Enable effective communication among clinical members - Expectation- Enables effective communication of clinical members
Z	-1.742[b]
Asymp. Sig. (2-tailed)	.081

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 4- 23 Wilcoxon Signed Rank Test- PACS enables effective communication of clinical members

4.6. Results and discussion conclusion:

In this chapter, the researcher conducted detailed analysis of data collected from the survey. The chapter commenced with describing the reliability and validity of the results followed by the general demographics of the participants.

The researcher explained in detail about the descriptive statistics of user's expectations level and realisation level. The researcher compared user's benefit expectations and subsequent realisation level. Further, the radiologists and clinician's expectations level and realisation level were compared separately. The researcher conducted hypothesis testing for each benefit item to determine the statistical significance of the results and discussed in detail.

In the next chapter, the researcher concludes the study and provides detailed recommendation for the future and limitations of the study.

CHAPTER 5

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction:

The researcher conducted the present study to evaluate the benefit expectations and realisation of PACS in the hospital. In this study, the researcher carried out an extensive literature review and conducted a survey of PACS users. The findings from the study are discussed in the previous chapter. This is the last chapter of the present study. In this chapter, the researcher concludes the study and provides the recommendations to other researchers for the future study. At the end, this chapter contains detailed limitations of the study.

5.2. Conclusion:

The ability of PACS to deliver a real service to health care and the ability to support the users in their work and goals are very important. The researcher conducted this study with the aim to evaluate the user's benefit expectations and realisation of PACS. User's responses from the study and extensive literature review about PACS benefits helped the researcher to conclude the present study by answering the main research questions as follows:

5.2.1. **User's level of benefit expectations of PACS**:

Like in any other technology implementation in the hospital, the present study users were also had high expectations from PACS. Though both radiologists and clinicians showed higher expectations, the clinician's level of expectations were high for majority of benefit

items. This may be due to their less exposure to digital radiological services in the hospital. Both radiologist's and clinician's expectations were low that PACS will have less complicated workflow or ordering.

5.2.2. **User's level of benefit realisation**:

The user's realisation levels varied for different benefit items in this study. The radiologists scored higher realisation scores for majority of benefit items than the clinicians. This explains that radiologists use PACS regularly unlike clinicians. The clinicians utilises PACS mainly to order tests and procedures for patients and to retrieve images and/ or reports.

5.2.3. **Comparison between user's benefit expectations and realisation**:

The researcher compared the user's expectations and realisation of benefits level. Most of the benefits realisation levels of users were low compared to their expectation levels except for the benefit items *'quality of images is diagnostic'*. Radiologists' realised majority of PACS benefits in contrary to clinicians.

The hypothesis testing on each individual benefits expectations and realisation conducted. Although benefit expectations level scores were higher than benefit realised, the benefits which were not achieved and the statistical significance of difference noted only for the benefit items: *'saves staff time'*, *'increases clinical efficiency'*, *'less time finding images/reports'*, *'user-friendly'*, *'reliable'*, *'increased confidence in patient diagnosis'*, and *'cost efficient'*. These results clearly provides conclusion that the benefit expectation of PACS are not fully realised by its users in the hospital.

5.2.4. **Comparison between the radiologist's and clinician's expectations and realisation of PACS benefits**:

The results show that radiologists realised majority of PACS benefits. However, they were not satisfied with the current PAC system in the hospital. On the other hand, the clinician's realisation levels were far short of all their expectations except the benefit item *'quality of images is diagnostic'*. Both radiologists and clinicians claim that PACS is not user friendly and reliable.

The current system is already implemented in many Irish hospitals under NIMIS project. Both radiologists and clinicians are not satisfied with the system used in the hospital and found to be not user-friendly and reliable. The researcher considers this as a matter of concern. This may result in user resistance, low productivity of users and may delay in realising further benefits.

The other concern is about benefit item '*less complicated workflow/ordering*' due to PACS. Unlike user's high expectations and realisation level for other benefit items, users had low expectation as well as low realisation level. This may suggest that the problem is ongoing and change to PACS hasn't resolved it completely.

PACS is a relatively new technology implemented in the researcher's hospital. Despite spending millions of Euros, PACS benefits are not fully realised by its users as noted in the present study. Based on the study results, the researcher's answer to the question asked at the beginning of the study is *'currently, PACS hasn't completely revolutionised the clinical practice and it is simply an automated process in health sector'*. So, the researcher doubts the justification of the money spent on PACS. However, PACS has a potential to deliver many benefits as noted in other studies. So, the researcher hopes that PACS will revolutionise the clinical practice and users will realise those benefits in the near future. In order, researcher suggests the project team to evaluate the system regularly, resolve the issues identified, and provide support and user training for successful benefit realisation.

5.3. Recommendations for the future:

The researcher conducted this study to evaluate the user's benefit realisation of PACS. The researcher used *'one group both before and after'* method in this study as PACS has been already implemented in the researcher's hospital. Though this evaluation of PACS benefits expectations and realisation by same individual participants eliminates the chances of biased results, the chances of participant's remembering their PACS expectations may not be accurate. So, the researcher recommends measuring the user's expectations before implementing PACS in other hospitals. The researcher also recommends assessing the pre PACS measurements such as the turnaround time, cost, and patient length of stay in order to compare PACS impact after implementation.

The present study recruited users only from the tertiary level hospital. The researcher recommends assessing the impact of PACS in primary and secondary level in Ireland.

Many participants reported that PACS is not user friendly and reliable. They also expressed dissatisfaction with the current PACS in the hospital. These issues of PACS require further evaluation in the future. The researcher recommends PACS project manager and the system provider to consider these issues and resolve before its negative impact on the users.

5.4. Study limitations:

Though there are number of positive aspects in this research, there are a number of limitations noted by the researcher. First, the measurement of benefit expectations of PACS should have been done before implementation of PACS in the hospital. The separate measurement of PACS expectations and realisation of benefits research would have yielded more accurate results.

The second limitation was, the study included the medical professionals at consultant and SPR/ registrar status. PACS has been used by other medical professionals, including Senior Health Officers (SHO), interns, nurses, radiographers, physiotherapists and other were omitted from this study.

