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Dedication

To Him who makes all things happen. Thank you.

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Finally, to my family, Xolie, Nelisa – thank you.

Declaration

The work presented in this dissertation is my own unaided work, except only where acknowledgements and references have been made in the text. I am aware, have read, and fully understood the University's Policy on Plagiarism.

I declare that I have not submitted this dissertation before, to any other institution, either in part or in whole, for award of any degree or examination.

_____

Bheki S. Gule

Date: February 26, 2016

Abstract

Electronic Medical Records (EMR) systems aim to provide an integrated solution to a number of hospital processes, including supporting administrative functions such as patient billing, providing clinical guidelines, and allowing clinicians to order and view lab reports. Yet with all these possible benefits, like many other types of information systems and technologies, their impact on hospital performance has been a key area of interest and a source of debate.

This study examines the extent to which EMR systems are available across South African hospitals as well as how well they have been integrated into the processes of the said hospitals. The diffusion of EMR systems means they are available in the relevant clinical units whilst their infusion suggests they are comprehensively embedded into the processes that they are meant to support. The most important question answered in this study was whether the diffusion and infusion of these systems had any impact on the performance of hospitals. Answering this question would aid decision makers on whether more effort is indeed needed to ensure their availability across units and their embedding into hospital processes. The study collected data from a number of hospitals in the private and public sector with multiple informants providing data on diffusion and infusion of these systems as well as on hospital performance. Performance measures included the hospitals' economic efficiency, their clinical effectiveness, patient safety, and patient satisfaction.

Key findings were that while there are performance benefits in the diffusion of EMR systems across units, the impacts are not always positive for some hospitals. Large hospitals were less likely to benefit from the diffusion of these systems. However the comprehensive use of these systems provided benefits for all types of hospitals, suggesting that while availability may be important, it is the comprehensive embedding of the EMR system into the hospital's processes that is more beneficial to all types of hospitals. These results present further opportunity for research into why the impact of EMR systems is not always positive for some hospitals.

Keywords: Electronic Medical Record Systems, EMR systems, diffusion, infusion, South Africa, private hospitals, public hospitals, hospital information systems.

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1 Chapter 1 - Introduction

1.1 Background

The performance of hospitals is gaining attention, both in South Africa and internationally (Mammen and Weeks, 2014; Blumenthal and Tavenner, 2010; Jha, 2010). In South Africa, the imminent introduction of the National Health Insurance (NHI), initially scheduled to begin in 2012[1] required hospital organisations that seek to provide healthcare under the NHI to be accredited. In order to be accredited and remain accredited these hospital organisations must meet certain performance levels.

Internationally, the spiraling costs of healthcare is leading to more concerted efforts toward assessing whether hospital organisations are being efficient in the way they provide their services (Blumenthal and Tavenner, 2010, Jha 2010), thus placing hospital performance under increasing public scrutiny and making studies of hospital performance a key academic priority.

A number of researchers, such as Narver and Slater (1990), Vera and Kuntz (2007), Fottler (1987), have however identified the difficulty of assessing hospital performance. Operationalising hospital performance thus remains a challenge for researchers in the field (Giuffrida, Gravelle, and Roland, 1999) leading to varying definitions. For instance, some researchers, when considering hospital performance, have focused on the financial outcomes, such as return on investment and reduced costs of care (Alexander, Weiner, and Griffith, 2006) or market outcomes such as the market share that the hospital maintains as a measure of its performance (Trinh and O'Conner, 2002). Others have looked at the clinical outcomes, such as reduced errors (Mutter, Rosko, and Wong, 2008) or have focused on patient outcomes, such as patient satisfaction (Rosen et al. 2011).

Hospital performance is therefore multi-dimensional. Identifying and assessing the determinants of the various dimensions of hospital performance is a research priority.

1.1.1 IS&T in Healthcare

The use of information systems and technologies (IS&T) has been suggested as one way to improve hospital performance (Blumenthal and Tavenner, 2010; Jha, 2010; Miller and Sim, 2004; American Hospital Association Report, 2005). Studies, especially systematic review studies, have shown that IS&T impact a number of the hospital performance dimensions. For instance studies by Poon et al. (2010), Brotzman et al. (2009), Chaudhry et al. (2006) show that IS&T provides opportunities to

[1] National Department of Health. National Health Insurance in South Africa. The Policy Paper. Available on www.gov.za/sites/www.gov.za/files/nationalhealthinsurance.pdf. Accessed October 2011.

improve hospital efficiencies and effectiveness, improve patient outcomes and their satisfaction, as well as enhance the quality of care in the form of improved patient safety. Carrera and Dunleavy (2010) also found that IS&T improved hospital productivity in poorly managed hospital facilities whilst Park et al. (2015) found that IS&T reduced the costs of healthcare delivery.

There are a number of different IS&T applications in use in hospitals. Van Der Meijden et al. (2003) classifies these as general or specific systems. General systems are available in more than one unit of the hospital whereas specific systems are those designed for a particular unit e.g. those used only in the intensive care unit. General systems are the most common and they include physician order entry systems, and electronic medical records systems.

This study focuses on the electronic medical record (EMR) systems. EMR systems are seen as one of the most promising IS&T applications for the hospital context.

The International Standards Organisation defines an EMR as

> "*A repository of information regarding the health status of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorised users. Its primary purpose is the support of continuing, efficient and quality integrated health care and it contains information which is retrospective, concurrent, and prospective*" (ISO standard 18308 : https://www.iso.org/obp/ui/#iso:std:iso:18308:ed-1:v1:en).

Hayrinen, Saranto, and Nykanen (2008) in their 2008 review of literature on EMR noted that this definition was the basis for most work that has been done in this area of medical / health informatics and is consequently adopted for this study.

EMR systems provide a number of functionalities, captured under eight core modules, from which benefits are intended to be derived. These benefits and functionalities are discussed next.

1.1.2 EMR Functionalities

EMR systems (their functionalities and intended benefits) have been a subject of study and classification by international organisations such as the World Health Organisation (WHO), national organisations such as the Institute of Medicine (IOM), the Agency for Healthcare Research and Quality (AHRQ), the Australian Council on Healthcare Standards, and a number of academic and research institutions such as Ontario's Hospital Association. Although most of these studies differ in

their classification of benefits and functionalities, most can be subsumed into the IOM's classification. This study adopted the IOM's classification for both benefits and functionalities.

1.1.3 EMR Benefits

According to the Institute of Medicine (IOM) 2003 Letter Report, aside from being feasible to implement, EMR systems must:

1. Improve patient safety
2. Support the delivery of effective patient care
3. Facilitate the management of chronic conditions
4. Improve efficiency

As can be seen from the above, EMR systems are intended to play a role in achieving hospital outcomes that include providing safe and effective care to the patient, as well as improving the operational performance of hospitals.

The potential benefits to patient care and operating efficiencies are reported in various ways in literature. For instance, studies have shown that organisations using EMR systems report:

- Reduced cost of care to the patient (Taylor et al. 2005),
- Improved productivity and efficiency, and reduced waiting times (Alamo et al. 2011),
- Patient satisfaction with clinical experience (Rosen et al. 2011), and
- Shorter patient turnaround times (Lo et al. 2007; Pizziferri et al. 2005).

Although these studies reflect a mix of organisational-level and individual-level impacts (how EMR system users were being impacted) their results nonetheless are encouraging for healthcare organisations and governments. For instance, the U.S, Canada, and the United Kingdom, have used the potential of these kinds of benefits to vigorously promote the adoption of EMR systems as a way of improving hospital performance, curbing the rising costs of healthcare, and improving patient outcomes (Jha, et al. 2009; Robert Wood Johnson Foundation Report, 2009).

EMR systems provide these potential benefits through implementation of various modules. These modules are discussed next.

1.1.4 EMR Modules

In 2003, the IOM published eight core areas of EMR functionality. According to the IOM, a comprehensive EMR system must be able to provide these eight modules, which are made up of several functionalities.

These are:

1. Clinical information and Health Data module: this functional area provides for problem lists, procedure lists, medication lists, and diagnoses.
2. Results Management module: this functional area includes results reporting, results notification.
3. Order Entry / Management module: this module encompasses electronic prescribing, laboratory, supplies.
4. Decision Support module: this module encompasses drug alerts, reminders, clinical guidelines, diagnostic decision support.
5. Electronic Communication and Connectivity module: this module allows for provider-to-provider communication, patient-to-provider communication, and for an integrated medical record.
6. Patient Support module: this module includes the ability to provide patient education, to capture data entered by patient, family, and/ or information giver.
7. Administrative Processes module: this module includes the ability to manage scheduling of activities such as inpatient and outpatient procedures, and hospital admissions.
8. Reporting and Population health management module: this module encompasses the ability to do public health reporting, keep disease registries, and report on patient safety and quality issues.

Figure 1 on the next page summarizes these core modules.

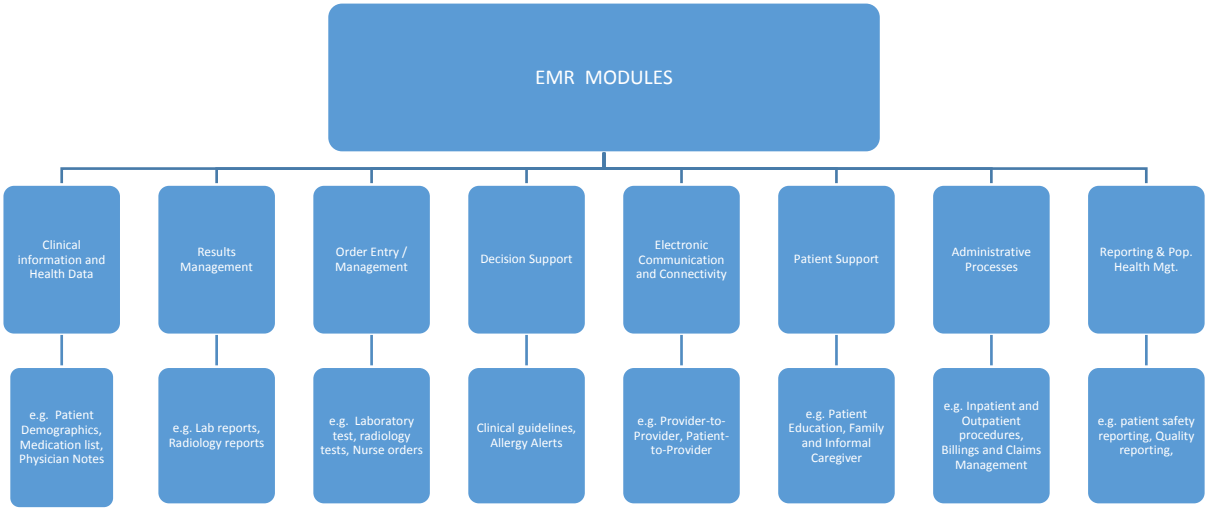


Figure 1: Core Modules and examples of functionalities, adapted from IOM Letter Report 2003.

Although EMR systems provide benefits and functionalities which can improve hospital performance, researchers such as Blumenthal and Tavenner, (2010); Jha, (2010); DesRoches et al. (2008) note that EMR systems are both uncommon in hospitals and their use also limited. Data on EMR systems availability and use in developing countries is even scantier. As such the functionalities available and being used as well as the benefits of the EMR systems in developing countries is unknown. Therefore the understanding of their availability and use of EMR systems in hospitals remains a research problem. This research problem is discussed further in the following section.

1.2 Problem Statement

Empirical evidence from recent studies in developed countries suggests that the diffusion and infusion[2] of EMR systems is limited. Little is known about the diffusion and infusion of EMR systems in developing countries. The Robert Wood Johnson Foundation Report, published in 2009, noted that there was little or no information from developing countries in terms of whether EMR systems were in place and the level and extent of adoption. In particular, those researchers indicated their disappointment in their inability to comment on the state of EMR systems adoption in South Africa (pg. 125). The existence of EMR systems in South African hospitals is acknowledged (Ruxwana, Herselman and Conradie, 2010; Health Systems Trust, 1998; Littlejohns, Wyatt, and Garvican, 2003), but the functionality and the levels of diffusion and infusion, is not known (Ruxwana et al. 2010; Littlejohns et al. 2003).

[2] Diffusion is the spread of an IT across the organisation (Ash, 1997) and infusion is the comprehensive embedding of an IT within organisational processes (Zmud and Apple, 1992).

This limited knowledge is a concern for both researchers and practitioners in the developing countries who have no benchmark for their respective work. This also presents challenges to industry leaders and policy makers who have limited basis to suggest EMR systems as tools to improve healthcare. In some instances the lack of evidence of the sustainable impact of health information technologies on health indicators is seen as a contributor to low uptake of such technologies (Chib, van Velthoven, and Car, 2015). Research that identifies the levels of diffusion and infusion will provide a much needed guide to understanding where the healthcare industry is at and how far it needs to go to be at par with other countries.

In addition, there has been little empirical evidence at organisational-level analysis on EMR system effects on hospital performance. Reviews of past studies show that research into the organisational impact of EMR systems has focused on particular organisational processes and not on hospital performance (Hayrinen et al. 2008). Furthermore, past studies have either looked at EMR systems availability (Jha et al. 2009; DesRoches et al. 2008), EMR systems use in hospitals (Blumenthal and Tavenner, 2010; Jha, 2010), or practitioners use of EMR systems (Lenhart et al. 2000; Makoul, Curry, and Tang, 2001; Laerum, Ellingsen, and Faxvaag, 2001), but have neglected their impacts on hospital performance. Those that have looked at impacts have done so either at the individual-level such as the effects of EMR systems on individual practitioners (Poissant et al. 2005; Lo et al. 2007), or the effects on clinical processes (Vishwanath et al. 2010; Zalis and Harris, 2010). Research that focuses on EMR systems and their impacts on multiple dimensions of hospital performance, for example as defined in Table 1A (see Appendix A), has been limited.

Consequently, the purpose of this study is to describe the current state of EMR systems in the hospitals of South Africa as well as assess the extent to which the diffusion and infusion of EMR systems impact the performance of hospitals in South Africa.

This purpose is articulated in objectives and questions that will assist in addressing this research problem. The following section highlights these objectives and research questions.

1.3 Research Objectives and Questions

To address the research problem stated above, the two main objectives of this study are

1. To describe the current state of EMR systems in the hospitals of South Africa.
   To achieve this first objective, the study will address the following research questions;
   a. What is the current state of EMR systems diffusion in hospitals of South Africa?
   b. What is the current state of EMR systems infusion in hospitals of South Africa?

2. To assess the extent to which the diffusion and infusion of Electronic Medical Record Systems impacts the performance of hospitals in South Africa.

   To achieve this second objective, the study will address the following research questions;

   a. What are the direct effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction?
   b. What are the indirect effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction, through improved information management capabilities?

The objectives of the study are to be achieved through the use of quantitative survey methodology involving the administration of structured questionnaires to key informants (hospital CEOs, chief administrators, I.T / Operation heads) in a sample of private and public hospitals in South Africa. The results of the study will be used to make recommendations to practice and to derive implications for theory and future research. The South African healthcare environment is discussed next.

1.4 Context of the Study

South Africa operates a two-tier healthcare system, with both the public and private healthcare providers. Overall, the South African healthcare sector is undergoing significant reforms, following the government's decision to implement a National Health Insurance (NHI) programme. The NHI programme, which was meant to begin in earnest in 2012, aims to provide healthcare cover to all citizens of South Africa, enabling them to access healthcare at any accredited healthcare provider within the country, whether the healthcare provider is a public or private entity. Specifically, the stated objectives of National Health Insurance are[3]:

a) To provide improved access to quality health services for all South Africans irrespective of whether they are employed or not.

b) To pool risks and funds so that equity and social solidarity will be achieved through the creation of a single fund.

c) To procure services on behalf of the entire population and efficiently mobilize and control key financial resources.

d) To strengthen the under-resourced and strained public sector so as to improve health systems performance.

[3] National Department of Health. The National Insurance Green Paper. Available on http://www.doh.gov.za/list.php?type=National%20Health%20Insurance. Accessed October 2011.

The NHI Green paper has been available for public scrutiny since 12 August 2011. It was used as a discussion document throughout 2011 by both the public and private sectors. This exercise of refining the green paper into a policy document culminated with a national conference held on December 7 -8, 2011 at Gallagher Estates in Midrand.

The NHI programme requires hospital organisations to meet certain performance standards for them to be accredited. These standards will be assessed by another newly established body, the Office of Health Standards Compliance, and they apply to both public and private sector hospitals. Hospital performance is seen as an influencing factor to sustaining this programme, underscoring the need to understand hospital performance.

The implementation of an Electronic Medical Record system in South Africa is supported by the National Strategic Framework for Electronic Health Record Implementation, a product of the Electronic Health Record Group which was established in May 2002. A subsequent workshop in September 2003 formed the basis of the current National Strategic Framework for EMR in South Africa with the implementation of an EMR system becoming a departmental priority for the years 2004 – 2009 (Department of Health, Strategic Priorities for the National Health System 2004-2009 document). However it is worth mentioning that the introduction of EMR technology in South Africa is still considered to be at its preliminary stages (Mammen and Weeks, 2014).

Although there have been a number of studies and reports on EMR systems in the public sector, there is very little information on their existence and use in the private sector. Yet the private sector is a crucial component of the healthcare system in South Africa. For instance, it attracts around 60% of resources (human and financial resources) spent on health in the country (Blecher and Harrison, 2006; Dambisya and Modipa, 2009), whilst other researchers such as Cullinan, (2006) suggests that this figure could be higher. The private sector accounts for approximately 21% of the total hospital beds in South Africa (Matsebula and Willies, 2007) and it serves approximately 20% of the population (Cullinan, 2006; Dambisya and Modipa, 2009).

As mentioned earlier as well, a vast majority of the private hospitals are for-profit entities. Their investment in IS&T in general, and EMR systems in particular, is most likely to be for strategic reasons. Hospital administrators are therefore most likely to track the impact of such systems on their organisations. Thirdly, given again that the majority belong to listed entities, hospital

performance is most likely to be a major concern, since the value of listed entities is influenced by financial markets. Financial markets base their assessment largely on performance (Becker and Stafford, 1967). Their ability to raise funding for more investment is also influenced by their performance. Public sector hospitals, on the other hand, may not face the same concerns.

While there may be some similarities in the expectations of each sector from investment in EMR systems e.g. improved efficiencies and patient safety, there are also likely to be differences. For example, the private sector is a for-profit industry and may consider EMR systems a necessity not only because of the operational benefits but also because they may be used to attract health consumers and create a competitive advantage. On the other hand, EMR systems are seen as of strategic value in public hospitals (Cline and Luiz, 2013).

Given the private / public sector differences, it is important that EMR systems are examined in each of these contexts. Although there is some literature with regards to EMR systems in the public sector (e.g. Littlejohns et al. 2003; Ruxwana et al. 2010) and government report of progress[4], knowledge of EMR systems in the private sector is less documented in the literature. Likewise, while some studies, such as O'Mahony, Wright, Yogeswaran, and Govere (2014) note that clinicians in public hospitals are aware of EMR systems, the literature on EMR systems in public sector is does not provide a clear picture of how available these systems are across the country. For this and other reasons outlined above, this study therefore focuses on the current state of EMR systems in these two sectors.

Specifically, this study explores the state of EMR systems within hospitals in terms of their *diffusion* and *infusion, and impacts on hospital performance*. Its contribution to the theoretical, contextual, methodological, and practical space is discussed next.

1.5 Importance of this Study

This study makes a number of contributions, summarized below;

1.5.1 Theoretical

Foremost, this study extends the work of other researchers who have studied diffusion and infusion of IS&T. It also extends the work of researchers who have studied the impact of IS&T on hospital performance.

Secondly, this study aims to empirically test and validate a model that associates the diffusion and infusion of EMR systems in a hospital organisation to four (4) hospital performance indicators.

[4] For instance in November 2008, the Gauteng Department of Health launched its EMR project after a 6 months piloting phase (http://www.healthcareitnews.com/news/south-african-hospitals-clinics-get-hospital-information-systems).

Additionally, the study empirically tests the effect of EMRs on hospitals' information management capability and consequent implications for hospital performance.

1.5.2 Contextual

This is one of the first studies on EMR systems diffusion and infusion in hospitals of South Africa. Although there have been studies that have looked at the impact of EMR in a rural setting (O'Mahony, 2009) there is limited evidence of any studies that have focused on EMR systems diffusion and infusion across the country. The comprehensiveness of the study – as it sought to report on both private and public hospitals – provides an opportunity to draw a clear picture on EMR systems in South Africa. Future researchers can use the results of this study as a benchmark when assessing future states of EMR systems in South Africa.

1.5.3 Methodological

This study contributes a modified instrument to capture the current state of EMR systems diffusion and infusion and can be used by future researchers looking at how EMR systems diffusion and infusion can be measured in the healthcare context. Moreover, it offers up key hospital performance measures that can be used in similar survey studies in the future.

1.5.4 Practical

This study reports on the impacts of EMR systems on four hospital performance measures. Such results are important to hospital administrators who have to make investment decisions on systems. Do EMR systems have any effect on hospital performance? This is a question that a hospital administrator may have and this study helps to answer this question.

