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Dimensions of growth:

A Maturity Model for continuous quality improvement of a clinical information system used in critical care medicine

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A Research Dissertation submitted in partial fulfilment for the Degree of Masters of Science in Technology Management of the National University of Ireland, Galway

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Abstract

Most studies of Clinical Information System (CIS) implementations tend to limit the inquiry to the installation phase. This research extends this perspective of the CIS lifecycle to the years post-installation. This study examines the development of a maturity model to both assess and guide the ongoing development of a locally customised hospital critical care CIS, in response to the continuous quality improvement initiatives of the service.

The model arose from qualitative data collected from a critical care service in a large teaching hospital. The method involved a first principles examination of the priorities of a critical care service through an inductive textual analysis of the documents that underpin the strategic, professional and operational requirements of the critical care service. These priorities form the dimensions of the traditional maturity model, where a series of interviews with clinical experts examine how the CIS can facilitate improvement along each dimension.

The maturity model developed consists of seven dimensions, each described in terms of four levels of increasing sophistication. This model is piloted in the critical care department of a large university hospital, which has been using a CIS for over four years.

Results show that the method proposed is suitable for the development of a CIS maturity model. The results of the pilot study highlight different individual perspectives on the current level of CIS maturity. This study concludes that this model is a suitable tool to assess current performance, and as a strategic guide to organise for ongoing CIS success.
Chapter 1   Introduction and Background

1.0 Introduction

This opening chapter of the thesis looks at the background to, and context of the research along with the rationale for undertaking it. It firstly outlines the current thinking in the literature on need for innovation and change in healthcare. It follows with a review of how Information and Communications Technology (ICT) can facilitate this improvement effort. This is discussed in terms of a critical care service at a major academic and publically funded hospital, and this organisation’s efforts to implement an example of the latest generation health ICT solutions, known as a Clinical Information System (CIS). It examines how this unit organises itself for continuous improvement of CIS functionality and use, and presents a rational for the study and opportunities for research.

This chapter concludes with an account of the structure of the thesis.

1.1 Drivers for Change and Innovation in Healthcare

Healthcare is an industry in need of change. There is widespread consensus in the healthcare and quality literature that healthcare needs to address inconsistencies in quality and efficiency. Some of the primary forces serving as catalysts for healthcare innovation and change include;

- Patient Safety and Clinical quality- The emphasis on quality and patient safety has not abated since the release of the influential US Institute of Medicine (IOM) report, “To Err is human” in 2000 (Kohn et al.), which called for a national effort to make health safer. Stelfox (2006) showed that this report has changed the very nature of the patient safety conversation from focussing on dispensing blame to improving systems.

- The move towards digitization – For both safety and efficiency improvements, the push to adopt IT systems will continue, as patient care settings become increasingly filmless and paperless. If this migration is to successful, it must be accompanied by process adaptation an change management techniques that will engender acceptance among staff and clinicians (Pexton, 2005)
• Demographic changes including an aging population will significantly impact healthcare. In Ireland, by 2030, 25% of the population will be over 65 years of age, with the consequent demand on health services (HSE, 2006)

• Workforce shortages, especially in certain areas (critical care) and specialities (medical intensivists) continue to strain the system. This, both severely limits ability to cater for current demand but, also adversely impacts resources available to plan for future demand. Optimal use of all existing resources is critical to success (Pronovost et al., 2002, Pronovost et al., 2004).

• Financial challenges- Healthcare providers continue to feel the financial pressures as they deal with rising demand in the face of increasing costs of new technologies, medicines and facilities (Halpern et al., 2004, Pexton, 2005).

• Patient empowerment – the widespread availability of information through the internet, has empowered patients to become more than just passive patients, but to be ‘consumers’ of a service, for which they demand quality, excellence and choice (Lazakidou and Siassiakos, 2009).

All these factors are converging to create what may be termed a ‘perfect storm’ that requires new thinking and comprehensive solutions (McBride, 2008).

It is increasingly the case that, of all the technologies that affect the healthcare experience; ICT holds the greatest potential for yielding positive changes for both patients and staff. Examples include more rapid and accurate diagnosis, fewer medical errors, and less wasted time from duplicative information. Despite this, health IT adoption is significantly slower than other areas such as finance, retail and industry as a whole (Bates and Gawande, 2003, Fonkych, 2007, Reece, 2007).

1.2 The role of ICT in healthcare

The wider medical and safety literature has an established opinion that the modern healthcare system cannot deliver high quality care in an efficient manner without having timely and appropriate clinical information and decision support at the point of care. Moreover, there are substantial difficulties with appropriate monitoring of quality, safety, efficacy and efficiency of delivered health care in the absence of appropriate infrastructure for capture and analysis of clinical information. Healthcare
and IT experts argue that adoption of advanced clinical health information technology (HIT) is an essential tool to transform modern healthcare into the system that delivers consistently high quality of care with greater efficiency for more patients.

The term “e-Health” usually means electronically-facilitated clinical and service functions that go beyond business and financial transactions (Hagland, 2008). Terms such as, health informatics, medical informatics, and e-health are established in common vocabulary, but few people have come up with a clear definition of this comparatively new term. First used circa 1999, this term now seems to serve as a general “catchphrase”, used to characterize not only “Internet medicine”, but also virtually everything related to computers and medicine (Eysenbach, 2002, Oh et al., 2005, Steinfield et al., 2000).

As such, the “e” in e-health does not only stand for “electronic”, but implies ten other “e’s: ‘efficiency’; ‘enhancing quality’; ‘evidence based’; ‘empowerment’; ‘encouragement’; ‘education’; ‘enabling’; ‘extending’; ‘ethics’; and, ‘equity’, which together perhaps best characterize what e-health is (or should be) about (Hagland, 2008, Oh et al., 2005).

An established but stylised fact of adoption theory (Rogers, 1995) is that diffusion of most innovations takes an "S-shaped" cumulative adoption curve, when cumulative number of adopters is plotted over time (Stoneman and Diederen, 1994).

Healthcare in general has been a relatively late adopter of ICT. Katya Fonkych (2007) reviewed the literature to determine the extent of health information technology (IT) used at the point-of-care. This review provides a diffusion curve (S-curve) for the major healthcare based IT applications such as; Electronic Medical Record (EMR, notes, diagnostic results, treatment plans, etc.), Computerised Provider Order Entry system (CPOE; electronic prescriptions, medical orders, etc.) and PACS (Picture Archiving and Communication, used to manage and present radiology images). Figure 1.1 illustrates this in the context of the US Healthcare system.
These are the ‘new’ ICT technologies that operate in the ‘e-Health’ sphere. They are frequently referred to as Clinical Information Systems (CIS), in an effort to distinguish them from other, non point-of-care, IS solutions used in healthcare. CIS technologies represent the more complex and sophisticated end of the health IT market, and are a mix of specialised software and supporting hardware, that directly impact the course of clinical care, and are showing signs of strong, sudden, and widespread adoption (Tan, 2009). CIS technologies are typically designed for a particular medical speciality, such as; critical care, obstetrics, cardiology, peri-operative care, emergency care, and so on. (Vedvik et al., 2009)

1.3 Use of ICT in the critical care service at Galway University Hospital

The Galway University Hospital (GUH) is a university teaching hospital 545-bed capacity and tertiary referral centre for the western seaboard of Ireland. The GUH organization structure is illustrated in Appendix IV.

A core component of any acute hospital, and wider health system, is the critical care service. At GUH, the critical care service is divided into an 18 bed ICU (Intensive care unit), where the highest level of care is given to the sickest patients, and a 16 bed HDU (High Dependency Units), where an intermediate level of care is provided for those who are not well enough to go back to general wards. The combination of both these facilities are referred to as “critical care”.

Figure 1.1 Diffusion of various e-health systems from 1991 to 2003, the system termed “CPOE” most closely represents the CIS system discussed in this thesis. From Fonkych (2007, p.45)
The critical care service at GUH is a tertiary referral centre for the west of Ireland. In 2008 there were over 1300 admissions to the service (GUH, 2009). Teams of highly trained professionals use technology as an integral part of their work in critical care.

There are approximately 200 practitioners working in, or who provide clinical support to the critical care units. There are at least 40 on duty at any one time. These practitioners include consultant intensivists/anaesthetists, consultant surgeons, specialist medical and surgical registrars, clinical nurse managers and specialists, critical care staff nurses, clinical pharmacists, dieticians, physiotherapists, occupational therapists, microbiologists, and range of referring medical teams, along with technical and scientific support staff.

During the stay of a critically ill patient in a critical care area, approximately 1500-2000 data items (medical notes, physiological signals, parameters, test results, medical orders) are documented and derived daily. Effective patient care is limited by the difficulty in managing this large amount of data and contributes to an increased risk to the patient. Improving the workflow and presentation of information leads to marked improvements in outcome in critical care areas (Breslow and Stone, 2005, Rivers et al., 2001, Scales, 2004). The traditional paper based critical care medical record, recognised as the most complex and expansive in acute care, is no longer sustainable as an adequate means to manage information (Frassica, 2004).

CIS solutions exist so as to offer greater potential to enhance the quality and safety of patient care, and increase provider effectiveness. A critical care CIS was first defined by Morris (1998) as a means to integrate clinical information at the point-of-care. A CIS allows the captures of the entire patient generated clinical and physiological data, and present it in a form that makes it available as useful information. The real power of the CIS, which facilitates real patient benefits, is that it can become a clinical decision support tool that supports evidence based practice (Bates and Gawande, 2003, Crane and Raymond, 2003, Pronovost et al., 1999).

More recent advances in this technology allow CIS platforms to be locally customized by clinicians, to provide for a close fit with existing work practices, while allowing for continued improvement through further customization (Eden et al., 2006, Kooij et al., 2008).
The process of CIS customization is brought about by continuous quality improvement initiatives that are driven by the ‘evidence based medicine’ philosophy of care. High performing critical care departments are constantly improving and refining procedures, technology, policies, and so on. It is this drive to keep abreast of the latest technological and practice developments that fuels the need for continuous improvement of the CIS platform. The CIS has a dual role; to facilitate the change process through design of the CIS application workflow; and to assess performance through measurement and audit of key indices (Higgins, 2007).

GUH undertook a procurement process for a Clinical Information System (CIS) for these reasons.

1.4 **The critical care Clinical Information System at GUH**

The Critical Care service at GUH is at the forefront of medical technology, and implemented a CIS to Intensive Care in March 2005, and expanded to all 34 critical care beds over the following 18 months. The CIS purchased is a commercially available system, known as *Metavision*™ (iMDSoft; Needham; Massachusetts; USA). This implementation project, its project management structures and experiences of this team is described in an account by Kirrane et al (2005).

The system IT architecture for the CIS, as illustrated in figure 1.2, is an industry standard, but high performance infrastructure.
Photographs of the CIS in use at GUH are shown in figure 1.3 and 1.4. Figure 1.5 is a screen shot of an actual patient file (made anonymous), this is termed the critical care ‘flow-sheet’ record. The software application, which provides the user interface, data repository and supporting functions, is specialised software that is classified as a medical device as defined by various regulatory authorities such as the European Union Medical Device Directive and the US FDA.

**Figure 1.2** CIS IT infrastructure architecture
Figure 1.3  Point-of-care CIS workstation location in the Intensive Care Unit

Figure 1.4  Use of remote “wireless” CIS workstation
The CIS was implemented using standard project management techniques. The final phase was installed to the Cardiothoracic ICU and HDU in November 2006. The CIS has been in routine clinical use since this time, has fulfilled its original project objectives, and was implemented on time and within budget. The project team responsible for the original implementation continue to work on the system. The work of this ‘CIS project team’ involves improving functions, improving data compliance and use, training new members of staff, and implementing system upgrades as required by the manufacturer.

The CIS project team are all clinicians in critical care. CIS related customisation work ‘fits around’ the normal clinical and service duties. In effect, the CIS team operate on a part-time and cost neutral basis. For instance, the author of this thesis (a hospital physicist/bioengineer) was the original project manager for implementation, and continues to provide a project management role, along with technical and scientific advice to clinical and service improvement initiatives, to which the CIS has an established and central role. The case is similar for other members of the “CIS Team” which comprises; intensivists (x3), Clinical Nurse Managers (x 4), physiotherapist (x1), clinical pharmacist (x1), and an IT professional (x1)

The day to day role of the CIS team is to continually develop and improve CIS functionality. This is achieved through a suite of tools, along with specialist training
members of the team receive from the CIS manufacturer. Team members received change requests via a number of routes. The typical routes of change requests are:

- scheduled quality improvement initiatives
- from individual staff members, through ad-hoc daily interaction
- New features released from the CIS manufacturer
- Data quality and clinical audit work
- Hospital management requests for service activity data

The CIS team is thus positioned at the interface between the clinicians and patient, and the technology. Figure 1.6 illustrates this customisation workflow process.

**Figure 1.6** CIS customisation work flow model. The CIS Team and its customisation efforts sit in the interface between the unit management and the end users. A range of specialist Metavision™ application tools are used in the customisation process.
Central to the suite of tools used to continually develop the CIS application, is the “customisation suite” where the user interface and functions of the CIS are created, controlled, and implemented. This application is where the database dataset is created, and from which the “look and feel”, and the workflow functions at the user interface are developed.

The “Query Wizard” is a data mining tool. It is used to send structured queries to the database, and receive data that supports activities such as audit and research. It is designed to allow non-programmer clinicians to graphically create complex queries on individual patient files, or cohorts of patient file populations. Raw data is typically exported to third party reporting and statistical analysis packages.

The “Event Manager” is a sophisticated user-defined multi-parametric event tool. It is designed to assist clinicians in research and quality assurance activities by notifying, in real-time, when a pre-defined set of logical conditions are met (for example, IF Heart Rate >120 bpm AND Respiratory Rate >20/min AND systolic Blood Pressure >90 mmHg, THEN send safety alert message to bedside clinician). The Event Manager is the application that provides for computer mediated clinical decision support opportunities.

Internal GUH records show that the CIS team have made over two-thousand changes to the CIS database in the years since installation. Some of these changes have been minor modifications, other changes have taken several months to design, perfect, test and launch into clinical use. As such, the CIS at GUH is a stable, but continually growing platform that is responsive to clinical user demands and service requirements. The CIS has significantly added value to the process of continuous quality improvement (CQI). Facilitating the process of CQI is considered the primary purpose of the CIS at GUH.

1.5 Rationale for the study

After four years since the first phase of installation, it has become clear to the CIS team, that in order to continually improve the CIS towards optimisation of potential benefits, requires a shift in emphasis from the ad-hoc to a more strategic approach to how the CIS team and critical care unit are “organised” for continued success. This is particularly the case because, as a member of the CIS team put it, “we have picked all the low hanging fruit”.

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Another important issue that is increasingly prevalent is that the resources, principally human, employed for CIS customisation projects are becoming more constrained in the tightening healthcare fiscal environment. It has become increasingly important to the unit, and the CIS team members, to demonstrate efficient use of its resources and to strategically leverage those areas of CIS potential to greatest patient and business benefits.

In addition, GUH is one of only two hospitals in Ireland that, at the time of writing, have implemented CIS technology in critical care. GUH, the latest to install a CIS, is the first to implement the system from this manufacturer, which is considered to be the “latest generation” in terms of technological sophistication. As early adopters (as in Roger’s ‘Theory of technology Diffusion’, 2005), the critical care unit members have a limited peer group of other ‘CIS units’ to collaborate with, and the unit may be considered, what Wheatley (2006) describes as ‘self-referencing’ from an organisational development perspective.

Following from this, the GUH CIS team are enthusiastic about the continued potential this technology can offer. In addition, team members and the wider user group, have a professional pride in what has been accomplished to date, but as medical professionals, want to optimise all available resources to achieve best practice in the field of critical care medicine.

1.6 Research Objective

This research seeks to address these issues by; (a) providing a framework that provides a basis for a more strategic, targeted approached to CIS development, and (b) pilot this framework as a model that will provide a means to both assess and benchmark efforts to optimise CIS improvement initiatives.

The primary Research Question that this research seeks to address is:

How may a practice framework, or ‘maturity model’ be developed, for the continued quality improvement of a locally customised critical care Clinical Information System?
1.7 Overview of Thesis Chapters

Including this introduction chapter, this thesis consists of six chapters, a bibliography, and a set of four appendices.