The third limitation was, the researcher didn't measure the actual impact of PACS such as TAT, patient's length of stay, cost as there was no pre PACS data available to compare against.

Finally, the researcher used the quantitative method to evaluate the benefits of PACS. In addition, the study queried participants about how to improve PACS and its impact on saving staff time. However, the user's actual experiences and concerns about PACS individual benefit items were not enquired.

References:

AAS, I. M. 2006. *Organizational centralization in radiology. Journal of telemedicine and telecare, 12,* 27-32.

AGGARWAL, R. & REZAEE, Z. 1996. *Total quality management for bridging the expectations gap in systems development. International Journal of Project Management, 14,* 115-120.

ALDOSARI, B. 2012. *User acceptance of a picture archiving and communication system (PACS) in a Saudi Arabian hospital radiology department. BMC Medical Informatics and Decision Making, 12,* 44.

ALEXANDER H. TOLEDO, ROBERT FLIKKEMA & TOLEDO-PEREYRA, L. H. 2011. *Developing the Research Hypothesis. Journal of Investigative Surgery, 24,* 191-194.

ASHURST, C. & DOHERTY, N. 2011. *Benefits Realization from Information Technology, Palgrave Macmillan.*

ASHURST, C. & DOHERTY, N. F. 2003. *Towards the formulation of a 'best practice'framework for benefits realisation in IT projects. Electronic Journal of Information Systems Evaluation, 6,* 1-10.

ASHURST, C. & HODGES, J. 2010. *Exploring Business Transformation: The Challenges of Developing a Benefits Realization Capability. Journal of Change Management, 10,* 217-237.

AYAL, M. & SEIDMAN, A. 2009. *An empirical investigation of the value of integrating enterprise information systems: The case of medical imaging informatics. Journal of Management Information Systems, 26,* 43-68.

AYAL, M. & SEIDMANN, A. *On the economic role of ris/pacs in healthcare: an empirical study. System Sciences, 2009. HICSS'09. 42nd Hawaii International Conference on, 2009. IEEE, 1-10.*

BABBIE, E. R. 1990. *Survey research methods, Wadsworth Publishing Company Belmont, CA.*

BANSAL, G. 2006. *Digital radiography. A comparison with modern conventional imaging. Postgraduate medical journal, 82,* 425-428.

BAUMAN, R. A. & GELL, G. 2000. *The reality of picture archiving and communication systems (PACS): a survey. Journal of Digital Imaging, 13,* 157-169.

BENNINGTON, P. & BACCARINI, D. 2004. *Project benefits management in IT projects-an Australian perspective. Project management journal, 35,* 20-30.

BERNARD, H. R. 2011. *Research methods in anthropology: Qualitative and quantitative approaches, Altamira press.*

BICK, U. & LENZEN, H. 1999. *PACS: the silent revolution. European Radiology, 9,* 1152-1160.

BOOTE, D. N. & BEILE, P. 2005. *Scholars before researchers: On the centrality of the dissertation literature review in research preparation. Educational researcher, 34,* 3-15.

BRADLEY, G. 2010. *Benefit Realisation Management: A Practical Guide to Achieving Benefits Through Change*, Gower Publishing Company.

BRAUN, J., MOHAN, K. & AHLEMANN, F. 2010. How benefits from IS/IT investments are successfully realized: The role of business process know how and benefits management practices. *ICIS 2010 Proceedings*.

BRYAN, S., WEATHERBURN, G., BUXTON, M., WATKINS, J., KEEN, J. & MURIS, N. 1999a. Evaluation of a hospital picture archiving and communication system. *Journal of health services research & policy,* 4**,** 204.

BRYAN, S., WEATHERBURN, G. C., WATKINS, J. R. & BUXTON, M. J. 1999b. The benefits of hospital-wide picture archiving and communication systems: a survey of clinical users of radiology services. *British Journal of Radiology,* 72**,** 469-78.

CALDEIRA, M., SERRANO, A., QUARESMA, R., PEDRON, C. & ROMÃO, M. 2012. Information and communication technology adoption for business benefits: A case analysis of an integrated paperless system. *International Journal of Information Management,* 32**,** 196-202.

CHEN, J., BRADSHAW, J. & NAGY, P. 2011. Has the Picture Archiving and Communication System (PACS) Become a Commodity? *Journal of Digital Imaging,* 24**,** 6-10.

CHURCHILL, G. A. & IACOBUCCI, D. 2009. *Marketing research: methodological foundations*, South-Western Pub.

COLIN, C., VERGNON, P., GUIBAUD, L., BORSON, O., PINAUDEAU, D., PERRET DU CRAY, M. H., PASQUIER, J. M. & TRAN-MINH, V. 1998. Comparative assessment of digital and analog radiography: diagnostic accuracy, cost analysis and quality of care. *European Journal of Radiology,* 26**,** 226-234.

COLLIN, S., REEVES, B. C., HENDY, J., FULOP, N., HUTCHINGS, A. & PRIEDANE, E. 2008. Implementation of computerised physician order entry (CPOE) and picture archiving and communication systems (PACS) in the NHS: quantitative before and after study. *BMJ: British Medical Journal,* 337.

CRESWELL, J. W. 1994. *Research design*, Sage publications Thousand Oaks, CA.

CROWE, B. & SIM, L. 2004. Implementation of a radiology information system/picture archiving and communication system and an image transfer system at a large public teaching hospital—assessment of success of adoption by clinicians. *Journal of telemedicine and telecare,* 10**,** 25-27.

CROWE, B. & SIM, L. 2005. An assessment of the effect of the introduction of a PACS and RIS on clinical decision making and patient management at Princess Alexandra Hospital Brisbane, Australia: Final report—December 2004. *International Congress Series,* 1281**,** 964-967.