The study also reports on the current levels of EMR systems diffusion and infusion across the country's private and public hospitals. These results inform hospital organisations of the current state of EMR systems diffusion and infusion in the country and also provide an opportunity for these hospital organisations to benchmark themselves so they know where they are positioned on the diffusion / infusion curve. Such information is vital for organisations if they are to remain competitive, if in the private healthcare sector or relevant if they are in the public healthcare sector.

The next section summarises the structure of this research report.

1.6 Structure of this Research Report.

This research report follows the following structure.

Chapter 1 – Introduction and Background to study

This section provides a summary of the background information on healthcare in South Africa, the role of information systems and technology in healthcare as well as an introduction to Electronic

Medical Record systems. The problem statement and research objectives and questions to address the research problem are also discussed before the key contributions that the study aims to make are highlighted.

Chapter 2 – Literature Review

This chapter will present a review of literature on IS&T in hospitals, on hospital performance in general, and EMR systems diffusion, infusion, and their impacts on hospital performance. Gaps in literature findings will also be identified and highlighted. The research model used and its underpinnings are discussed as well in this chapter.

Chapter 3 – Research Methodology

The research methodology that has been used in this study and the supporting literature is discussed in detail in this chapter, as well as the research instrument, including its development. The methods used to analyse the data and literature supporting the choice of those methods are detailed as well in this section.

Chapter 4 – Research Findings

Research findings on the study objectives are covered in Chapter 4. The findings are presented in a number of ways, including tables and graphs, consistent with other researchers such as Jha et al. (2009) and DesRoches et al. (2008) who have studied similar phenomena. This section also covers the model testing.

Chapter 5 – Discussions of Findings

This section contains discussions of the findings presented in Chapters 4 and 5.

Chapter 6 – Summary and Contributions

Chapter 6 addresses the summary and implications of the study as well as the recommendations. The limitations, contributions, and conclusions of the study are also addressed in Chapter 6.

1.7 Summary

The first chapter has highlighted the role of information systems and technologies in healthcare, as well as provided an overview of the South African healthcare context. Research objectives and research questions, aimed at addressing the stated research problem were also discussed in detail before highlighting the study's contributions. The next chapter interrogates existing literature on the subjects of diffusion and infusion of information systems and technologies in hospital organisations, as well as literature on hospital performance.

2 Chapter 2 - Literature Review

2.1 Introduction

This chapter evaluates existing literature on the diffusion and infusion of information systems and technologies in hospital organisations. Literature on hospital performance is also discussed especially the focus of past studies when assessing hospital performance. This chapter also discusses the effect of IS&T on organisational performance, and moves specifically into the effects of EMR systems on hospital performance. Finally the chapter discusses the development and theoretical underpinnings of the research model to be used and the associated hypotheses that guide this study.

2.2 Diffusion and Infusion of Information Systems and Technology

2.2.1 Diffusion of IS&T

Diffusion has been defined varyingly in the literature. Ash (1997) refers to diffusion as the extent to which IT use has spread across an organisation. Eder and Igbaria (2001) have considered diffusion as the percentage of processes supported by the IT, while others such as Li and Collier (2000) have considered diffusion as the extent of the IT's availability.

Taken together, diffusion of an information technology can be defined as the extent to which the IT functionality is available across the organisation and is observable by the percentage of users and processes supported by the IT.

This definition is consistent with Rogers' classical definition of diffusion. Rogers (1995) defines diffusion as "the process by which an innovation is communicated through certain channels over time among members of a social system"(pg. 5). Technology is considered an innovation and studying the diffusion of a system allows researchers to understand the breadth of the innovation's presence (Ash 1997).

Organisations can be at different levels of diffusion with respect to the same technology with factors such as earliness of adoption, top management support, organisational structure, organisational size, IT infrastructure, and IS structure accountable for the differences (Eder and Igbaria 2001; Kraemer et al. 2006). EMR systems are examples of technology innovation and their current state of availability within South African hospitals can be usefully explored through the concept of diffusion.

2.2.2 Diffusion of EMR systems

The existence and use of EMR functionalities in systems of hospital organisations has been a research priority. Jha et al. (2009) used this functionality set to conduct a study on EMR systems use in the US and they noted that very few hospitals had comprehensive (full functionalities in all clinical units)

EMR systems (1.5 % of 3, 049 hospitals), and only 7.6% had a basic EMR system. DesRoches et al. (2008) reporting on results from 2, 758 physicians found that only four percent had comprehensive EMR systems and only 13% had a basic EMR system. Jha et al. (2009) and DesRoches et al. (2008) took different perspectives in defining the features that should be in place for a basic EMR system. Jha et al. defined a basic EMR system to have a pre-defined set of eight functionalities fully implemented in at least one clinical area, while DesRoches et al. suggest that a basic EMR system must have at least seven pre-defined functionalities fully implemented in at least one clinical area. These functionalities were spread over the first three EMR modules, namely Clinical Documentation and Health Data, Results Management, and Computerised Physician Order Entry modules.

While Jha et al. define basic EMR systems as systems that have a set of eight pre-defined functionalities available across all clinical units (see Table 2.1 below), DesRoches et al. on the other hand, define a basic EMR system as one with seven of the Jha's et al. study's eight functionalities. The two studies agree on the seven functionalities, with the Jha et al. study adding an additional capability.

However, they differ significantly in their definition of a comprehensive EMR system. The Jha et al. study suggests a comprehensive EMR system as one with twenty-four functionalities available in all clinical areas. The DesRoches et al. study on the other hand, suggests a comprehensive EMR system to be one with sixteen functionalities on site. The Jha et al. definition of comprehensive EMR systems includes all DesRoches et al.'s sixteen functionalities.

The DesRoches et al. comprehensive EMR system requirement is less stringent as it did not require the system capability to be available in all clinical units. It only requires that the capability be available.

Table 2.1 highlights the modules and the relevant supporting functionalities that both studies considered.

Table 2.1 – Basic and Comprehensive EMR Systems functionalities used in the two studies

	Basic EMR Systems		Comprehensive EMR systems	
	DesRoches et al.	**Jha et al.**	**DesRoches et al.**	**Jha et al.**
Clinical Documentation and Health Data				
Maintaining Active Diagnoses				
Maintaining Active Medication Lists	√	√	√	√
Maintaining Advanced Directives				√
Maintaining Clinical Notes	√		√	√
Maintaining Current Procedures				
Maintaining Discharge Summaries		√	√	√
Maintaining Nursing Assessments				√
Maintaining Patient Demographics	√	√	√	√
Maintaining Problem Lists	√	√	√	√

Results Viewing				
Viewing Consultant Reports				√
Viewing Diagnostic Test Images				√
Viewing Diagnostic Test Results		√		√
Viewing Lab Reports	√	√	√	√
Viewing Radiology Images	√		√	√
Viewing Radiology Reports		√	√	√
Computerised Physician Order Entry				
Entering Consultation Requests			√	√
Entering Medication Orders	√	√	√	√
Entering Nursing Orders			√	√
Ordering Laboratory Tests			√	√
Ordering Radiology Tests			√	√
Decision Support				
Providing Clinical Guidelines			√	√
Providing Clinical Reminders			√	√
Providing Drug Allergy Alerts				√
Providing Drug Dosing Support				√
Providing Drug-Drug Interaction Alerts			√	√
Providing Drug-Lab Interaction Alerts				√

A detailed analysis of these pre-defined modules and functionalities is presented later in Chapter 4 as the basis for reporting EMR systems diffusion.

Comprehensive EMR systems, noted to have a pre-defined set of twenty-four (24) system capabilties available at all units of the hospital organisation (Jha et al. 2009) or a pre-defined set of sixteen (16) such capabilities (DesRoches et al. 2008), are not common in hospital organisations – as noted from the abovementioned previous studies. Very few organisations have these in place. The Robert Wood Johnson Foundation Report (2009) notes that only three out of the 30 developed and developing countries they surveyed had comprehensive EMR systems in 50% or more of their hospitals. Only thirteen out of the thirty countries had EMR systems in at least the Ambulatory unit. Therefore the extent to which EMR systems are diffusing into hospitals and positively impacting their performance is clearly a problem requiring further investigation. This research problem is addressed through the study's first research question.

RQ1: What is the current state of EMR systems diffusion in the hospitals of South Africa?

2.2.3 Infusion of IS&T

Infusion is different from diffusion in that it relates to the depth of an innovation's presence whereas diffusion relates to the breadth of the innovation's presence (Ash, 1997). Infusion is thus often defined as the degree to which an innovation is comprehensively embedded or integrated within an

organisation's operational and managerial processes (Zmud and Apple, 1992). Infusion is a process in which a technology moves through a succession of configurations with each succession facilitating a deeper, more comprehensive embedding of the innovation's functionality into the organisation to the extent that the innovation is frequently used and its use has replaced paper and manual processes (Eder and Igbaria, 2001; Zmud and Apple, 1992)

2.2.4 Infusion of EMR systems

In the EMR context, infusion is seen as a succession of configurations, from a basic EMR system to a comprehensive EMR system, with each succession implying a deeper or more comprehensive embedding of the eight software functions of an EMR system into a hospital organisation (Eder and Igbaria, 2001; Zmud and Apple, 1992). Infusion thus sits on a continuum from nil through to a basic configuration of EMR functionality which, as defined by DesRoches et al. (2008), is three modules available in at least one unit; towards the most comprehensive embedding of the innovation observable as full functionality being used in all hospital units. The use of full functionality implies paper systems have been replaced. The depth of EMR systems presence within hospitals in South Africa can be usefully explored through the above conceptualization of infusion.

However, empirical evidence for the South African context has not been easily available. There is therefore a need to investigate how EMR systems have infused in South African hospitals as well as their impacts on hospital performance.

This research gap is articulated in the study's second research question;

RQ2: What is the current state of EMR systems infusion in the hospitals of South Africa?

Having considered the diffusion and infusion of EMR systems, the next section examines the literature on EMR systems and their impacts on hospital performance.

2.3 EMR Systems and Hospital Performance

Exploring the impacts of EMR systems is part of a broader review of the impacts of information systems and technologies on organisational performance. As such, a review of IS&T impacts on organisational performance is discussed first.

2.3.1 Information Systems and Technology and Organisational Performance

The contribution of IS&T to firm performance remains a key research interest to IS/IT researchers. Some studies have shown that IS&T have direct effects on the performance of organisations. For instance Acosta, Colomo-Palacios, and Loukis (2011), looking at IS&T effects on organisations involved in e-business noted that IS&T had a direct effect on organisational performance, which they had conceptualised as e-business value. Their study was consistent with Zhu and Kraemer (2002) who also found IS&T to have a direct effect on firm performance, which they had conceptualised as e-business value as well.

Bharadwaj (2000) in her seminal work on IT capabilities and their impact on firm performance; noted that organisations that were able to mobilize and deploy IT-based resources in combination with other resources had superior performance measures. Although her study incorporated other resources as being part of the equation, she was nonetheless able to show that information systems and technology have a direct effect on performance.

The direct effect of IS&T has been questioned by other researchers. This is in light of studies that have provided empirical evidence that IS&T can influence organisational performance only through influencing other organisational resources and capabilities. These researchers suggest the relationship between IS&T and performance will be mediated by the capabilities that these IS&T are meant to enhance. Among those researchers who have argued for the indirect effects of IS&T are Ravichandran and Lertwongsatien (2005) who suggest that it is the way that IS&T are used to support core capabilities that will impact performance. Zhang (2007) argues that IS&T, if used properly, will create unique knowledge and information, and this combination in turn will impact performance. Other researchers, for instance Zhu (2004), Wade and Hulland (2004), have used concepts such as the complementarity or co-presence of resources to explain the indirect effect of IS&T on performance. Complementarity occurs when a resource produces greater value in the presence (co-presence) of another resource than by itself (Zhu, 2004). These researchers suggest that IS&T will provide added value, not by themselves, but in the presence of other resources.

These differing views make the assessment of the direct and indirect impact that IS&T have on organisational performance a research priority. The next section addresses IS&T in the hospital context.

2.3.2 EMR Systems and Hospital Performance

In hospital organisations, the role of IS&T can also be assessed through the impact that EMR systems have had on some of the performance measures used in past studies. To this end, a number of studies that assessed organisations that had implemented EMR systems as an intervention strategy found that EMR systems have a positive impact. For instance a one year intervention study at four urban primary health care centres, by Fiks et al. (2007), showed the EMR systems intervention led to improvements in vaccination rates as well as immunization rates among children. Another EMR systems intervention study also revealed that the EMR intervention led to reduced number of ambulatory visits and unnecessary clinical processes (Garrido et al. 2005). A systematic review by Fischer, Tjia, and Field (2010) on the impact of hospital information technology (HIT) interventions to improve medication and laboratory monitoring revealed that 63% of studies had found HIT had provided significant improvements. 75% of those studies assessed had used EMR systems as the intervention.

These studies are summarized in Table A1 (see Appendix A)

2.4 Hospital Performance

One important factor impacting more widespread diffusion is whether there is sufficient evidence linking diffusion to organisational performance, i.e. do those organisations with greater diffusion of technology outperform those with less diffusion? Also, although deeper levels of infusion have been associated with greater levels of diffusion (Zmud and Apple 1992; Eder and Igbaria, 2001), its relationship with the performance of an organisation has not been fully explored. Likewise the question whether deeper levels of infusion can be associated with better performing organisations remains.

In order to answer that question in this study, it is necessary to conceptualise hospital performance. Conceptualising and operationalising hospital performance remains a key challenge for researchers (Giuffrida et al. 1999). A number of researchers, such as Narver and Slater (1990), Vera and Kuntz (2007), and Fottler (1987), have expressed the difficulty of assessing hospital performance, including the operationalising of hospital performance leading to varying definitions. Consequently, past studies have used multiple dimensions to capture the complex nature of hospital performance (see Tables A1 and A2, Appendix).

The following section highlights some of the dimensions used in past studies.

2.4.1 Financial dimension

The most common of measures for hospital performance has been associated with the financial performance of the hospital. To this end, researchers have used operational definitions such as operational profitability, e.g. net revenue per admission, net revenue per day, cost per day (Goes and Zhan, 1995; Devaraj and Kohli, 2000; 2003; Jiang, Friedman, and Begun, 2006), marginal revenue (Menon, Lee, and Eldenburg, 2000), economic efficiency (Georgopoulos, 1985), while others such as Je'McCracken, McIlwain, and Fottler (2001) have considered a combination of financial measures.

The use of financial data is considered by most researchers as objective and a good indicator of performance (Je'McCracken et al. 2001). However, others have questioned this, stating that the primary aim of hospitals may not be financial improvements (Minvielle et al. 2008). In a study to find out what hospital stakeholders (physicians, caregivers, and administrative staff) viewed as more important, Minvielle et al. (2008) found that out of 66 items, those measuring financial or cost/control efficiency dimensions were ranked the lowest. Their study results are consistent with Gans et al. (2005) findings as well. These researchers, evaluating EMR systems benefits, noted that most respondents scored higher the features that were seen more important to the direct care of patients than those related to cost savings.

Based on past literature, it would seem the use of financial measures is not the only relevant measure.

2.4.2 Clinical / Unit Effectiveness dimension

There are a number of performance dimensions used to assess a hospital unit's effectiveness. For instance Shortell et al. (1991) have assessed unit effectiveness through quality of care provided, meeting family member needs, and nurse turnover ratios.

An assessment of units enables researchers to understand the performance of organisations at scaled levels. If units perform well within the hospital organisation then it is more likely the hospital as a whole will perform well.

Clinical effectiveness is included as a dimension of performance in this study and is defined as the perceived effectiveness of the unit with regard to patient needs and outcomes.

Patient safety as a dimension of hospital performance is discussed next.

2.4.3 Patient safety dimension

Patient safety lacks a common definition. A number of studies have highlighted the changing and often times overlapping nature of the terminology used to define patient safety. For instance some studies have used medical errors (Dovey et al. 2002), medical injuries (Cole, 2000) or adverse events (Thomas et al. 2000, Jha et al. 1998) to define and measure patient safety. Lately studies, such as

DesRoches et al. (2008), have used quality of care as a measure of patient safety, incorporating the overlapping terminology mentioned earlier.

Zhan et al. (2005) suggest a taxonomy for patient safety assessment. They categorize patient safety into three measure sets, namely *structural measures*, which assess systems in use as well as staffing issues; *process measures*, which assess medical/medication errors; and *outcome measures*, which assess adverse events and adverse drug effects. They suggest that an appropriate assessment of patient safety must incorporate these measure sets.

Hospital organisations that improve their patient safety standards are also likely to perform better in other dimensions of performance e.g. patient satisfaction, which is discussed next.

2.4.4 Patient satisfaction dimension

The use of patient satisfaction as a hospital performance measure is not very common at organisational level studies. Fottler (1987), Harber (1998), Devaraj and Kohli (2000), are some of the few studies to have used patient satisfaction as a measure of hospital performance. Patient satisfaction refers to the organisations' assessment of patients' satisfaction about the medical care provided by the organisation. Furthermore, there have been very few studies that have considered the impact of EMR systems on patients. One such study by Rosen et al. (2011) noted that patients rated highly practitioners who used EMR systems compared to those who did not. The study revealed that patients felt they had had a better experience when visiting practitioners who used EMR systems than when they went to those who did not.

EMR systems allow practitioners to access data quicker and provides them with relevant up to date information (Lenhart et al. 2000), allowing them to make better decisions. For instance the use of EMR systems has been found to reduce the chances of unnecessary repeat tests (Taylor et al. 2005; Lo et al. 2007).

However, as literature suggests, there have been few organisational studies that have used self-reported data from organisations on patient satisfaction.

2.5 Studies on hospital performance in South Africa

In South Africa there have been limited studies on assessing hospital performance, especially in the private sector. The public sector, on the other, has recently undertaken a comprehensive assessment of its hospitals. This assessment, undertaken by the Health Systems Trust – a government sponsored entity – evaluated public hospitals across all nine provinces. Their evaluation was based on seven performance measures covering financial, operational, or clinical outcomes but ignoring patient satisfaction. Empirical studies that assess hospital performance, taking into account broader performance measures, are a necessity within the South African context.

Based on the above review of past studies, hospital performance was conceptualized in this study as consisting of four dimensions (see Table 2.2). Specifically they include dimensions of efficiency, clinical effectiveness, patient safety, and patient satisfaction.

Table 2.2 – Performance dimensions and their definition

Construct	Source	Definition
Economic efficiency	Georgopoulos (1985)	The financial/ non-financial cost of an activity relative to the available resources. This refers to how well resources are being utilised.
Clinical Effectiveness	Shortell et al. (1991)	This is the perceived effectiveness of the unit (facility) with regard to patient care needs and outcomes.
Patient Safety	Agency of Healthcare Research and Quality (AHRQ)[5]	This is the freedom from accidental or preventable injuries from medical care. Adopted from AHRQ.
Patient Satisfaction	Ware et al. (1983)	This is the organisation's assessment of its patients' satisfaction about the medical care provided by the organisation.

This leads to the study's third research question;

RQ3: What are the direct effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction?

Another aspect of an organisation's performance is its ability to provide accurate, timely and reliable information to its stakeholders, which can positively influence other activities and in turn influence the organisation's performance (Mithas, Ramasubbu, and Sambamurthy, 2011).

Mithas et al. (2011) define this as "information management capability" that is, the ability to provide data and information to users with the appropriate levels of accuracy, timeliness, reliability, security, confidentiality, connectivity, and access. It is also the ability to tailor these responses to changing business needs and direction (pg. 240).

[5] http://archive.ahrq.gov/research/findings/nhqrdr/nhqr10/Chap3.html#support

2.6 Information Management Capability

The aforementioned studies, as well as others, reveal that EMR systems provide valuable information that help caregivers make decisions. For effective delivery of care, accurate and reliable information is a prerequisite in hospital organisation (McKnight et al. 2001). This calls for hospital organisations to have systems and processes that allow them to capture data, safeguard it, and disseminate it as accurate, timely and reliable information to its stakeholders. Once an organisation can do this, it creates an ability that can positively influence other activities within the organisation - in the process influencing the organisation's performance (Mithas et al. 2011). This capability, defined as an information management capability, reflects an organisation's capacity to provide data and information to users with appropriate levels of accuracy, timeliness, reliability, security, confidentiality, connectivity, and access as well as tailor responses to business needs and directions (Mithas et al. 2011).

Andersson, Hallberg, and Timpka (2003), in an attempt to develop a model that explains clinical work, looked at three aspects within the hospital setting. They considered the care activity, the co-ordination activity involved, and the supply activity. The care activity related to care being provided to the patient; the co-ordination activity related to the internal and external co-ordination that needed to be undertaken in the process of providing care to the patient; and the supply activity involved support activities such as materials needed, and psychological assistance. In their study, they noted that organisations that were able to effectively manage the capturing, and disseminating of accurate information to the various stakeholders involved in the three activities, were able to provide better care to the patient than organisations that lacked this ability. Their findings were consistent with Preuss (2003) who found that the quality of information made available to stakeholders internally mediated these organisations' performance. Information quality, defined as the accuracy, completeness, legibility, and timeliness of information (DeLone and McLean, 1992) is the most assessed attribute of healthcare systems both at individual and organisational level (Van Der Meijden et al. 2003), further highlighting the significant role that information management capability has in determining the healthcare organisation's performance.