Chapter two presents a review of the literature that searches for previous research that may help address the research objectives. In this chapter the author examines the wider healthcare information technology (HIT) literature, and more specifically the area of HIT evaluation, concentrating on those factors that contribute to successful adoption. The author then expands the search to the wider IS/IT literature and introduces what are termed “models of success”, and examines how these have been applied to the health arena. The discussion then turns to the area of Business Process Management (BPM) to investigate the organisation aspects of success, change, and improvement. This area of literature provides for the notion of benchmarking, frameworks, and maturity models. It concludes with how this thesis draws from the extant literature, and sets-out how it intends to contribute to the body of knowledge that surrounds critical care CIS technology.

Chapter three discusses the various research methodological options available to address the research objectives. It provides the rational for the methodological options taken, along with a detailed account of the method itself. This data collection strategy is undertaken in three phases, and the critical care units of an acute hospital act as the case study for this research. Phase I grounds the research to the reality of critical care medicine, by determining the key process areas, or dimensions, that describe “the business” of critical care. These dimensions, in turn, provide the foundation to the second phase of research which examines how the CIS may be continually improved to address the key process areas within each of these dimensions. The format for this work draws on the areas of maturity models, benchmarking, business process management, and models of IS success, as described in chapter two. The writing proceeds with a description of phase III of the research; the steps taken to pilot the framework maturity model developed in phase II. Finally, the chapter concludes with an account of steps taken to ensure trustworthiness of the research.

Chapter four presents the results and findings of the work. These are presented in turn for each of the three phases of research.
Chapter five discusses and analyses the findings presented in chapter four. This chapter discusses the usefulness of the method to develop what is termed a ‘CIS maturity model’ that addresses the research objectives. The results of the pilot phase of the research, with eight subject matter experts, are discussed. The chapter concludes with a proposal on how the research may be used in practice.

Chapter six provides the main conclusions of the research. It discusses how the research undertaken addresses the original research objectives, and how it contributes to the wider research literature. This chapter then discusses the implications for practice in critical care. The limitations of the research are also identified. The chapter concludes with an account of opportunities for further research that follow from this study.
Chapter 2  Literature Review

2.0  Introduction

This chapter presents a review of the literature to examine the nature of health information technology research. It examines how information system (IS) project success is determined in the wider IS and project management research literature, and how these models are applied to the healthcare environments.

This account then examines how this research strives to address opportunities to contribute to the body of literature in the area of continuous quality improvement of a Clinical Information System (CIS) used in critical care medicine. To address this, the chapter turns to the business and practitioner literature to examine how organisations “organise” for success. This introduces the subject of ‘maturity models’, and analyses examples where this concept has been applied in the health IS literature and elsewhere.

2.1  The Health Informatics Research Landscape

A clinical information system (CIS) is a collection of various information technology applications that provides a centralised database or repository of information related to patient care across distributed locations. This repository represents the patient’s history and course of illness and interactions with care providers by encoding knowledge capable of helping clinicians decide about the patient’s condition and treatment options. (Morrisson et al., 2008, Sittig et al., 2002)

The influential US Institute of Medicine (2001) report, “Crossing the Quality Chasm: A new Health System for the 21st Century”, identified the development and application of more sophisticated clinical information systems as essential for health care improvement. Central to this call is to generate activity and debate, in both academic and practitioner research circles, on the development of new ways of thinking, novel technologies, evaluation of existing technologies, along with examining those factors that contribute to the success (or failure) of implementing CIS solutions for patient benefit.
A review of the CIS literature classifies the direction of the research along a number of fields of study. These are associated with: (a) the clinical and business case to leverage the potential of ICT in healthcare, (b) evaluation studies during the lifecycle of the technology (Sittig et al., 2002). While there is often overlap between these fields, it is useful to categorise the CIS research “landscape” in this way.

Part (a), often categorised as “the need for change” has been considered in chapter one of this thesis. Chapter two will turn attention to part (b); the extant literature on the nature of CIS and health informatics research.

2.2 Evaluation Studies in Health Informatics

Evaluation studies in health informatics has been defined as a “study that measures or explores the attributes of health information systems throughout the system lifecycle”, with the aim “to inform a decision to be made concerning that system in a specific context” (Ammenwerth et al., 2004 p.480)

Evaluation seeks to answer the why (objective of evaluation), who (which stakeholders perspective), how (methods of evaluation), what (aspects or focus of evaluation), and when (which phase in the product life cycle) questions (Burkle et al., 2001, Wyatt and Wyatt, 2003, Yusof et al., 2008b).

It is useful to categorise the extant literature on evaluation studies in this manner.

2.2.1 Objectives of evaluation (“The why”)

HIT, and particularly CIS technology, is a continuously evolving technology that has a direct impact on the course of patient care. Therefore, like all medical devices and systems are subject to continuous and rigorous evaluation. Such evaluations, that address clearly stated research objectives, are of great importance for decision makers and users. Such research efforts can be used to improve the technology through past experience, to investigate failure, and to identify more effective techniques or methods (Armoni, 2000, Nemeth, 2005, Sittig et al., 2002, Yusof et al., 2008b).
2.2.2 Evaluation Perspectives (“The Who”)

Evaluation involves many stakeholders, who have different, and often competing, perspectives on the systems. Popular types of stakeholders of Clinical Information Systems include the developer, user, patient and purchaser (Yusof et al., 2008a).

Much of the literature focuses on models that assess the adoption of IS products and subsequent success. These include; technology acceptance model (TAM), information technology adoption model (ITAM), fit between individual, task and technology (FITT), among others (Goodhue, 1995, Otieno et al., 2008, Otieno et al., 2007, Yusof et al., 2008a). Such models assess how individuals and organisations restructure their operations to cope with and accommodate new technologies.

The potential of CIS technology to improve patient care is often thwarted by the users reluctant to accept and adopt it. These difficulties highlight the lack of understanding of the factors and mechanisms influencing user acceptance. Some researchers have identified dimensions that allow for comparative evaluations of CIS applications, based on the area of technology acceptance by users (Despont-Gros et al., 2004).

2.2.3 Methods of Evaluation (The “How”)

Evaluation can be conveniently classified into objectivist and subjectivist approaches (Saunders, 2007).

The objectivist approach assumes that the “objective truth” can be measured, explained and predicted. Researchers can come to a consensus on what is good and right about important system properties (Ammenwerth et al., 2003, Yusof et al., 2008b). This approach lends itself to quantitative studies, such as random control trials (Kaplan, 2001).

On the other hand, the subjectivist approach assumes that “when phenomenon involve people and become complex, there is no single truth about them” (Friedman et al. 1997, cited in Yusof, Papazafeiropoulou et al. (2008b p. 381). In contrast to the objectivist approach, verbal description is fundamental to illustrating the differing perspectives. Research is conducted based on the judgements of expert evaluators or
system stakeholders in the “natural environment of the subjects” (Remenyi et al., 1998)

According to Kaplan, subjectivist inquiry may be more beneficial as evaluation approaches need to “include, social, organisational, cultural, cognitive, and contextual issues”, so that the key questions as to why clinicians use or do not use an informatics application can be answered (2001 p.42)

2.2.4 Focus of Evaluation (The “What”)

Many aspects of CIS type technologies can be evaluated. Evaluation involves human, technology, organisations, and interactions between them (Ammenwerth and de Keizer, 2005, Wyatt and Wyatt, 2003).

Hence, evaluation can cover technical, professional, organisational, economic, ethical and legal domains. For example, Amarasingham, Plantinga et al. (2009) conducted a cross sectional study of urban hospitals, to measure the level of automation based on physician interaction with the system. The results show that greater level of automation may be associated with better patient outcomes. Other authors focus on machine-human factors such as usability, perceived ease of use, and so on (Amarasingham et al., 2006, Amarasingham et al., 2009, Amarasingham et al., 2007).

Culler, Hawley et al.(2007) looked at the evidence that the “availability” of IT applications to clinicians is associated with clinical performance and outcomes. The conclusion is that “more does not mean better”

In recent years, reviews of the literature demonstrate that the evaluation trend of health informatics is moving towards those human and organisational factors of evaluation (Kaplan and Shaw, 2002, Yusof et al., 2008a).

2.2.5 Timeframe of Evaluation (The “When”)

In general, IS evaluation can be carried out during four main phases – pre-implementation (design and development), during implementation, post implementation or routine operation (Willcocks, 2003).
In an effort to uncover the determinants of success and failure, much of the literature focuses on the implementation and immediate post-implementation phases of the life cycle. This is termed ‘summative evaluation’, where the aim is to assess a system in operation and to provide information for determining system continuation (Yusof et al., 2008b).

Much research work is devoted to examining aspects of “risk” that affect implementation of CIS projects in hospitals. A study by Kaplan (2001) indicates that 50% of projects fail to meet their objectives. George Mihalas, speaking of HIT in general, makes the point that it is difficult to measure the true extent of failures based on actual data, because “failures are more rarely reported than successes and are often masked by mild terms (“modest results”) or even partially hidden” (Mihalas, 2009, p. 9).

Many experts attribute the problems to project management and socio-cultural factors, rather than the technology itself (Wakefield et al., 2007). Pare, Sicotte et al. (2008) provide a framework for identifying risks in the timeframe before, and during CIS implementation of projects. The factors within this framework are: technological, human/user, usability, project team, project management, organisational, and strategic/political. It is also noted that some new CIS projects need time to succeed, to become truly integrated. This points out that the timing of when an evaluation takes place is an important factor.

### 2.3 Determinants of IS Success

The “CIS research landscape” is a phrase coined by Sittig, Hazlehurst et al. (2002) to categorise the focus of the extant medical and technology literature. An adapted version of this is shown graphically in figure 2.1. It may be described as ‘co-orbiting spheres’ of research effort, that extend from the vision and new design development of pure research, to technological and organisational evaluation, and onto learning and use knowledge from system adoption and implementation. Each of these ‘spheres’ operate within the context of the organisational culture, its innovative capacity, technological capacity, resources, and the forces for change within and external to the organisation. This is also referred to as the organisations “cultural web” (Johnson et al., 2006).
Whichever course the CIS research literature takes to address the questions of “who”, “what”, “why”, “when” and “how”; the answer to each is often couched in terms of project, system, or organisational success or failure. Articulating, and defining terms such as ‘success’, ‘failure’, ‘partial failure’, and even what some authors refer to as ‘partial success’ (surely contradictory?), is important. Drawing back the review scope from the CIS research field to the wider research areas of project management can give some advice in this regard.

**Figure 2.1** Diagram illustrates some stages in the iterative process for conducting CIS research, including basic research (shown at left) to applied research (shown at right). Adapted from (Sittig et al., 2002)

The wider Project Management academic literature draws attention to subtle, but important, distinctions in the terminology used. Some writers distinguish between project management success, determined by the so-called “triple constraints” (time,
cost and quality), and project success which is measured against the overall objectives of the project (Cooke-Davies, 2002, de Wit, 1988, Thomas and Fernandez, 2008). Project management success is subordinate to and may also contribute to project success.

Richard Heeks in Armoni (2000 p.97) contends that “many – even most- healthcare information systems are failures”. A more recent review gives the more sobering opinion that the actual failure rate is somewhere between 40% and 70% (Mihalas, 2008). This opinion is corroborated by previous reviews of the wider healthcare IS literature (Despont-Gros et al., 2004). Much of the discussion centres on the type of failure:

“Total failure”, where the system is never implemented or abandoned shortly after implementation

“Partial Failure”, where the major goals are unattained or in which there is significant undesirable outcomes

“Sustainability failure” of an initiative that succeeds initially but then fails after a year or so

“Replication failure”, where the pilot phase has been successful but cannot be repeated elsewhere within the organisation.

Richard Heeks also notes that “this all points to the yawning gap between the positive potential for IS to contribute to the work of healthcare organisations and the largely negative reality” (Armoni, 2000 p.98)

Paré and Elam (1998) note that most past investigation into failure of healthcare IS has tended to be normative, focusing on

“a set of managerial prescriptions which, taken as a whole, constitute the ‘ideal’ way to implement an information system. Yet, despite these normative principles, many organizations and health care institutions find their attempts to make use of computer-based information systems fraught with difficulty.”

2.4 Theoretical Models of success

Success for IT/IS projects is not a “black and white” concept (Thomas and Fernandez, 2008). It is best considered as a multidimensional construct that is a combination of implementation success and system success (Espinosa et al., 2006)

In order to organise diverse research and to present a more integrated view of the concept of IS success, seminal work by DeLone and McLean reviewed the existing definitions of IS success in the literature (commercial, e-commerce fields), along with their corresponding measures, and classified these into six major categories. Thus, they introduced a comprehensive, multidimensional measuring model with interdependencies between the different success categories. (DeLone and McLean, 1992).

Motivated by DeLone and McLean’s (1992) call for further development and validation of their model, many researchers have attempted to empirically validate, extend or re-specify the original model. Ten years after the publication of their first model, DeLone and McLean published an updated (2003) model based on an examination of “almost 300 articles in referred journals that have referred to, or made use of the original model (DeLone and McLean, 2003)

This updated model consists of six interrelated dimensions of IS success: information quality, system quality, service quality, (intention to)use, user satisfaction, and net benefits (DeLone and McLean, 2003) This model is illustrated graphically in figure 2.2. Examples of attributes of each dimension are also shown. The arrows demonstrate proposed associations between the success dimensions.

The DeLone and McLean (2003) model may be interpreted as follows: A system can be evaluated in terms of information, system or service quality; these characteristics affect the subsequent ‘use’ or ‘intention to use’, and ‘user satisfaction’. As a result of using the system, certain benefits will be achieved. The ‘net benefits’ will (positively or negatively) influence ‘user satisfaction’ and the further ‘use’ of the information system.

According to DeLone and McLean (2003), ‘net benefits’ address the ultimate impact of the system and therefore represent the most important category of success measurement. However, success criteria in terms of benefits delivered (as opposed to
the traditional triple constraints view, or what clinicians assume would be delivered) are the “exception rather than the rule, and in many cases are defined after implementation or not at all”. This is because benefits are difficult to measure, particularly at the start of the project, and are often different to those anticipated when the project was first proposed (Thomas and Fernandez, 2008).

Figure 2.3 The updated DeLone and McLean model for Information Success. Adapted from DeLone and McLean (2003, p.24)
The success of the Delone and McLean model (in terms of the attention it has received in the IS literature) may be attributed to the fact that: (a) it is a validated model which shows that information system success, is a multidimensional construct, where “success” is a dynamic process rather than a static state, and (b) there is both a causal and temporal interdependency between the dimensions of success.

Van der Meijden, Tange et al. (2003) reviewed the literature to uncover the determinants of success for CIS technology, and based these on the DeLone and McLean (1992) model. They note that the success dimensions for the wider management information or e-commerce systems are equally valid for patient care information systems.

This review also showed that many of the evaluations of installed CIS projects finished within a six months after introduction; “probably too soon to measure all organisational impacts” (van der Meijden et al., 2003 p.341). Equally evident was that in many cases, aspects of organisational culture, such as professional values, were seldom taken into account (van der Meijden et al., 2003).

They also conclude that the Delone and McLean model be modified to include contingent factors such as user involvement during system design and implementation, and aspects of organisation culture. They note that these factors help explain the failure of patient care systems. It is also likely that such factors also play a role in success of information systems (van der Meijden et al., 2003). This point is supported by wider, non healthcare, ICT research literature (Shaw, 2002).

The primary message from the medical and technical literature on the concept of “CIS success” is that efforts to introduce CIS technology in practice settings will result in failures and unanticipated consequences if their technical aspects are emphasised and their social and organisational factors are overlooked (Nemeth, 2005, Pare et al., 2008, Sicotte et al., 2006).

This has an impact across the evaluation landscape. It is not just an issue for the developers of new technologies and functionalities. For the potential purchaser of this technology, the clinician using it, or the end user organisation (for example the hospital), it also has consequences. The literature is quite clear that; even if a hospital acquires a well established technology and product that meets all the regulatory
requirements (FDA, CE and so on), and is proven in the market place to be “fit-for-purpose”; implementation success is not guaranteed.

IS success is about a matching between the reality and conception, this “R-C gap” is what, according to Heeks, needs to be managed. Central to the success or failure of CIS projects is the amount of change between ‘where we are now’ and where the ‘where the CIS wants to take us’ (Armoni, 2000)

Incrementalisation, small steps toward a greater aim is an important tactic to overall success; it allows the technology- organisation adaption process to bridge smaller gaps incrementally. This is one of the reasons why more sophisticated CIS applications are designed to provide scope for equally sophisticated end-user (clinician) localisation and customisation. This approach allows clinicians to continuously refine and develop the CIS, where the system essentially ‘grows into its organisation’, and becomes a mutually reinforcing process of continuous improvement (Callen, 2008).