DAVERN, M. J. & KAUFFMAN, R. J. 2000. Discovering potential and realizing value from information technology investments. *Journal of Management Information Systems***, 121-143.**

DELONE, W. H. & MCLEAN, E. R. Information systems success revisited. *System Sciences, 2002. HICSS. Proceedings of the 35th Annual Hawaii International Conference on, 2002. IEEE, 2966-2976.*

DHILLON, G. 2005. Gaining benefits from IS/IT implementation: Interpretations from case studies. *International Journal of Information Management, 25***, 502-515.**

DOHERTY, N. F. & KING, M. 2003. From technical change to socio-technical change: towards a proactive approach to the treatment of organisational issues. ed.) Clarke, S., Coakes, E., Hunter, GM and Wenn, A.: Socio-technical and human cognition elements of information systems**, 22-40.**

DUYCK, P., PYNOO, B., DEVOLDER, P., VOET, T., ADANG, L., OVAERE, D. & VERCRUYSSE, J. 2010. Monitoring the PACS Implementation Process in a Large University Hospital—Discrepancies Between Radiologists and Physicians. *Journal of Digital Imaging, 23***, 73-80.**

DUYCK, P., PYNOO, B., DEVOLDER, P., VOET, T., ADANG, L. & VERCRUYSSE, J. 2008. User Acceptance of a Picture Archiving and Communication System--Applying the Unified Theory of Acceptance and Use of Technology in a Radiological Setting. *Methods of information in medicine, 47***, 149-156.**

FAGGIONI, L., NERI, E., CASTELLANA, C., CARAMELLA, D. & BARTOLOZZI, C. 2011. The future of PACS in healthcare enterprises. *European journal of radiology, 78***, 253-258.**

FANG, Y.-C., YANG, M.-C. & HSUEH, Y.-S. 2006. Financial Assessment of a Picture Archiving and Communication System Implemented all at Once. *Journal of Digital Imaging, 19***, 44-51.**

FARBEY, B., LAND, F. & TARGETT, D. 1999. The moving staircase–problems of appraisal and evaluation in a turbulent environment. *Information Technology & People, 12***, 238-252.**

FREEMAN, H. E. 1999. Divergent stakeholder theory. *Academy of management review, 24***, 233-236.**

FRIDELL, K., ASPELIN, P., FELLÄNDER-TSAI, L. & LUNDBERG, N. 2011. The effect of PACS on the practice of orthopaedic surgeons. *Journal of Telemedicine and Telecare, 17***, 137-141.**

GARRARD, J. 2010. *Health sciences literature review made easy, Jones & Bartlett Learning.*

GARVAN, G. 2011. *Health Link; the national health link project. 1.* Available: http://www.healthlink.ie/newsletter10.pdf

GEISLER, E. & TURCHETTI, G. A novel explanation of why organizations fail to adopt proven technologies: The special case of imaging in the healthcare sector. *Technology Management in the Energy Smart World (PICMET), 2011 Proceedings of PICMET '11:, July 31 2011-Aug. 4 2011 2011. 1-10.*

GELL, G. 2006. PACS Development in Austria: A Discussion of Success Criteria and Success Factors. *Methods of Information in Medicine 45***, 102-107.*

GOH, K. H. & KAUFFMAN, R. J. 2006. MEASURING THE POTENTIAL AND REALIZED VALUE OF IT1.

GRAY, D. E. 2009. Doing research in the real world, SAGE Publications Limited.

HEALTH MATTERS 2010. National Staff Magazine for the Health Service Executives. . Health Matters National Staff Magazine for the Health Service Executives.

HEALTH SERVICE EXECUTIVE. 2012. Welcome to NIMIs project [Online]. Available: www.hse.ie/eng/services/News/NIMIS/ [Accessed 10th Jan 2013].

HECHT, M. 2008. PACS-Picture Archiving and Communication System. Vienna University of Technology, University of Paderborn.

HELFERT, M. 2009. Challenges of business processes management in healthcare: Experience in the Irish healthcare sector. *Business Process Management Journal, 15***, 937-952.*

HOOD, M. N. & SCOTT, H. 2006. Introduction to Picture Archive and Communication Systems. *Journal of Radiology Nursing, 25***, 69-74.*

HORII, S., FEINGOLD, E. & KUNDEL, H. 2000. Radiology workflow and patient volume: effect of picture archiving and communication systems on technologists and radiologists. *Journal of Digital Imaging, 13***, 97-100.*

JAJROUDI, M. & AZIZIAN, A. R. 2010. Assessment of Cost Benefits of Establishing Picture Archiving and Communication Systems (PACS) in Clinical Centers Using Economic Models. *Iranian Journal of Radiology, 7.*

JANKOWICZ, A. D. 2005. Business research projects, Cengage Learning Business Press.

KOTHARI, C. 2009. Research methodology: methods and techniques, New Age International.

KUMAR, R. 2011. Research methodology, APH publishing.

LEDERER, A. L. & MIRANI, R. 1995. Anticipating the benefits of proposed information systems. *Journal of Information Technology (Routledge, Ltd.), 10***, 159.*

LEE, I. 2004. Evaluating business process-integrated information technology investment. *Business Process Management Journal, 10***, 214-233.*

LEMKE, H. U. 2011. Short history of PACS (Part II: Europe). *European Journal of Radiology, 78***, 177-183.*

LETTIERI, E. & MASELLA, C. 2009. Priority setting for technology adoption at a hospital level: Relevant issues from the literature. *Health policy, 90***, 81-88.*

LIN, C. & PERVAN, G. 2003. The practice of IS/IT benefits management in large Australian organizations. *Information & Management, 41***, 13-24.*

LINDSAY, R., MCKINSTRY, S., VALLELY, S. & THORNBURY, G. 2011. What influences clinician's satisfaction with radiology services? Insights into imaging, 2, 425-430.

LOISELLE, C. G., PROFETTO-MCGRATH, J., POLIT, D. F. & BECK, C. T. 2004. Canadian essentials of nursing research, Lippincott Williams & Wilkins.

MACDONALD, D. & NEVILLE, D. 2010. Evaluating the Implementation of Picture Archiving and Communication Systems in Newfoundland and Labrador—a Cost Benefit Analysis. Journal of Digital Imaging, 23, 721-731.

MACDONALD, D. D. 2011. Assessing physicians perceptions of the benefits of PACS- a regional survey pre and post PACS implementation. DI Europe. UK: DI Europe Ltd.