For hospitals, accurate information is not only vital but it must also be available at key points where and when it is needed (Baggs et al. 1999; McKnight et al. 2002). Information management capability is therefore considered an important additional dimension of hospital performance.

Hospital organisations must be provided with more empirical evidence to motivate them to develop their information management capability. Research that identifies and addresses the role of this

capability is most likely to be relevant to healthcare practitioners and should contribute to the improvement of hospital performance.

Given the need for information management capability and given also that EMR systems can provide this capability, this leads to the fourth research question.

RQ4: What are the indirect effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction, through improved information management capabilities?

Having addressed the background regarding the variables associated with this study, the next section presents the theoretical underpinnings that guided the development of the research model.

2.7 Theoretical Underpinning

2.7.1 Resource Based View of the Firm.

The Resource-based view posits that an organisation's resources will enable it to achieve competitive advantage, only if they perform better compared to similar assets of competitors (Bharadwaj, 2000; Barney, 1991). Resources have been described in many terms, such as capabilities (Gold et al. 2001), competencies (Prahalad and Hamel, 1990), and sometimes assets (Wade and Hulland, 2004). The resource-based view therefore suggests there are resources, capabilities, competencies, and assets that enable the organisation to achieve competitive advantage. The use of these resources, capabilities, competencies, and assets must enable the organisation to detect and respond to market opportunities or threats (Wade and Hulland, 2004).

Wade and Hulland (2004) further provide guidance to differentiating these terms. They define assets as anything tangible or intangible that the firm can use in its processes for creating, producing, and /or offering its products and/or services to the market. Capabilities, on the other hand, refer to repeatable patterns of action in the use of assets to create, produce, and / or offer products and /or services to a market. Quoting Hall (1997) and Srivastava et al. (1998), they suggest examples of assets to include information systems hardware, software, and network infrastructure. The key function of capabilities is to transfer inputs into outputs of greater worth (Wade and Hulland, 2004).

Bharadwaj (2000) notes that capabilities have been defined as the organisation's ability to assemble, integrate and deploy its resources. Organisations that can properly assemble, integrate and deploy their resources will normally have superior performance. The existence of resources does not mean an organisation can properly integrate and deploy them. Moreover the strategic intent, rather than the mere technology deployment, is the differentiating factor for improved organisational performance (Acosta et al. 2011).

Others suggest capabilities include complex, coordinated patterns of skills and knowledge that become embedded as routines over time, and because they are performed better than their rivals, these patterns of skills and knowledge becomes an organisation's capability (Morgan, Vorhies, and Mason, 2009). They become rooted in the organisation's processes and routines (Acosta et al. 2011) which make it hard to duplicate them; thus becoming firm specific. Given that they are performed better than the competition, these capabilities become valuable to the organisation because they become tools for competitive advantage, all of which are key characteristics of what would be classified as a resource under the resource-based view (Bharadwaj, 2000; Barney, 1991).

Capabilities therefore become firm-specific whereas resources may not be - since competing organisations may purchase the same resources. Accordingly, the purchase of EMR systems does not make them a valued resource to the organisation per se but the extent to which they have spread across the organisation (observable by the percentage of users and processes they support); and the degree to which they are comprehensively embedded or integrated within an organisation's operational and managerial processes (observable through the number of units using EMR systems or functionalities that have been implemented); reflects a valued capability. As they spread across the organisation, a process also called diffusion, they become part of organisational processes and as they are used over time they become rooted in organisational routines and processes (they are infused).

Some IS researchers suggest that information systems on their own cannot provide continued competitive advantage and therefore they cannot sustain an organisation's superior performance unless they are able to influence other resources and capabilities (Melville, Kraemer, and Gurbaxani, 2004; Bharadwaj, 2000; Wade and Hulland, 2004). As a result, IS researchers, such as Wade and Hulland, have called for research that assesses the effects of information systems on other *organisational* resources and capabilities. This suggests information systems indirectly affecting organisational performance by affecting other organisational resources and capabilities. A meta-

analysis by Liang and You (2009) on the use of the resource-based view in information systems research revealed that models with organisational capabilities e.g. managing internal relationships, as mediators better explain the effect of IS on organisational performance. This therefore suggests that research should not only consider the direct effects of IS&T on performance but it should also assess the impact of IS&T on performance, mediated by organisational resources and capabilities.

The use of the resource –based view in public organisations is also worth noting. Bryson, Ackerman, and Eden (2007) used the RBV to assess how the ability to formulate strategy in public organisations could be seen as a key resource. Harvey et al. (2010) used the RBV to show that a public organisation's knowledge absoption capability can be seen as a critical resource. The resource-based view of the firm was also used by Janssen and Joha (2007) to assess how different organisations' IT governance of shared services related to improved services and accomplishment of efficiency gains. Likewise other researchers such as Kamoche (2007) identified the continuous development of human resources as a key capability that public sector organisations could use to be more competitive in their industry.

In summary, the resource-based view provides guidance on identifying the contributions of various organisational resources, such as information technology, which may impact organisational performance (Santhanam and Hartono, 2003; Barney, 2001; Bharadwaj, 2000; Zhu, Kraemer, and Xu, 2006). It also facilitates the specification of information systems resources, as the resource based view also defines resources, attributes, and characteristics (Wade and Hulland, 2004). In this study, EMR systems are considered an advantage creating resource, and their diffusion and infusion as organisational capabilities. Furthermore, information management can also be considered an organisational capability (Mithas et al. 2011) and a mediator that better explains the effects of diffusion and infusion of EMR systems on hospital performance. Together these resources and capabilities are hypothesized to be interconnected and performance enhancing. These inter-relationships are discussed next.

2.7.2 EMR Diffusion and Hospital Performance

Diffusion, the extent to which an IT has spread across the organisation, reflects an organisational capability which may enhance performance (Yu and Xin-quan, 2011; Ross, Beath, and Goodhue, 1996). Ross et al. (1996) note that, based on the resource-based view of the firm, it is the consistent development of the capability to apply IT to business opportunities which enhances performance. Such consistent development includes the diffusion of systems into the organisation which provides

organisational members the opportunity to actively use the systems. Kreamer et al. (2006) also suggest that IT diffusion will lead to positive impacts on the performance of a firm.

DesRoches et al. (2008) found that health facilities which had comprehensive EMR systems reported greater positive effects on patient and clinical outcomes, compared to facilities that had no or basic EMR systems. Consistent with DesRoches et al., Miller and Tucker (2009) noted that hospital organisations with diffused systems achieved improved quality of care and reduced administrative costs. Therefore;

H1a: The level of EMR system diffusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction).

2.7.3 EMR Infusion and Hospital Performance

Infusion, the extent to which an IT has been comprehensively embedded in organisational processes, is an organisational capability. Organisations that have integrated their business processes to the implemented technology are most likely to achieve greater performance improvements. Studies by Zhu et al. (2006); and Kraemer et al. (2006) similarly reveal that organisations where technology has been institutionalised within business activities realise performance benefits. Hospital organisations that have fully functional EMR systems supporting their processes achieve reduced administration cost and less patient errors (Lenhart et al. 2000). These researchers - Lenhart et al. - also noted that hospital organisations where EMR systems had either partially or fully replaced paper were performing better than those still relying on paper systems. Therefore;

H1b: The level of EMR system infusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction).

2.7.4 Information Management Capability and Hospital Performance

Organisations that view information as a strategic asset require information management capabilities (Glazer, 1991), and are likely to protect and enhance those information capabilities in the same way they protect and enhance other organisational assets. Mithas et al. (2011), in a study of organisations, confirm that information management capability has an effect on performance.

Hospital organisations have a strong need for accurate and reliable information for their delivery of patient care (McKnight et al. 2001). Better information management capabilities enable hospitals to spend less time and resources capturing patient data. Therefore they are most likely to have fewer

errors and also most likely to have the right information available at the healthcare provider that requires the information. Hospitals that can provide accurate and reliable information about their patients to healthcare providers are less likely to have patient safety concerns. Therefore,

H2: Information Management Capability is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction).

2.7.5 Diffusion and Information Management Capability

Information systems provide capabilities that allow the capture and dissemination of data to key personnel within the organisation. Zuboff (1985) highlights that one of the benefits of information systems is that it allows information to be available where needed within the organisation. Where such systems are diffused, this benefit is enhanced because there are fewer errors in capturing, less time spent on recapturing, increasing the comprehension of activities performed and organisations are able to control and safeguard data as a resource (Zuboff, 1985; Laudon and Laudon, 2008).

Diffusion of EMR systems suggests hospital organisations can provide systems users with data that is accurate, timely, reliable, and secure. Miller and Tucker (2009) suggest that EMR systems enable quick, reliable, and cost-efficient communication. These are key characteristics of the type of information that is vital in hospital organisations. Such information must also be available at key points where and when it is needed (Baggs et al. 1999; McKnight et al. 2002). Therefore;

H3a: The level of EMR system diffusion is positively related to the information management capability of the hospital organisation.

2.7.6 Infusion and Information Management Capability

Computer-based information systems improve the efficiency and effectiveness of data capturing, storing, retrieving, protecting, and disseminating information both within and between organisations (Bharadwaj, 2000; Armstrong and Sambamurthy, 1999; Liang and You, 2009). The greater the degree to which information systems and technology has been infused to become embedded across organisational units (the more information intensive tasks are being supported by information systems and technology); the more likely it is for these advantages to occur. EMR systems can enable just such improvements in how information is managed. EMR systems that are used frequently and that are replacing paper should bring improvements to how information is managed. Lenhart et al. (2000) found that facilities with EMR systems were reporting those systems as superior to their paper

systems in terms of their ability to capture, store, retrieve, protect, and disseminate information. Therefore;

H3b: The level of EMR system infusion is positively related to the information management capability of the hospital organisation.

2.8 Research Model

Figure 2 below is the research model, which depicts the hypothesized effects of EMR systems diffusion and infusion on hospital performance directly and via information management capability. The arrows in the model denote the hypothesized relationships as developed in the previous section.

The development of the model and hypotheses drew from different theoretical perspectives namely, diffusion and infusion from Ash (1997), Zmud and Apple (1992), and Eder and Igbaria (2001); and the resource-based view of the firm theory and organizational capabilities literature from Barney (1991), Wade and Hulland (2004), and Bharadwaj (2000).

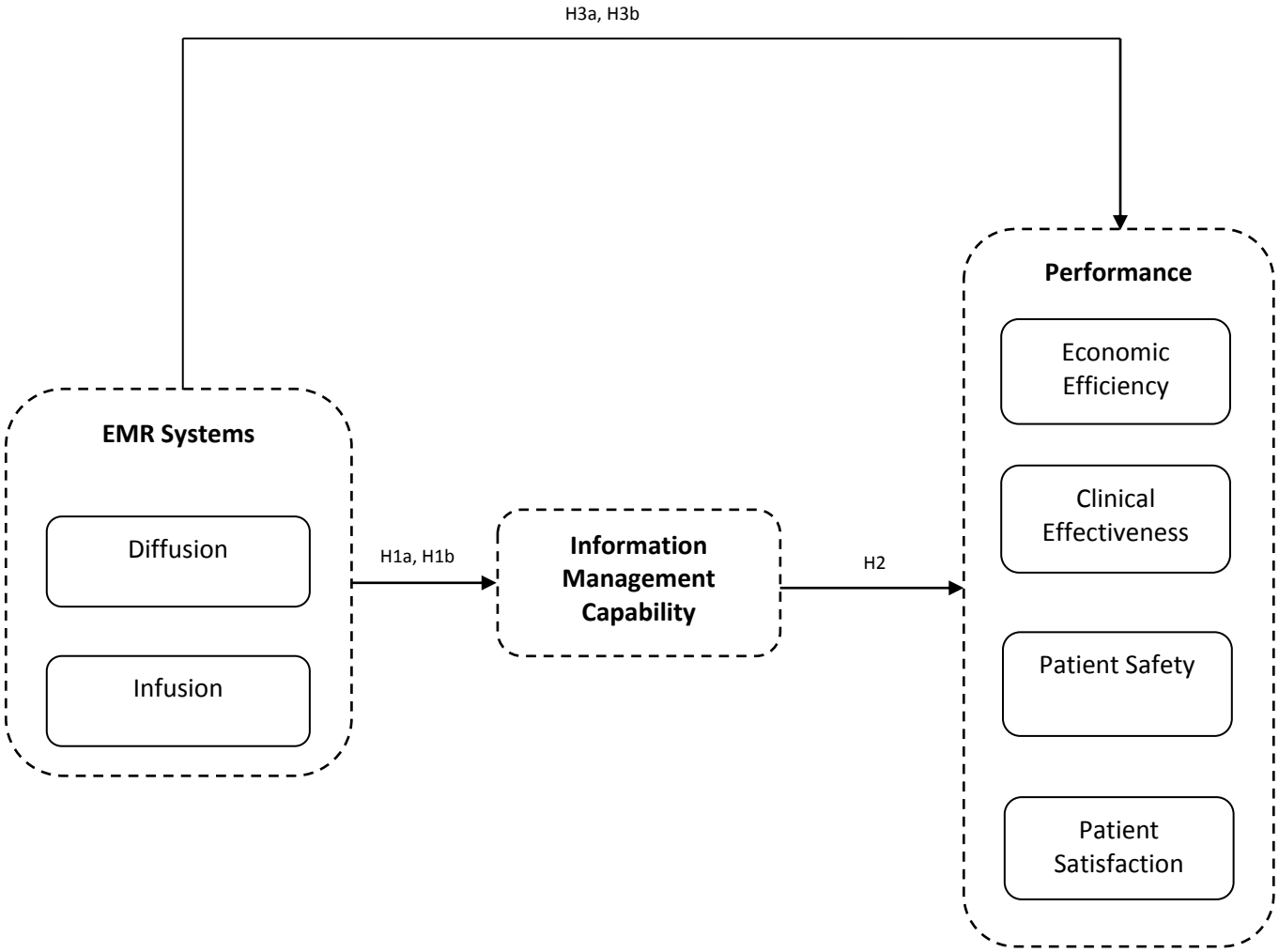


Figure 2 – Research model

2.9 Summary

This chapter has highlighted some of the past studies undertaken to assess hospital performance, as well as the direct and indirect effect of IS&T on an organisation's performance. Also discussed were the effects of EMR systems on hospital performance and the role of information management capability. Consequently, four research questions were developed. These were;

RQ1: What is the current state of EMR systems diffusion in the hospitals of South Africa?

RQ2: What is the current state of EMR systems infusion in the hospitals of South Africa?

RQ3: What are the direct effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction?

RQ4: What are the indirect effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction, through improved information management capabilities?

Based on these research questions, five hypotheses were developed. These are presented in tabular form below.

	Hypotheses
H1a	"The level of EMR system diffusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."
H1b	"The level of EMR system infusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."
H2	"Information Management Capability is positively related to the performance of the hospital organisation (clinical processes effectiveness, team process effectiveness, economic efficiency, and patient satisfaction)."
H3a	"The level of EMR system diffusion is positively related to the information management capability of the hospital organisation."
H3b	"The level of EMR system infusion is positively related to the information management capability of the hospital organisation."

Having discussed the research questions and the associated hypotheses, the theoretical underpinnings that informed the research model development were discussed and subsequently the research model was presented.

The next chapter will discuss the research methodology to be employed as well as the justifications from literature for employing the chosen research methodology. The sampling strategy, development of the research instrument, and strategies for data analysis will also be described.

3 Chapter 3 – Research Methodology

3.1 Introduction

This chapter discusses the research approach that has been adopted for this study. First, the two dominant knowledge acquisition claims (positivism and interpretivism) are reviewed and the associated research methodologies (quantitative and qualitative) are discussed. Second, the applicability of each to this study is examined before a detailed discussion of this study's methodology is presented. The detailed discussion focuses on data collection (sampling, informants, and instrument design) and data analysis strategies.

3.2 Research Methodology

The research methodology is the strategy that the researcher uses to inquire about a phenomenon (Creswell, 2003). This strategy must be appropriate and relevant to the research question that the researcher wishes to answer. Although a choice prevails, Creswell also notes that in certain instances, the research problem will dictate the most appropriate research methodology that the researcher must employ.

Researchers such as Creswell (2003), Hirschheim (1985), Bryman (1984), Hovorka and Lee (2010) have associated different types of research methodology to different beliefs about how knowledge is acquired. Generally two belief systems about knowledge acquisition claims are dominant in social science research; positivism and interpretivism.

Positivism is a research tradition with natural sciences roots. It involves "the manipulation of theoretical propositions using the rules of formal logic and the rules of hypothetic-deductive logic" (Lee, 1991, pg. 343). The theoretical propositions must satisfy these rules (rules of formal and hypothetic-deductive logic). The researcher defines formal propositions, based on this existing logic, which specify independent variables, dependent variables, and the relationship among them. Such logic, or fixed relationship between propositions, is considered to be pre-existent within the phenomena (Orlikowski and Baroudi, 1991).

Hypothetico-deductive logic suggests that although the major premise may not be observable, it can be broken down to minor premises which can be observable (Lee, 1991) i.e. the phenomenon of interest is single and fragmentable and that there is a unique, best description of any chosen aspect

of the phenomenon (Orlikowski and Baroudi, 1991) hence the researcher's ability to define propositions based on existing logic.

As such, positivism suggests that the researcher and reality are separate and that the research object has inherent qualities that exist independently of the researcher.

On the other hand interpretivism believes researcher and reality are inseparable and that the research object is interpreted based on the researcher's lived experiences (Weber, 2004). This knowledge acquisition claim "assumes that people create and associate their own subjective meanings as they interact with the world around them" (Orlikowski and Baroudi, 1991 pg.5). This suggests the world is structured by the individual and therefore any rules or laws or meanings that may exist are subjective, based on the individual's experiences. (Miles and Huberman, 1984; Creswell, 2003; Gregor, 2006; Johnson and Onwuegbuzie, 2004).

As such, to the interpretivists, the world must be viewed from the subject's point of view, contrary to positivism where the constructs and variables that represent the world are defined by the researcher and not the subject (Hovorka and Lee, 2010). Therefore the interpretivist researcher sees themselves playing an important role in the research process - that of interpreting what the world means to the human subjects under observation (Hovorka and Lee, 2010).

Associated with these two knowledge acquisition perspectives are a set of research methodologies namely the quantitative and qualitative research methodologies. These are discussed next.

3.2.1 Quantitative and Qualitative Research Methodologies

Quantitative research, most typically associate with positivism, assumes that the researcher is objective in their study. The belief, based on positivism, is that social science inquiry must be objective and that it must be possible to make time and context-free generalization (Johnson and Onwuegbuzie, 2004). Quoting Smith (1975), Schofield (2002) notes that quantitative researchers believe the goal of science is to be able to generalize findings to diverse populations and times. To achieve this, the researcher need not be a direct participant of the study as this would make it impossible to generalize, given that their subjectivity will influence the direction and outcome of the study. Quantitative methodologies typically rely on statistical analysis, measurement scales, and specifically defined variables. Common quantitative research methods include surveys and experiments (Creswell, 2003).

Grounded on and associated with the interpretivist perspective, qualitative research methodologies assume that the researcher must be a direct participant of the study. The ability to generalize results is not a priority among qualitative researchers (Orlikowski and Baroudi, 1991). Others have argued that generalizability is not a relevant consideration for qualitative studies (Schofield, 2002). Qualitative methodologies typically include content analysis, observation, and narrative interviews.

A further distinction between the objective methodology and the subjective methodology is the degree to which the research can be replicated elsewhere to produce similar results. Replication typically is not feasible within an approach that is subjective. Johnson and Onwuegbuzie (2004) suggest that, since qualitative research cannot be repeated in the same fashion for the same responses, given that the researcher becomes directly involved and therefore their subjectivity plays a major part; results from such an approach should be considered as opinions or perspectives of the researcher. By using research tools, such as questionnaires, quantitative methodologies provide a standardized way of doing doings, enabling researchers to replicate the research.

Quantitative research distinguishes between study results and the interpretation of those results, allowing readers and other researchers to draw their own conclusions to either agree or disagree with discussions put forward by the researcher. This may not be possible with qualitative research as the results in such a methodology are in fact an interpretation of the researcher (Lakshman et al. 2000).

The research approach adopted for this study is justified next.

3.2.2 Research Approach

Creswell (2003) suggests that where the research problem involves identifying factors that influence an outcome; or understanding the best predictors of outcome, then a quantitative approach is best. He notes also that quantitative approach is best to use when testing a theory.

This study has questioned the current state of EMR system diffusion and infusion and hypothesized the impact of higher levels of EMR diffusion and infusion on information management, and on economic efficiency, clinical effectiveness, patient safety, and patient satisfaction within hospitals.

A quantitative research methodology will allow the researcher to test the relationships among the identified variables (EMR diffusion, EMR infusion, information management, economic efficiency, clinical effectiveness, patient safety, and patient satisfaction). This methodological approach also

helps to achieve the study's objectives through the use of statistical procedures and techniques, including both descriptive and inferential statistics.