Berg writes that CIS implementation is a process of ‘mutual transformation’, where the organisation and the technology transform each other during the implementation process. What determines successful implementation is “decided on the work-floor, by middle management, by top managers – and it is the outcome of these interactions that settles on the systems fate” (2001 p.144).

Success has many dimensions; effectiveness, efficiency, organisations attitudes and commitment, worker satisfaction, patient satisfaction – and not all parties agree which dimension is the most relevant. Success is also dynamic, because it fluctuates over time (Berg, 2001).

2.5 Opportunities to contribute the CIS research literature

The CIS literature on both system design and evaluation, are clear that one should not separate the technology from its organisational context; the culture, organisation capabilities, the people, the processes, and so on.

System designs have become more sophisticated, such that they allow flexibility within a design framework, that provide for safe localisation and customisation by the clinical end user. Aarts, Doorewaard et al. (2004 p. 208) cites Orlikowski (2000) who notes that “this process of “change” never stops; even when implementation is
“formally” finished, users will still shape and craft the information system to fit their particular requirements or interests”. This provides for the notion that implementation of a solution is not a one time event for the project team and end-users; the project essentially does not end. The post-implementation phase becomes one of continuous development and improvement. It may even be necessary to distinguish successful ‘installation’ (a one time event), from successful ‘implementation’ (a more longitudinal perspective).

This has important implications for the clinicians, and wider CIS research. If the health professional, purchaser or clinician turn to the CIS research landscape, as illustrated in Fig 2.1, and looks to the left, to the area of “vision and design”, there is much advice and analysis, on the those issues that surround the future developments and direction of CIS technology research; along with a strong case for the “need” to leverage the possibilities of ICT in healthcare.

Similarly, for the clinician or healthcare professional, considering the purchase of CIS technology for their institution, the “evaluation” part of the research landscape in figure 2.1, provides many case studies, and empirical evidence in the areas of technology assessment, and comparative studies. Some of these have been discussed above in terms the “what” aspect of evaluation research.

For those practitioners embarking on project management or CIS installation, the “implementation” sphere of the landscape, benefits from much applied research and practical advice on “how” to conduct a successful implementation project.

What is also evident in the literature is that, much of the evaluation literature limits data collection up to the months (or weeks) post implementation (Byrd et al., 2006), and after this point assumes the CIS remains a success. Van der Meijden, in his review of the DeLone and McLean (1992) model of success applications to CIS success, notes that evaluation of such systems should start before the development and should have “no fixed end point” (2003). His point is that such evaluations are equivalent to post market surveillance requirements for medicines. He notes that “formative evaluation” – aiming at improving information systems during development or implementation - were difficult to locate in a review of the literature.

This adds to this thesis that successful implementations can essentially become unsuccessful systems in the absence of a continuous evaluation, improvement and
feedback mechanisms (van der Meijden et al., 2003). His research adds to understanding by exposing a potential problem, but stops short of proposing a practical solution for clinicians.

This is essentially the ‘gap in the literature’ that this research attempts to contribute. For an institution that has successfully implemented CIS technology, user satisfaction is high, the technology has untapped potential that can offer further “net benefits”, and users have an open-mindedness for change, there is scant advice in the extant literature on how to continually assure success of successful implemented CIS technologies. This is particularly relevant as the technological sophistication of current CIS applications includes specialised tools that may be used by the clinical users for continued customisation and improvement of the CIS. How does a healthcare institution organise for mining this seam of this continued new potential?

This research attempts to provide a roadmap for ongoing success. Thomas and Fernandez make a pertinent point; “having a well defined perception of what has to be achieved at attain success may indeed contribute to achieving the evasive target of project success” (2008 p.734)

2.6 Maturity models

The wider business and organisational development literature may provide advice on the socio-technical factors that underpin efforts to drive continued success in high performing, high technology environments such as the use of CIS technology in critical care medicine.

Business Process Management (BPM) is a field of management focused on aligning organizations with the needs and wants of clients. It is considered a “holistic management” approach that promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology. BPM attempts to improve processes continuously. It is also described as a "process optimization process" (Andersen, 2007, Smith, 2003)

BPM has its roots in a number of approaches including Business Process Reengineering, Quality Management (e.g., TQM, Six Sigma), Operations Management (e.g., MRP II, Kanban), Business Process Modelling and Process-Aware
Information Systems (e.g., workflow management systems, service-oriented architectures). It is widely recognised as a foundation for contemporary management approaches as the analysis of business processes drives understanding to the roots of an organisation (Rosemann et al., 2006).

At the core of BPM is the concept of process maturity. The term “maturity” is defined by Fraser et al. (2002) by its literal meaning: “ripeness”. It conveys a notion of development or progression from some initial state to a more advanced state.

First published in 1989 by Watts Humphrey, and later by the software Engineering Institute at Carnegie Mellon, the Capability Maturity Model (CMM) – later superseded by CMM integrated - has become an established model in the field of IS development. The CMM provides software organisations with guidance in the form of a framework on how to gain control of their processes (developing and maintaining software). It can help improve the maturity of these processes. This model comprises five levels, each defined as an evolutionary plateau of process improvement and includes a checklist to evolve on to the next level (van de Wetering and Batenburg, 2009). This maturity levels in this model are illustrated in figure 2.4.

<table>
<thead>
<tr>
<th>Maturity stage</th>
<th>Clarification</th>
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| Initial        | - Carry out work on an ad hoc basis  
- Formal processes unclear  
- Poor control  
- Effort of a few enterprising individuals instead of the whole organization |
| Repeatable     | - Depend on policies for managing a software process and measures  
- Processes of the organizations stay institutionalized through experience instead of detailed procedures |
| Defined        | - Engineering activities and processes of management are formally defined  
- Newer methods and tools can be added |
| Managed        | - Detailed measures of the software process and product quality are collected  
- Setting quantitative goals  
- New sets of tools are added/adjustments are made to existing processes |
| Optimising     | - Focus on continuous process improvement  
- Instead of correcting defects, a firm stalls further defects and addresses the key to those defects by planning ahead |

Figure 2.4  The five levels of the Software Engineering Institute Capability Maturity Model Integration maturity model (van der Wetering and Battenburg, 2009 p. 130)
A maturity level is a way to characterise the dimensions that describe the process, system or organisation, by assigning a level of performance with regard to the activities contained within each dimension. These levels range from the ad-hoc, or depend on the initiative of an individual so that the outcome is less likely to be repeatable, or as the level increases, to one where the activities are performed systematically, and are well defined and managed (Farrukh et al., 2003b)

Maturity models are used as an evaluative and comparative basis for improvement, and also to derive an informed approach for increasing the capability of a specific area within an organisation. They are designed to assess the maturity (i.e. competency, capability, level of sophistication) of a selected domain based on a more or less comprehensive set of criteria. (Dooley et al., 2001b, Fisher, 2004, Harmon, 2004, Rosemann et al., 2006)

Fraser, Moultrie et al (2002) make the point that in practice, maturity models are used as part of an improvement process, and not primarily as absolute measures of success or performance. Its principle function is to identify gaps which can be targeted in subsequent improvement actions, along a pre-defined scale.

In particular, maturity models can be used for three purposes including:

- as a descriptive tool enabling an ‘as-is’ assessment of strengths and weaknesses;
- as a prescriptive tool enabling the development of roadmap for improvement; and
- as a comparative tool enabling benchmarking framework to assess against industry standards and other organisations.

More recently, maturity models (also termed ‘maturity frameworks’ by some authors) have been used in the healthcare IS research. Van de Wetering and Batenburg (2009) provide a maturity model for the technological sophistication of Picture Archiving and Communication Systems (PACS) in hospitals. A PACS is an IT system for the management of medial images and radiological reporting. A PACS is to Diagnostic Radiology as a CIS is to Critical Care.
These authors, through an analysis of the literature on the maturity and ‘evolvability’ of PACS in the hospital enterprise, develop a maturity model for PACS technology. They provide for 5 levels of maturity, based on other work by Holland and Light (2001) for enterprise resource planning (ERP) systems. The levels of maturity extend from; level 1, the basic image management; to level 5 which comprises a fully “integrated, optimized enterprise PACS chain”.

The focus of the van de Wetering and Batenburg (2009) work is to examine a staged approached to the technical and technological dimensions of a PACS system, and places less emphasis on the cultural, socio-political and organisational aspects of such implementations.

On the other hand, Elwyn, Rhydderch et al. (2004) focus predominantly on the organisational development aspects of health care provision. In this research, the authors describe the development of a ‘Maturity Matrix’ for assessing the organisational development in a primary care group of medical practices. The assessment tool takes the traditional framework maturity model format. It is composed of eight dimensions, or key practice activities, described by a column, subdivided into a set of cells that describe increasing “development” in a common direction for primary care organisations. The methodological approach was a survey questionnaire of draft maturity matrix to 390 participants.

The dimensions in this study include key process areas (KPA) that consider how the GP practice network organises itself with regard to; clinical records, audit of clinical performance, access to clinical information, use of guidelines, prescribing monitoring, practice communication and collaboration, patient-clinician interaction, and patient feedback systems. (Elwyn et al., 2004)

Common threads from both the PACS (van de Wetering and Batenburg, 2009) and the General Practice (Elwyn et al., 2004) maturity models, that are of particular importance in the healthcare are that; (a) the process of developing the model is itself is a useful tool for fostering effective intra-professional collaboration, (b) the model provides a useful self assessment or benchmarking tool for an “as-is” assessment of performance, and (c) it provided a forum to develop ex-ante perspective or vision of the more mature, and sophisticated “to-be” state, (d) it facilitates a “bottom up” approach to quality improvement, (e) aligns the strategic and tactical priorities of the organisation and (f) the group assessment process encourages the concept of “double
loop learning”, where “the organisation ‘learns how to learn’ so that the concepts of change management are second nature” (Elwyn et al., 2004).

2.7 Chapter Conclusion

This chapter provides a review of the wider ICT, IS and Health Informatics literature, and investigates how ‘success’ is defined and determined. It also reviews the extant project management and business process management literature, to determine how researchers in these fields organise for continued success.

The models of success, such as that of DeLone and McLean, provide a concept that teases out those factors that are important to practitioners that allow them to optimise efforts to assure CIS project success. While this is a useful model, it remains a “concept” that does not easily bridge the practice theory gap, to provide an intuitive roadmap for success (Rosemann and Vessey, 2005).

On the other hand, the maturity model or framework provide a clear and intuitive roadmap for practice development to some “optimised” state, but do not explicitly provide the tools to navigate from one level of maturity to a higher one. In effect the model provides a vision for success, but not the means to achieve it.

If these approaches are combined, by considering the context of the wider maturity model literature, and with due consideration to the determinants and factors that relate to “success” as a concept, as in the DeLone and Mclean models success, it may provide a basis for the development and practical use of a maturity model for the continued development of a critical care clinical information system. This research proceeds with this aim in mind.
Chapter 3  Research Methodology

3.0  Introduction

This chapter introduces the research question and related objectives. It discusses research methods in general and then describes the chosen research design, a case study method, along with the approach taken to collect the research data.

The research was conducted over a number of phases. The primary methodological approach taken in this study was a qualitative content analysis of a number of textual based documentation that was representative of the operational, strategic and professional imperatives of a critical care service delivery. This phase was followed by a series of semi-structured interviews with expert practitioners of critical care. These interviews formed the basis for the construction of a maturity framework model. Each interview participant was then requested to review and pilot the final maturity model framework.

Finally, the case study context and methodological limitations of the research are set out

3.1  Research Question

The research question at the centre of this study is

How may a practice framework, or ‘maturity model’ be developed for the continued quality improvement of a locally customised critical care Clinical Information System?

3.1.1  Secondary Research Questions

To answer this question two secondary research questions (SRQ) need to be addressed

SRQ 1  What are the key dimensions that represent the priorities and objectives of a best practice critical care service?

SRQ 2  How can these dimensions be operationalised in a model that will provide a mechanism for;
(a) Self assessment and benchmarking of CIS sophistication and use? and,
(b) Provide a framework success continued quality improvement of the CIS?

3.1.2 Research Objectives

The Objectives of this research are

a) Using recognised Qualitative Content Analysis techniques, determine the key priorities of the critical care service from an operational, professional and strategic perspective. This aims to address secondary research question one (SRQ 1).

b) Use the outcome of this analysis as the basic construct for a series of semi-structured interviews with members of the critical care leadership team, to further develop these dimensions into a framework for continuous CIS development and maturity. This aims to address secondary research questions two, part a (SRQ 2a).

c) Based on the content of the interview recordings, build a maturity model, and pilot this with the interview participants. This aims to address secondary research question two, part b (SRQ 2b).

3.2 Research Approaches

Remenyi et al. (1998) describe many different ways of categorising research. Firstly, there are two classes of research: theoretical and empirical. Theoretical research primarily involves studying the subject through subject matter experts, either through their writings, or by communicating directly with them. The theorist then considers these ideas and proposes a new or different view of the situation. Empirical research methods are a class of research methods in which empirical observations or data are collected in order to answer particular research questions, i.e., the findings are based on observation and evidence, rather than theory.
Research can also be classified by its orientation, which can either be positivistic or phenomenological. Phenomenological inquiry, or qualitative research, uses a naturalistic approach that seeks to understand phenomena in context specific settings. Logical positivism, or quantitative research, uses experimental methods and quantitative measures to test hypothetical generalisations (Patton, 1990)

Remenyi et al. (1998) also discuss the concept of “research tactics”, which are the various designs or techniques that can be used to collect and analyse research information. Blaikie (1999) describes eleven classifications of research design prominent in the literature; experiment and survey, fieldwork/ethnography, comparative/historical, case study, content analysis, secondary analysis, observation, simulations and gaming, evaluation research, social impact assessment, and action research.

The case study is one of the more prominent techniques, and is described as a research tactic that can be used in “establishing valid and reliable evidence” (Remenyi et al., 1998), to one that “entails the detailed examination of a single case” (Saunders, 2007), and which is suitable for “exploratory”, and “explanatory” inquiry (Yin, 2008)

### 3.3 Data Collection Techniques

Qualitative research provides for a number of data collection techniques. Four of the more prominent techniques of data collection in the qualitative research literature are; (a) interviews (b) indirect and immersed, participant observation of study phenomenon, (c) survey questionnaire, and (d) secondary sources of data in textual documentation and other media formats. (Byram, 2006, Yin, 2008)

#### 3.3.1 Interviews

Qualitative interviewing utilises open-ended questions that allow for individual variations (Hoepfl, 1997). Patton discusses three types of qualitative interviewing; (a) informal, conversational interviews, (b) semi-structured interviews, and (c) standardised, open ended interviews (Patton, 1990)

In addition to one-to-one interviews, other options include group interviews, also termed “focus groups” or “workshops”, which are composed of a small number of
participants, where a “moderator” facilitates discussion of pre-defined and focussed topics (Powell and Single, 1996, Saunders, 2007)

### 3.3.2 Observation

Two types of observation are described in the literature; participant observation and structured observation.

Participant observation has its roots in social anthropology and the social sciences. It involves the researcher being immersed in the research setting, in order to learn both the latent and manifest details of the phenomenon under inquiry (Saunders, 2007).

In contrast, structured observation, involves the researcher adopting a more detached stance. This technique provides for a more pre-defined and systematic approach that lends itself to the objective of quantifying behaviour. Time-in-motion studies are a prominent example in the literature (Patton, 2002, Saunders, 2007).

### 3.3.3 Survey Questionnaire

The use of questionnaires is a prominent tool in the survey methodological strategy. The term questionnaire has been defined by deVaus (2002) to include all techniques of data collection in which each respondent is asked to answer the same particular set of questions in a predetermined sequence. It is used frequently as part a large sample inquiry in quantitative research (Saunders, 2007).

### 3.3.4 Analysis of textual documentation

Another source of information that can be invaluable to qualitative researchers is an analysis of documents, which are often referred to as secondary sources of data (Saunders, 2007). Such documents might include official records, letters, media accounts, diaries and reports, as well as published data used to review the literature (Burnard, 1996, Krippendorff, 1980).

There are a number of specialised forms of qualitative research which rely solely on analysis of documents. One of the more extensively employed analytical tools in this area is known as content analysis.
3.4 Choice of Research Method

3.4.0 Introduction

Strauss and Corbin (1990) claim that qualitative methods can be used to better understand any phenomenon about which is little is known yet, and also to gain more in-depth information that may be difficult to convey quantitatively.

Due to the exploratory nature of this research, a qualitative orientation that addresses the research questions is most relevant.