MACKINNON, A. D., BILLINGTON, R. A., ADAM, E. J., DUNDAS, D. D. & PATEL, U. 2008. Picture archiving and communication systems lead to sustained improvements in reporting times and productivity: results of a 5-year audit. Clinical Radiology, 63, 796-804.

MANSOORI, B., ERHARD, K. K. & SUNSHINE, J. L. 2012. Picture Archiving and Communication System (PACS) Implementation, Integration & Benefits in an Integrated Health System. Academic Radiology, 19, 229-235.

MCGUINNESS, S. 2009. PACS/RIS Implementation. Management and Patient Solutions PACS/ RIS PROJECT BUSINESS CASE.

MEHTA, A., DREYER, K., BOLAND, G. & FRANK, M. 2000. Do picture archiving and communication systems improve report turnaround times? Journal of digital imaging, 13, 105-107.

MORSE, J. M. & FIELD, P. A. 1995. Qualitative research methods for health professionals, Sage.

MULLINS, M. E., MEHTA, A., PATEL, H., MCLOUD, T. C. & NOVELLINE, R. A. 2001. Impact of PACS on the Education of Radiology Residents: The Residents' Perspective. Academic radiology, 8, 67-73.

NAUL, L. G. & SINCLEAIR, S. T. 2001. Radiology goes filmless. What does this mean for primary care physicians? Postgraduate medicine, 109, 107.

NITROSI, A., BORASI, G., NICOLI, F., MODIGLIANI, G., BOTTI, A., BERTOLINI, M. & NOTARI, P. 2007. A Filmless Radiology Department in a Full Digital Regional Hospital: Quantitative Evaluation of the Increased Quality and Efficiency. Journal of Digital Imaging, 20, 140-148.

O'HARE, N. 2008. National Integrated Medical Imaging System (NIMIS) project- Business case. In: EXECUTIVE, H. S. (ed.). Dublin: Health Service Executive.

PARÉ, G. & TRUDEL, M.-C. 2007. Knowledge barriers to PACS adoption and implementation in hospitals. International journal of medical informatics, 76, 22-33.

PARVINEN, P. & TOLKKI, O. 2007. Using the benefits of picture archiving and communicating systems constraints in stakeholder governance. *International Journal of Healthcare Technology and Management, 8,* 644-660.

PARVINEN, P., TOLKKI, O. & FYHR, N. 2005. *UTILIZING THE BENEFITS OF PICTURE ARCHIVING AND COMMUNICATING SYSTEM–GOVERNANCE CONSTRAINTS.*

PEACOCK, J. & PEACOCK, P. 2010. *Oxford handbook of medical statistics,* OUP Oxford.

PEPPARD, J., WARD, J. A. & DANIEL, E. 2007. Managing the realization of business benefits from IT investments. *MIS Quarterly Executive, 6,* 1–11.

PILLING, J. 2002. Lessons learned from a whole hospital PACS installation. *Clinical Radiology, 57,* 784-788.

PILLING, J. R. 2003. Picture archiving and communication systems: the users' view. *British Journal of Radiology, 76,* 519-524.

PYNOO, B., DEVOLDER, P., DUYCK, W., VAN BRAAK, J., SIJNAVE, B. & DUYCK, P. 2011. Do hospital physicians' attitudes change during PACS implementation? A cross-sectional acceptance study. *International Journal of Medical Informatics.*

RATIB, O., LIGIER, Y., BANDON, D. & VALENTINO, D. 2000. Update on digital image management and PACS. *Abdominal imaging, 25,* 333-340.

REA, L. M. & PARKER, R. A. 2012. *Designing and conducting survey research: A comprehensive guide,* Jossey-Bass.

REDDY, A. S., LOH, S. & KANE, R. A. 2006. Budget variance analysis of a departmentwide implementation of a PACS at a major academic medical center. *Journal of Digital Imaging, 19,* 66-71.

REINER BI, SIEGEL EL & HOOPER FJ, E. A. 1998. Effect of film-based versus filmless operation on the productivity of CT technologists. *Radiology,*

207, 481–448.

REINER, B. I., SIEGEL, E. L. & HOOPER, F. J. 2002. Accuracy of Interpretation of CT Scans: Comparing PACS Monitor Displays and Hard-Copy Images. *American Journal of Roentgenology, 179,* 1407-1410.

REISS, G. 2006. *Handbook of Programme Management,* Gower Publishing Company, Limited.

REMENYI, D. & SHERWOOD-SMITH, M. 1998. Business benefits from information systems through an active benefits realisation programme. *International Journal of Project Management, 16,* 81-98.

SAPOUNTZIS, S., HARRIS, K. & KAGIOGLOU, M. 2007. Benefits realisation process for healthcare.

SAPOUNTZIS, S., YATES, K., KAGIOGLOU, M. & AOUAD, G. 2009. *Realising benefits in primary healthcare infrastructures. Facilities, 27, 74-87.*

SCHUBERT, P. & WILLIAMS, S. P. 2009. *Constructing a framework for investigating and visualizing ERP benefits and business change. Proceedings of the 22nd International Bled eConference, 14-17.*

SHTUB, A., BARD, J. F. & GLOBERSON, S. 2005. *Project management: Processes, methodologies, and economics, Pearson Prentice Hall.*

SHUEN, W. M. V. 2010. *Impact of PACS in fracture clinic.*

SIEGEL, E. L. & REINER, B. I. 2003. *Filmless radiology at the Baltimore VA Medical Center: a 9 year retrospective. Computerized medical imaging and graphics : the official journal of the Computerized Medical Imaging Society, 27, 101-109.*

SINGH, S., GULATI, A., HARRISON, B. D., CURTIN, J. J. & SEATON, D. 2007. *Picture archiving and communications system (PACS): the benefits and problems of digital imaging in the NHS. Clinical medicine, 7, 202-203.*

SIRCAR, S., TURNBOW, J. L. & BORDOLOI, B. 2000. *A framework for assessing the relationship between information technology investments and firm performance. Journal of Management Information Systems, 69-97.*

SMITH, D. C., DOMBO, H. & NKEHLI, N. *Benefits realisation management in information technology projects. Management of Engineering & Technology, 2008. PICMET 2008. Portland International Conference on, 27-31 July 2008 2008. 1442-1455.*