Given also that this study is primarily a descriptive research study, a survey research approach is adopted. Descriptive research involves examining a phenomenon to more fully define it or to differentiate it from other phenomena (Dane, 1990). A survey approach is therefore a more appropriate approach, given also that its intention is to generalise from a sample to a population (Creswell, 2003). Survey research also enables the researcher to test objective theories by collecting large amounts of data needed to examine relationships among variables (Creswell, 2003).

Survey research may also contribute to greater confidence in the generalizability of results (Jick, 1979) mainly because the research instrument used creates a standardized form, which increases the reliability, comparability, and precision of data from one region or time frame to another (Lakshman et al. 2000). These survey research instruments will allow for the study to be replicable, in the process enhancing its objectivity.

Given also the first two research objectives of assessing the current state of EMR systems in hospitals across South Africa, a cross-sectional study is more appropriate as it allows the researcher to report on the current availability levels, thus addressing the objective. This cross-sectional approach is consistent with both Jha et al. (2009) and DesRoches et al. (2008) studies as well as Lærum et al.'s (2001) study who looked at the use of EMR systems by doctors across Norwegian hospitals.

In summary, the choice of quantitative research methodology is motivated by the methodology's flexibility to allow for; theory testing, objectivity, generalizability, and the replication of the study.

Following the choice of survey research design, two key issues must still be addressed; how the data is to be collected and how it will be analysed. The next section discusses the specific approaches to both data collection and analysis that are used in this study.

3.3 Data Collection

To address how data has been collected for this study, three key elements are discussed in detail. These are the sampling method, the choice of key informants to serve as survey respondents, and the measurement of the study variables and the construction of the survey instrument.

3.3.1 Sample

As mentioned in the preceding sections, this study seeks to assess the current state of EMR systems in South African hospitals. Ideally knowledge about the entire South African hospital context would be the target. However knowledge about an entire class, which is called a population, cannot always be obtained because the population may not always be available for observation, hence the use of a sample. A sample can be defined as a representation of the population (Babbie, 1989). It is important that the sample be representative of the population i.e. it must display the same qualities and characteristics as the population. Results or findings obtained from the sample can then be extended (generalized) to the entire population (Singleton and Straits, 2005).

A number of considerations are presented in literature as to why one samples. Practical considerations are important. For instance, issues of time constraint and financial costs make it impractical to gather data from a bigger sample. If the data gathering process is done over a longer period then there is also the possibility that the population's attitude towards what was being measured may have changed. This may also present a challenge in terms of comparing results from the first set of observations to those observed last.

Once the decision to sample has been made, the first consideration is the sampling technique. A number of sampling techniques exist but they fall under two broad categories, probability and non-probability sampling. Under probability sampling, where population members have an equal chance of being included in the sample, a researcher can use either simple random, stratified, cluster, or systematic sampling. Non probability sampling, where the selection of subjects from the population is based on particular rules set up by the researcher, includes quota, purposive, and convenience sampling procedures (Bradley, 1999).

The target population of a study is defined by identifying the unit of analysis. This identification is influenced by the research objectives. Sampling requires that the unit of analysis (the target population) must be carefully defined. Based on this unit of analysis, a sampling frame is drawn. The sampling frame is thus the researcher's operational definition of the population (Singleton and Straits, 2005).

In this study the target population (unit of analysis) is hospital organisations, both private and public, in South Africa. The sampling frame for the private hospitals is the publicly accessible list of the 297 members of the Hospital Association of South Africa (HASA) as of August 2011. HASA is the

representative body of private hospitals in South Africa. Of the 297 members, 217 are located within South Africa. Despite being a convenience sample, according to the HASA website (www.hasa.co.za), HASA represents the interests of more than 90% of private hospitals in South Africa, and its list is therefore considered appropriately representative of the population. Given that this list contains a manageable number for sampling; all 217 members who are based in South Africa will be invited to participate.

The sampling frame for the public hospitals is the publicly available list from all the Provincial Departments of Health websites. Each of the nine provincial health department lists all public (government) hospitals in their province. This list stood at 400 hospitals. Table B1 in the appendices shows the total number of hospitals per province.

3.3.2 Key informants

Key informants are respondents capable of providing data and representing the unit of analysis. For studies in which the unit of analysis is an organisation, key informants are usually chosen because of their formal positions in the organisation and their perceived knowledge of the issues related to the study (Gupta, Shaw, and Delery, 2000; Kumar, Stern, and Anderson, 1993). Key informants will summarise their views, based on observed and /or expected organisational activities (Kumar et al. 1993).

The variables, as discussed in chapter 2, that this study intends to report on are diffusion of EMR systems, infusion of EMR systems, and hospital performance. These are reported by the hospital organisation. The use of a single key informant to provide data on both the study's independent and the dependent performance measure would be susceptible to common method bias. Common method bias (or common method variance) is the variance attributable to the measurement method rather than the constructs the measure represents (Podsakoff et al. 2003) and is a main concern for self-reported data (Meade, Watson, and Kroustalis, 2007). Therefore, a number of researchers such as Podsakoff and Organ (1986), Podsakoff et al. (2003) have suggested that researchers should attempt to obtain data on independent and dependent variables from different sources to avoid effects of common method bias. A good strategy to overcome common method bias is through the use of multiple key informants.

This study has adopted an approach that relies on two informants per organisation. This was to ensure that a different respondent responded on the study's independent variables and another different respondent responded on the dependent variables. This multiple respondent or matched pair responses approach is consistent with that used by researchers such as Podsakoff and Organ

(1986), Glick, Jenkins, and Gupta (1986), and Smith, Organ, and Near (1983). This approach, as mentioned earlier, will help reduce common method bias.

Data about hospital performance measures will be obtained from hospital administration. From hospital administration the intended respondent is any of the following relevant individuals who can report on the hospitals' performance: Hospital CEO, Hospital Administrator, Head of Operations, Head of Quality Assurance, and Chief Medical Officer. As mentioned earlier, the study does not aim at investigating specific clinical processes which would require specific knowledge from the medical practitioner performing those processes but its focus is on the EMR systems and their impact on hospital performance. The abovementioned respondents are most likely to know their organisation's performance levels. The data will be obtained using questionnaire instrument 1 – the hospital performance instrument questionnaire.

Data about EMR diffusion and infusion within the hospital will be obtained from any of the following individuals who can report on the availability and use of EMR systems software: Chief Information Officer (or equivalent), I.T Director, or Head of Operations. Given that they have the primary responsibility of making decisions and making sure that EMR systems work well, they represent appropriate key informants. The data will be obtained using questionnaire instrument 2 – the EMR diffusion and infusion questionnaire.

The construction of these two instruments is discussed next.

3.3.3 Instrument construction – the hospital performance instrument

The hospital performance instrument was designed to be completed by the hospital administration, e.g. CEO. It was divided into two parts.

Part A collected the demographics of the organisation to use as controls. Items for this section were adapted from similar studies that have researched on healthcare organisations. To categorize hospitals, the instrument used Cullinan's categorization of South African public hospitals (Cullinan, 2006).

The following four control variables were captured in Part A.

1. Size: the size of a hospital is likely to influence the levels of IT availability (Simon et al. 2008; DesRoches et al. 2008; Jha et al. 2009). Size was measured in terms of number of inpatient / acute care beds, consistent with the aforementioned researchers.

2. Location: hospitals situated in urban areas are more likely to have IT systems in place than hospitals in rural areas. (DesRoches et al. 2008; Jha et al. 2009; Ruxwana et al. 2010). Location was measured as location in rural or urban community. The use of location as a control variable is consistent with Menachemi et al. (2007) and Hikmet et al. (2008).
3. Type of hospital: tertiary or teaching hospitals are more likely to have IT systems in place (Cullinan, 2006). The use of type of hospital as a control variable is consistent with Devaraj and Kohli (2000), and the American Hospital Association Report (2005).
4. Ownership: Organisations that belong to a group or are members of a network are more likely to have IT systems in place than independent hospitals (Jha et al. 2009; American Hospital Association Report, 2005). Secondly, researchers such Taylor et al. (2005), and Parente and Van Horn, (2006), have noted that not-for profit hospitals are most likely to have invested more in IT systems. This would suggest, in the South African context, listed organisations (which are considered for-profit entities), are most likely to have invested less in IT systems than unlisted organisations. Ownership is measured as the type of ownership structure in place, and includes public hospital, private-public-partnership, and part of a group, amongst others.

Part B measured the organisation's performance across information management capability and the four performance indicators namely economic efficiency, clinical effectiveness, patient safety, and patient satisfaction. The variables and items in this section were adapted from a number of published studies.

Table 3.1. below shows the performance dimensions including the information management capability and the four performance indicators.

Table 3.1 –Performance Dimensions and examples of questions and scales used

Construct	Source	Definition	Example of question	Scale used
Information Management	Mithias et al. (2011)	The organisation's capacity to provide data and information to users with appropriate levels of accuracy, timeliness, reliability, security, confidentiality, connectivity, and access (Mithas et al. 2011).	Our facility performs very well at capturing patient details e.g. demographics.	Seven point scale. 7. Strongly Agree 6. Agree 5. Somewhat Agree 4. Neither Agree nor Disagree 3. Somewhat Disagree 2. Disagree 1. Strongly Disagree

Economic efficiency	Georgopoulos (1985)	The financial/ non-financial cost of an activity relative to the available resources. This refers to how well resources are being utilised. Adapted from Georgopoulos (1985)	We are satisfied with the current total cost to the facility of an average patient visit.	Seven point scale. 7. Strongly Agree 6. Agree 5. Somewhat Agree 4. Neither Agree nor Disagree 3. Somewhat Disagree 2. Disagree 1. Strongly Disagree
Clinical Effectiveness	Shortell et al. (1991)	This is the perceived effectiveness of the unit (facility) with regard to patient care needs and outcomes. Adopted from Shortell et al. (1991)	Our facility almost always meets its patient care treatment goals.	Seven point scale. 7. Strongly Agree 6. Agree 5. Somewhat Agree 4. Neither Agree nor Disagree 3. Somewhat Disagree 2. Disagree 1. Strongly Disagree
Patient Safety	Agency of Healthcare Research and Quality (AHRQ)	This is the freedom from accidental or preventable injuries from medical care. Adopted from AHRQ	We have fewer preventable falls, infections, or medical errors than do similar private hospital facilities.	Seven point scale. 7. Strongly Agree 6. Agree 5. Somewhat Agree 4. Neither Agree nor Disagree 3. Somewhat Disagree 2. Disagree 1. Strongly Disagree
Patient Satisfaction	Ware et al. (1983)	This is the organisations' assessment of patients' satisfaction about the medical care provided by the organisation.	The care our patients receive is just about perfect.	Seven point scale. 7. Strongly Agree 6. Agree 5. Somewhat Agree 4. Neither Agree nor Disagree 3. Somewhat Disagree 2. Disagree 1. Strongly Disagree

The difficulty of measuring organisational performance has resulted in the use of self-reported data in a number of past studies such as Powell and Dent-Micallef (1997), Armstrong and Sambamurthy (1999), Raju and Lonial (2001), Narver and Slater (1990), and and Jaworski and Kohli (1993). Narver and Slater note that past studies have found a strong correlation between subjective performance measures and objective performance measures. Other researchers, such as Howard (1980) found that in some instances, self-reports represented more accurate measures than other forms of measures. Therefore this study similarly will rely on self-reports of the responding senior hospital manager.

Secondly, the use of patient satisfaction as a measure of hospital performance has been criticised especially where the unit of analysis is the organisation. This could be because it is a measure that is not captured directly from patients. However, as noted by researchers such as Devaraj and Kohli (2000), organisational representatives responding to questions on patient satisfaction are likely to draw their conclusions from patient satisfaction surveys that have been administered on patients.

3.3.4 Instrument construction – the EMR diffusion and infusion instrument

The EMR diffusion and infusion questionnaire was designed for the hospital's I.T. / Operations function. It was also divided into two parts.

Part A, Questions 1 and 2 focused on diffusion. Diffusion is reflected in availability of EMR modules and frequency of use of EMR functionalities (Ash, 1997). Frequency in this instance referring to their availability to be used for that process.

Part A, Question 1 measured the availability of EMR within the respondent's organisation. This section was partly adapted from Jha et al.'s (2009) work on EHR across the United States. However, Jha et al.'s work only considered four out of the eight core modules of an EMR system as outlined by the IOM. Since this is a descriptive study aimed at fully defining the phenomena of EMR diffusion and infusion in South African hospitals, and given that there has been limited studies covering the diffusion and infusion of EMR systems along all the eight core modules of EMR in South Africa, this instrument incorporated all eight core modules.

By asking respondents to indicate whether each of the eight core modules are *6= available in all relevant clinical units, 5= available in a majority of clinical units, 4= available within at least one but not the majority of clinical units, 3= already beginning to make available, 2= planning to make available within a year, or 1= not in place*; the instrument captured the diffusion of EMR systems within the hospital organisation. This is consistent with the definition of diffusion presented earlier as being the spread of an IT across the organisation (Ash, 1997).

Part A, Question 2 captured the current use of the EMR systems functionalities based on their availability. By asking the respondents to indicate whether the EMR systems functionalities are 5= *used all the time 4= often used 3=sometimes used 2=hardly used 1= not available to be used;* the instrument will capture the alternative measure of the diffusion of the EMR system functionalities, again consistent with Ash (1997) definition. A *not sure* response was also provided for.

Part A, Questions 3 and 7 focused on infusion. Infusion is reflected by the degree to which an innovation is comprehensively embedded or integrated within an organisation's operational and managerial processes (Zmud and Apple, 1992). As mentioned earlier, Infusion is a process in which a technology moves through a succession of configurations with each succession facilitating a deeper, more comprehensive embedding of the innovation's functionality into the organisation to the extent that the innovation is frequently used and its use has replaced paper and manual processes (Eder and Igbaria, 2001; Zmud and Apple, 1992). Specifically;

Part A, Question 3 captured the levels of EMR system usage in certain processes within the respondent's organisation. The items were adapted from Thakkar and Davies (2006) work. By asking respondents to indicate the percentage of; *patients for whom clinical documentation is written electronically, patients for whom lab results are viewed electronically, patients for whom physician orders are entered electronically, physicians and nurses who use electronic decision support physicians and nurses who use electronic communication (e.g. email, intranet) to communicate with other healthcare providers, patients performing direct data entry electronically, patients at your facility performing direct data entry electronically, inpatient and outpatient administrative procedures at your facility done electronically, source data used in public health reporting that is collected electronically*; this scale provides a measure of the level of the organisational infusion of EMR systems. Six scales were used to assess this percentage, namely 0%, 1 – 25%, 26 – 50%, 51 – 75%, 76 – 100%. A Don't Know / Not Sure scale was also included.

Part A, Question 7 captured the extent to which computerized EMR systems have replaced paper in specific departments within the respondent's organisation. By asking the extent to which computerised electronic medical record systems have 5= *completely replaced paper 4= replaced paper for the most part 3= available and replacing paper in many ways 2= available and replacing paper in some ways 1= not implemented;* this scale provides an alternative measure of the infusion of EMR systems in specific departments (Eder and Igbaria, 2001; Zmud and Apple, 1992). A *not applicable* response was also provided for.

Part A, Questions 4, 5, and 6 captured other relevant data about the EMR, namely the year that the EMR system was implemented, whether it is integrated with other organisational systems, and how long it had taken the organisation to achieve its current level of integration. This data was for descriptive purposes.

Part B captured data on selected control variables. It captured the general state of IT diffusion within the hospital as the availability of other technologies within the respondent's hospital. These were barcoding technologies for laboratory specimen, for patient identification, and for medication administration; as well as I.T. applications to control patient flow, to monitor bed status, telemedicine, RFID for tracking equipment, physician use of personal digital assistants or tablets, and check-in / check-out or way-finding kiosks for patient use. The scale was *5= available in a majority of clinical units, 4= available within at least one but not the majority of clinical units, 3= already beginning to make available, 2= planning to make available within a year, or 1= not in place*. The items were also partly adapted from Jha et al.'s (2009) work.

Table 3.2 on the next page summarises the seven variables captured by the research instruments. The number of items and the source of items to be used to measure that variable are also highlighted. The use of literature to support the operationalisation of the variables in the study helped to ensure their content validity.

Table 3.2 – Study variables

Variable	Number of Items	Informant	Source
EMR Diffusion This is the extent to which an innovation has spread across the organisation, observable by 1. Its availability 2. Its frequency of being used	40 items 8 items	IT	Jha et al. (2009) IOM (2003)
EMR Infusion The degree to which an innovation is comprehensively embedded or integrated within an organisation's operational and managerial processes, observable by 1. The percentage of users and processes it supports. 2. Its ability to replace manual systems.	10 items 7 items	IT	Thakkar and Davis (2006) Jha et al. (2009)
Information Management	10 items	Admin	Thakkar and Davis (2006); Lee at al. (2002)
Clinical Effectiveness	6 items	Admin	Shortell et al. (1991)
Economic Efficiency	8 items	Admin	Georgopoulos (1985); Devaraj and Kohli (2000)
Patient Safety	5 items	Admin	Agency of Healthcare Research and Quality
Patient Satisfaction	5 items	Admin	Ware et al. (1983)

IT = Head of I.T / Operation Function **Admin = Hospital Administration e.g. CEO or Medical Director**

Prior to the administration of the questionnaire to the sample, it is important to confirm its face and content validity. This was achieved through pre and pilot testing.

3.3.5 Pre – Test study

The original questionnaire was sent to five individuals; two academics and researchers in the fields of information systems, two academics and researchers in the field of health informatics; and one PhD student in Health Informatics. From the resultant comments, the wording on the instrument was

refined. For example, instructions such as "*Please complete the questionnaire by placing an X in the box you feel most closely represents your organisation's position*" were changed to "*Please complete the questionnaire by placing X in the box that most closely represents your organisation's position"*. Secondly the recommendation that the instrument be split into two was accepted; one for the hospital administration and another for the IT / Operations function. Splitting the questionnaire was an appropriate strategy to reduce common method bias and also addressed concern over the length of the questionnaire. The split questionnaires became the Administrator Questionnaire and Hospital Information System Questionnaire.

The split questionnaires were then further tested at three hospitals around the Johannesburg area, as part of the pilot testing. The aim of this expert practitioner review was to assess whether questions could be interpreted or had meaning from the perspective of the potential respondents (face validity). This review also assessed the time it took to complete the questionnaires. Organisational members in charge of the IT departments participated in this review.

Based on feedback from these three hospitals, minor wording on the instruments was refined and the questionnaires finalised. For instance the diffusion scale headers were refined **from** *(a) fully implemented across all units, (b) implemented in at least one unit, (c) beginning to implement in at least one unit, (d) have the resources to implement in the next year, (e) do not have the resources but considering implementing, or (f) not in place and not considering implementing* **to** *(a) available in all relevant clinical units, (b) available in a majority of clinical units, (c) available within at least one but not the majority of clinical units, (d) already beginning to make available, (e) planning to make available within a year, or (f) not in place;* in order to better reflect the conceptual definition of diffusion as the extent to which an innovation has spread across the organisation, observable by its availability.

3.3.6 Pilot-Test Study

As mentioned above, three hospitals in Johannesburg two public and one private institution were identified for the pilot study. These hospitals were selected due to their proximity to the researcher's place of study. The main objective of this pilot study was to assess whether the functionalities identified in the study were relevant and known to hospital institutions in South Africa.

The results from the pilot study revealed that these EMR functionalities were relevant to the hospitals under study, albeit that each participant in the pilot reported different levels of availability. The pilot test participants also made a number of observations and recommendations about the research instruments. These observations and recommendations were taken into consideration and

some aspects of the instrument were adapted to reflect these observations and recommendations. A summary of these comments is attached as Appendix C.

The final versions of the research instruments, namely Administrator Questionnaire (Public), Administrator Questionnaire (Private) and Hospital Information Systems Questionnaire are attached as Appendix D, Appendix E, and Appendix F. The Administrator Questionnaire (Public) had to use different hospital categorisation e.g. District and Regional hospitals, which private hospitals do not use. Likewise the ownership structure in private hospitals is different to public e.g. listed group, private group. The aim was to make it more manageable for the respondents and, in the process, less lengthy. Thirdly, in 2013 the National Department of Health hired 102 new hospital CEOs (Kahn, 2013; Hartmann and Mauda, 2015). A question asking how many years the respondent had worked at that hospital was therefore considered necessary for future analysis.

3.3.7 Administration of the instruments

The questionnaires were initially administered through paper-based questionnaires, in the form of booklets, to ten (10) respondents. The booklets were sent in two packets, via post. One packet was addressed to the Administrator and it included the cover letter that introduced the study and administrator questionnaire. The other packet was addressed to the Operations Head and it included the cover letter introducing the study and the hospital information systems questionnaire. To select these ten respondents the researcher initially used the publicly available list of the 297 HASA members. The researcher exported this list to Microsoft Excel. Using province to sort the list, only members who were located in any nine of South Africa's provinces were selected. This new list was then exported to a separate Excel sheet within the same workbook. Using Microsoft Excel's Random function {Rand ( )}, the researcher, using highest random number to sort the list, was able to create a randomized list of the 217 members that are located in the Republic of South Africa.