The research philosophy taken in this thesis is empirical in nature. The research design may be described as a cross-sectional case study. The sampling technique is defined as “purposeful sampling”, which is the dominant strategy in the qualitative research literature. Purposeful sampling inquires of information-rich cases which can be studied in depth (Hoepfl, 1977, Hoepfl, 1997, Patton, 1990, Saunders, 2007). This study involves the detailed examination of a single case, at a particular point in time. This decision fits within the scope of the study, and the time available for data collection (3 months).

The author did not derive variables/categories from existing theories or previous related studies, and did not strive to explicitly verify existing theories. A grounded theory approach guides the data analysis (Strauss and Corbin, 1998).

3.4.1 Data collection methods chosen for this research

Three techniques for data collection were used in this research.

3.4.1.1 Qualitative Content Analysis

The first approach was a Qualitative Content Analysis (QCA) of textual documents that were an integral part of the critical care service at the core of the case study. QCA is a specialised form of qualitative research, which is an extensively employed analytical tool for the systematic analysis of documents (Krippendorff, 1980).
The method employed was an inductive approach to the qualitative content analysis of three text documents, where the categories were allowed to “emerge” from the text data (Patton, 2002)

3.4.1.2 Semi-Structured Interviews

The results of the QCA process informed the course and nature of a series of semi-structured interviews with expert members of the critical care clinical and non-clinical leadership team.

3.4.1.3 Participant Observation

Observation techniques were also evident in this work, as the researcher has been working in a professional capacity as a hospital Physicist/Bioengineer in the critical care service (the case study) for the previous ten years. The researcher was also the project manager for the implementation of the CIS five years prior to this research.

3.4.1.4 Techniques considered but excluded from this research

The exploratory nature of the proposed study, the lack of existing and well grounded theories in the extant literature that address the research question, and the relatively small sample size (based on the number of critical care units which have implemented CIS technology), precluded the use of survey type questionnaires as a useful and valid data collection tool to address the research objectives.

Other approaches to data collection, as defined by Blaikie (1999), were excluded because they were outside the scope of the study (such as; action research, ethnography), or lent themselves to more quantitative examination of existing theoretical models (including; simulation, impact assessment, comparative, or empirical experiment).
3.5 Research Execution

3.5.0 Introduction

This section describes the methodological process undertaken in this research. The data collection was performed in three phases. The first phase was a QCA of three texts to determine the themes or categories that describe the dimensions of the critical care service. The texts chosen were originally prepared by the critical care team leaders and staff, as part of normal service delivery and are considered important to the provision of best practice critical care medicine.

The second phase was a series of semi-structures interviews based on the results of phase I. The objective was to give the team members an opportunity to validate the results of QCA, to add depth, to enrich, and to add vitality to these dimensions. Through the course of these interviews the detail of the maturity model developed.

The third and final phase was a pilot of the final version of the maturity model, where each participant was asked to provide any comments, and score the CIS project along each dimension from each individual perspective.

The first phase, the qualitative content analysis, is considered first.

3.5.1 Research execution – Phase I: Qualitative Content Analysis

To support valid and reliable inferences, qualitative content analysis involves a set of systematic and transparent procedures for processing data. A number of authors provide direction to the practitioner on the process of QCA (Burnard, 1991, Burnard, 1996, Elo and Kyngas, 2007, Granheim and Lundman, 2004, Kondracki et al., 2002). The process steps are iterative in nature and is presented in figure 3.1

The first step in the process is the selection of texts to analyse, termed the “unit of analysis”, that represents the phenomenon under inquiry. In this research three texts were chosen by the author, in conjunction with the critical care leadership team at a routine operational team meeting. The texts were chosen because they were considered by the leadership team to provide the strategic, operational and professional perspectives of the critical care service.
The process of qualitative content analysis, as described by Kondracki (2002) and Granheim and Lundman (2004) was adopted. Each text was read by the researcher a number of times, and open-coded headings (also termed “meaning units”) were used to describe all aspects of the content. These “meaning units” were transcribed electronically to an Excel™ (Microsoft Inc.) spreadsheet. Headings were transferred to coding columns, and were used to generate categories. These categories were then grouped under higher order headings and, using a circular process; categories that were deemed redundant were collapsed. Through an iterative process of “abstraction and distillation”, sub-categories and then main categories (termed “dimensions”) were identified (Granheim and Lundman, 2004).

Figure 3.1 Process map of the inductive Qualitative Content Analysis. Adapted from the text of Burnard (1991), Granheim and Lundman (2004) and Kondracki (2002)
A number of “quality steps” were integrated into the process. A colleague of the researcher was recruited to test for inter coder agreement, and coding consistency. This process is considered the appropriate step to test for clarity, consonance and consistency of the category definitions and coding scheme (Schilling, 2006, Weber, 1990).

After QCA of each unit of analysis was completed, the process re-commenced with the remaining texts (PDU document and then the MATH Accreditation document).

3.5.2 Research Execution – Phase II: Semi structured interviews

A total of eight interviews were conducted. Participants were chosen by the researcher. The criteria for selection to participate were:

1. The participant was a member of the critical care operational team, acted in leadership and managerial roles in the critical care department, and was either routine users of the CIS, or would typically expect to receive information output from the system, such as hospital management.
2. Each participant had some experience with the customisation or functionality potential of the CIS, but not necessarily possesses the technical proficiency for use of the customisation application itself.
3. Along with providing clinical, managerial or service role within the department, each was also involved, to a lesser or greater extent, with ongoing quality improvement initiatives in the critical care service.

The basis for these criteria was that the research was exploratory in nature, which necessitated expert knowledge and focussed opinion in order to meet the objectives of the research.

Ten members of the critical care staff were invited to participate; two declined because of time commitments or were not available during the interview phase of this study.

Some information on the participants and their role is shown in table 3.1 The participants presented a wide cross section of professions, medical (n=3), nursing
(n=3), allied health (n=1), and administration/management (n=1). Also shown is if the participant was involved in technical aspects of the CIS (i.e.; direct use of the CIS customisation application suite.) Each participant is provided with pseudonym code.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Profession/Position</th>
<th>Current User</th>
<th>Years of experience to date with CIS</th>
<th>Involved with direct CIS customisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA1</td>
<td>Physician/Consultant Anaesthetist-Director</td>
<td>Yes</td>
<td>5</td>
<td>No</td>
</tr>
<tr>
<td>CA2</td>
<td>Physician/Consultant Anaesthetist</td>
<td>Yes</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>CA 3</td>
<td>Physician/Consultant Anaesthetist</td>
<td>Yes</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>CNM 1</td>
<td>Nurse/Lead Nursing Manager</td>
<td>Yes</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>CNM 2</td>
<td>Nurse/Practice Development Coordinator</td>
<td>Yes</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>CNM 3</td>
<td>Nurse/Informatics Nurse specialist</td>
<td>Yes</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>P 1</td>
<td>Clinical Pharmacist/Chief</td>
<td>Yes</td>
<td>5</td>
<td>Yes</td>
</tr>
<tr>
<td>RM</td>
<td>Manager/ Hospital Risk Manager</td>
<td>No</td>
<td>2</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 3.1 Details of participants in the interview phase of the research

Interviews were conducted over a two week period. Each participant, on acceptance of the interview request, was sent an email that included a two page summary of the project, along with an account of the results of the preceding QCA phase. These results comprised the “dimensions” that represent the principle priorities of the critical care service. They were also explanatory examples from the literature that illustrate the concept of benchmarking frameworks (Kahn et al., 2006) and maturity models (Elwyn et al., 2004). This is provided in Appendix I.

These themes provided the structure for the interview. Each participant was asked the following questions, which they were asked to consider in advance, and around which the interview discussion developed:

1. “Do you believe that the “dimensions” that derive from the QCA process represent the “body of work” that describe the priority activities of the unit for the delivery of high quality critical care?”
2. “Can you suggest others that may be included as a subset of those outlined above, or other dimensions, tasks or activities, that are omitted from those presented above?”

3. “We will discuss what each dimension means to you, and your work. For example, how would you define each? Which is the most important? How do they relate to each other? Are they mutually exclusive?”

4. “Please rate, in order of importance as you see fit, each of the dimensions listed”

5. “Considering each dimension in turn, what are the area of activities, or tasks (also termed Process Areas in the literature), with which the CIS has a part to play in supporting, driving, facilitating, or to positively impact each dimension. Consider those that it does now, but also those where there is room to improve or others not yet addressed. This will be a type of brainstorming conversation, which includes words, phrases, themes, examples, and so on”

Each interview was held in an office adjacent to the critical care department. Each interviewee gave prior permission for recording the interview conversation.

The practical aspects of the interview technique that surround both the preparation for the interview, and how it was conducted was informed by an account of an experienced researcher (Dearnley, 2005).

Detailed notes of each interview, providing the main themes, notable verbatim sentences and phrasing, were transcribed by the researcher from each recording, to a textual format. Care was taken to accurately articulate in text the “tone and context” of the interview. The advice and techniques offered by Kvale (1996) were applied in this research.

Participants were asked to review the transcribed account, and note any objections, or clarifications they felt were necessary. This is consistent with similar approaches taken in the literature (Dearnley, 2005)
Questions one through to four, were used to determine the validity, comprehensiveness of the dimensions presented from phase I (QCA), and to seek out any omissions, based on the experience and perspective of each interviewee.

The main points and themes received from the interview transcripts were used to complete the cells within the framework template. The responses to interview question five (“consider each dimension in turn”) was the main source of detail for the developing framework. After the third interview, subsequent participants had sight of the working draft framework, to aid the course of the conversation. With each subsequent interview, more detail was added, and existing detail was refined.

3.5.3 Pilot of the maturity model

The final version of the maturity model, along with instructions on how to complete it, was presented to each participant in a pilot phase of the research. Each was given time to reflect on the document, and were requested to post back the completed document to the researcher. The researcher was also available to the participants to provide any necessary clarification.

3.6 Methodological Limitations and measures for achieving trustworthiness

3.6.0 Introduction

Research findings should be as trustworthy as possible and every research study must be evaluated in relation to the procedures used to generate the findings (Granheim and Lundman, 2004)

When judging qualitative work, Strauss and Corbin believe that the “usual canons of good science have value but require redefinition to fit the realities of qualitative research” (1998 p.266). Recognizing this gap, Lincoln and Guba (1985) proposed four criteria for evaluating interpretive research work: credibility, transferability, dependability, and confirmability. These correspond to those typically employed to judge quantitative work. These are presented in Table 4.2. They are shown because the terminology is often used interchangeably in qualitative research.
Table 4.2 Corresponding terminology that describe research trustworthiness from the conventional and naturalistic approaches

<table>
<thead>
<tr>
<th>Conventional terms</th>
<th>Naturalistic terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal validity</td>
<td>Credibility</td>
</tr>
<tr>
<td>External validity</td>
<td>Transferability</td>
</tr>
<tr>
<td>Reliability</td>
<td>Dependability</td>
</tr>
<tr>
<td>Objectivity</td>
<td>Confirmability</td>
</tr>
</tbody>
</table>

These are now presented in turn, along with how each was considered in both the methodological design and data collection phases of this research.

3.6.1 Credibility (Internal Validity)

Credibility deals with the focus of the research and refers to confidence in how well data and processes of analysis address the intended focus (Polit and Hungler, 1999).

This research followed the advice from the literature to address the question of research credibility. These tests of credibility included; “prolonged engagement in the field” through experience in working in critical care (Lincoln and Guba 1985), and “triangulation” between different parts of the same unit of analysis, and between different documents. Techniques also used by the author to counter inadvertent research bias included constant comparison, peer debriefing, interview transcript validation, and a systematic approach to analysis (Duncan, 1989, Hoepfl, 1997, Lincoln and Guba, 1985, Patton, 2002).

3.6.2 Transferability (external Validity)

Transferability refers to the extent to which the researcher’s working hypothesis can be applied to another context (Lincoln and Guba, 1985).

While it is not the researcher’s task to provide an index of transferability; the researcher is responsible for providing data sets and descriptions that are rich enough so that other researchers are able to make judgments about the findings’ transferability to different settings or contexts (Hoepfl, 1997). In this research, each document chosen, representing the “unit of analysis”, would not be considered unique to this case study alone. Equivalent documentation, representing strategic, professional and
tactical aspects of critical care provision, would be available from any critical care unit.

The pre-prepared interview questions were generic in nature, not particular or specific to the unit or persons interviewed.

3.6.3 Dependability (Reliability)

Dependability refers to “the coherence of the internal process and the way the researcher accounts for changing conditions in the phenomena” (Bradley, 1993) p. 437).

There are two types of dependability in qualitative content analysis; intra-coder and inter-coder. The literature provides advice in this regard (Rourke and Anderson, 2004, Sandelowski, 1995). While the investigator was the sole coder for this research, a colleague was requested to independently code a small sample of text, and then come to a consensus with the researcher on the coding criteria. Intra-coder dependability was also verified by including a number of “inquiry audits” within the process, where the researcher re-coded subsets of the data to ensure that the coder has not altered their coding technique or decisions over time (Lincoln and Guba, 1985). This step was at the midway point of each unit of analysis, with a small (between 12 and 15 meaning units) but representative samples of text of the previously coded unit of analysis.

The interview conversations were recorded digitally, and transcription work followed accepted approaches (Burnard, 1991, Burnard, 1996, Kvale, 1996).

3.6.4 Confirmability (Objectivity)

Confirmability refers to “the extent to which the characteristics of the data, as posited by the researcher, can be confirmed by others who read or review the research results” (Bradley, 1993).

The investigator strived to remain objective through the methodological processes. This was achieved through detailed documentation of procedures and appropriate record keeping. Sound research management processes were followed (Rowley, 2002), such as a detailed fieldwork log taken throughout data collection. In the QCA stage of data collection, the process itself remained faithful to the advice of the
practitioner literature. This militated against the methodological limitation take comes from lack of experience by the researcher in the “art of QCA”

During the interview stage, the possible impact of interviewer bias was reduced by allowing the results that emerged inductively of the preceding QCA phase to act as a structure for the interview. Interviewee subjectivity which would lend to bias, was considered in the preparation of the participant interview preparation notes (Saunders, 2007). In addition, each participant, as staff members in an academic teaching hospital were aware of the requirements of academic rigour. This was discussed and agreed at the start of each interview.

3.7 Chapter Conclusion

This chapter discussed the various research and methodological options available to the author to address the data collection requirements necessary to answer the research questions present at the start of the chapter.

Due to the exploratory nature of the inquiry, and qualitative research stance was taken.

The first objective of the research was to determine, in a methodologically robust way, the “dimensions” that represent the key process areas for the best practice delivery of a critical care service, the case study under investigation. These dimensions “emerged” inductively from a qualitative content analysis of three documents that were at the core of the strategic, tactical, and professional requirements of the case study in question.

These dimensions and the key process areas that define them, were validated, expanded, refined and enriched through a number of semi-structured interviews held with members of the critical care leadership team. This satisfied the requirements to develop a framework maturity model, as outlined by the second research objective.

The final draft of the maturity model was issued to each participant for independent scoring.

This chapter concludes with the various measures taken to ensure research trustworthiness, consistent with the advice of the qualitative research literature.
Chapter 4  Results and Findings

4.0  Introduction

The methodology described in chapter three of this thesis, provides for three sequential phases of research. This chapter presents the findings from each phase.

Phase I of the research is the qualitative content analysis, employed to determine the key priorities or process areas of the critical care service under evaluation. These are termed dimensions, which represent the tactical, professional and strategic perspective of the service.

Phase II of this study involves using the dimensions derived from phase I, as the basis of a series of questions and discussion points in semi-structured interviews with key expert members of the critical care leadership team at GUH. Through these interviews, the process areas within each dimensions to which the CIS can positively contribute are set-out in a framework. The structure of the framework is based on four levels in a traditional maturity model, as discussed in chapter two of this thesis.

The final part, Phase III, involves presenting the final maturity model to each interview participants. This is best described as a pilot phase of the research, where each participant rates their perspective of the current state maturity of the CIS, for each dimension.

This chapter concludes with a summary of the key findings.

4.1  Phase I Results and Findings -Qualitative Content Analysis

A qualitative content analysis was performed on three documents, chosen by the researcher in conjunction with members of the critical care service. The selected texts represent the operational, professional and wider strategic imperatives of the service. The results of the inductive Qualitative Content Analysis (QCA) process are presented for each document in turn, and begin with a summary account of the details and original purpose of each document.
4.1.1 Practice Development Unit re-accreditation documentation

The critical care service at GUH is an accredited Practice Development Unit (PDU) since 2005. The document comprises a detailed response to a wide range of practice development issues, provided as a template by the University of Leeds Centre for Development of Health Care Policy and Practice submission guidelines (Totterdell, 2004). This document is the outcome of an eight month long multi-disciplinary process to provide documentary evidence of the critical care service’s professional and practice development activities, which is required to achieve re-accreditation in October 2009. This document was chosen because it represents the professional and practice priorities of the critical care service at Galway University Hospital (GUH).