SZAJNA, B. & SCAMELL, R. W. 1993. *The effects of information system user expectations on their performance and perceptions. Mis Quarterly, 493-516.*

TAN, S. L. & LEWIS, R. A. 2010. *Picture archiving and communication systems: A multicentre survey of users experience and satisfaction. European Journal of Radiology, 75, 406-410.*

THORP, J. 2002. *A benefits realization approach to IT investments. Information Systems Evaluation Management, 75.*

TOP, M. 2012. *Physicians' Views and Assessments on Picture Archiving and Communication Systems (PACS) in Two Turkish Public Hospitals. Journal of medical systems, 36, 3555-3562.*

TURCHETTI, G. & GEISLER, E. *Health technology assessment in the context of private and public models of national health systems. Management of Engineering & Technology, 2009. PICMET 2009. Portland International Conference on, 2-6 Aug. 2009 2009. 2983-2985.*

TWAIR, A., TORREGGIANI, W., MAHMUD, S., RAMESH, N. & HOGAN, B. 2000. *Significant savings in radiologic report turnaround time after implementation of a complete picture archiving and communication system (PACS). Journal of Digital Imaging, 13, 175-177.*

VAN DE WETERING, R., BATENBURG, R., VERSENDAAL, J., LEDERMAN, R. & FIRTH, L. 2006. A balanced evaluation perspective: picture archiving and communication system impacts on hospital workflow. J Digit Imaging, 19 Suppl 1, 10-7.

WADLEY, B. D., HAYWARD, U., TRAMBERT, M., KYWI, A. & HARTZMAN, S. 2002. Are referring doctors ready for enterprise and community wide immediate image and report access? Journal of Digital Imaging, 15, 140-143.

WAGER, K. A., LEE, F. W. & GLASER, J. P. 2009. Health care information systems: a practical approach for health care management, Jossey-Bass.

WAKEFIELD, D. S., HALBESLEBEN, J. R. B., WARD, M. M., QIU, Q., BROKEL, J. & CRANDALL, D. 2007. Development of a measure of clinical information systems expectations and experiences. Medical care, 45, 884-890.

WARD, J. & DANIEL, E. 2012. Benefits Management: How to Increase the Business Value of Your IT Projects, Wiley.

WARD, J., TAYLOR, P. & BOND, P. 1996. Evaluation and realisation of IS/IT benefits: an empirical study of current practice. European Journal of Information Systems, 4, 214-225.

WARD, J. L. & DANIEL, E. 2006. Benefits management: delivering value from IS and IT investments, Wiley.

WARD, R., STEVENS, C., BRENTNALL, P. & BRIDDON, J. 2008. The attitudes of health care staff to information technology: a comprehensive review of the research literature. Health Information & Libraries Journal, 25, 81-97.

WATKINS, J., WEATHERBURN, G. & BRYAN, S. 2000. The impact of a picture archiving and communication system (PACS) upon an intensive care unit. European Journal of Radiology, 34, 3-8.

WESTBROOK, J. I. & BRAITHWAITE, J. 2010. Will information and communication technology disrupt the health system and deliver on its promise? Medical Journal of Australia, 193, 399.

YATES, K., SAPOUNTZIS, S., LOU, E. & KAGIOGLOU, M. 2009. BeReal: Tools and methods for implementing benefits realisation and management.

Appendix 1. Details of the Hospitals using NIMIS RIS/PACS (On live before 1st September)

Beaumont Hospital and St. Joseph's Raheny	Mater University Hospital
Sligo General Hospital and Manor	Waterford Regional Hospital
Our Lady of Lourdes, Drogheda	Cavan General Hospital
Our Lady's Children Hospital, Crumlin	Our Lady's, Navan
St. Lukes Hospital, Rathgar	Louth County Hospital,
St. Lukes Hospital, Kilkenny	Connolly Hospital, Blanchard town
Mayo General Hospital, Castlebar	Naas General Hospital
South Tipperary General (Clonmel & Cashel)	Wexford General Hospital
Cappagh National Orthopaedic Hospital	National Rehabilitation Hospital
Louth County Hospital, Dundalk	Saint Columcille's Hospital
Mid West Regional- Dooradoyle	Portincula Hospital, Ballinasloe
Mid West Regional- Limerick Maternity	Mid West Regional- Nenagh
Mid West Regional- Ennis	Mid West Regional- Croom

List of hospitals due to go live in 2013

Midlands Regional Hospital Tullamore	Midlands Regional Hospital Mullingar
Midlands Regional Hospital Port Laois	Kerry General Hospital
South Infirmary Victoria Hospital.	