A few weeks later, a further twenty similar packets to the next twenty respondents on the list were sent out in a similar manner i.e. one packet addressed to the Administration with a cover letter and Administrator questionnaire and another to the Operations Head with a cover letter and Hospital Information Systems questionnaire.

The cover letters that were included in each packet are shown as Appendix G and Appendix H.

However, given the low response to this strategy, an email version of the same questionnaire was then sent to non-responding hospitals. The researcher also made a number of follow-up visits to

hospitals closer as well as phone calls to distant hospitals. This approach (email and follow-up) seemed to work and was adopted as the approach to data collection for this study.

For the researcher to send and receive data from public hospitals, Government policy had to be followed. This involved making an application to the specific provincial department of health for permission to collect the data on public hospitals. Initially permission was requested from all nine provinces. Appendix I is the letter that was sent to each of the nine provinces' departments of health. However, given the time taken by this process and the continued delays in getting the approval, the researcher then focused on getting approval from the top three provinces, based on economic activity, namely Gauteng, KwaZulu Natal, and the Western Cape.

After concerted efforts, permission was eventually obtained from Gauteng and KwaZulu-Natal Provincial Departments of Health. The Western Cape Provincial Health Department chose not to participate in the study. Appendices J and K are the letters of permission from the two provincial departments of health.

Upon receiving permission, emails containing the cover letters and questionnaires for both the Administrator and Hospital Information Systems Questionnaires were sent to the Hospital Administrator and Matron / Operations Head (see Appendix L and Appendix M for public sector letters, which make reference to Provincial permission).

The next section addresses key issues that are necessary before the data is analysed. These issues relate to the validation of the instrument to ensure it is appropriate, as well as the validation of the instrument items. These issues are addressed under measurement validation.

3.4 Measurement Validation

Quoting Nunnally (1978), Straub, Boudreau, and Gefen (2004) suggest the purpose of validation is to give "researchers, their peers, and society as a whole a high degree of confidence that positivist methods being selected are useful in the quest for scientific truth" (pg. 383).

Although a number of validity measures are used in positivist research, this study utilized four critical ones; content validity, face validity, construct validity, and reliability.

3.4.1 Content and Face Validity

Content validity refers to the congruence between the operational definition of a variable and the concept it is supposed to measure (Singleton and Straits, 2004). In other words, it is the extent to which elements of the instrument, which may include measurement items and instructions, are

relevant and capture the intended construct (Haynes, Richard, and Kubany, 1995). Face validity, on the other hand, simply assesses whether the instrument is understood by and has meaning from the perspective of the intended respondents. These concepts are assessed differently and, generally, no statistical procedures are required (Straub et al. 2004).

Content validity is largely established by drawing on the literature for existing scales that were previously validated in other contexts. For this study, evidence of content validity was achieved firstly by drawing on the literature and secondly by subjecting the measurement instrument during the pre-test (see section 3.3.4) to experts in information systems and healthcare practice for their contributions and assistance in pinpointing the areas where the instrument may not be meeting its objective.

Face validity is assessed by subjecting the instrument to potential respondents. In this study face validity was achieved by confirming with the three hospital respondents. Content validity, on the other hand, was achieved by subjecting the instrument to the initial expert reviewers of five academicians and researchers.

3.4.2 Construct Validity

Construct validity assesses whether the measures being used by the researcher "move or fit" together to the extent that they can be said to be measuring the same thing (Straub et al. 2004; Trochim, 2006). Items must load to the measure they are purported to measure, otherwise the instrument's ability to capture what it supposes to capture is compromised. Two key construct validity measures, convergent and discriminant validity were considered for this study.

3.4.2.1 Convergent and Discriminant Validity

Convergent validity is defined as the convergence of items to the one measure or construct that they are purported to measure. This can be seen by high correlation scores between the items, especially when compared to the convergence of items to other constructs (Straub et al. 2004). On the other hand, discriminant validity confirms that certain items that measure different things are in fact measuring different things. As such their correlation scores must be closer to zero.

Assessing convergent and discriminant validity is important so that individual constructs are confirmed first prior to testing the research model and hypotheses, so that the researcher is not rejecting or accepting hypotheses based on results from items not measuring what they are posited to measure.

To assess convergent and discriminant validity, *Principal Component Factor Analysis* (PCFA) was performed on the performance dimensions (information management, economic efficiency, clinical effectiveness, patient safety, and patient satisfaction). PCFA was used to find out if items loaded onto the hypothesized factors, i.e. whether the factors actually measured what they were meant to measure by having all their items load onto them. When performing a PCFA, many authors suggest the use of Kaiser-Guttman criterion, where only the factors with eigenvalues above 1 need to be considered (Kaiser, 1991; Jackson, 1993).

PCFA was also performed on the diffusion and infusion measures. This was an exploratory exercise to assess whether the functionalities could be grouped and their impacts on performance assessed as a group (i.e. factors).

Prior to PCFA inter-item correlations were examined. The aim of an inter-item correlation analysis is to identify whether items measuring the same construct are correlated with each other more than they are with other items that measuring different constructs.

3.4.3 Reliability

Reliability refers to "the extent to which the respondent can answer or approximately answer the same questions the same way each time" (Straub, 1989 pg. 151). It is a measurement of the accuracy of the measures (Cronbach, 1951). Different approaches are used to assess reliability, such as split half tests, test re-test, inter-rater reliability, and internal consistency. This study adopted the internal consistency approach. Internal consistency refers to the interrelatedness of the set of items within the instrument (Schmitt, 1996).

Using internal consistency approach to scales reliability requires the use of Cronbach's Alpha. Reliability is acceptable when Cronbach Alpha is greater than 0.70 (Hiidenhovi et al. 2001; Ferketich, 1990). For this study, the performance measures were subjected to the Cronbach Alpha tests. Results thereof are discussed in Chapter 4 (see section 4.5.2.5)

3.4.4 Test for non- response bias

Non-response bias occurs if there is a difference between respondents and non- respondents (Pearl and Fairley, 1985). Although a number of researchers, such as Pearl and Fairley, (1985); Barclay et al. (2002); and Khare et al. (1994); provide a number of processes that can be used to reduce non-response bias, a uniform approach to testing for non-response bias is not evident. To test for non-response bias, this study investigated the relationship between the demographic characteristics (e.g. provincial location and group membership) of responding hospitals against the original sampling

frame (all HASA members) to determine whether there are any significant differences. This methodology is noted by Khare et al. (1994) as being the one dominantly used by researchers.

Having addressed the data collection aspect, the second important issue of the research design is the data analysis. The following section will address this aspect, highlighting the strategy and statistical procedures employed in the data analysis.

3.5 Data Analysis

Once the data has been gathered, the researcher must analyse the data. The next section is a detailed discussion of the strategy employed in the analysis of the data, after it had been collected.

3.5.1 Strategy for analysis of data

To analyse the data, SPSS version 20 was used.

Foremost, the data was captured onto an SPSS spreadsheet. After capturing, the process of screening and cleaning the data followed. Cleaning the data involved identifying outliers, incomplete questionnaires, missing data, and ensuring proper coding.

Once the data had been screened and cleaned, the following analyses were performed.

To address objective 1, the analysis involved the following.

- To describe the level of diffusion and infusion, the study will present aggregated results in table format, consistent with the Jha et al. (2009) and DesRoches et al. (2008) approach to presenting the levels of diffusion and infusion.
- Chapter 4 (see section 4.3.2) discusses in detail how diffusion and infusion scores were calculated and eventually used in subsequent regression analysis. That chapter uses the actual results to make illustrations of these calculations.

To address objective 2, the analysis involved the following.

1. Testing for reliability and validity

- *Principal Component Factor Analysis* (PCFA) was performed to confirm validity of instrument. This analysis is detailed in the preceding section on measurement validation.
- Cronbach's Alpha statistics was used to measure internal consistency of the instrument. This has also been discussed in the above measurement validation section.

2. For hypothesis testing

- The use of the correlation matrix to analyse relationships between variables. Correlation coefficients can take any value between-1 and 1. The ideal situation is that when variables relationships are measured, they are not highly correlated i.e. they do not score values above 0.5. Primarily, the performance dimensions were subjected to Spearman correlation analysis. Secondarily, the diffusion and infusion variables were also subjected to Spearman correlation analysis as part of the exploratory process of assessing whether the reported availability, usage, and infusion levels of EMR functionalities had any significant relationship with the performance measures.
- Multiple regression analysis was also performed to test the strength of predictor variables on the dependent variable. The following equations have been hypothesized.
    i. Equation 1 will be IMC ƒ(D+I)
    ii. Equation 2a will be EE ƒ(D+I+IMC)
    iii. Equation 2b will be CE ƒ(D+I+IMC)
    iv. Equation 2c will be PSaf ƒ(D+I+IMC)
    v. Equation 2d will be PSat ƒ(D+I+IMC)

    where IMC = Information Management Capability; EE = Economic Efficiency; CE = Clinical Effectiveness; PSaf = Patient Safety; and PSat = Patient Satisfaction; D = Diffusion; I = Infusion.

The following section highlights some of the ethical issues that were considered for this study.

3.6 Ethical Considerations

Social scientists have to be ethical when conducting their research (Babbie, 1989). Reese and Fremouw (1984) note that ethical behavior is expected in: the collection of data; the treatment of participants; and the responsibility to society. Being ethical when conducting research is synonymous with being a good research scientist (Singleton and Straits, 2005). Related to this study, four key issues (*confidentiality /anonymity; informed consent; withdrawal from the study, and ethical clearance*) are addressed under this section.

Of note is that the aim of this study was <u>not</u> to collect identified or de-identified or aggregate data about any individual patient or patient population. The study also did not require respondents to report on patients or their patient population. The study focused exclusively on the self-reports of hospitals regarding the system software functionalities they had implemented and aggregate hospital performance.

3.6.1 Confidentiality / Anonymity

Respondents were expressly guaranteed confidentiality through the introductory letter that accompanied the questionnaire. These letters are attached as Appendix G, H, L, and M. The instrument itself did not require the respondents to identify themselves nor their organisation.

To guarantee anonymity, participants were not asked personal details other than their title, and only the demographics of the organisation were requested, excluding the name of the organisation. Results are reported in the aggregate. Importantly the completed questionnaires will be locked up in a file cabinet in the Department of I.S. West Campus. Electronically captured data will be stored in a password protected file.

3.6.2 Informed Consent

Pedroni and Pimple (2001) suggest that where the subject's consent has been obtained; the subject is most likely to adhere to the research protocols and expectations. Faden, Beauchamp, and King (1986) suggest that informed consent has a moral and socio-legal aspect, where the moral aspect is the individual's willingness and agreement to take part in the study and the socio-legal aspect being the institutional authorization.

To achieve informed consent, an introductory letter was sent to the respondent with the relevant questionnaire. On it the participants were informed about the purpose of the study and the intended manner of reporting (aggregate reporting). They were also informed that their participation is entirely voluntary and that there would be no loss of benefit whether or not they chose to participate. For this study, the respondent was considered to have given consent if they chose to continue to complete the questionnaire.

The researcher did not anticipate any problems such as disturbing the clinicians work as the questionnaires were being sent to senior management and IT / Operations staff, and not to the clinical staff who may have had patients to see. Active clinicians were not the intended respondents and the study did not, in any way, interfere with performance of clinical duties.

3.6.3 Withdrawal from study

The respondents were also expressly guaranteed that they could withdraw from the study at any time. This guarantee was also contained in the introductory letter sent with the questionnaire. As mentioned earlier, there would be no loss of benefit had the respondents chosen to withdraw from the study.

3.6.4 Ethical Clearance

Approval from the University of Witwatersrand Human Research Ethics Committee was obtained. Two ethical clearance applications were made – one specifically for private hospitals and the other specifically for public hospitals. The protocol number for the private hospitals is H110930 and the protocol number for the public hospitals is H130203. A copy of each of the clearance certificates is attached as Appendix N and Appendix O.

3.7 Limitations of study

This was a correlational study which is cross-sectional and as such the responses were obtained at one point in time. This presents a limitation for the establishment of causality because temporal precedence cannot be confirmed.

Secondly, this study was restricted to sampling private and public hospitals whose details were publicly available and therefore the results may not necessarily be generalised to all hospitals, especially private hospitals who may not be members of HASA.

Thirdly, there is a possibility of subjective responses by key informants. Although this was partially addressed by splitting the questionnaire and using multiple respondents to reduce common method bias, data collected from self-reports tend to be subjective, compared to objective data.

Finally, given that participation in the study was voluntary, there may have been a self-selection bias where only certain types of organisations responded e.g. those that are performing well, as such not all the population is analysed.

3.8 Summary

This chapter highlighted the dominant knowledge acquisition claims as well as the associated research methodologies. Quantitative research methodology, which is the most applicable research approach for this study, was discussed and its relevance to this study's objectives highlighted. The study's sampling frame, instrument development and administration, measurement validation, and ethical issues were also discussed, and limitations noted. The following section discusses the results and findings of the study.

4 Chapter 4 – Results: EMR Systems diffusion, infusion, and Hospital Performance

4.1 Introduction

Following the discussion of the research methodology in chapter 3, this chapter presents the analysis of the data collected from the target respondents. As highlighted in the preceding chapter, two questionnaires were sent to each hospital organisation. One questionnaire (hospital information systems questionnaire) asked the organisation to report on the availability of EMR functionalities within the hospital. The other questionnaire (the administrator questionnaire) asked the administrators to report on key hospital performance indicators.

First, the response profile and sample demographic information are presented. Next, to address the study's first objective, the current state of EMR systems within hospitals in South Africa is presented. Data collected from the hospital information system questionnaire is used in the presentation of this objective.

Thereafter, to address the study's second objective, the hypotheses and research model are tested. To do this, data collected from matched questionnaires will be used.

4.2 Respondent profile

Table 4.1 on the next page shows the distribution of returned questionnaires. For the purposes of describing EMR diffusion and infusion within SA hospitals and answering research questions 1 and 2, 98 questionnaires were returned from the relevant key informants. This represented a response rate of 28%. For answering research question 3, and testing hypothesized effects of EMR diffusion and infusion on hospital performance, 64 matched-pair responses were received i.e. the hospital returned both the administrator's questionnaire on hospital performance and the questionnaire on IT and EMR investments. The profile of these 64 organisations is described in greater detail in Table 4. 2 on page 54.

Table 4.1 Summary of returned questionnaires

	Type of Hospital	*No. of Administrator Questionnaires*	*No. of Hospital Information Systems Questionnaires*	*No. of matched Questionnaires*
Private	Independent Facility	17	17	16
	Part of a listed Group	36	32	0[6]
	Part of non-listed Group	3	3	3
Public	Provincially Aided	2	2	2
	Private Public Partnership	1	1	1
	Public Hospital	44	43	42
Total		103	98	64

Table 4.2 summarises the 64 matched responses across a number of hospital characteristics. The hospital information systems questionnaire did not require the respondents to provide any demographics, as these demographics were captured in the Administrator questionnaire.

[6] The administration of the questionnaires within the hospital facilities of a listed hospital group was coordinated through their Group IT office. Unfortunately, due to the network system used within this Group, all responses returned the same IP address and matching questionnaires was not possible.

Table 4.2 – Respondent profile	Number of respondents	%
Respondents Job Title		
Chief Executive / General Manager	7	11.1
Hospital Administrator	17	27.0
Operations Head	3	3.2
Matron	8	12.7
Unit Manager	10	15.9
Other	19	30.2
Kind of hospital		
1st level (No ICU)	21	32.8
2nd level (at least 1 Specialty unit)	15	23.4
2nd level (at least 5 Specialty units)	11	17.2
Specialised	10	15.6
Academic	2	3.1
Day Clinic	4	6.3
Other	1	1.6
Geographic location (province)		
Gauteng	25	39.1
Western Cape	1	1.6
Free State	12	18.8
Limpopo	1	1.6
Kwazulu-Natal	25	39.1
Number of employees		
Less than 200 Employees	18	28.1
201 - 400 Employees	16	25.1
401- 600 Employees	10	15.7
601- 800 Employees	4	6.3
801- 1,000 Employees	5	7.8
More than 1,000 Employees	11	17.2
Number of Nurses		
Less than 100 Nurses	15	23.4
101-200 Nurses	20	31.3
201-300 Nurses	11	17.2
301-400 Nurses	5	7.8
401-500 Nurses	1	1.6
More than 500 Nurses	12	18.8
Number of physicians		
Less than 10	21	33.3
11 - 50 Physicians	37	58.7
51 - 100 Physicians	3	4.8
101 - 150 Physicians	1	1.6
Above 200 Physicians	1	1.6
Missing	1	
Number of outpatients per day		
Less than 50 Outpatients per day	28	44.4
51-100 Outpatients	12	19.0
101-200 Outpatients	10	15.8
201- 400 Outpatients	5	8.0
Above 400 Outpatients per day	8	12.7
Missing	1	

4.3 EMR Diffusion and Infusion

The study posits that the diffusion and infusion of information technologies within hospitals can impact on their performance. To this end, the study had two key objectives; foremost to describe the state of EMR diffusion and infusion within South African hospitals, and secondly to assess the impact of the diffusion and infusion of EMR systems on performance. To address the first objective, two sub-objectives were formulated, namely to assess the level of EMR systems diffusion within South African hospitals, and secondly to assess the level of EMR systems infusion within South African hospitals.

Responses from the Hospital Information Systems questionnaire were used to report on this objective. As mentioned earlier, 98 hospitals provided responses. These 98 responses are used in the proceeding analysis.

4.3.1 General information systems diffusion levels

In order to ascertain the levels of general information technology diffusion within hospitals, hospitals were asked to report on the level of availability of certain technologies. These technologies are not necessarily linked to EMR systems. As indicated in Table 4.1, 98 hospitals provided this data. Table 4.3 below illustrates the extent to which these 98 hospitals have embraced the use of various types of information technology.

Table 4.3 –Availability levels of selected technologies across clinical units

Technology	Available in all relevant clinical units (number of hospitals in %)	Available in some clinical units (number of hospitals in %)	Not in place in any clinical unit (number of hospitals in %)
a. Barcoding technology for laboratory specimens	50.5	13.7	35.8
b. Barcoding technology for patient identification	16.8	16.8	66.4
c. Barcoding technology for medication administration	17.9	12.7	69.4
d. I.T applications to control patient flow	20.0	21.0	59.0
e. I.T applications to monitor bed status	16.8	14.8	68.4
f. Telemedicine	33.7	12.6	53.7
g. Radio Frequency ID for tracking equipment	22.1	4.3	73.7
h. Physician use of personal digital assistant (PDA or tablets)	22.1	13.7	64.2
i. Check-in / Check-out or way-finding kiosks for use by patients	26.3	2.1	71.6

51% of hospitals surveyed reported to having barcoding technology for lab specimens available in all clinical units. Barcoding technology provides a number of benefits such as matching patients to their

lab specimens, significantly increasing safety measures. Telemedicine was also reported as widely available with 12.6% hospitals reporting that it was in place in at least some of the clinical units and more than a third of hospitals (33.7%) reporting that it was available in all relevant clinical units. Telemedicine allows remote hospitals to connect with medical practitioners at other hospitals (AHA, 2005). In South Africa, the national department of health introduced the first phase of its telemedicine project in 1999, beginning with 28 pilot sites in 6 provinces[7]. In 2002 the project moved into the second phase with an additional 75 sites before a third phase was introduced in 2004 (van Dyk et al. 2012). As such it is encouraging to observe that public-sector hospitals are diffusing telemedicine technology into their clinical units.

There is however generally a low level of diffusion of information technology in hospitals with key technologies for patient and medication administration, and asset monitoring not in place with 66.4% 69.4%, and 73.7% of hospitals respectively. South African hospitals have not sufficiently implemented consumer friendly technologies such as way-finding kiosks (with more than 71.6% not having implemented). Physicians too are reported to be making little use of technologies (less than 36%) such as PDAs and tablets with hospital infrastructure, such as the required wireless networks, not supporting their use.

4.3.2 EMR Systems Diffusion

To assess the current levels of EMR diffusion in hospitals across South Africa, the IOM list of core functionalities was used. As mentioned in Chapter 1, a comprehensive EMR system must be able to provide these eight modules. These core modules are

1. Clinical Documentation and Health data
2. Results Viewing
3. Computerised Physician Order Entry / Management (CPOE)
4. Decision Support
5. Electronic Communication and Connectivity
6. Integrated Patient Support
7. Administrative Support
8. Reporting and Population Health Management

Within these eight core modules, a number of system functionalities are used to assess each module. As there has been limited literature on the level of availability of these systems capabilities in the South African context, it was necessary to include all modules and functionalities that make up that EMR system module.

[7] Kwazulu-Natal Provincial Department of Health. Available at http://www.kznhealth.gov.za/telemedicine1.pdf.

As indicated previously (Table 4.1), 52 private hospitals, 45 public hospitals, and 1 private-public partnership hospital returned the questionnaire that provided data on their EMR systems (hospital information systems questionnaire). Table 4.4 presents a summary of the diffusion of each of the EMR functionalities within the 98 hospitals, where the level of diffusion is reflected by the availability of the functionality in all relevant clinical units, in some clinical units, or not available in any clinical unit.