The document comprises of 15 sections, over 37 pages of text.

The number of meaning units selected from the text is 95, which comprises of words, phrases or sentences. These were selected verbatim from the text, and inserted into an Excel™ (Microsoft Inc.) spreadsheet file, with a template heading structure as shown below (Figure 4.1)

An illustrative example of meaning units from this QCA process that distilled down to contribute to the dimension “Strategic Practice Development” is shown below, figure 4.1, and for the dimension “Multidisciplinary team (MDT) Communication and Collaboration” in Figure 4.2.

Also shown is the reference identifier to the source document.

This exercise provided three dimensions that emerged from the inductive Qualitative Content Analysis process for the text labelled “PDU Documentation”. These are;

- Multidisciplinary Team (MDT) Collaboration and Communication
- Strategic Practice development
- Leadership and staff empowerment
<table>
<thead>
<tr>
<th>Source ID</th>
<th>Meaning unit</th>
<th>Condensed Meaning Unit</th>
<th>Interpretation of underlying meaning (Coding)</th>
<th>Sub-theme</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0/10</td>
<td>“The unit acts as an agent of change within the organisation, the region and nationally, publicising its success to promote the value of best practice”</td>
<td>Critical Care is an agent of change for the organisation and nationally</td>
<td>Practice change</td>
<td>continuous practice development</td>
<td>strategic practice development</td>
</tr>
<tr>
<td>10.1/42</td>
<td>“Practice development is viewed as a continuous process of improvement toward increased effectiveness in person centred care”</td>
<td>Continuous practice improvement effective</td>
<td>practice development and CQI</td>
<td>practice development</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.1** Selected section of the QCA analysis for the PDU unit of analysis. The Meaning Unit (2nd column), are drawn from different parts of the text (as per source identifier). Each contribute through a process of abstraction and distillation (columns 3 and 4), to the dimension labelled “strategic practice development”

<table>
<thead>
<tr>
<th>Source ID</th>
<th>Meaning unit</th>
<th>Condensed Meaning Unit</th>
<th>Interpretation of underlying meaning (Coding)</th>
<th>Sub-theme</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.6.200</td>
<td>Concerns were express in relation to the way ward rounds are currently being conducted in that decisions made particularly in relation to prescribing and administering of drugs needs to be addressed before staff leave the unit.</td>
<td>ward round communication-nurse-doctor</td>
<td>communication</td>
<td>MDT Communication</td>
<td>MDT collaboration and Communication</td>
</tr>
<tr>
<td>8/143</td>
<td>Protocol for decanting patients to CT ICU when need arises</td>
<td>cardiac ICU and general ICU collaboration</td>
<td>Collaboration between units</td>
<td>MDT collaboration</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.2** Selected section of the QCA analysis for the PDU unit of analysis. The meaning units (2nd column), are drawn from different parts of the text (as per source identifier). Each contribute through a process of abstraction and distillation (columns 3 and 4), to the dimension labelled “MDT Collaboration and Communication”
The relative strength of contribution to each dimension from the total number of meaning units is shown in the figure 4.3.

![Proportion of Meaning Units that contribute to each dimension - PDU document](image)

**Figure 4.3** A pie chart that illustrates how the 95 meaning units from the PDU unit of analysis are distributed across the three dimensions

### 4.1.2 MATH Accreditation documentation

The second source of data for analysis was the critical care service chapter of the GUH Hospital Accreditation process, known as ‘MATH’ (Major Academic Teaching Hospital) Accreditation. This was a two year process undertaken sponsored by the hospital executive management team to be accredited as a major academic teaching hospital. Galway University Hospitals was one of the eight participating hospital in the standards development process for the national accreditation scheme. The project was officially launched by the Minister for Health and Children on the 3rd February 2000, with the signing of a contract with the Canadian Council on Health Services Accreditation (CCHSA) for assistance in development of the Irish scheme. Each hospital was assigned specific standard groupings using the Canadian AIM Standards as a template.

The written report was published in October 2007. It was selected because it represents the overall hospital strategic requirements and priorities of the critical care service. The authorised submitted document was received in electronic format (Adobe Acrobat Inc.)
The full body of text comprised 52 pages. A total of 101 meaning units were derived from this text.

The dimensions that developed from an inductive QCA of this text, provided for 6 dimensions:

- Risk Management
- MDT Collaboration and Communication
- Policy and Practice Development
- External benchmarking
- Business Efficiency
- Research

An illustrative example of three meaning units from this QCA process that distilled down to contribute to the dimension “Policy and Practice Development” is shown below, figure 4.5. Also shown is the reference identifier to the source document.

Figure 4.4 shows the percentage contribution of meaning units to each dimension.

![Proportion of Meaning Units that Contribute to each Dimension - MATH Accreditation Submission](chart.png)

**Figure 4.4** A pie chart that illustrates how the 105 meaning units from the MATH unit of analysis are distributed across the six dimensions from this text.
<table>
<thead>
<tr>
<th>Source ID</th>
<th>Meaning unit</th>
<th>Condensed Meaning Unit</th>
<th>Interpretation of underlying meaning (Coding)</th>
<th>Sub-theme</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS02.02/8</td>
<td>Best practice guidelines, which address the continuum of care/service are established, adopted, maintained and evaluated, with input from providers and patients/clients, by the team.</td>
<td>Best practice guidelines established</td>
<td>guidelines</td>
<td>Best practice</td>
<td></td>
</tr>
<tr>
<td>CS20.2/11</td>
<td>Before their routine use, the team carries out a process for assessing new interventions and changes to existing ones.</td>
<td>process for assessing new interventions</td>
<td>Continuous policy improvement</td>
<td>Policy development</td>
<td>Policy and Practice Development</td>
</tr>
<tr>
<td>CS08.02/84</td>
<td>The team has a process for determining whether patients/clients are capable of giving their informed consent and uses a range of methods to help those with special needs make informed decisions and exercise their personal freedom</td>
<td>Capable of giving their informed consent and uses a range of methods</td>
<td>Consent policy</td>
<td>Hospital policy</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.5**  
Selected section of the QCA analysis for the MATH unit of analysis. The meaning units (2nd column), are drawn from different parts of the text (as per source identifier). Each contribute through a process of abstraction and distillation (columns 3 and 4), to the dimension labelled “Policy and Practice Development”
4.1.3 Operational Team Meeting minutes

The corpus of text labelled as the “Critical Care operation teams meeting minutes”, comprises of meeting minutes from October 2006 to April 2009. A total 25 documents were included in this study.

The full body of text comprised 75 pages. A total of 271 meaning units were derived from this text.

All minutes, “signed-off” by each annual chairperson, were received in electronic format (Word™ Microsoft Inc.). The operational team consists of eighteen professions that represent the clinical, technical and scientific departments that interface with the critical care service at GUH. These operational team meeting minutes are the mechanism by which the team discusses the operational priorities of the unit, and how the critical care service formally aligns itself with the Clinical Directorate management structure. These documents were chosen for analysis as they represent the operational imperatives of the service.

An illustrative example of the QCA process from this text is shown in Figure 4.6. Also shown is the reference identifier to the source document.

The dimension that emerged from this text through the inductive QCA, provided for 6 dimensions:

- Infection Control
- Risk Management
- MDT Collaboration and Communication
- Policy and Practice Development
- External benchmarking
- Business Efficiency
<table>
<thead>
<tr>
<th>Source ID</th>
<th>Meaning unit</th>
<th>Condensed Meaning Unit</th>
<th>Interpretation of underlying meaning (Coding)</th>
<th>Sub-theme</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.3.200 7</td>
<td>“A network wide report was done on the Bed Utilization Study. The discharge process was very poor in comparison to other hospitals. A new group is being set up to look at the discharge procedures from this”</td>
<td>bed discharge process</td>
<td>bed usage data</td>
<td>resource utilization data</td>
<td></td>
</tr>
<tr>
<td>3.12.20 08</td>
<td>“Store Costing A list of what is being sent in stores was circulated. A discussion was held on how to reduce costs and where cutbacks can be made.”</td>
<td>Clinical supplies costs control</td>
<td>Supplies usage data</td>
<td>resource utilization data</td>
<td>Business Efficiency</td>
</tr>
<tr>
<td>4.2.200 9</td>
<td>“Issues with the cost and amount of out of hours labs being done have been highlighted. While it is not possible to stop out of hours bloods as they are needed for morning rounds, ICU are asked to be mindful when sending bloods to labs, and to review 4am bloods.”</td>
<td>cost of out of hours labs</td>
<td>cost containment</td>
<td>Lab resources</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4.6** Selected section of the QCA analysis for the MATH unit of analysis. The meaning units (2nd column), are drawn from different parts of the text (as per source identifier). Each contribute through a process of abstraction and distillation (columns 3 and 4), to the dimension labelled “Policy and Practice Development”

The relative strength of contribution of the total number of meaning units to each dimension is shown in the figure 4.7.
4.1.4 Summary of Findings from the QCA process.

The cumulative outcome of the QCA analysis provides the strategic, professional and operational priorities of the critical care service, based on the documents analysed in this study, as shown in figure 4.8. This addresses the first objective of the research.

4.2 Phase II Semi-structured Interviews

The results of phase I, as illustrated in the top half of figure 4.8, are the pre-cursor for phase II of the research; a series of semi-structured interviews. The interview was structured around five interview questions or discussion areas, based on the dimensions as derived from the QCA. The results and findings that relate to each discussion are presented below.

Eight interviews were conducted. The average interview time was 69 minutes (range; 45 to 88 minutes).
Figure 4.8 QCA findings for each document, and final dimensions
Top part illustrates the outcome of the QCA on each text – phase I
Also shown in the bottom half is the outcome the phase II of the research as discussed in section 4.2
4.2.1 Interview Question 1

“Do you believe that the “dimensions” that derive from my QCA process represent the “body of work” that describe the priority activities of the unit for the delivery of high quality critical care?”

All participants agreed that the dimensions were a comprehensive representation of the critical care service at GUH.

One participant suggested “Quality and Risk are the two sides of the same coin, they should be included together. Reducing risk increases quality, and often vice versa”

They were considered higher level components of the critical care service

A notable comment was “when we started out with the CIS we did explicitly see these dimensions as the reason for its purchase, but I can see now that, as it is laid out before me in this form, how is has merit in translating what we have almost subconsciously to a conscious effort”

4.2.2 Interview Question 2

“Can you suggest others that may be included as a subset of those outlined above, or other dimensions, tasks or activities, that are omitted from those presented above?”

Some participants did not understand the meaning of the term “strategic” in the context of “strategic Practice Development”, the consensus opinion is summed up by the comment “practice development is strategic by its nature”. The word strategic was removed from this dimension label.

Business efficiency should include ‘reporting’. “Efficiency is only applicable if it is measureable, this is the greatest strength of the CIS – it can measure like we never could on paper”
One comment was; “Research is part of Practice development, they exist along a continuum.

Others participants disagreed, noting that when research is “bolted on to practice development” it invariably gets lost in audit, not research”, and continuing “it deserves a dimension of its own, especially at a university teaching hospital”

On the dimension Policy and Practice Development, a participant suggested that it include the word “guideline” which is distinct from “policy” – “Doctors traditionally use “Guidelines”, I suggest this should be re-written. This is something us doctors need to work on, we’re not as mature in terms of using the CIS as a portal to guidelines as the nurses are”

A critical care unit annual report, the first draft had been completed in the week prior to the interview, was mentioned several times. This was seen as the first important step to reporting service and clinical statistics formally to hospital management.

4.2.3 Interview Question 3

“We will discuss what each dimension means to you, and your work. For example, how would you define each? Which is the most important? How do they relate to each other? Are they mutually exclusive?”

Based on the explanations provided by the participants, there was a consistent and common understanding of what the dimensions mean. Some participants felt that “leadership”, and how the CIS facilitates this, was a difficult concept that did not seem to fit.

Many participants made the point that all dimensions are inter-related, and it is difficult to make them mutually exclusive, and for example, it takes MDT collaboration to implement risk reduction strategies. Many also noted that “each dimension would need to be measureable to be useful”

One participant noted; “The system was never really about the engineering or the technology, it was always about our people, how we all acted as leaders. The op [sic] meetings are critical to how we communicate throughout the unit”
4.2.4 Interview Question 4

"Rate the relative importance each dimension"

All participants expressed the view that the dimensions were inter-related, where success in one was dependant on another. As a result, participants had difficulty rating the dimensions sequentially from 1 (most important) to 7 (least important). Participants were thus free to rate two or more dimensions as equally important.

The rating score assigned by all participants is shown in Table 4.1

<table>
<thead>
<tr>
<th>Participant Dimension</th>
<th>CNM 3</th>
<th>CA2</th>
<th>CNM 1</th>
<th>CA 1</th>
<th>CA 3</th>
<th>CNM 2</th>
<th>P 1</th>
<th>RM 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>MDT collaboration and communication</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Guideline, Policy and Practice Development</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>External benchmarking</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Business efficiency and reporting</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Leadership and staff empowerment</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Research and Teaching</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 4.1 Interview responses when requested to rate the importance of each dimension. Each assigned a score 1 to 7 (1 being most important), and were free to rate one or more dimensions as equally important

4.3.5 Interview Question 5

"Considering each dimension in turn, what are the area of activities, or tasks (also termed Process Areas in the literature), with which the CIS has a part to play in supporting, driving, facilitating, or to positively impact each dimension. Consider those that it does now, but also those where there is room to improve or others not yet addressed. This will be a type of brainstorming conversation, which includes words, phrases, themes, examples, and so on"
This occupied approximately 75% of the interview time. Main interview points were recorded to textual format. These points became the suggestions that completed the cells within the framework template. The template below was completed, each entry could relate back to points raised during the interviews.

After the first three interviews, a “working draft” of the framework maturity model was made available to subsequent participants at question five stage of the interview process. This acted a visual aid to refine existing cells, and extrapolate along the maturity levels to add new detail. This was an iterative process, and with each new perspective, the working document development and matured.