Appendix 2. The Clinical Process in the Department Before it Goes Filmless
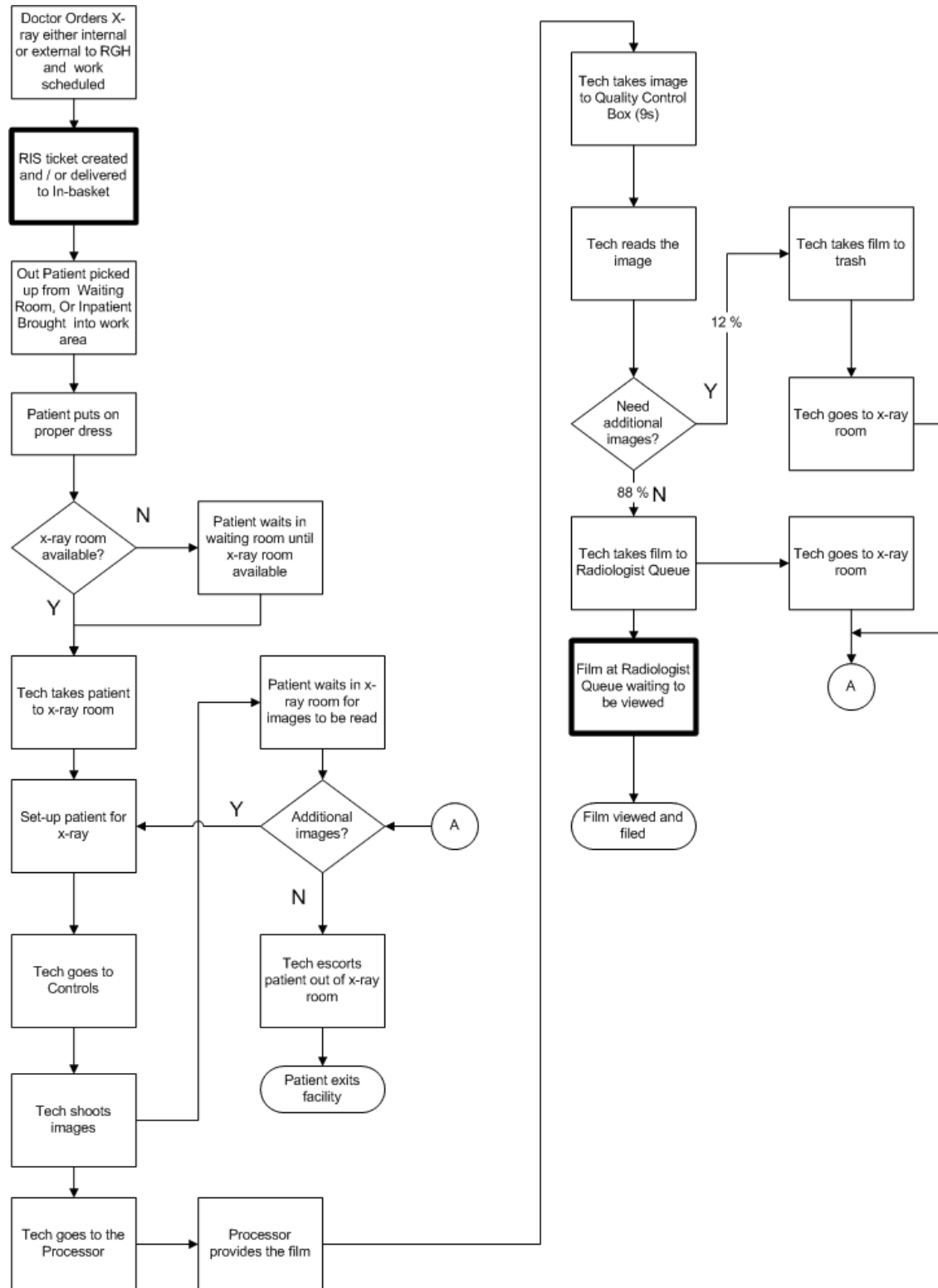
(Retrieved from Ayal and Seidmann (2009, p. 4)).

Appendix 3. Benefits types:

Observable	Benefits on the basis of experience, an expert or a specific group of people uses agreed criteria to decide to what extent the benefits have been realized
Measurable	Benefits that are currently being measured or appropriate measures can be implemented, but it is not possible to estimate within a reasonable degree of rigor, the future improvement of organizational processes when the changes are completed.
Quantifiable	Benefits provide sufficient evidence of how much improvement should result from the implementation of the new system.
financial	a financial value can be calculated

(Retrieved from Caldeira et al. (2012, p. 197))

Tangible (hard/Direct)	Judged objectively, uses quantitative measures which are often but not always financial
Intangible (soft/indirect)	Judged subjectively and tend to employ qualitative measures, often difficult to measure and almost always difficult to convert to monetary values
By organisational or business impact	These come in five different business streams: strategic; management; operational; functional; support
By stakeholder or actor-oriented	Classification of benefits and disbenefits according to the stakeholder (groups) who will feel or experience their impact. In an investment, project or programme the actors/stakeholders can be classified in four main categories: providers; acceptors; supporters; controllers, both human or organisational
Unplanned/Emergent	These are often a consequence of a change implemented or another benefit gained. They are documented in business cases as a result of a change or an investment

(Retrieved from Sapountzis et al. (2009, p. 78))

Appendix 4. Benefit management frameworks:

Approach/model	Details
Active benefits management (Leyton, 1995)	Sets the benefits management activity in the context of business change. Identifies continuous flow between change and benefits
The Cranfield process model of benefits management (Ward *et al.*, 1996)	Key feature of this model is benefits monitoring. This compares project results with the benefits realisation plan during the project and assesses whether any internal or external changes have occurred that will affect the delivery of planned benefits. Potential benefits are identified, a plan is devised for their realisation, the plan is executed, the results reviewed and evaluated and feedback occurs
The benefits realisation approach (BRA) (Thorp, 1998)	Is based on two corner-stones: (1) The shift from standalone project management to: business programme management, disciplined portfolio management, full cycle governance (2) The three necessary conditions for the successful implementation of the BRA are: (a) accountability of activists; (b) relevant measure; and (c) proactive management of change to give people ownership stakes in programs
Active benefit realisation (ABR) (Remenyi and Sherwood-Smith, 1998)	A process for managing information systems' development through a continuous evaluation approach. ABR requires a direct and continuous focus on business benefits realisation and is based on a contingency philosophy
Towards best practice to benefits management (Ashurst and Doherty, 2003)	In this approach benefits realisation is a continuous process through an evolving organisational context. But it does not take into account influences that external factors may have on a project
Managing successful programmes (MSP) (OGC, 2007)	MSP represents the UK Government's view on the programme management principles and techniques. MSP identifies benefits management as "a core activity and a continuous 'thread' throughout the programme" (OGC, 2007), and fundamental to the realisation of benefits from new capabilities delivered by projects within the programme. Emphasis is placed on identification, quantification, assignment of owners and tracking, it has been heavily influenced by Cranfield's benefits management model and Bradley's benefits realisation management 2006
The Gateway™ Process	The Gateway Review Process indicates, at a high level, dependencies between a typical Benefits Management process and the steps for managing a major delivery programme. It also maps the main benefits management steps on to the standard delivery stages described in both MSP and OGC Gateway Reviews, but the approach can be used for any type of more specialised change initiative. This process contains identification of potential benefits, their planning, modelling and tracking, the assignment of responsibilities and authorities and their actual realisation
Benefits management in the *Handbook of Programme Management* (Reiss *et al.*, 2006)	This approach focuses the benefits management model in the delivery of benefits by projects (Nogeste and Walker, 2005). Reiss *et al.* (2006) define the scope of benefits management as "the management and monitoring of benefits during and after execution phase" and depicts the "value path" relationship between benefits and projects as a hierarchical benefits structure (Nogeste and Walker, 2005)