Table 4.4– Summary of EMR systems functionality availability in hospital units

	Available in all relevant clinical units (%)*	Available in at least one clinical unit (%)	Not available in any clinical unit (%)
Clinical Documentation and Health Data			
Maintaining Patient Demographics	57.1	10.2	32.7
Maintaining Discharge Summaries	53.1	7.1	39.8
Maintaining Problem Lists	33.7	8.2	58.1
Maintaining Active Medication Lists	32.7	9.2	58.1
Maintaining Clinical Notes	28.6	7.1	64.3
Maintaining Active Diagnoses	27.6	7.1	65.3
Maintaining Current Procedures	27.6	4.1	68.3
Maintaining Nursing Assessments	23.5	6.1	70.4
Maintaining Advanced Directives	22.4	4.1	73.5
Results Viewing			
Viewing Lab Reports	50.0	14.3	35.7
Viewing Radiology Images	38.8	16.3	44.9
Viewing Radiology Reports	27.6	16.3	56.1
Viewing Diagnostic Test Results	26.5	12.2	61.3
Viewing Consultant Reports	26.5	6.1	67.4
Viewing Diagnostic Test Images	23.5	10.2	66.3
Computerised Physician Order Entry			
Ordering Laboratory Tests	48.0	6.1	45.9
Ordering Radiology Tests	46.9	6.2	46.9
Entering Medication Orders	35.7	3.2	61.1
Entering Nursing Orders	30.6	3.1	66.3
Entering Consultation Requests	29.6	2.0	68.4
Decision Support			
Providing Clinical Guidelines	39.8	9.2	51.0
Providing Drug Dosing Support	28.6	5.1	66.3
Providing Drug-Lab Interaction Alerts	26.5	6.1	67.4
Providing Clinical Reminders	25.5	6.1	68.4
Providing Drug-Drug Interaction Alerts	25.5	6.1	68.4
Providing Drug Allergy Alerts	24.5	6.1	69.4
Electronic Communication and			
Enabling Facility to External Parties	41.8	17.3	40.8
Enabling Physician to Physician Communication	39.8	11.2	49.0
Enabling Patient to Physician Communication	28.6	2.0	69.4
Integrated Patient Support			
Supporting Family and informal caregiver	34.7	5.1	60.2
Supporting Patient education	33.7	9.2	57.1
Patient Access to medical record	30.6	2.0	67.4
Supporting direct data entry by patient, family, and/or caregiver	25.5	5.1	69.4

Administrative Support			
Supporting Payment Determination	36.7	22.5	40.8
Supporting Billings and Claims Management	36.7	14.3	49.0
Supporting Inpatient and Outpatient administrative procedures	35.7	18.4	45.9
Supporting Scheduling management	27.6	13.2	59.2
Reporting & Population Health Mgt.			
Maintaining Disease registries	43.9	21.4	34.7
Public health reporting	42.9	18.3	38.8
Reporting on Patient safety and quality.	27.6	19.4	53.0

* *Results presented in descending order, based on availability in all relevant clinical units*

As can be noted from Table 4.4, EMR systems, according to the IOM list of core activities, can have up to forty (40) key functionalities. However, a number of studies have identified a handful of these functionalities as necessary to represent an EMR system, either as a basic system or as a comprehensive one. Based on the two definitions of basic and comprehensive EMR systems (refer to section 2.2.2.). Table 4.5 describes the level of diffusion of basic and comprehensive EMR systems across the hospitals. A frequency count of hospitals that have the relevant number of functionalities based on the Jha et al. and DesRoches et al. definitions is presented.

Table 4.5 – Diffusion of basic and comprehensive EMR systems in South Africa, using Jha et al. (2009) and DesRoches (2008) definitions

	Number of hospital (in %) with	
	Basic EMR system	Comprehensive EMR system
Jha et al. definition	4%	1.5%
DesRoches et al. definition	13%	4%

As highlighted in the table above, based on the Jha et al. study definition, only 4% of hospitals had basic EMR systems[8] in place and only 1.5% of the hospitals had comprehensive EMR systems in place[9]. On the other hand, based on the DesRoches et al. study definition of basic EMR systems, 13% of hospitals had basic EMR systems[10] in place and 4% with comprehensive EMR systems[11].

[8] With the eight functionalities namely maintaining active medication list, discharge summaries, patient demographics, and problem lists, viewing lab reports, radiology reports, and entering medication orders (Jha et al. 2009).

[9] With the 24 functionalities namely maintaining active medication lists, advanced directives, clinical notes, discharge summaries, nursing assessments, patient demographics, problem lists; viewing consultants reports, diagnostics test images, diagnostics test results, lab reports, radiology images, and radiology reports as well as entering consultation requests, medication orders, nursing orders, ordering lab tests, ordering radiology tests, providing clinical guidelines, clinical reminders, drug allergy alerts, drug dosing support, drug-drug interaction alerts, and drug-lab interaction alerts (Jha et al. 2009).

[10] With seven functionalities namely maintaining active medication lists, clinical notes, patient demographics, problem lists, viewing lab reports, radiology images, and entering medication orders (DesRoches et al. 2008).

[11] With the sixteen functionalities namely maintaining active medication lists, clinical notes, discharge summaries, patient demographics, and problem lists; viewing lab reports, radiology images, and radiology reports; entering consultation requests, medication orders, nursing orders, ordering lab tests, ordering radiology tests, providing clinical guidelines, clinical reminders, and drug-drug interaction alerts (DesRoches et al. 2008).

It would seem that South African hospitals have not been far off from where US hospitals were in 2008 when the US studies were conducted. As mentioned in Chapter 2 the Jha et al. study found that 1.5 % of the hospitals surveyed had comprehensive EMR systems. Similarly in South Africa only 1.5% of the hospitals surveyed met the Jha et al. (2009) definition of having comprehensive systems. However, only 4% of hospitals surveyed in South Africa met that study's definition of having basic systems, compared to the US hospitals where 7.6% had a basic EMR system.

DesRoches et al. (2008) reporting on results from 2, 758 physicians found that only four percent had comprehensive EMR systems and only 13% had a basic EMR system. Using DesRoches definition in the South African hospitals, the same number, percentage-wise, had basic and comprehensive systems. However these results are not easily comparable as the DesRoches et al. study focused on physician facilities, which may not have as many units as hospitals, which was the focus of this study.

The two definitions are different in two ways; the Jha et al. definition is relatively rigorous as it requires hospitals to have eight functionalities fully implemented in at least one clinical unit. DesRoches et al. definition, on the other hand requires a facility to have at least seven in one facility. Likewise, the Jha et al. study required hospitals to have a specific twenty-four functionalities implemented in all clinical units for that hospital to be considered to have a comprehensive EMR system. The DesRoches et al. study, on the other hand, required hospitals to have a specific sixteen functionalities implemented in at least one clinical facility, as opposed to all clinical units. It is also worth noting that the Jha et al. study focused on hospitals whereas the DesRoches et al. study focused on physician practices, which may not have had as many clinical units as hospitals.

An alternative approach to describing the diffusion of EMR systems within SA hospitals has been developed for the purposes of this study. This approach bands the responding hospitals into four categories, namely high EMR diffusion, moderate EMR diffusion, low EMR diffusion, and no EMR diffusion using the scoring system described below. This scoring system was considered useful to overcome the limitation of the Jha et al. approach whereby as an example a hospital with seven of the eight functionalities available in clinical units is considered as not having even a basic EMR system, just like a hospital that had no EMR system at all, thus not providing a nuanced picture on EMR diffusion.

4.3.2.1 Calculating diffusion

Based on the structure of the questionnaire the six anchors of the diffusion measure were scored from six to one; six being the highest score, capturing "available in all relevant clinical units"; five capturing "available in a majority but not all relevant clinical units"; four capturing "available within at least one but not the majority of relevant clinical units"; three capturing "already beginning to

make available"; two capturing "planning to make available within one year"; and one capturing "not in place". Depending on the number of functionalities that make up a particular module (e.g. for Clinical and Health Documentation only four functionalities make up a basic EMR system), a maximum possible score was calculated for each diffusion level. For instance the maximum score for high diffusion of Clinical and Health Documentation was 6 x 4 = 24 (the highest score of six multiplied by the total number of functionalities making up that module). Likewise for moderate diffusion the score of five multiplied by the four functionalities gave a maximum score of twenty. These maximum scores defined the limits of each diffusion category. Hence, if a hospital scored twenty-one then it would be classified as having high diffusion in Clinical and Health documentation, as it was above the moderate level of twenty but within the maximum of twenty-four, which was the high diffusion maximum score.

Table 4.6 below summarises how the scores for each category were calculated. Note that, as explained in Chapter 2, basic EMR systems only have three modules, namely Clinical Documentation and Health Data, Results Viewing, and Computerised Physician Order Entry.

Table 4.6 – Diffusion categories : Basic EMR systems

	Available in all relevant clinical units	Available in a majority of clinical units	Available within at least one but not the majority of clinical units	Already beginning to make available	Planning to make available within a year	Not in Place
Score allocated	**6**	**5**	**4**	**3**	**2**	**1**
Clinical Documentation and Health Data						
Number of functionalities making up Basic EMR system	**4**	**4**	**4**	**4**	**4**	**4**
Maximum score possible*	**24**	**20**	**16**	**12**	**8**	**4**
Results Viewing						
Number of functionalities making up Basic EMR system	**3**	**3**	**3**	**3**	**3**	**3**
Maximum score possible*	**18**	**15**	**12**	**9**	**6**	**3**
Computerised Physician Order Entry						
Number of functionalities making up Basic EMR system	**1**	**1**	**1**	**1**	**1**	**1**
Maximum score possible*	**6**	**5**	**4**	**3**	**2**	**1**
Diffusion Category	**High**	**Moderate**	**Low**		**No diffusion**	

***Number of functionalities multiplied by score allocated**

Each responding hospital was then scored according to their response on the availability of the particular functionality. For instance, using Clinical Documentation and Health data module as an example, if they had indicated that the first functionality was available in all relevant clinical units they were awarded a six for that functionality. Likewise if they had indicated available in a majority

of clinical units for the second functionality they were awarded a five. If they indicated available in all clinical units for the third functionality they were awarded a six; and if they had responded planning to make available within a year for the last functionality they were awarded a two. This hospital therefore got a score of 6+5+6+2= 19. A score of 19 sits above low diffusion but below the maximum moderate diffusion score of 20. This hospital would then be classified as having moderate diffusion levels of Clinical Documentation and Health data functionalities.

Table 4.7 below provides a summary of how the upper and lower limits were created for the basic EMR systems functionalities. The same approach was taken for comprehensive systems as well when creating the upper and lower limits for overall diffusion.

Table 4. 7 – Upper and lower limits of diffusion categories

		High	Moderate	Low	No
Clinical Documentation	Max possible score	24	20	16	8
	Upper limit	24	20	16	8
	Lower limit	21	17	9	4
Results Viewing	Max possible score	18	15	12	9
	Upper limit	18	15	12	6
	Lower limit	16	13	7	3
CPOE	Max possible score	6	5	4	3
	Upper limit	6	5	4	2
	Lower limit	6	5	3	1

Given that the EMR system is measured as a composition of functionalities it is important to recall the definition of the terms being used. Diffusion has been defined as the extent to which a technology is available. High diffusion therefore in this regard means the module's availability across the hospital is high.

The following section discusses the results of basic EMR systems modules.

4.3.2.2 Clinical Documentation and Health Data module

Of the hospitals surveyed, 15 % had highly diffused the four Clinical Documentation and Health Data functionalities that make up a basic EMR system. 24% had moderately diffused the functionalities and close to a third of hospitals surveyed had low or no diffusion of these functionalities. The clinical documentation and health data module is considered one of the important modules of the EMR system. The basic EMR systems definition, which incorporates eight system functionalities, consists of four of these functionalities from the clinical documentation. In the case of South African hospitals, this module is not highly diffused. In fact they have a long way to go as more than a third

(36%) of the hospitals do not have the module available at all and a further 26% have it available in at least one clinical unit.

4.3.2.3 Results viewing module

14% of the hospitals surveyed had results viewing module highly diffused. This extent of availability of the results viewing module is encouraging, as overall 41% of the hospitals had the module moderately and highly diffused, suggesting the module was available in a majority of clinical units. Given the national government's effort through the National Laboratory Health Services, to computerise the collection, capturing, and storage of lab specimen data, (http://www.healthsystems.co.za/?page_id=19) these levels of diffusion are an encouraging reflection of national government effort.

Roughly 59% of the hospitals reported low or no diffusion of the three functionalities that make up the module.

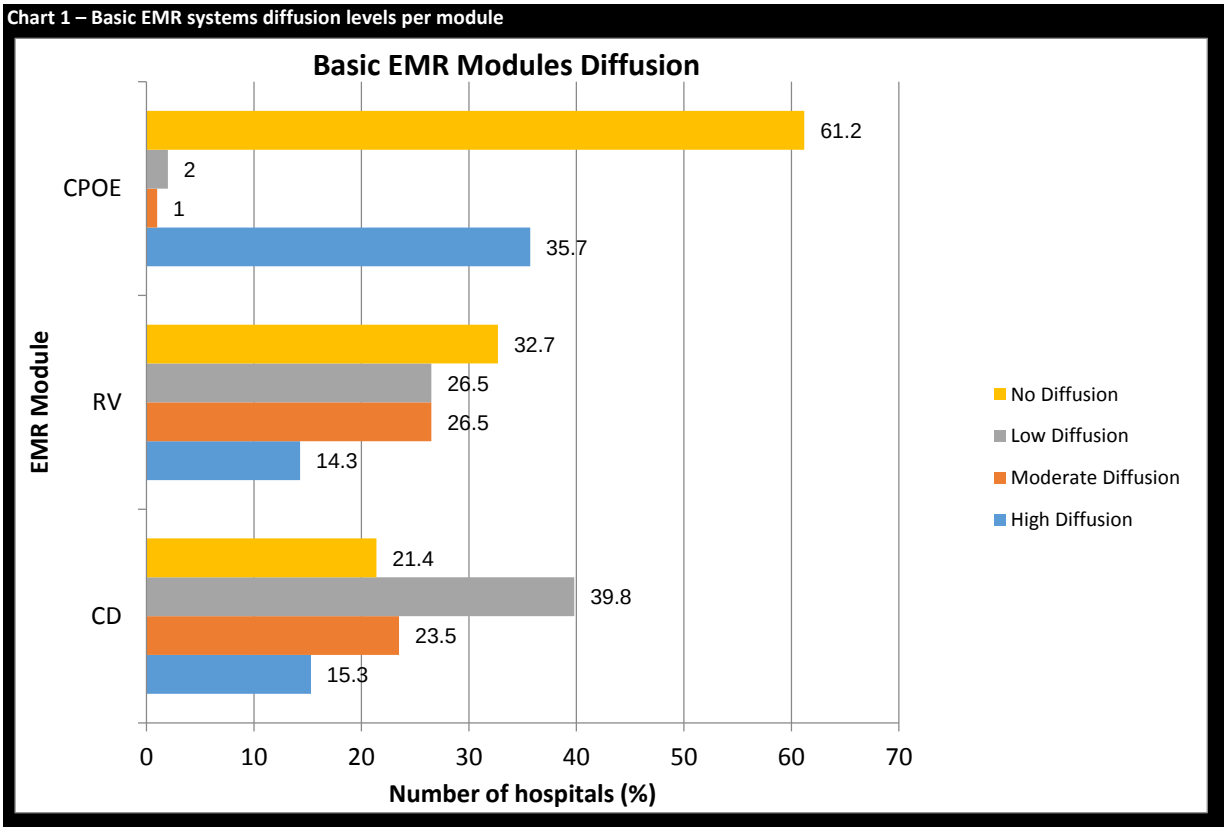
4.3.2.4 Computerised Physician Order Entry (CPOE) module

Only one CPOE functionality makes up a basic EMR system. This functionality enables hospitals to enter medication orders. 36% of surveyed hospitals had the CPOE module highly diffused. In this instance, as only one functionality makes up the CPOE module for basic EMR systems, the results mean 36% of the hospitals surveyed had the functionality that allowed for entering medication orders available across all relevant clinical units. Only one percent of hospitals had the functionality available in a majority of clinical units. On the other hand, 61% of hospitals surveyed did not have this functionality and only 2% were beginning to have it available in at least one unit.

Given that only one functionality is being assessed the relatively high diffusion levels relative to other modules seems justified. Secondly, a review of literature does suggest that CPOE is one of the most prevalent standalone systems in hospitals. Systematic reviews by Van der Meijden et al. (2003), Kaushal, Shojania, and Bates (2003), Poissant et al. (2005) on IT applications used in hospitals reveal that CPOE was the most available technology and was frequently used for assessing the impact of IT in hospitals.

Chart 1 on the next page summarises the diffusion levels of the three modules that make up a basic EMR system.

Chart 1 – Basic EMR systems diffusion levels per module

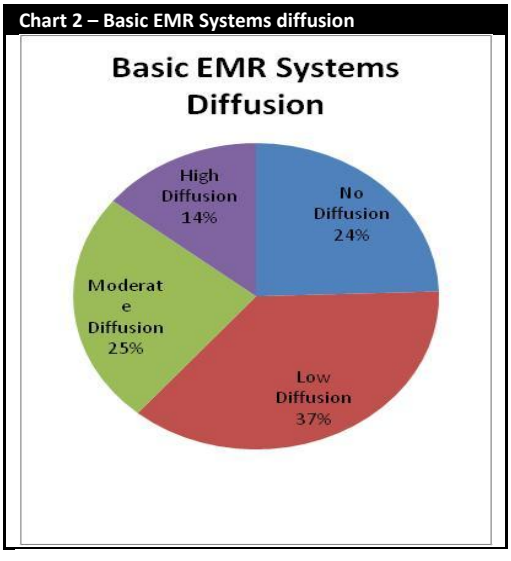


CPOE = Computerised Physician Order Entry; RV = Results viewing; CD = Clinical Documentation and Health Data

4.3.3 Basic EMR systems diffusion

In summary, SA hospitals, based on this study's definition of diffusion, are moving towards meeting expectations of a basic EMR system as 14% have basic EMR systems highly diffused and a quarter of the hospitals surveyed have basic EMR systems moderately diffused across their hospitals (see Chart 2 below). 37% of hospitals surveyed had basic EMR systems implemented in at least one clinical unit and only 25% of hospitals do not have basic EMR systems in place.

Chart 2 – Basic EMR Systems diffusion



The next section discusses the availability of comprehensive systems

4.3.4 Comprehensive EMR systems

As stated previously, the same approach used to create the diffusion categories in basic EMR systems was used with regards to comprehensive EMR systems. Table 4.8 below shows how the scores were calculated. As with basic systems, four categories of diffusion were created for comprehensive EMR systems, namely high, moderate, low, and no diffusion.

Table 4.8 – Diffusion categories : Comprehensive EMR systems

	Available in all relevant clinical units	Available in a majority of clinical units	Available within at least one but not the majority of clinical units	Already beginning to make available	Planning to make available within a year	Not in Place
Score allocated	**6**	**5**	**4**	**3**	**2**	**1**
Clinical Documentation and Health Data						
Number of functionalities making up Basic EMR system	**7**	**7**	**7**	**7**	**7**	**7**
Maximum score possible*	**42**	**35**	**28**	**21**	**14**	**7**
Results Viewing						
Number of functionalities making up Basic EMR system	**6**	**6**	**6**	**6**	**6**	**6**
Maximum score possible*	**36**	**30**	**24**	**18**	**12**	**6**
Computerised Physician Order Entry						
Number of functionalities making up Basic EMR system	**5**	**5**	**5**	**5**	**5**	**5**
Maximum score possible*	**30**	**25**	**20**	**15**	**10**	**5**
Decision Support						
Number of functionalities making up Basic EMR system	**6**	**6**	**6**	**6**	**6**	**6**
Maximum score possible*	**36**	**30**	**24**	**18**	**12**	**6**
Diffusion Category	**High**	**Moderate**	**Low**		**No diffusion**	

***Number of functionalities multiplied by score allocated**

The next section summarises the diffusion results for each of the modules that make up comprehensive EMR systems.

4.3.4.1 Clinical Documentation and Health Data module

Of the hospitals surveyed, 17% had high diffusion of the seven functionalities that make up a comprehensive clinical documentation and health data functionality, with 8% categorised as moderately diffused. Half (50%) of the hospitals surveyed have not diffused the eight functionalities required to meet a comprehensive EMR system. This percentage is higher than the 36% that had not diffused basic systems. However it should be expected as the requirement for comprehensive systems is more stringent, requiring eight functionalities for the clinical documentation and health data module, compared to the four required for basic systems.

4.3.4.2 Results viewing module

Similarly, more than half (52%) of the hospital surveyed did not have a comprehensive results viewing module diffused. Only 13% of hospitals had highly diffused the four functionalities that make up the comprehensive system.