The final outcome of this exercise for each dimension is presented in the following sections, from table 4.2 through to 4.8. Also shown for each dimension is the “common” explanation of each dimension in response to interview question 3, part a.
### 4.3.5.1 Risk and Quality Management

How the CIS contributes to reducing risk to patient, staff and organisation. How the
CIS contributes to increasing quality of care and service delivery

<table>
<thead>
<tr>
<th>Maturity Dimension</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk and Quality Management</td>
<td>no link between CIS customisations and risk register</td>
<td>Ad hoc approach to managing risk from CIS perspective.</td>
<td>most serious or higher profile risks are brought to CIS team to analyse and mitigate through CIS</td>
<td>CIS customisation is closely related and fully integrated with RM procedures – risk registers, monitoring, analysis, action, feedback &amp; reporting</td>
</tr>
<tr>
<td></td>
<td>No monitoring of CIS related risks</td>
<td>No formal procedure for CIS team to address risks reported.</td>
<td>Procedure in line with overall hospital policy for reacting to risk identified</td>
<td>Automated, strategically important risk management reports generated monthly</td>
</tr>
<tr>
<td></td>
<td>All of the basic risk benefit components of the CIS, such as CPOE, fluid manager, allergy system, are in use.</td>
<td>Little use clinically of Event Manager. Some offline experimental use evident. No clinical demand for development</td>
<td>High level risk alerts through &quot;CIS Event Manager&quot;</td>
<td>Sophisticated ability to strategically “flag” highest risk medication events</td>
</tr>
<tr>
<td></td>
<td>No use of Clinical Decision Support tools or “Event Manager” evident</td>
<td>Ad hoc monitoring of risks that occur</td>
<td>CIS is viewed by the enterprise as a model for e-prescribing initiatives</td>
<td>Continuous monitoring of inadvertent CIS related risks-documentation compliance, double order entry scripts, etc.</td>
</tr>
<tr>
<td></td>
<td>Little interaction with Maintenance/IT on network works or risks</td>
<td>Retrospective analysis of risks evident.</td>
<td>Some of the accessible risks dealt with by EM.</td>
<td>Procedure for continuous development of EM, for real-time events, and for audit purposes and targeted record compliance work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some examples of proactive risk analysis evident.</td>
<td>CIS facilitates the routine communication and audit of risk communication to staff</td>
<td>CIS team contribute to hospital EPR initiatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IT upgrade works are planning and risk assessed in advance</td>
<td>Risk monitoring is a standing item at all CIS data quality meetings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Proactive project evident – FMEA, Sigma, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Drug interaction protocols and algorithms in place for high risk drugs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Monitoring of all downtime evident. 99.5% target uptime achievable</td>
</tr>
</tbody>
</table>

Table 4.2 Maturity model for the ‘Risk and Quality Management dimension
4.3.5.2  **Multidisciplinary Team Collaboration and Communication**

How the CIS can facilitate and foster good inter profession communication and collaboration

<table>
<thead>
<tr>
<th>Maturity Description</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDT Collaboration and Communication</td>
<td>Paper notes continue to be used by critical care providers.</td>
<td>Significant proportion of providers use CIS for documentation, mix of paper and CIS still evident</td>
<td>Majority of professions access CIS for daily documentation.</td>
<td>All anaesthesia, referring, nursing, ICD, ICNARC and SAPII are integrated to CIS.</td>
</tr>
<tr>
<td></td>
<td>Individual paper notes, and workarounds evident - mismatch of doc. Media formats</td>
<td>Ad hoc approach to coding of disease and treatments.</td>
<td>CIS documentation easily accessible and presented to all users</td>
<td>Referring teams have a customised views and input particular to their needs</td>
</tr>
<tr>
<td></td>
<td>Isolated professions notes evident</td>
<td>CIS used as an auditable communication tool of hospital and critical care safety and risk notices</td>
<td>Some disease and treatment coding models used.</td>
<td>Close links with “sister” units for co-development of CQI initiatives with CIS.</td>
</tr>
<tr>
<td></td>
<td>Little evidence of collaborative links or ongoing communications with external CIS users</td>
<td>Coding difficult to use and search</td>
<td>HIPE coding used for a majority of patients.</td>
<td>CIS team active members of Informatics organisations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some evidence of collaborative efforts to infuse coding with documentation process</td>
<td>Existence of in roads to integrated coding - pet projects</td>
<td>Coding used is an integral part of the documentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ad hoc or opportunity link with external CIS users and organisations</td>
<td>Some evidence of collaborative problem solving of CIS issues with external users.</td>
<td>Anaesthetists not physically in unit have remote access to CIS during telephone consultation with nurse at bed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good collaboration between different care units in place</td>
<td>Comparative exercise in place</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Some evidence of joint CIS customisation and use efforts presentations at conferences.</td>
<td></td>
</tr>
<tr>
<td>sub level graduation</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

*Table 4.3*  Maturity model for the ‘MDT Collaboration and Communication’ dimension
### 4.3.5.3 Business Efficiency & Reporting

How the CIS facilitates efficient work practices, and monitors efficiency

<table>
<thead>
<tr>
<th>Maturity Description</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Efficiency</td>
<td>Little evidence of documented and validated examples of CIS customisations that have enhanced efficiency</td>
<td>Some evidence of continued efforts to use CIS to improve efficiency, these are documented. Work flow studies are a part of CIS customisation process. A forum to determine and report progress of initiative in place.</td>
<td>Some examples of six sigma and lean improvement projects efforts. Evidence that data collected is used as information. New staff training comprehensive, online learning tools. Cost of stay per patient calculated by CIS, for drugs and supplies.</td>
<td>Systematic reviews and reporting of CIS workflow efficiency projects. These include time-in-motion studies, BPR initiatives, Lean/Sigma. Close link between hospital efficiency priorities and CIS efficiency projects. CIS with future pharmacy system to monitor drug usage. Six sigma and lean type projects scheduled and resourced. Efficiency gains achieved in Unit are replicated or repeated in other areas of the hospital. CIS links with hospital pharmacy dispensary automatically.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sub level graduation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

Table 4.4 Maturity model for the ‘Business Efficiency & Reporting’ dimension
**4.3.5.4 Leadership and Empowerment**

How the CIS helps staff feel empowered in their professional duties, with good quality information and control over CIS functions and its use.

<table>
<thead>
<tr>
<th>Maturity Description</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership and Empowerment</td>
<td>staff generally not actively involved in the direction of CIS customisation</td>
<td>Staff provided a mechanism for CIS improvement suggestions.</td>
<td>Staff can identify with all CIS improvement projects.</td>
<td>CIS demonstrates implementation of number of staff projects.</td>
</tr>
<tr>
<td></td>
<td>Staff do not feel in control of CIS developments</td>
<td>Staff feel confident of the system, this is monitored by survey annually</td>
<td>Staff form groups to brainstorm improvement initiatives</td>
<td>Documentation audit undertaken by staff every 6 months, results sent to customisation team</td>
</tr>
<tr>
<td></td>
<td>Tail is wagging the dog</td>
<td>Staff resourced to contribute actively to CIS CQI projects</td>
<td>Annual reviews of projects, and schedule.</td>
<td>Staff presentations of identifiable improvement initiatives at conferences etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New customisation released with appropriate training support tools</td>
<td>Annual user survey of various aspects of use and development</td>
<td>Continual efforts to streamline the user interface, with new technologies and tools, to increase ease of use for infrequent users</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sub level graduation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

**Table 4.5** Maturity model for the ‘Leadership and Empowerment’ dimension
### 4.3.5.6 Guideline, Policy and Practice Development

How the CIS contributes to good compliance with implementation of unit guidelines, best practices and policies

<table>
<thead>
<tr>
<th>Maturity Description</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>staff access policy on q pulse at POC at CIS pc</td>
<td>Electronic versions of policies and practice information are available from within the CIS application</td>
<td>P&amp;P are integrated into CIS customisation processes for clinical workflow use</td>
<td>CIS guides the course of treatment and care along predefined pathways for many patient disease presentations.</td>
<td>Evidence of a systematic approach to early CIS customisation in P&amp;P design and development</td>
</tr>
<tr>
<td>P &amp;P development in isolation from CIS</td>
<td>CIS has an infrequent or ad hoc involvement in P&amp;P development and implementation, but high priority P&amp;P are considered in CIS customisation</td>
<td>All policies are made available in targeted and context sensitive way.</td>
<td>Projects for new and improved ICPs planned and resourced</td>
<td>Ongoing monitoring and reporting tools for policy compliance evident</td>
</tr>
<tr>
<td>CIS has little part to play in P&amp;P implementation</td>
<td>No CIS integrated protocols of care</td>
<td>Compliance of policy is measured in quasi- real-time report.</td>
<td>Clinical Decision support tools are developed in a systematic and focused way.</td>
<td>Clinical Decision support tools are developed in a systematic and focused way.</td>
</tr>
<tr>
<td>Guideline, Policy, Guideline and Practice Development</td>
<td>Policy Update staff notification process in place</td>
<td>Practice development adjusted in response to audit data</td>
<td>Disease and treatment specific medication guidelines integrated into workflow</td>
<td>Disease and treatment specific medication guidelines integrated into workflow</td>
</tr>
<tr>
<td>sub level graduation</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Table 4.6 Maturity model for the ‘Guideline, Policy and Practice Development’
4.3.5.7 External Benchmarking

How the CIS generates good quality data that allows the service performance to be benchmarked

<table>
<thead>
<tr>
<th>Maturity Description</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Benchmarking</td>
<td>Little evidence of repeatedly reported clinical or business performance indicators</td>
<td>CIS contributes to the Annual unit report of service activity and performance</td>
<td>Unit has a system for continually monitoring existing and generating new KPI indices.</td>
<td>Unit has a key of KPI that are automatically generated on a monthly basis, or on demand, from the CIS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indices easily available to all staff</td>
<td>Unit has a national reputation for CQI using CIS</td>
<td>KPI and indices are benchmarked against known and validated external measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit has a reputation for high performance CIS</td>
<td>“Menu” of new KPIs measured and reported by CIS</td>
<td>CIS interfaces to external audit agencies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Evidence that unit and Hospital Management act on these indices</td>
<td>Unit is an active part of the international CIS Users groups</td>
</tr>
</tbody>
</table>

| sub level graduation      | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |

Table 4.7 Maturity model for the ‘External Benchmarking’ dimension
4.3.5.8 Research

How the CIS contributes, or initiates, medical, nursing and allied health research.

<table>
<thead>
<tr>
<th>Maturity Description</th>
<th>level 1</th>
<th>level 2</th>
<th>level 3</th>
<th>level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>Little evidence of Research or teaching role for CIS</td>
<td>ad hoc, CIS team provide data as requested to support any research project IS supports grand rounds teaching sessions, on request</td>
<td>Demonstrated efforts of CIS and CIS team involvement in research design, idea generation, data collection, and research facilitation. More formal mechanism for research involvement A number of student project are supported by CIS. CIS is used to present interesting cases for grand rounds teaching sessions</td>
<td>CIS team have formal links with research institutions for research and teaching Evidence of CIS Team involved in teaching of academic informatics courses CIS facilitates data collection for grant funded research. CIS Team involved with wider informatics research agencies, including presentation of results</td>
</tr>
</tbody>
</table>

Table 4.8 Maturity model for the ‘Research’ dimension

4.4 Phase III Pilot of the final CIS Maturity Model

Each participant was issued a copy of the final version of is termed the ‘CIS maturity model’, and were requested to provide a maturity score (level and sub-level) for each dimension. Each participant was provided with an explanatory notes that requested that they address this from a critical perspective of the current “as-is” situation. This correspondence of shown in Appendix III.
The pilot test of the maturity framework, independently by each participant, acted as an assessment tool of the current level of maturity or sophistication from an individual perspective. It was found to be both useful and informative by the participants, and could be completed within 15 minutes. Each participant was provided written instructions on how to use the model.

One participant, the hospital Risk and Quality Manager (RM), chose not to rate some of the dimensions, because, as she did not work within critical care unit, she did not feel she had sufficient knowledge of some of the internal processes. She did however contribute to the development of the framework detail, and does have an important perspective on the two dimensions she did score.

The results of this process are tabulated in Table 4.9. The results within each cell are presented as x,y; where x is the maturity level, and y is the sub-level within in this.

<table>
<thead>
<tr>
<th>Participant Dimension</th>
<th>CNM 3</th>
<th>CA2</th>
<th>CNM 1</th>
<th>CA 1</th>
<th>CA 3</th>
<th>CNM 2</th>
<th>P 1</th>
<th>RM 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management</td>
<td>3,2</td>
<td>3,3</td>
<td>4,1</td>
<td>3,4</td>
<td>3,2</td>
<td>2,5</td>
<td>3,3</td>
<td>2,5</td>
</tr>
<tr>
<td>MDT Collaboration and Communication</td>
<td>3,3</td>
<td>2,3</td>
<td>2,5</td>
<td>3,3</td>
<td>2,4</td>
<td>2,2</td>
<td>2,1</td>
<td>Not rated</td>
</tr>
<tr>
<td>Business Efficiency &amp; Reporting</td>
<td>3,3</td>
<td>2,4</td>
<td>3,5</td>
<td>3,3</td>
<td>2,1</td>
<td>3,4</td>
<td>2,1</td>
<td>2,2</td>
</tr>
<tr>
<td>Leadership and Empowerment</td>
<td>2,1</td>
<td>2,4</td>
<td>2,5</td>
<td>3,3</td>
<td>3,1</td>
<td>3,1</td>
<td>3,1</td>
<td>Not rated</td>
</tr>
<tr>
<td>Guideline, Policy and Practice Development</td>
<td>2,2</td>
<td>2,5</td>
<td>4,4</td>
<td>2,5</td>
<td>2,5</td>
<td>4,3</td>
<td>3,1</td>
<td>Not rated</td>
</tr>
<tr>
<td>External Benchmarking</td>
<td>2,2</td>
<td>2,5</td>
<td>2,5</td>
<td>2,5</td>
<td>1,4</td>
<td>3,5</td>
<td>1,5</td>
<td>Not rated</td>
</tr>
<tr>
<td>Research</td>
<td>2,2</td>
<td>3,2</td>
<td>3,5</td>
<td>3,4</td>
<td>2,5</td>
<td>3,5</td>
<td>2,3</td>
<td>Not rated</td>
</tr>
</tbody>
</table>

Table 4.9 Results returned from the eight participants. Format of each result is x,y, where x is the maturity level, and y is the sub-level within in it. RM did not work within critical care, and did not feel she was in a position to score all dimensions.
4.5 Summary of Key Findings

The results of this research indicate that the method set out in chapter three, is an appropriate instrument to develop the dimensions that represent the priority process area of the critical care service under inquiry. Seven dimensions are identified.

The interview phase of the research shows that these dimensions are a valid basis for the development of framework maturity model that may be used as part of a CIS mediated continuous quality improvement process. The model comprises four levels of maturity.

The pilot phase of the research demonstrates that the model can be used in practice and the results of this phase of research shows that the model may guide local CIS development to those areas with the lowest level of maturity or sophistication.
Chapter 5  Discussion

5.0  Introduction

The purpose of this chapter is to evaluate and analyse the findings presented in chapter four, and to show how these results relate to published research as presented in review of the literature in chapter two.

The research question is provided as “How may a practice framework, or ‘maturity model’, be developed for the continued quality improvement of a locally customised critical care Clinical Information System?”

The answer to this question was sought by addressing the following research objectives. These were conducted sequentially over three phases of research:

d) Phase I: Using the recognised text analysis technique, Qualitative Content Analysis, determine the key priorities of the critical care service, from an operational, professional and strategic perspective.

e) Phase II: Use the outcome of this analysis, as construct for semi-structured interviews with members of the critical care leadership team, to further develop these dimensions into a framework for continuous CIS development and maturity.

f) Phase III: Pilot the results of this maturity framework with the interview participants.

The findings are discussed by addressing each of the three research objectives. The chapter will begin with a discussion on the overall methodological stance taken in this research.

5.1  Methodological Approach

This research takes a subjectivist approach to the inquiry. The use of qualitative research methods has been promoted for IS research (Callen et al., 2006). This is consistent with the current ‘trends’ in informatics research (Yusof et al., 2008b), as discussed in chapter two of this thesis. The method chosen in this research is
inductive in nature, being in effect, a ‘first principles’ consideration on how a critical care CIS may be optimised for continued success. This stance directs attention towards the needs and requirements of the service providers, which would then inform the course of any subsequent technologically focussed improvement efforts. Other approaches, such as technological “as-is” or “gap”-analysis, would place organisational or service requirements secondary to technological considerations which, while interesting, may or may not be aligned with the (locally) most important service priorities.

5.2 Phase I – QCA and Critical Care service priorities

The first objective of this research is to develop a method to determine the high level dimensions that represent the key priorities of the critical care service at GUH (the case study). The method chosen is based on the systematic inductive analysis of documents that represents the strategic, tactical, and professional perspectives of the service. While these documents are local to the organisation at the centre of this study, summary descriptions of the detail and function of each document are provided, that demonstrate that an ‘equivalent unit of analysis’ would be available in other critical care units.

Seven dimensions culminated from the QCA of the three texts (or “units of analysis”) chosen. The document referred to as “MATH Accreditation” contributed six dimensions to the final seven dimensions in the model, one of which (Research) is exclusive to this document. The “Operational team meeting minutes” unit of analysis, contributed five dimensions to the final seven dimensions. The “PDU” text contributed 3 dimensions, one of which (Leadership and Empowerment) is exclusive to this unit of analysis.

There is strongest agreement between the “MATH” text, and the “Operational team meeting minutes” text, where the QCA process provided five equivalent dimensions. This would be expected as the Operational Team meetings minutes are part of the wider hospital strategy of “clinicians in management”. The organisational structure at GUH, shown in Appendix IV, reflects this. The monthly operational team meeting minutes are an integral part of this strategy. An important part of achieving MATH accreditation is providing evidence that clinicians and service providers inform the overall hospital strategic direction.
The QCA of the PDU text demonstrates that this text concentrates on the more academic, and professional requirements of the service, with less emphasis on those operational or strategic aspects. This clearly provides an important perspective of a university teaching hospital, and for a critical care unit that has close links with academic institutions and professional bodies for trainee placement programmes.

In Chapter four, figures 4.3, 4.4, and 4.7, show the relative strength of contribution to each dimension, based on a summation of contributing text meaning units. Taking an overall average of these of all three texts, would provide an indicative measure of the most important dimensions derived from the QCA process as a whole. This is illustrated in figure 5.1 below.

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**Figure 5.1** Relative importance of each dimensions, calculated as a average of the sum of dimensions from the three units of analysis – ‘PDU’, ‘MATH’, ‘Operational Team Meetings’

This indicates that, based on the QCA, the highest priority initiatives for CIS improvement should concentrate on optimising CIS use and functions based on these top three dimensions; ‘Risk Management’, ‘MDT Collaboration and Communication’,

and ‘Policy and Practice Development’. These ‘top three’ represent 75% of the contribution from all seven dimensions.