Source: Sapountzis *et al.* (2008a)

Appendix 5. NIMIS Objectives and Benefits Realisation Timetable:

(Retrieved from O'Hare (2008, p. 60))

Project Implementation Start   **0 month**

PD.21	Single approach to procurement

First Individual Site(s) Go-Live: **Start + 8 months**

PD.1	Reduction in Report "Turn-Around" time:
PD.2	Improved clinical consultation
PD.3	Record Retrieval
PD.4	Filmless Hospitals
PD.5	Paperless for all Radiology Requests and Results
PD.7	Streamlining of Radiology Work-processes
PD.11	Improved facilities for academic consultation and teaching
PD.12	Integration of Radiology and Non-Radiology Imaging
PD.13	Improved Access & Availability of Patient Information

PD.14	Optimisation of Radiology Reporting
PD.15	Increased clinical efficiency and accuracy in patient care
PD.16	Fewer repeat examinations
PD.17	ED Waiting Times Reduced
PD.18	Reduction in the need for Transcriptionists
PD.24	Cost savings related to X-Ray film usage and management
PD.26	Cost savings related to film copying
PD.27	Environmental effects
PD.28	Image Transfer Costs
PD.29	Reduced Travel Time
PD.31	Maximum utilisation efficiency of technical staff resources
PD.32	Unreported and lost film
PD.34	Patient Data Security
PD.35	Clinical Audit
PD.37	Support for Research & Development
PD.38	Reduction in collective radiation dose
PD.39	Ensuring a Closed-Loop Process for Test Ordering
PD.40	Linking of Imaging from Different Modalities
PD.41	Utilisation of Computer Aided Detection (CAD)
PD.42	Reduced Medico-Legal Costs
PD.43	Image post-processing

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Central Data Repository Go-Live: **Start + 18 months**

PD.6	Integration with Radiation Oncology Centres
PD.8	Provision of Out-Of-Hours Cover
PD.10	Remote / Outsourced Reporting
PD.33	Images follow patient through Care Pathway
PD.45	Aiding Development within Primary Care
PD.46	Facilitate the HSE Transformation Programme

Project Completion: **Start + 30 months**

PD.9	Cornerstone to development of a full EPR
PD.19	System Training Efficiencies
PD.20	Provision of Management Information
PD.22	Removal of the need to manage the storage of x-ray film
PD.23	Space Reductions
PD.25	Offsite Storage of X-Ray Films
PD.30	Removal in the need for Dark room technicians
PD.36	Diagnostic Reference Levels

Appendix 6. Ethics approval from the Trinity College Dublin

Research Ethics <research-ethics@scss.tcd.ie>

to me

12 Feb

Dear Giribabu,

Thank you for these clarifications and revisions. You may now proceed with this study.

We wish you success in your research.

Kind regards

Gillian

Appendix 7: Inforamtion sheet for participants
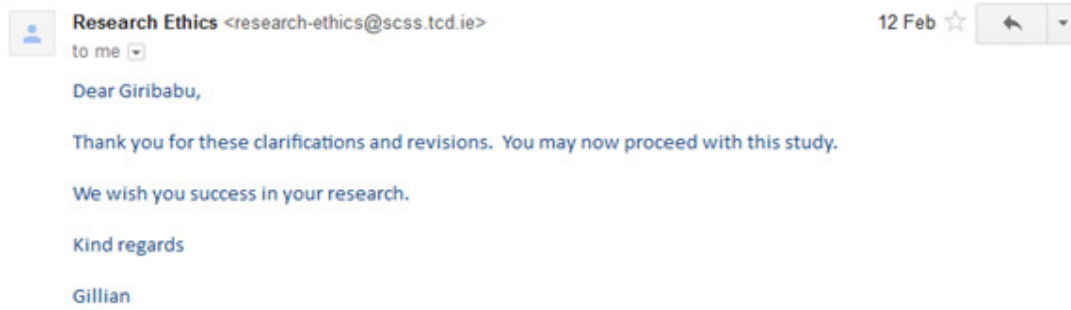
INFORMATION SHEET FOR PARTICIPANTS

Dear Doctor,

BENEFITS EXPECTATIONS AND PERCEIVED BENEFITS REALISATION OF PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS)

You are invited to take part in a service evaluation exercise to assess expectations and benefit realization of the PACS system in Beaumont Hospital. This service evaluation project is part of Master of Sciences in Health Informatics in Trinity College Dublin.

Please take time to read the following information and discuss it with others if you wish. Your participation in this survey is optional/ voluntary but will be much appreciated.

The purpose of the questionnaire is to assess if the introduction of the PACS system in Beaumont Hospital has met the expectations of its user. Filling out the questionnaire should take approximately 15 (fifteen) minutes of your time. I enclose free-post envelopes for your convenience in returning the completed form and copy of signed consent form (copy no 2) separately to me. This information sheet is for you to keep.

You have been asked to complete this survey because you are a Consultant/SPR/Registrar working in Beaumont Hospital and you are among 250 people receiving this questionnaire. Your response will be treated with full confidentiality and all information is completely anonymous.

The information gained from this survey will be conveyed to the PACS Manager in Beaumont Hospital and may be published in peer reviewed journals and conference presentations. You will not be identifiable from any publications.

Please return the completed questionnaire on / before 25th April 2013.

Please do not hesitate to contact me if you need further information.

Yours sincerely,

Mr. Giribabu K. Muniyappa

Staff Nurse

General Intensive Care Unit

087 63 73 153

Appendix 8. Informed Consent form

INFORMED CONSENT FORM (Copy 1)

(Please retain this copy)

Research Title: **BENEFITS EXPECTATIONS AND PERCEIVED BENEFITS REALISATION OF PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS)**

Researcher Name: GIRIBABU KALUKONDANAHALLY MUNIYAPPA

DECLARATION:

- I am 18 years or older and competent to supply consent

- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.

- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.

- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.

- I understand that my participation is fully anonymous and that no personal details about me will be recorded.

- I have received a copy of this agreement.

- In the extremely unlikely event that illicit activity is reported by me during the study, the researcher will be obliged to report it to appropriate authorities.
- I agree to participate in this study

PARTICIPANT'S NAME: ....
PARTICIPANT'S SIGNATURE: ....Date: ..../......../..........

I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS: e mail- kalukong@tcd.ie
                              Mobile- 087 63 73 153
RESEARCHERS SIGNATURE: ....Date: ……/…..../….......

INFORMED CONSENT FORM (Copy 2)

(Please sign and return this copy in a free post envelope provided)

Research Title: **BENEFITS EXPECTATIONS AND PERCEIVED BENEFITS REALISATION OF PICTURE ARCHIVING AND COMMUNICATION SYSTEM (PACS)**

Researcher Name: GIRIBABU KALUKONDANAHALLY MUNIYAPPA

DECLARATION:

- I am 18 years or older and competent to supply consent

- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.

- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.

- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.

- I understand that my participation is fully anonymous and that no personal details about me will be recorded.

- I have received a copy of this agreement.

- In the extremely unlikely event that illicit activity is reported by me during the study, the researcher will be obliged to report it to appropriate authorities.
- I agree to participate in this study

PARTICIPANT'S NAME: ....

PARTICIPANT'S SIGNATURE: ....Date: ..../........./...........

I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS: e mail- kalukong@tcd.ie

Mobile- 087 63 73 153

RESEARCHERS SIGNATURE: ....Date: ……/…../…........

Appendix 9: Survey Questionnaire:

Part 1. General Information/ Demographics

(Each question is optional. Feel free to omit a response to any question; however the researcher would be grateful if all questions are responded to)

1. Gender
   - Male ☐
   - Female ☐

2. Professional qualification
   - Consultant ☐
   - SPR/ Registrar ☐

3. Specialty
   - Radiologist ☐
   - Clinician (All departments) ☐

4. Have you used both conventional and digital imaging system (PACS) in your career?

   Yes ☐   No ☐

5. How long have you used or been using PACS system?

   < 1 year ☐ 1-5 years ☐ >5years ☐

6. Do you personally use the PACS to view images and reports

   Yes ☐   No ☐

7. How long did you use or were you using conventional system?

   < 1 year ☐ 1-5 years ☐ >5years ☐

Part 2. EXPECTED BENEFITS OF PACS

(Each question is optional. Feel free to omit a response to any question; however the researcher would be grateful if all questions are responded to)

<u>Important Note:</u>

Before completing section B, please cast your mind back to the time before the PACS system was implemented in Beaumont Hospital. Please answer the questions below, in as far as you can remember, with the beliefs you've held about PACS then.

Strongly Disagree-1, Disagree-2, Neutral-N/A-3, Agree-4, Strongly Agree-5

1	PACS will provide more rapid access to radiographic images	1	2	3	4	5
2	PACS will provide more rapid access to the radiologist's formal report	1	2	3	4	5
3	PACS will improve continuity of care of patients	1	2	3	4	5
4	PACS will save staff time	1	2	3	4	5
5	PACS will minimize loss of data/films	1	2	3	4	5
6	PACS will increase the efficiency of your clinical practice	1	2	3	4	5
7	PACS will improve the delivery of quality health care	1	2	3	4	5
8	Quality of images will be diagnostic	1	2	3	4	5
9	The time spent finding images & reports will be less	1	2	3	4	5

10	Radiology workflow/ ordering will be less complicated	1	2	3	4	5
11	The ability to review images simultaneously in more than one location will be possible	1	2	3	4	5
12	PACS should be user friendly	1	2	3	4	5
13	PACS should be reliable	1	2	3	4	5
14	PACS should increase confidence in patients diagnosis	1	2	3	4	5
15	Will be fully satisfied with the PACS system	1	2	3	4	5
16	PACS will be cost efficient	1	2	3	4	5
17	PACS will enable me as a Radiologist/Clinician to communicate more effectively with clinical members	1	2	3	4	5

Part 3. REALISED BENEFITS OF PACS

(Each question is optional. Feel free to omit a response to any question; however the researcher would be grateful if all questions are responded to)

Important Note:
Please complete Section C based on your experience of using PACS in Beaumont Hospital. The questions in the section ask what benefits (if any) you have experienced since the introduction of PACS

Strongly Disagree-1, Disagree-2, Neutral/ N/A-3, Agree-4, Strongly Agree-5

1	PACS provides more rapid access to radiographic images than before	1	2	3	4	5
2	PACS provides more rapid access to the radiologist's formal report than before PACS	1	2	3	4	5
3	PACS improves continuity of care for patients	1	2	3	4	5
4	Saves staff time	1	2	3	4	5
5	Minimises loss of data/films	1	2	3	4	5
6	Increases the efficiency of your clinical practice	1	2	3	4	5
7	PACS improves the delivery of quality health care	1	2	3	4	5
8	Quality of PACS images are diagnostic	1	2	3	4	5
9	The time spent finding images & reports are less	1	2	3	4	5
10	Radiology workflow/ ordering less complicated	1	2	3	4	5
11	The ability to review images simultaneously in more than one location is possible	1	2	3	4	5
12	PACS is user friendly	1	2	3	4	5

13	PACS is reliable	1	2	3	4	5
14	PACS increases confidence in patient diagnosis	1	2	3	4	5
15	Fully satisfied with the PACS system	1	2	3	4	5
16	PACS is cost efficient	1	2	3	4	5
17	PACS enables me as a Radiologist/Clinician to communicate more effectively with clinical members than before	1	2	3	4	5

Part 4. Any other comments

(Each question is optional. Feel free to omit a response to any question; however the researcher would be grateful if all questions are responded to)
Please answer the following questions based on your experience of using PACS in Beaumont Hospital.

1. How could PACS be improved?

----

2. If you agree that PACS saves staff time, How would you utilise the time?

----

3. Any comments,

*****Thank you for your time and cooperation*****