4.3.4.3 CPOE module

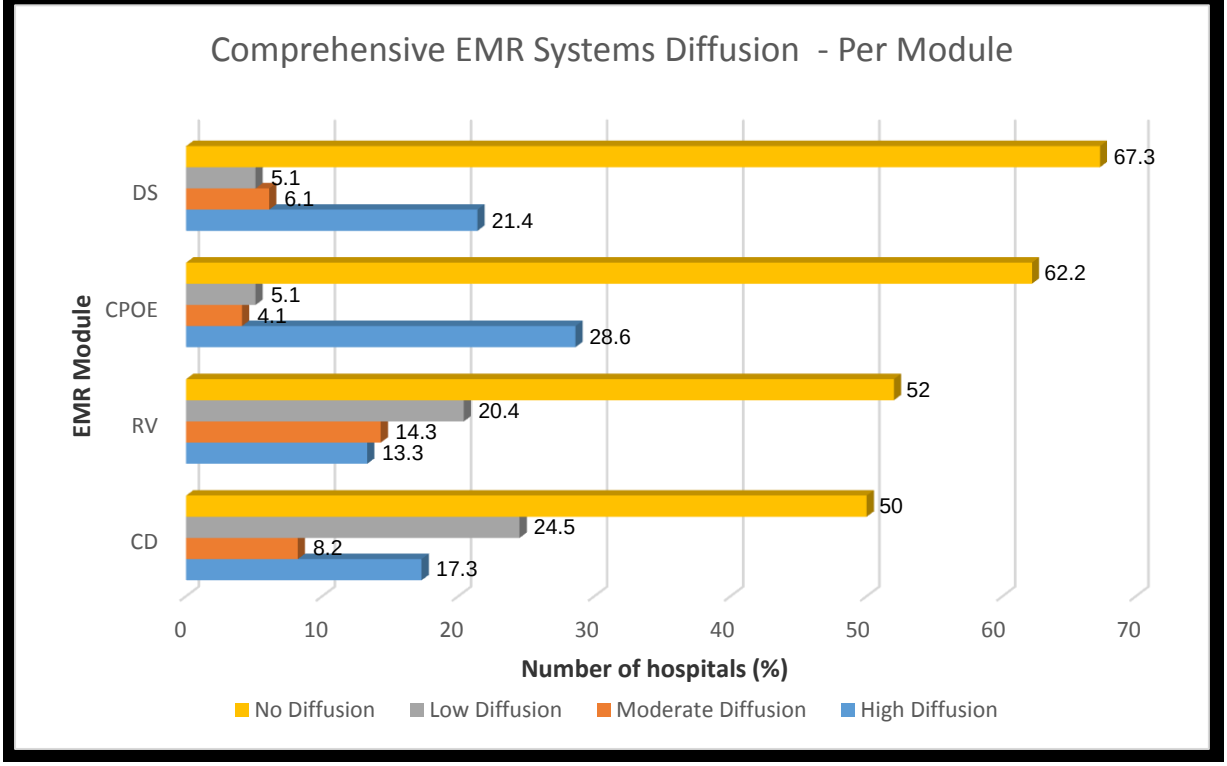
Five functionalities make up a comprehensive CPOE module. This is one of the most highly diffused module across hospitals surveyed as 29% of all hospitals had the five functionalities highly diffused. However, it is also one of the most unevenly distributed modules as only 4% had it moderately diffused, 5% of the hospitals were categorised as low diffusers of the module, and 62% have not made comprehensive CPOE functionalities available in their hospital units. As mentioned earlier, these results are consistent with most research that found CPOE as the most common type of system in hospitals (Van der Meijden et al. 2003; Kaushal et al. 2003; Poissant et al. 2005).

4.3.4.4 Decision support module

Two-thirds of the hospitals (67%) surveyed did not have comprehensive decision support functionalities diffused in their hospitals. This was the least diffused of the modules. Decision support module has functionalities that provide clinical guidelines, drug dosing support, drug-lab interaction alerts, clinical reminders, drug-drug interaction alerts, and drug allergy alerts. Likewise this module was also one of the unevenly distributed modules as 21% of the hospitals have it highly diffused while 6% of hospitals have it available in a majority of their units. Given that this module is clinician focussed compared to the others that are patient data focussed, the results do raise some interesting discussion points on clinicians' needs of information systems within hospitals. It would seem clinicians either have a greater need for information systems that will support their interaction with patients than they need information systems that will provide them with their practice guidelines and alerts or hospitals are investing more in systems that relate to patients than in decision support systems that are focussed on their clinicians.

The diffusion of the modules making up comprehensive systems is summarised on Chart 3 on the next page.

Chart 3 – Comprehensive EMR systems diffusion levels per module

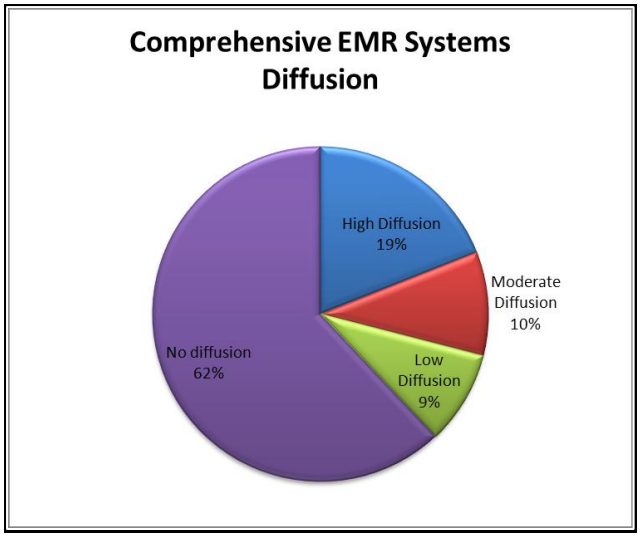


CD = Clinical documentation and Health Data; RV = Results Viewing; CPOE = Computerised Physician Order Entry; DS = Decision Support

4.3.4.5 Summary of comprehensive EMR systems diffusion

Chart 4 below summarises the diffusion of comprehensive EMR systems across South African hospitals.

Chart 4 – Comprehensive EMR systems Diffusion Levels.



Overall, 19% of South African hospitals surveyed had highly diffused comprehensive EMR systems while 10% had moderately diffused comprehensive systems and 9% had low diffusion of comprehensive systems. 62% of hospitals had not diffused comprehensive systems.

The results suggest South African hospitals have a long way to go to achieving moderate and high levels of comprehensive systems. As noted earlier, comprehensive systems require twenty-four functionalities across four key modules. With 61% of the hospitals surveyed reporting they have not made the twenty-four key functionalities available, South African hospitals have a considerable way to go before this hospital technology is available across clinical units in hospitals.

The next section addresses the infusion of EMR systems.

4.4 EMR Systems infusion

The second sub-objective of the study was to assess the current state of EMR systems infusion in hospitals of South Africa.

This definition of EMR infusion was operationalized as the extent to which the EMR system has replaced the use of paper records. EMR systems, like most processing systems provide a number of benefits such as better and safer storage capacity. The use of EMR systems to replace paper can be seen as one key indicator of the technology being used in such a way that it is becoming more embedded into the execution of hospital processes.

To assess this, respondents were asked to indicate the extent to which paper had been replaced by the use of the EMR in key hospital departments, namely emergency department, ICU department, general medical/surgical wards, obstetrics specialty ward, and paediatrics specialty ward; as well as other specialty wards and onsite ambulatory practices. Table 4.9 below provides a summary of the results.

Table 4.9 – EMR Systems and the replacing of paper in selected hospital departments

Department	Has completely replaced paper	Has replaced paper for the most part	Available and replacing paper in many ways	Available but only replacing paper in some ways	Not implemented	Not Applicable
Emergency Department	12.2	12.2	6.1	12.2	44.9	12.2
ICU	10.2	14.3	4.1	5.1	53.1	13.3
General Medical / Surgical Wards	8.2	17.3	3.1	6.1	52	13.3
Specialty Ward - Obstetrics	13.3	13.3	2	6.1	51	14.3
Specialty Ward - Paediatrics	11.2	15.3	2	5.1	52	14.3
Other Specialty Wards	9.2	14.3	4.1	6.1	53.1	13.3
Onsite Ambulatory Practices	12.5	14.6	3.1	6.3	49	14.6

Table 4.9 shows that where EMR functionality has been implemented, it has been able to mostly or completely replace paper at around 25% of all departments. This is encouraging as it suggests that once implemented there are few hospital departments that are maintaining parallel paper-based

systems alongside the use of their EMR system (only around 10%, except for emergency departments at 18%).

However the high number of hospitals that have not implemented EMR systems in these departments is worth noting, as around 50% of hospital departments do not have the technology implemented.

4.4.1 Infusion of EMR Systems into Hospital Processes

As an additional assessment of infusion, the hospitals were asked to report on the extent to which a number of administrative and clinical processes were supported by the use of EMR system functionalities. The aim here was to understand the level of infusion of EMR functionalities, by measuring their level of support provided by EMR modules for certain processes. The higher the levels of use of the EMR system to support that process, the most strongly the technology is becoming embedded into the process. For instance, if above 75% of the clinical documentation is done electronically then one can infer that EMR technology is highly embedded into the clinical documentation process. Table 4.10 summarises the results from the 98 hospitals.

Table 4.10– Percentage of use of EMR systems to perform certain processes

Process	0%	1-25%	26-50%	51-75%	76-100%	Don't Know / Not Sure
The percentage of *inpatient and outpatient administrative procedures* at your facility that are done electronically	24.5	6.1	5.1	8.2	32.7	23.5
The percentage of physicians at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	11.2	15.3	13.3	16.3	17.3	26.5
The percentage of source data used in *public health reporting* that is collected electronically	25.5	6.1	6.1	4.1	15.3	42.9
The percentage of patients at your facility for whom *clinical documentation* is written electronically	46.9	8.2	3.1	5.1	13.3	23.5
The percentage of patients at your facility performing *direct data entry* electronically	64.3	2	1	1	11.2	20.4
The percentage of patients at your facility for whom lab *results* are viewed electronically	32.7	12.2	15.3	8.2	9.2	22.4
The percentage of nurses at your facilities who use electronic *decision support*	57.1	3.1	1	1	8.2	29.6
The percentage of nurses at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	23.5	20.4	3.1	10.2	8.2	34.7
The percentage of physicians at your facilities who use electronic *decision support*	56.1	6.1	3.1	2	7.1	25.5
The percentage of patients at your facility for whom *physician orders* are entered electronically	60.2	0	1	3.1	6.1	29.6

The table shows that administrative support activities are widely supported by EMR systems as a third of the hospitals (32.7%) reported that 76-100% of their inpatient and outpatient administrative

procedures were done electronically. This was the highest single activity that was performed electronically[12].

Electronic physician orders were the least performed in hospitals as 60.2% of surveyed hospitals reported that none of their physician orders were done electronically. This finding is consistent with findings from prior studies such as Van der Meijden et al. (2003) that suggest the use of IT by physicians is not high. CPOE systems, although widely available in many hospitals, remains one of the least used IT applications in hospitals (Kaushal et al. 2003; Collin et al. 2008; Al-Dorzi et al. 2011).

Likewise, 64.3% of hospitals reported none of their patients were performing their own direct data entry electronically. Direct data entry is the ability of patients to interact with their own hospital records or submit electronic documentation such as pre-admissions forms. Such a result is least surprising as 69.4% of hospitals (Table 4.4) reported they did not have this functionality in place within any of their units. Ownership of patient data remains an important debate. Rodin et al. (2009) notes that while patients supply the data and believe they own the data as it is about them, organisations that hold such health data, such as hospitals, view the data as theirs. So, while there is potential for patients to interact with their data, the ownership and therefore eventual use of the data, even if de-identified, still remains a main concern.

However, other functionalities of direct data entry, such as patients' ability to view their medical records electronically as well as updating patient demographics remain a high potential area of use.

Of particular note as well are the high numbers of Do Not Know responses. This may suggest that IT and operations managers within the hospitals are not sufficiently aware of and are not always adequately tracking the use of the EMR technology.

4.4.2 Infusion of EMR Modules

The ten administrative and clinical processes can be mapped to the eight EMR modules as illustrated in Table 4.11 on the next page.

[12] Although this might seem contradictory to the availability levels reported in Table 4.4, as only 36% of hospitals were reported to have this functionality in all clinical units, it must be noted that most South African hospitals use centralised patient admission processes (Matshidze and Hanmer, 2007) and therefore the capturing of administrative procedures is most likely to happen centrally and therefore the diffusion of the functionality into the clinical units has not yet occurred. Matshidze and Hanmer (2007) also note that the most common data collected is submitted to medical schemes primarily for reimbursement purposes (pg. 94), which again could explain the high level of use of EMR system functionalities that support inpatient and outpatient administrative procedures.

Table 4.11 – Infusion processes and corresponding EMR Module

Process	Corresponding EMR Module
The percentage of *inpatient and outpatient administrative procedures* at your facility that are done electronically	Administrative Support
The percentage of *physicians* at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	Electronic Communication
The percentage of source data used in *public health reporting* that is collected electronically	Public Reporting
The percentage of patients at your facility for whom *clinical documentation* is written electronically	Clinical Documentation
The percentage of patients at your facility performing *direct data entry* electronically	Integrated Patient Support
The percentage of patients at your facility for whom lab *results* are viewed electronically	Results Viewing
The percentage of *nurses* at your facilities who use electronic *decision support*	Decision Support
The percentage of *nurses* at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	Electronic Communication
The percentage of *physicians* at your facilities who use electronic *decision support*	Decision Support
The percentage of patients at your facility for whom *physician orders* are entered electronically	CPOE

Based on the extent to which the various administrative and clinical processes were reported as being supported by the use of EMR systems, four infusion categories were created. These four categories capture the extent of infusion of the various EMR systems modules in hospitals as follows:

No infusion: this category captured the hospitals that reported zero percent level of use. No infusion therefore meant the particular process was not being supported by an EMR system.

Low infusion: this category captured the hospitals that had reported 1 – 25% level of use. Low infusion therefore meant that up to a quarter of all the work related to that process was being supported by an EMR system.

Moderate infusion: this category captured the hospitals that had reported 26 – 50% level of use. This meant that hospitals had reported above a quarter (but not more than half) of the activities related to that process were being supported by an EMR system.

High infusion: this category captured the hospitals that had reported above 50% level of use. This meant the hospitals had reported that more than half of their activities related to that process were supported by the EMR system.

As can be noted on Table 4.10, some of the hospitals reported not knowing or not being sure of the percentage of processes or users that were being supported by the EMR system. These latter responses were not included in determining the different levels of infusion of the eight core modules. Secondly, as noted again in Table 4.10, some modules were assessed using more than one process. Specifically Electronic Communication and Decision Support modules were assessed using two processes. This was necessary as the two processes were related to two different types of clinicians, namely physicians and nurses. As highlighted earlier, the infusion measure did not follow the definitions of basic and comprehensive EMR systems. However the ten processes identified and measured were adopted from the Jha et al. (2009) study.

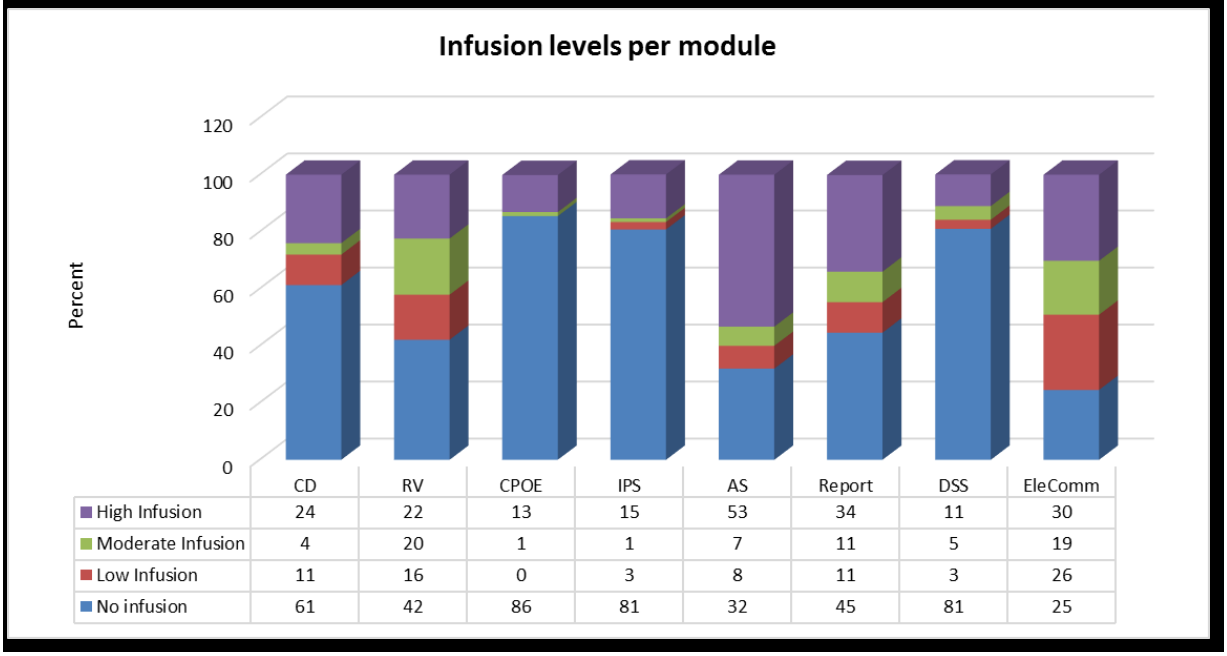
Where the module was assessed using more than one process, a new variable on the SPSS spreadsheet was created and recoded as the main module variable. To calculate this new variable the sum of the scores on the processes was divided by the number of processes. In this case two processes. For instance if hospital A had scored 2 on PhysicianElectronicComm and a 4 on NurseElectronicComm then the new variable would be (2 + 4= 6) / 2 = 3. Hospital A would then have a score of 3 on Electronic Communication module. This was also the case where the hospital had indicated not knowing the level of usage on one of the two processes.

To calculate the infusion score, the scores were recoded to the created infusion categories. Appendix Q Part A, Question 3, shows how the hospitals' responses were initially coded. The recoding is summarized in tabular form below.

	0%	1 – 25%	26 – 50%	51 – 75 %	76 – 100%	Don't Know / Not Sure
Original Score	2	3	4	5	6	1
Recoded Score	1	2	3	4		Missing
Infusion Category	**No**	**Low**	**Moderate**	**High Infusion**		

Having recoded the infusion scores, a frequency count for each module was performed. Chart 5 on the next page shows the summary of the infusion levels of each EMR module

Chart 5 – EMR system infusion levels per module



	CD	RV	CPOE	IPS	AS	Report	DSS	EleComm
High Infusion	24	22	13	15	53	34	11	30
Moderate Infusion	4	20	1	1	7	11	5	19
Low Infusion	11	16	0	3	8	11	3	26
No infusion	61	42	86	81	32	45	81	25

*CD=Clinical Documentation and Health Data; RV = Results Viewing; CPOE = Computerised Physician Order Entry; IPS = integrated Patient Support; AS = Administrative Support; Report = Reporting; DSS = Decision Support; EleComm = Electronic Communication and Connectivity.

The following section discusses the infusion levels of the eight core EMR systems modules, as presented on Chart 5 above.

4.4.2.1 Clinical Documentation and Health Data (CDHD) Module

Only 24% of hospitals that were aware of their usage levels reported having high infusion of a CDHD module i.e. more than half (50%) of their clinical documentation was being done electronically. Of the 75 hospitals that were able to report the levels of clinical documentation done electronically, 61% had no infusion of a CDHD module i.e. they did not perform any of their clinical documentation electronically, while 11% had up to a quarter (25%) of their clinical documentation done electronically (low infusion). Only 4% reported moderate infusion, between 26 – 50% of their documentation being done electronically. This suggests that hospitals may not be maintaining clinical documentation on EMR systems, as less than a third of all hospitals have moderately and highly infused their CDHD module into their processes. It would suggest hospitals are still using paper to support their clinical documentation. 23 hospital organisations were not aware how much of their clinical documentation was done electronically.

4.4.2.2 Results Viewing

Usage of the results viewing module was generally well distributed across the categories, with 22% of hospitals reporting their usage levels had more than half of their lab results being viewed electronically. A further 20% had 26-50% of their lab results being viewed electronically, while 16% had up to a quarter (25%) of their lab results viewed electronically. Less than half of the hospitals

(41%) that were aware of their usage levels did not view lab results electronically. These infusion levels suggest hospitals have generally infused results viewing functionalities. This is encouraging as the Government of South Africa continues to motivate the use of electronic lab reporting, through the National Laboratory Services. Twenty-two hospital organisations were not aware of their level of use of EMR functionalities for viewing lab results.

4.4.2.3 Computerised Physician Order Entry

Computerised Physician Order Entry (CPOE) use remains limited. These results are consistent with prior studies such as Kaushal et al. (2003) and Poissant et al. (2005) who noted that, although quite prevalent in hospital settings, CPOE systems use remains limited. These systems, which allow physicians to enter medication orders, would most probably be used by physicians. 86% of hospitals reporting on their usage levels did not have patients for whom physician orders were entered electronically. Only 13% had more than half (high infusion) of their patients' medication being captured electronically, while no hospital reported low infusion. Only 1 % had moderately infused their CPOE, meaning their EMR systems were used for 26 -50% of their patients' medication orders. Twenty-nine hospitals were not aware of their CPOE usage levels.