5.3 Phase II – presentation of QCA results, and interview phase

5.3.0 Introduction

An important part of the Phase II research is to provide the leaders and experts of the critical care service in this case study, an opportunity to independently validate or refute the findings of phase I (QCA).

The interview phase centres around five interview questions. The first four questions are concerned with examining, from the perspective of each participant, both the concept, and results of the QCA process in Phase I. This part of the interview process served a number of functions. Firstly, it allowed participants to examine both the usefulness, and completeness of the dimensions presented to them. Secondly, it provided an opportunity to examine ways in which the dimensions are inter-related, or distinct from each other. Finally, the process served to allow the researcher gauge the common understanding of what defines each dimension, among the case study participants.

The most pertinent points are set out below.

5.3.1 Presentation of QCA results to interview participants

The interview participants were all in clinical leadership roles within the critical care service. Participants responses to interview questions one, two and three, are discussed below.

Each was asked to consider and reflect on the dimensions. There was general agreement that the dimensions presented to them from the QCA exercise were representative of the key priorities in the provision of critical care.

Many participants noted that the dimensions were a useful construct to categorise their thoughts, and aid reflection, on how the CIS may facilitate continues quality improvement.
There was a common understanding of what defined each dimension.

Amendments to the dimensions during the interview stage included the issue of reporting of CIS generated data and the outcome of improvement initiatives, both internally and externally. This was particularly the case for the dimension “business efficiency”. The participants were of consensus opinion that much of the improvement work to date has been successfully implemented, but there has been relatively little attention given to reporting to hospital management of both the existence and outcome of these initiatives.

The dimensions derived from the QCA process proved a useful tool to keep the interview discussion focussed on, and grounded to, the service aspects of critical care, as opposed to the technological capabilities of the CIS alone. This was noted by some participants as strength of the QCA methodological approach. None of the participants had any experience with such textual analysis techniques.

Thus, a narrow analysis of CIS that centres around a sort of “technological gap analysis”, was avoided, to be replaced by the more holistic, Business Process Management approach, where CIS development was sought to strategically address business or clinical needs rather than, as one interviewee put it, “exploiting technological features just because they are available”

5.3.2 Rate of importance of Dimensions

Question four of the interview preparation notes requested participants to rate each in terms of importance, based on their perspective.

A graphical representation of how the participants rated the importance of each dimension is shown below in figure 5.2

The results of this exercise are consistent with those results independently determined from the QCA process, and provides for useful data triangulation. This does show that there is congruence between what the participants believe are the most important dimensions, and what the QCA determines as most important from the written documentation that underpins service provision.
Figure 5.2  Graphical representation of the participants (n=8) rating of the relative importance of each dimension.

If the data is examined in more detail, by isolating results returned from the two primary users of the CIS (nurses and doctors), it shows that these professional groups agree on which are the top two priority dimensions for CIS improvement (circled in figure 5.3).
Figure 5.3 Graphical representation of relative importance (normalised percentage) for the two primary professional groups—nurses and doctors, interviewed in this study.

It is difficult, due to the small sample size, to make any further statistically valid inferences on what the data reveals about the perceptions of these two professional groups, except to point out that there seems to be congruence of opinion on importance across all dimensions.

5.4 Development of the CIS maturity model

Interview question five involved the development of the maturity model. The content within each maturity level described activities or examples that would be representative of that level of sophistication.

Eight participants proved an adequate number to develop the detail of the model. Towards the end of this process, evidence of new knowledge to the CIS maturity model decreased. Four states of maturity were decided, as this was deemed by the researcher and participants, a workable construct at a practical level. This was in line with other researchers in the maturity models and benchmarking fields (Dooley et al., 2001a, Kahn et al., 2006).
The detail that provides the criteria and descriptions that signify each level of maturity for each of the seven dimensions are shown in table 4.2 through 4.8 (Chapter 4). The main themes of each are summarily discussed below.

Risk and Quality Management represents one of the cornerstones of best practice healthcare provision. For the critical care unit, reducing risk and increasing quality of treatment to patients, work hand-in-hand. Much of the detail of the maturity levels centres on how the CIS customisation efforts are integrated into the wider hospital risk and quality management structures. Level one describes limited, or at best ad-hoc, CIS mediated risk management processes. Level four describes CIS configuration that is fully integrated to the risk management strategy, clinical adverse events are routinely monitored, many in an automated way. The CIS is constantly improved proactively to limit the chance of identified risk events re-occurring.

Multidisciplinary Team Collaboration and Communication is concerned with how the CIS improved the way the professionals interacted with each other towards a common goal. Much of the framework detail focussed on evidence that the medical record was generated in a collaborative way which aided communication on the course of patient treatment and care. Increasing maturity is also signified as evolving from an inward or local view of the CIS, to one where routine and managed collaboration with other institutions are an integral part of the CIS improvement process.

The dimension for Guideline, Policy and Practice Development considers levels of sophistication with regard to two issues. The first is how the CIS facilitates presentation of policies, procedures, and guidelines at the point of care. This maturity ranged from availability of the documentation from the computer, to the highest maturity level where policies and guidelines are ‘knitted into’ the programming of the CIS workflow, where clinicians are guided along a path of best practice. The second issue describes how the CIS facilitates continuous monitoring of best practice documentation, by providing statistics of procedure compliance.

The Business Efficiency and Reporting dimension concentrates on how the CIS generates data to support, for example; “Lean” initiatives, “time-in-motion” studies, resource utilization measurement, and so on. Sophistication within this dimension ranged from the once-off, ad-hoc efficiency projects, to repeatable, automated efficiency projects which included regular reporting of results to hospital management.
Leadership and Empowerment, describes how the CIS helps the staff worker to feel ‘in control’ of the patient care and treatment process. The continuum ranged from staff members having little control over CIS customisation and use decisions, to one where staff members were an integral part of the process of idea generation, new function concept testing, and where various staff teams take ownership of clinical documentation quality audits.

External Benchmarking is concerned with how the critical care unit reports progress to external agencies, and how it generates data that supports benchmarking of key process indicators. Examples include mortality and morbidity measures, severity of illness indices, length of stay measures, and so on. Maturity ranges from; little measurement of progress, to higher maturity that includes interfacing with national and international audit agencies for critical care.

As a powerful database query tool, the CIS provides significant opportunity for staff to be involved in applied research. It is clear from the interviews that creating significant research profile was an important strategy for the Unit. The CIS was seen as an avenue to engage in multi-unit research initiatives, and the maturity levels indicated the extent to which the CIS was in a position to engage in these efforts.

One of the over-riding messages that comes from the process of creating the maturity model, and that is evident in the final detail, is that the greatest improvements in quality of care come, not from the complex or leading edge initiatives but, from the those improvement processes that are small steps in the right direction. Higher levels of maturity are more about perfecting existing processes of care, rather than the introduction of new techniques alone.

5.5 Pilot of the maturity model

Participants reported completing the maturity model without difficulty. A principal finding is that the objective of building a maturity model that demonstrates high face validity was achieved.

The results from each participant are shown in table 4.1, chapter four.

Table 5.1 summarises the results of the scoring from participants in the pilot test, where the level and sub-level scores are transposed as a percentage (four levels of
maturity each representing 25%, where each comprises 5 sub-levels of 5% each). For example, maturity level of ‘2,1’ equates to 30%.

Also shown in Table 5.1, is the range of values, from lowest to highest score, for each dimension. The Mean (\(\mu\)), Standard deviation (\(\sigma\)), and coefficient of deviation (CV) are shown for each dimension. CV provides a statistical measure of agreement between groups of scores. A lower the value of CV indicates a narrow spread of scores. It is useful index when comparing different sets of numbers which have different mean values (as for different dimensions in this research) (Weiss, 1999).

\[
CV = \frac{\sigma}{\mu}
\]

**Figure 5.4**  Formula for calculating the coefficient of variation (CV) for a series of scores with standard deviation (\(\sigma\)) and mean (\(\mu\))

The dimensions for which there was most agreement (CV = 0.16) on the current level of maturity for the CIS was the Risk and Quality Management. The results returned cluster predominantly in level 3 maturity, with a mean value of 63 % (Level 3, 3).

The dimension where was least agreement was “External Benchmarking” (CV = 0.43). The breath of scores spanned just over 2 levels (range 20%-75%), with a mean value at the upper end of level 2 (58 %).
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Range %</th>
<th>Mean %</th>
<th>Std. Dev %</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Management</td>
<td>50-80</td>
<td>63</td>
<td>10.00</td>
<td>0.16</td>
</tr>
<tr>
<td>MDT Collaboration and Communication</td>
<td>35-65</td>
<td>47</td>
<td>13.50</td>
<td>0.29</td>
</tr>
<tr>
<td>Business Efficiency &amp; Reporting</td>
<td>30-65</td>
<td>43</td>
<td>13.36</td>
<td>0.31</td>
</tr>
<tr>
<td>Leadership and Empowerment</td>
<td>35-70</td>
<td>56</td>
<td>11.80</td>
<td>0.21</td>
</tr>
<tr>
<td>Guideline, Policy and Practice</td>
<td>45-70</td>
<td>58</td>
<td>12.20</td>
<td>0.21</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Benchmarking</td>
<td>20-75</td>
<td>44</td>
<td>18.64</td>
<td>0.43</td>
</tr>
<tr>
<td>Research</td>
<td>30-75</td>
<td>58</td>
<td>16.55</td>
<td>0.29</td>
</tr>
<tr>
<td>Average across all maturity levels</td>
<td></td>
<td>53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.1** Analysis of results from pilot of the maturity model from all respondents

The average range of results across all dimensions was 53%. This signifies that, overall maturity or sophistication of CIS customisation and its use is at the mid-way point between an ad-hoc, initial maturity state; and an optimised, strategically grounded state of maturity. This result points to further scope for improvement for the CIS team at GUH. In addition, the process areas described for the higher maturity levels help direct the course of this improvement effort.

Also evident is that, of the seven dimensions, three (MDT collaboration and Communication, Business Efficiency & Reporting, and External Benchmarking) are below the overall average.

Figure 5.5 shows graphically the mean value for each dimension, bounded by the range of results returned by the participants. Also shown is the mean across all dimensions, shown as vertical dashed line. This representation has been adopted by researchers in the maturity model field, as an intuitive representation of the most pertinent ‘messages from the model’ (Farrukh et al., 2003a)
Figure 5.5  Graphical representation of the range of scoring returned, along with the average score per dimension for all participants (n=8). The dashed vertical line represents the overall average score.

The broad spread of results within each dimension, seen in the results of this pilot study point to interesting issues. The first is that different perspectives exist, even when the members of the group that seem to work cohesively (as in this case study) on CIS development. The differences between individuals, and professions, have a bearing on the direction improvement initiatives the CIS will take. As discussed in chapter two in the context of BPM, uncovering and understanding the reasons for such differences of opinion is an important step first step in any improvement initiative.

Another possible reason for spread of scoring (or divergence of opinion) is difference in understanding of what the dimensions mean, or more particularly, what role the individual believes CIS technology could have on each in any improvement initiative. ‘Maturity’ implies that the “process is well understood, supported by documentation and training, is consistently applied through improvement projects and is continually being monitored and improved by its users” (Fraser et al., 2002). Difference of understanding, say between different leaders, is an issue that warrants attention in any improvement initiative, so that the basis for action is strategically sound, and understood by all.

Hammer and Champy (1993), in the context of Business Process Re-engineering, make the point that a consensus based understanding within the organisation of the current state is the critical first step in an improvement initiative. This would be
especially the case in complex organisational structures in critical care. A model that highlights differences between individuals, or between professions, is useful.

Nevertheless, the ultimate direction a CIS improvement process takes depends on successfully arriving at a consensus opinion, especially in an organisation composed of many different and powerful professional groupings. One means to arrive to arrive at a consensus rating for each dimension would be to use focus groups in brainstorming type processes conducive to creativity (De Bono, 1970), and which provide for a-priori consensus building. It can be argued that this step should be performed in-lieu of individual assessment. The broad spread of scores from this pilot study demonstrate that independent individual scoring is an important antecedent to group assessment, because multidisciplinary examination of the reasons for the broad range of opinion on a single dimension would be an important first step to group consensus.

Elwyn, Rhydderch et al. (2004) in the development of a ‘maturity matrix’ for organisational development in medical practice clinics, makes the point that individual assessment reduces the possibility of “gaming”, which is the extent to which those in powerful professional positions (notable feature of the healthcare organisational structures), who may have predetermined viewpoints can influence the scoring process.

It could also be argued that the spread of maturity framework scores across all dimensions in this pilot test, point to a model that lack discriminatory power. This is an issue that has also been considered in the wider maturity model literature. For example, lack of discrimination has been blamed for lack of bottom line results in industrial new product development processes (Kahn et al., 2006). These authors suggest that this is principally because such frameworks can be too subjective, and lack concrete measures indicators of success. Efforts to quantify the proposed framework will facilitate the measurement effort and may offer more concrete results (Kahn et al., 2006).

One way to achieve this would be to construct the detail of statement or criteria in each column, or dimension, as a series of Guttman scales, also known as cumulative scaling, where greater levels of achievement were dependent on the attainment of previous steps (Elwyn et al., 2004, Trochim, 2000). By this method is possible to provide a more objective means of level and sub-level selection.
Another issue worthy of discussion is whether the dimensions of the model are equally important. In a healthcare arena of decreasing resources and increasing demands, should the CIS customisation team concentrate their efforts on some dimensions more than others? This is a question common across the maturity framework literature. An answer is less common, and seems to be situation specific.

The interview phase of the research showed that, while the experts were in a position to rating of importance for each dimension, they also believe the dimensions are all interrelated. For example, while Risk and Quality Management is clearly very important, success in this regard is impossible without adequate “MDT collaboration and communication”

Though it is likely, as discussed above, that the seven dimensions are correlated, it is unknown to what extent. If strong correlation exists, there might be an alternative, more suitable clustering of characteristics. Even if the model explicitly gives each dimension equal importance, certain dimensions may (or must) be more critical than others. In such a case there may be merit in providing a means to normalise results along a sliding scale of importance. By this method, targeting resources at the dimensions with the lowest maturity score is informed by some index of criticality for each dimension.

In addition, given the breadth and scope of the rapid pace of change in both health informatics and critical care medicine, how stable and thorough are both the dimensions themselves, and the description characteristics within them? These characteristics may change over time.

A related issue is that, in addition to the dynamic nature of the technology and environment, it is also likely that the expertise and experience of the participants would change over time. In this case study, the participants had at the time of participation over four years experience with the CIS under inquiry. It is probable that participant experience has a significant bearing on the content of the maturity scales.

Participants with less experience, or different perspectives (for example from less successful CIS implementations), would operate from within a different frame of reference, and would thus, may produce different model characteristics.
The method described in this thesis is both repeatable, and reproducible in other environments, and may be sensitive enough to capture changes in the environment, assuming these changes are first reflected in the documentation of the organisation.

5.6 Proposal on how the CIS maturity framework may be used in practice

Many, if not all, of the continuous quality improvement initiatives may be facilitated or mediated by the CIS at the point of care. As described in Chapter one, and illustrated in figure 1.4, the ‘CIS customisation Team’ is positioned between; on one side, the service, quality and professional improvement requirements of the critical care unit; and on the other, the technological potential of the CIS and its use.

As discussed in chapter two, a practice framework or ‘maturity model’, such as one piloted in this research, acts as a valuable descriptive tool enabling as “as-is” assessment of areas of strength and weakness; as a comparative tool to benchmark performance against industry standards and other institutions, and as a prescriptive tool that shows the activities and processes that articulate the higher maturity level

The literature shows that for correctly configured maturity models, progressing up the maturity levels is difficult (Kahn et al., 2006). In the case of a critical care CIS, improvement and change initiatives are more than just customisation programming and testing work, but a complex mix of socio-political and socio-technical factors that mediate both the prospect of success, and pace of progress. The practice of critical care medicine in an acute hospital is recognised in the literature as one of the more complex environments in which to effect change and improvement (Callen, 2008, Callen et al., 2008, Pexton, 2005).

While the maturity model developed in this study provides a vision of a more sophisticated future, it does not provide the solutions or steps necessary to reach the higher level. As discussed in chapter two, the wider IS literature does however provide various “models of success” based on empirical research of previously successful, and unsuccessful, IS projects. One much cited model, referred to as the deLone and McLean (2003) IS success model, provides an integrated view of the factors that determine success. This model is described in chapter two, and the model constituents are illustrated in figure 2.3.
It may be useful to link the concept of the maturity model and the DeLone and McLean (2003) model for IS success. An initial attempt of this proposal is presented in figure 5.6

The alignment of the maturity model and the DeLone and McLean (2003) IS success model, may be interpreted as follows; once the framework has been completed, where the vision for future sophistication has been articulated as processes and activities that describe each maturity level. The next step is to select a dimension for consideration, with a view to improving its level of maturity. This then becomes a ‘project’, where the gap between the ‘current state’ and the ‘future state’ is analysed in terms of the six inter-related dimensions of the DeLone and McLean model.

In this approach, the DeLone and McLean (2003) model is used as a mechanism that fractionates the problem into constituent parts, each representing the various determinants of success; technological (system and information), support (service), user attributes (intention to use, usability), and net benefits (individual and organisational benefits).

As the CIS project team set about measuring and addressing potential barriers to success within each of these dimensions, a project solution is developed. Through this approach, proposed technological solutions are considered in close alignment with the wider organisational dynamics, which are at the heart of successful implementation.

Implementation of this solution, followed by a re-assessment of the state of maturity, will determine if and to what extent the project objectives have been reached. As discussed in chapter two, this feedback spiral is a feature of properly functioning quality improvement at organisational level. This approach encourages the concept of “double loop learning”, where the organisation strive to systematically address the ‘root causes’ of problems (Smith and Hitt, 2005).

The process of continuous improvement proceeds in this fashion, where at its centre is the CIS maturity model acting as the frame of reference.
Figure 5.6  Proposal for the use of the CIS maturity model in practice.
5.7 Chapter Conclusion

The chapter discusses the outcomes of each of the three phases of research undertaken in this study.

The qualitative content analysis of the textual documentation provided dimensions that are validated by subject matter experts in critical care. The pilot phase of the research demonstrates that the method by which the maturity model is developed, is validated as useful construct for continuous quality improvement of a critical care CIS.

The methodological approach, as described in chapter three, provides for an instrument with high face validity (Lewis-Beck et al., 2004).

Also provided in an initial proposal of how the CIS maturity model may be used in practice. This proposal also draws on the wider research on determinants of IS success, in particular the DeLone and McLean (2003) model for IS success.
Chapter 6 Conclusions

6.0 Introduction

The purpose of this chapter is to present the conclusions of the research outlines the limitations of the study, and recommend potential areas for further research.

6.1 Conclusions

The motivation for this research is to address a gap in the health information technology literature by evaluating the usefulness of developing CIS a maturity model to guide the ongoing improvement of a locally customised critical care Clinical Information System.

The research questions at the centre of this work were posited as a series of research objectives. The first two objectives were to develop a method that would allow a first principles approach to determining the key priorities of the critical care service, and to then use these dimensions as the bases for the construction of the maturity model. These objectives have been satisfied, the outcome of which has been presented in chapter four. The final objective required that this model be tested in practice. The pilot phase of this research satisfies this research objective.

The method by which this CIS maturity model has been developed provides for a path that is grounded in the tactical, strategic and professional requirements of the critical care service, in which it operates. These paths focus on seven general themes, or dimensions, that would be the focus for CIS facilitated continuous quality improvement: ‘Risk and quality management’; ‘Multidisciplinary team collaboration and communication’; ‘Business efficiency and reporting’; ‘Leadership and empowerment’; ‘Guideline, policy and practice development’; ‘External benchmarking’; and ‘Research’.

The portrayal of CIS customisation and improvement initiatives from a multidimensional construct is important because it guides the course of action the critical care unit can take to improve the sophistication of its CIS customisation, as part of the overall continuous quality improvement efforts. This research provides a method, that has been pilot tested, that provides such a construct. As far as can be
determined, through an extensive review of the literature by the author, the CIS maturity model presented in this thesis may be the first such attempt.

6.2 Implications for Practice

The critical care service at GUH is at the forefront of use of technology in the care and treatment of critically ill patients. At the core of the service is the requirement for continuous quality improvement of all practices that surround clinical management of patient illness and disease. Leveraging the potential of the CIS is not a one time event that is focused on installation, but a continuous and dynamic process of improvement over the lifecycle of its use.

This research provides a mechanism that culminates with a maturity model which guides this unit to continually customise and improve both the functions of the CIS, and its use, along a pre-defined strategically driven path. The pilot phase of this research demonstrates that the model does point those areas that should be the focus for improvement. For instance, the results of the pilot study show that ‘Business Efficiency & Reporting’ maturity clearly (figure 5.5) lags behind the other dimensions. Based on this, CIS improvement work should seek to target this dimension.

The implementation of CIS technology throughout the critical care network in Ireland is a stated policy the critical care medical and nursing professional bodies. The Health Services Executive, which the governing authority for the acute hospital system in Ireland, also sees the importance of CIS technology. At the time of writing, nine hospitals have commenced the process of public tender competition for the procurement and implementation of CIS technology to replace existing paper based documentation processes. Once these sites have successfully implemented the CIS, the maturity model developed in this research may have a useful framework for developing a collaborative role for continuous CIS improvement, and performance benchmarking.

As early adopters of CIS technology, the team at GUH are in a prominent position to inform the wider debate on advantages of using this technology, as well as helping overcome the barriers to adoption. One of the important aspects of this role would be to articulate the experiences of the team at GUH. An important means to achieve this
would be to present theses advantages of how the CIS facilitates change and quality improvement along each dimension.

6.3 Research Limitations

The research data was drawn from a cross sectional examination of one case study organisation, using CIS technology from one manufacturer. Therefore this research may be limited by the environment and the setting of the case study.

The cross sectional approach is a practical method for carrying out research within the time available to conduct it, but it does result limit the research in that it is a snap-shot in time. A longitudinal study over time would provide more extensive and conclusive data.

The pillars of the proposed framework are the seven dimensions around which the maturity model is constructed. The foundation to these dimensions comes from the analysis of textual documents from the case study (GUH critical care unit) under inquiry. These documents are unique to this case study, and while equivalent text would be available in other critical care services, a repeat analysis may lead to different dimensions. In addition, while the method outlined includes a phase of research where experts in the field of critical care medicine and CIS technology review and validate the outcome of the text analysis process, it is acknowledged that eight participants is a relatively small sample size.

The process used to develop the detail of the maturity model involved a series of semi-structured interviews performed separately between each of the eight interview participants and the researcher. An appropriate follow up to this would be to conduct focus group sessions, where the participants could essentially “brainstorm” the framework in a workshop type environment. The detail of the maturity model may have benefited from more creative aspects of this method of participation. Participant time constraints and scheduling difficulties meant that this approach was not adopted in this research.

6.4 Further Research Opportunities

There is an opportunity for more extensive empirical testing of the maturity model within the same case study. This may be achieved by opening up the development of
framework maturity model to a wider audience, and professional groupings within the critical care service at GUH. As discussed in chapter five, this may include a mix of workshop environment and independent interviews. Adding the opinion and perspectives of wider group of critical care professions would serve to further refine the detail of model, and add to the content validity of the model.

One of the issues highlighted from the pilot phase of the research, as discussed in chapter four, is that the spread of results returned from the individuals, points to the possibility of providing a more objective means of assessment within each dimensions. One such technique is to re-configure each level of the model to include a series of measurable performance indicators. One approach, that is discussed in chapter five, is the use of ‘Guttman scaling’ (Trochim, 2000) where the criteria within each dimension are provided as a series of steps, where a score is assigned based on meeting each exemplar and criteria that is presented in a sequence. This has been adopted previously by Elywn et al. (2004)

The research discussion in chapter five, concludes with a proposal on how this framework may be used in practice, where it draws on the advice of the wider IS success literature. In this proposal that maturity model is positioned between the DeLone and McLean model of IS success (2003), and best practice project management procedures. There is an opportunity to empirically test the usefulness of this proposal in practice.

The CIS customisation team at GUH, are part of a manufacturer facilitated network of approximately thirty Metavision™ (iMDSoft Inc.) users across Europe. This group meets annually to discuss new developments by the system designers, as well as sharing experiences and new ideas. An interesting area of potential research would be to assess the ‘transferability’ of the maturity model to other environments, and users of the same system. It would also assess the suitability of the maturity model as a benchmarking tool on how different critical care unit develop and utilize the CIS.

Following from this, there would be merit in also assessing the validity of the construct by assessing the transferability of the maturity model to other critical care units, which use also employ CIS technology, but from different manufacturers.

This CIS is part of a wider ‘family’ of clinical informatics technology used in other areas of the hospital, in which the researcher is involved. Notable examples include;
CARDAS™ (GE Medical Inc.) in medical cardiology, and LANTIS™ (Siemens Medical) in radiation oncology. Each of these CIS projects deal with many of the same challenges during their ongoing technical development and clinical use. It would be useful to determine if the overall method detailed in this thesis could be successfully deployed in these environments.
Chapter 7 Bibliography

7.0 References


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Appendix I

Abbreviations Used

BPM Business Process Management
CA Consultant Anaesthetist
CCHSA Canadian Council on Health Services Accreditation
CNM Clinical Nurse Manager
CE Conformité Européenne (French language), conformity marking that certifies that a product has met EU consumer safety, health or environmental requirements.
CIS Clinical Information System
CMM Capability Maturity Model
CMMI Capability Maturity Model Integrated
CPOE Computerised Provider Order Entry System
CQI Continuous Quality Improvement
CV Coefficient of Variation (statistics)
EMR Electronic Medical Record
EM Event Manager™ (CIS application suite from iMDSoft Inc. for clinical decision support algorithm)
FITT Fit between Individual, Task and Technology
GUH Galway University Hospital
HDU High Dependency Unit
HIPE Hospital Inpatient Episode
HIT Healthcare Information Technology
ICD International Classification of Diseases (World Health Organisation)
ICNARC Intensive Care National Audit & Research Centre (UK)
ICP Integrated Care Pathway
ICU Intensive Care Unit
ICT Information at Communications Technology
IS Information System
IT Information Technology
ITAM Information Technology Acceptance Model
KPI Key Performance Indicator
MATH Major Academic Teaching Hospital
MDT Multidisciplinary Team
MRP Manufacturing Resource Planning
PACS Picture Archiving and Communication System
PDU Practice Development Unit
QCA Qualitative Content Analysis
QW Query Wizard™ (CIS application suite from iMDSoft Inc. for database mining)
SAPII Simplified Acute Physiology Score II
SRQ Secondary Research Question
TAM Technology Acceptance Model
TQM Total Quality Management
US FDA United States Food and Drug Administration
Appendix II

Interview preparation material issued to participants

Semi-structure interview Introduction- Please Read

Interviewer: Frank Kirrane

Thank you for agreeing to participate with this interview and I really appreciate you making the time to meet with me. In order to frame a bit of structure around our discussion, which will be important for me to have so I can make best use of the information gained, this document explains the purpose of the interview and the context for it.

The study I am conducting is part of an M.Sc. in Technology Management, which focuses on the issues that surround technology and people, such as innovation, creativity, organisational culture, development, change management, etc.

To relate my course content to my work situation, and to fulfil the requirement to complete a dissertation, the area I am researching is with the CIS technology, and more specifically how it may be optimised to greatest organisational benefit.

For CIS systems that have been in routine use in an organisation for a number of years, like ours, there is little information in research literature that can help us determine how to best continually customise, adjust, or expand the system, in line with the changing demands, requirements, and evolving practices of the critical care service.

Also, there are limited ways for us to objectively assess how well we are currently realising the potential of CIS technology, or a pathway to show what level of sophistication we would like to the CIS to attain. In many respects, how we organise ourselves (because it takes many different people to make a CIS a continued success) at this stage is very different to how we ‘organised’ ourselves before and during implementation. We started with very strict project managements guidelines, based on the advice of the supplier principally, to one now where we are left to our own devices (to a large extent) to continually update and improve the system.

The idea behind my research is to determine how we should organise and structure how we all work to optimise the CIS. This extends from the core customisation work that Anne and others do (expertly), to the clinical users who “interact successfully” with the system, to the ideas, the motivation, and the culture of innovation and best practice, that drive the CIS system forward. The CIS “serves” the business of critical care, how do we ensure it continues to serve it well?

As this work is part of an academic course, it is important for me to tease out in a methodologically sound way (i.e. that could be repeated elsewhere and then corroborated or refuted):

(a) what is important to the “business of critical care”, and
(b) then to figure out how the CIS should contribute positively to this.

To attempt to “answer” part (a), I completed what is known as a Qualitative Content Analysis (QCA). This is a widely used technique in the health and social sciences fields of research. In summary, this is a means to determine from text documentation (and other sources of media), the key themes, or “dimensions” that illustrate the “essence” of the phenomenon under study (I can show you this in our interview).

In the case of the critical care service (the “phenomenon being studied) I completed a Content Analysis on the:

(a) PDU documentation (to get a professional perspective of what is important to critical care)
(b) Op-meeting minutes for the last three years (to get an operational perspective)
(c) The hospital MATH accreditation documentation (to get a wider organisational and strategic perspective)

From this analysis, 7 dimensions” that distil down all the documentation to words that illustrate what is important to the “providing best practice critical care”. These are shown below.
Clearly, there is nothing earth-shatteringly surprising about this, nor should there be. These are the words that describe (according to the documents at least) what you, as clinicians and leaders, strive to optimise everyday. The question is ‘what part should the CIS have to play in this? How can we demonstrate that we have a pre-defined path that shows where we direct our efforts and resources to improve the CIS technically and functionally, and how it is used clinically, to address each of these dimensions?.

This is the reason for my wishing to interview you. It is an effort to tease out each dimension, from your perspective, and look at the key tasks within each dimension, where the CIS can have a role, where is may be adapted, changed, customised, improved and so on.

The interview is intentionally open-ended but it requires some structure so as to help ensure we stay on track and allow me to collate my results.

Below are some questions that I will ask to get us started. The purpose of providing you with these in advance of our discussion is to give you an idea of the purpose of the study, and to trigger some of your thoughts on the study.

- Do you believe that the “dimensions” that derive from my QCA process represent the “body of work” that describe the priority activities of the unit for the delivery of high quality critical care?
- Can you suggest others that may be included as a subset of those outlined above, or other dimensions, tasks or activities, that are omitted from those presented above.
- We will discuss what each dimension means to you, and your work. For example, how would you define each?. Which is the most important? How do they relate to each other? Are they mutually exclusive?
- Rate these dimensions
- Considering each dimension in turn, what are the area of activities, or tasks (also termed Process Areas in the literature), with which the CIS has a part to play in supporting, driving, facilitating, or to positively impact each dimension. Consider those that it does now, but also those where there is room to improve or others not yet addressed. This will be a type of brainstorming conversation, which includes words, phrases, themes, examples, and so on.

I welcome your support with this research, and I appreciate your patience as I come to terms with the techniques of qualitative analysis.

I look forward to our meeting.

With best wishes

Frank Kirrane
Appendix III

Pilot study material circulated to participants by email

From: Kirrane, Frank, UCHG
Sent: Thu 13/08/2009 11:37
To: Clarkson, Kevin, UHG; Sheehan, Christine, UCHG; Bates, John, UCHG; Lee, Cathryn, UCHG; Harte, Brian, UHG; Mulvey, Anne, UCHG; Kidd, Peter, UCHG; Higgins, Carmel, UHG
Subject: Frank’s thesis project

Dear All,

Many thanks again for all the time you afforded me during our discussions and interview for my project, it is much appreciated.

There is one final part where I would be grateful for your input. I have finished the final draft of the framework “maturity model”, the detail of which came from the interviews. I would now like you to rate the model, attached.

It is necessary, for the academic rigour I need to demonstrate, to provide you “instructions”.

1. Considering each dimension in turn, start from the left hand column/maturity level, and review each of the activities/criteria within the level. If you feel the CIS, or its use, currently satisfies or exceed all of the criteria, then move up the next maturity level.

2. Review these activities/criteria, and if you believe that the CIS and its current use, partially meets some of these criteria, then place an X in the sub-level box at the bottom of the table that, from your perspective best scores this partial success.

3. Repeat for all dimensions.

Many thanks again for your input, and as this is an academic exercise I would be grateful if you give it the necessary ‘critique’. I would be pleased to receive any comments/suggestions you may have.

As time is against me, I’m afraid I’ll probably be nagging you for the next few days. I’ll chase each of you up in person if I can, but if you wish, you can drop it into Anne’s Office (put your name on it please).

It should take no longer than 10 minutes.

I would appreciate any comments, good and bad, on your impressions on completing the maturity model.

Thanks again

Frank Kirrane, Senior Physicist
Department of Medical Physics and Bioengineering,

/ENDS
Appendix IV

Galway University Hospital Management Structure

Critical Care Management

Critical Care Operational Team

Source: Internal GUH document