These infusion levels suggest that CPOE is not being used by physicians and clinicians, as this module is directly related to orders made by them. This may therefore suggest most physician orders are likely to be still written on paper.

4.4.2.4 Integrated Patient Support

Integrated Patient Support, which allows patients to make direct data entry onto their medical records also had lower levels of infusion. Only 15% of hospitals had more than half of their patients performing direct data entry. 81% of hospitals had no patients performing direct data entry. Twenty hospitals reported not being aware or not being sure of their usage levels of this module. The infusion levels suggest that most patients do not use EMR systems. This is not surprising given that most people who visit the hospital would rather have someone, most likely a clinical officer, do the data entry on their behalf than do it themselves.

4.4.2.5 Administrative Support

The Administrative Support module is one of the most highly used in hospitals. This module has functionalities that allow for the processing of billing information, as well as other inpatient and outpatient administrative processes. 53% of responding hospitals do more than half of their inpatient and outpatient administrative functions electronically, while 7% have moderately infused this module and 8% do up to a quarter (1 -25%) of their inpatient and outpatient administrative processes on this EMR system module. 32% of responding hospitals did not perform any inpatient and outpatient administrative processes electronically. Only twenty-three hospitals were not aware of their usage

levels. These infusion levels suggest hospitals have seen the benefits in automating their administrative processes. It is worth noting that it is a module less related to clinical processes that is highly infused.

4.4.2.6 Public Health Reporting

The Public Health Reporting module allows hospitals to collect and disseminate public health data. 34% of hospitals reported that more than half of their source data used for public health reporting was collected electronically, while 22% of hospitals reported they had between 1 and 50% of their source data collected electronically. Only 45% of hospitals reporting their usage levels did not have any source data being collected electronically. Forty-two hospitals were not aware of their usage levels of EMR systems functionalities to collect data for public health reporting. The number of hospitals reporting lack of awareness of their use of this module is worth noting. Overall, the infusion levels of this module suggests a lot still needs to be done in using EMR systems to collect data. These infusion levels suggest that indeed hospitals are not capturing their data electronically, as can be seen with the other modules. Had hospitals been using EMR systems to collect and disseminate data then this module would also reflect high levels of infusion.

4.4.2.7 Decision Support

81% of responding hospitals did not use the Decision Support module. Decision Support module has functionalities to provide clinical guidelines, clinical reminders and drug interactions amongst other things. These are most likely to be used by both nurses and physicians. The high levels of no use of the EMR system's decision support functionalities are worth noting. Only 11% of hospitals had half of their nurses and doctors using decision support functionalities, while 5% had between 26 – 50% of their clinicians and only 3% having between 1 -25% of their nurses and physicians using decision support functionalities. Thirty-five hospitals were not sure or didn't know how many of their clinicians were using decision support systems. Again, this module is directly related to clinicians. The low levels of infusion would suggest clinicians are not using the key functionalities of EMR systems directly linked to them as clinicians.

4.4.2.8 Electronic Communications and Connectivity

The Electronic Communications and Connectivity module has functionalities that enable clinicians to communicate with other healthcare providers. In this regard, a third (30%) of hospitals responding had more than half of their clinicians using electronic communication to communicate with other healthcare providers, while a quarter (25%) of hospitals reported that no clinicians were using this module in their facilities. 26% reported that between 1 -25% of their clinicians were using electronic communications and connectivity module and only 19% reported 26 -50% of their clinicians using the functionalities of this module. Forty-five hospitals were not aware or not sure how many of their

clinicians were using their electronic communication and connectivity module. The number of hospitals not aware of how they are using this module is worth noting. That said, the infusion levels of the reporting hospitals show a picture of clinicians that do use electronic communication mechanisms, as a third of hospitals report more than half their clinicians use this module. This would suggest that clinicians do in-fact use electronic communication, which is a good sign. The key challenge would be how this can be translated to the use of functionalities that directly relate to clinical practices.

The infusion of EMR systems in South African hospitals is encouraging as above 30% of most processes in the hospitals are done using EMR systems functionalities (see high and moderate infusion figures). However these hospitals still have a long way to go in embedding the technology into their processes, given the high levels of low and no infusion of a number of modules. Chart 5 shows that save for Electronic Communication and Administrative Support modules, the other six modules have not been embedded into hospital processes by more than 40% of responding hospitals.

Given that some hospitals reported their usage on some modules and were unable to report on others, it was not possible to calculate an overall infusion score for each hospital. In some instances hospitals were able to report on usage levels of say three modules and the remaining five modules reported as not sure or didn't know. Likewise the number of hospitals that were able to report on each module was not the same. As mentioned above for instance, forty-five hospitals could not report on electronic communication and connectivity yet only twenty were unable to report on integrated patient support. As such the total population that could be used to calculate overall infusion scores, based on all modules, could not be determined. The inability of hospitals to report on the level of usage does highlight a key concern that hospitals could be failing to effectively measure the usage of their technologies.

Having addressed the first objective of assessing the current state of EMR systems diffusion and infusion in South African hospitals, the next chapter addresses the second research objective i.e. assessing the impact of the diffusion and infusion of EMR systems on hospital performance.

4.5 Model Testing

Having addressed the first research objective; that of assessing the current state of EMR systems diffusion and infusion in the hospitals of South Africa, the next step was addressing the second research objective; assessing the extent to which the diffusion and infusion of EMR systems impacts the performance of hospitals in South Africa. Specifically, the study sought to assess the impact of EMR systems diffusion on economic efficiency, clinical effectiveness, patient safety, patient satisfaction, and on information management capability as well the impact of EMR systems infusion on economic efficiency, clinical effectiveness, patient safety, patient satisfaction, and information management capability.

To address this second objective only the matched questionnaires were used. Unlike the descriptive aspect of the research, the relational aspect requires an analysis of responses to both questionnaires that come from the same hospital organisation. Of the 103 responding hospitals, 64 responses were matched i.e. 64 hospital organisations responded to both Hospital Information Systems and Hospital Administration questionnaires.

Foremost, it was important to determine which functionalities to include in the diffusion and infusion scales as EMR functionalities range across eight modules. Past literature was used to make this determination.

First, the "meaningful use" criteria adopted by the US Department of Health sets a standard for the use of EMR systems within hospitals (Blumenthal and Tavenner, 2010; Jha, 2010). This standard is largely based on the use of EMRs for clinical documentation and physician order entry.

It was decided therefore that the diffusion and infusion scales should be based on the clinical documentation and CPOE system functionalities.

Moreover, as indicated in the literature review section, researchers such as DesRoches et al. (2008) and Jha et al. (2009), together with the American Hospital Association, have defined the basic functionalities for an EMR system as predominantly including clinical documentation and CPOE functionalities. The clinical documentation and health data module is considered one of the important modules of the EMR system. The basic EMR systems definition, which incorporates eight system functionalities, consists of four of these functionalities from the clinical documentation.

This analysis is therefore focused on the link between hospital performance and the diffusion and infusion of the clinical documentation and CPOE functionalities of an EMR system. The other functionalities covered in the remaining six modules were not included in this analysis.

The following table (Table 4.12) summarizes the EMR systems functionalities that were used to capture the diffusion and infusion variables. On the other hand, Appendix P in the appendices shows how the administrator questionnaire was coded for statistical analysis.

Table 4.12 – Diffusion and Infusion items

Items	Scale
Clinical Documentation Diffusion items To what extent are computerised systems within your facility available for; Items - Maintaining Patient Demographics - Maintaining Clinical Notes - Maintaining Active Diagnoses - Maintaining Current Procedures - Maintaining Nursing Assessments - Maintaining Problem Lists - Maintaining Active Medication Lists - Maintaining Discharge Summaries - Maintaining Advanced Directives (e.g. DNR)	Scale of 1 – 6 **1** = Not in place; **2** = Planning to make available in one year; **3** = Already beginning to make available; **4** = Available within at least one but not a majority of clinical units. **5** = Available in a majority but not all relevant clinical units; and **6** = Available in all relevant clinical units.
Computerised Physician Order Entry Diffusion items To what extent are computerised systems within your facility available for; - Ordering Laboratory Tests - Ordering Radiology Tests - Entering Medication Orders - Entering Consultation Requests - Entering Nursing Orders	Scale of 1 – 6 Same as Clinical Documentation (above)
Clinical Documentation alternative measure for Diffusion Please indicate the current frequency of usage of the following functionalities; Item Clinical Documentation and Health Data	Scale of 1 – 6 **1** = Not Sure; **2** = Not Available to be Used; **3** = Hardly Used; **4**= Sometimes Used; **5** = Often Used; **6** =Used All the Time
CPOE alternative measure for Diffusion Please indicate the current frequency of usage of the following functionalities; Item Computerised Physician Order Entry	Scale of 1 – 6 Same as Clinical Documentation alternative (above)
Clinical Documentation Infusion item Please provide your best estimate for; The percentage of patients at your facility for whom clinical documentation is written electronically	Scale of 1 – 6 **1** = Don't Know / Not Sure; **2**= 0% ; **3**= 1-25% **4**= 26-50% ; **5**= 51-75%; **6** = 76-100%
Computerised Physician Order Entry Infusion item Please provide your best estimate for; The percentage of patients at your facility for whom physician orders are entered electronically	Scale of 1 – 6 Same as Clinical documentation infusion (above)

4.5.1 Data preparation

The research model (Figure 2) identifies five hospital performance variables; information management capability, clinical effectiveness, economic efficiency, patient safety, and patient satisfaction. The data was provided by hospital administrators. Although 103 Hospital Administrator responses were received in total, only 64 could be matched to the Hospital IT questionnaire responses (refer to Table 4.1). The following sections discuss the preparation of data on these 64 cases before the testing of the model's hypotheses. . The approach to the data preparation and the selection of statistical techniques for analysis followed the typical approach for a quantitative survey-based study as recommended by researchers such as Bhattacherjee (2012), Babbie (1989), and Hair et al. (2010).

4.5.2 Data screening

Three steps were followed in the screening of the data. First the data was checked for missing values. Secondly it was then checked for outliers, and finally tested for normality. These processes are described next.

4.5.2.1 Missing data

Hair et al. (2010) suggest that missing data be viewed either from missing data per variable or missing data per case. They suggest that if missing data is above 10% for any one questionnaire item, then that item may should be excluded from the analysis.

In this data set, where missing data existed, it did not reach 10% for that particular item. As such, no variable was excluded from the analysis due to missing data. Missing values were identified in five cases. In this data set, where missing data existed, it did not reach 10% for that particular variable. As such no variable was excluded from the analysis due to missing data.

Missing data occurs when a respondent refuses or is unable to participate in the data collection process. This is called unit non-response. At other times the respondent can participate in the survey and choose, due to a number of reasons, not to respond to some aspects of the questionnaire. This is called non-item response. While the researcher may have little influence over the first scenario, they can employ recommended techniques to address the second. Where data is considered missing completely at random an appropriate technique is mean substitution (Cohen, 2013; Hair et al. 2010). This method has the advantage of not impacting the statistical power as it preserves data. However it does underestimate standard errors (Karanja, Zaveri, and Ahmed, 2013). This method was subsequently employed to missing data in this dataset.

4.5.2.2 Outliers

Before any analysis was performed, the data was checked for possible outliers. Researchers such as Cohen (2013) have recommended a threshold of 3 for standardised values of variables. Standardised scores of the variables were examined and using this benchmark of ± 3 as the threshold for standardised scores, two cases that were considered to be outliers. These were subsequently removed from the data set.

Once satisfied with the data cleaning process, the data was then subjected to further statistical tests in preparation for the model testing.

4.5.2.3 Test for normality

The data was also tested for normality. Normality measures how well the data represents a normal distribution. Two tests; skewness and kurtosis, were used to test for normality. As a rule of thumb, it is suggested that skewness should lie between ± 1 and kurtosis between $\pm$ 3 (Cohen 2013; Hair et al. 2010).

The two independent variables (diffusion and infusion) were captured as ordinal data, given that respondents assess the levels of availability (diffusion) and the levels of use of EMR systems within their organisations. Ordinal data does not follow a normal distribution as the position assumed by each value is a rank (Leedy and Ormrod, 2013).

The dependent variables were tested for normality and they were within the acceptable ± 1 for skewness and $\pm$ 3 for kurtosis, except for 6 of the 37 items. These were not deleted at this stage but noted for the factor analysis, which is described in the following sections.

4.5.2.4 Validity of the Hospital Performance Measures

Construct validity assesses whether the measures being used by the researcher "move or fit" together to the extent that they can be said to be measuring the same thing (Straub et al. 2004; Trochim, 2006). Two key construct validity measures, convergent and discriminant validity were considered for this study.

Principal components analysis, or factor analysis, demonstrates whether all items measuring a particular construct load highly onto the same factor or component. This provides evidence of convergent validity.

Varimax orthogonal rotation method was used. This method searches for the factor structure in which the independence of the factors is maximised (Cohen, 2013). To simplify the analysis, a cut-off loading of 0.4 was applied.

The various performance variables were thus subjected to a principal component factor analysis with varimax orthogonal rotation and the initial analysis revealed that certain items were cross-loading, meaning they were measuring more than one construct. Secondly, items initially operationalised to measure a particular construct were in fact measuring a different, previously unidentified construct.

As a result of this analysis, a number of items were eliminated until an acceptable factor solution was arrived at. Table 4.13 below summarises the items that were eliminated and the rational for eliminating them.

Table 4. 13 – List of items eliminated during the factor analysis

Construct	Item eliminated	Rationale for eliminating item
Information Management Capability	INFOMGT9	Cross-loading. Factor loading <0.5
Clinical Effectiveness	CLINEFFEC4	Cross-loading. Factor loading <0.5
	CLINEFFEC5	Factor loading <0.5
Economic Efficiency	ECONEFF6	Cross-loading
Patient Safety	PATSAF1	Cross-loading
	PATSAF2	Cross-loading
	PATSAF3	Cross-loading
	PATSAF4	Cross-loading
	PATSAF5	Cross-loading
	PATSAF6	Cross-loading
	PATSAF7	Cross-loading
Patient Satisfaction	PATSAT4	Cross-loading

To summarise the factoring process, the patient safety construct fell away as all of its items cross-loaded with patient satisfaction, suggesting that the manner in which the study had operationalized patient safety did not differ from patient satisfaction. The clinical effectiveness factor split into two factors. An in-depth analysis of the terminology used in the items suggested that one of the clinical effectiveness factors related to the effectiveness of clinical processes whilst the other related to the effectiveness of team processes. Therefore the split clinical effectiveness factor was *labelled Clinical Effectiveness Processes* and *Clinical Effectiveness Team*.

The final solution resulted in five factors, with eigenvalues greater than 1. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was 0.864, above the recommended 05 (Hair et al. 2010; Cohen 2013). The Bartlett's test of sphericity was statistically significant ($_{\chi}^{2}$ =2067.442; df=300; p=0.000). The lowest communalities value was 0.534 (INFOMGT8) and the highest was 0.942 (CLINEFFEC2). It is recommended that communalities be above 0.300.

This five-factor solution accounted for 71.80% of the total observed variability in the data, which is above the recommended 60%. Convergent and discriminant validity was therefore confirmed. Table 4.14 on the next page shows the final factor solution.

Table 4.14 – Principal components analysis of dependent variables

Item	Component				
	Information Management	**Economic Efficiency**	**Clinical Effectiveness - Teamwork**	**Patient Satisfaction**	**Clinical Effectiveness - Processes**
INFOMGT1	.755				
INFOMGT2	.630				
INFOMGT3	.793				
INFOMGT4	.815				
INFOMGT5	.772				
INFOMGT6	.792				
INFOMGT7	.749				
INFOMGT8	.681				
INFOMGT10	.609				
CLINEFFEC1					.857
CLINEFFEC2					.869
CLINEFFEC3					.871
CLINEFFEC6			.758		
CLINEFFEC7			.717		
CLINEFFEC8			.774		
CLINEFFEC9			.674		
ECONEFF1		.617			
ECONEFF2		.743			
ECONEFF3		.852			
ECONEFF4		.856			
ECONEFF5		.776			
PATSAT1				.679	
PATSAT2				.822	
PATSAT3				.775	
PATSAT5				.696	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations

b. KMO measure = 0.864.

4.5.2.5 Reliability

Having assessed validity, it was also necessary to examine the reliability of the measures of each construct resulting from the factor analysis. Using the internal consistency approach to scales reliability, Cronbach's Alpha was the preferred method. Reliability is acceptable when Cronbach Alpha is greater than 0.70 (Hair et al. 2010; Cohen, 2013, Hiidenhovi et al. 2001; Ferketich, 1990). Table 4.15 summarises the results of tests for validity and reliability.

Having established the reliability and validity of the performance measures, composite scores were calculated for each performance variable as the arithmetic average of the items weighted equally. These composite performance scores were then used in subsequent analyses.

Table 4.15 – validity and reliability measures

Construct	Initial no. of items	Final no. of items	Cronbach's Alpha	Mean	Standard Deviation
Information Management Capability	10	9	0.924	5.76	0.899
Clinical Effectiveness Processes	9	3	0.965	4.01	1.481
Clinical Effectiveness Team		4	0.835	5.81	0.800
Economic Efficiency	6	5	0.887	5.18	0.845
Patient Satisfaction	5	4	0.822	5.71	0.651

4.6 Addressing diffusion and infusion measures

A Spearman correlation analysis of the items used to measure the diffusion and infusion of EMR systems and those measuring performance was performed. This was done to assess if the reported availability, usage, and infusion levels of Clinical Documentation EMR functionality and Computerised Physician Order Entry EMR functionality had any significant relationship with the performance measures.

Appendix R in the appendices presents the correlation matrix of this analysis. The next section discusses the significant relationships identifiable on this table (Appendix R).

4.6.1 Diffusion, infusion, and Performance

From the preceding correlation analysis, significant relationships were identified between maintaining active diagnosis and economic efficiency (ρ=.260; $p<0.05$), maintaining current procedures and economic efficiency (ρ =.306; $p<0.05$), as well as maintaining advanced directives and the clinical efficiency of processes (ρ = -.338; $p<0.01$). Of particular note is that the latter relationship

was found to be negative, suggesting the availability of this functionality had a negative impact on the clinical efficiency of processes. This is discussed further in the next chapter of this report.

Similarly, as presented in the same table (Appendix R) a correlation analysis between the items used to measure the availability of computerised physician order entry (CPOE) and performance measures was undertaken.

A number of significant relationships were also identified from this analysis. Clinical efficiency of processes was significantly related to entering medication orders ($\rho = -.254$; $p<0.05$), entering nursing orders ($\rho = -.290$; $p<0.05$), and entering consultation requests ($\rho = -.351$; $p<0.01$). Likewise patient satisfaction had a significant relationship with entering medication orders ($\rho = -.271$; $p<0.05$). However, all of these significant relationships were negative, again suggesting that the availability of these functionalities in the hospitals had a negative effect on the identified performance measures. This is also discussed further in the next chapter of this report.

The Clinical Documentation infusion measure (labelled CDInfuse) was the only infusion measure that had any significant relationship with the performance variables ($\rho = .279$, $p<0.05$.)

Once the relationships between the functionalities' availability, their infusion, and performance measures had been assessed, a principal component analysis (PCA) was then conducted. The intention of this exercise was to assess whether the functionalities could be grouped and their impacts on performance assessed as a group (i.e. factors).

A PCA of the clinical documentation functionalities created three components. The ability to maintain problem lists was the only functionality that cross-loaded and was subsequently removed from the analysis. The resultant component matrix produced three distinct components. Based on the components created, functionalities identified as one component were summed up. These summed up scores are herein referred to as CDAvailComponent1 (made up of maintaining clinical notes, maintaining nursing assessments, and maintaining advanced directives functionalities), CDAvailComponent2 (made up of maintaining active diagnosis, maintaining clinical procedures, and maintaining active medication lists), and CDAvailComponent3 (made up of maintaining patient demographics and maintaining discharge summaries). Table 4.16 on the next page shows the resultant matrix.

Table 4.16 –PCA Matrix of Clinical Documentation items

Items	Component		
	CDAvailComponent1	**CDAvailComponent2**	**CDAvailComponent3**
CD_MPD			0.872
CD_MCN	0.715		
CD_MAD		0.847	
CD_MCP		0.638	
CD_MNA	0.792		
CD_MAML		0.648	
CD_MDS			0.858
CD_MAdDi	0.765		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

The items from each component were then summed in order to produce a total score for that component. These total scores were then correlated with the hospital performance measures. Table 4.17 on the following paragraph shows the results of this correlation analysis.

Table 4.17 – Correlation Matrix of Clinical Documentation Diffusion Components and Performance Measures

	CompInfoMgt	**CompClinEffecPro**	**CompClinEffecTeam**	**CompEconEff**	**CompPatSat**
CompInfoMgt	1.000				
CompClinEffecPro	.312*	1.000			
CompClinEffecTeam	.349**	.230	1.000		
CompEconEff	.253*	.259*	.432**	1.000	
CompPatSat	.478**	.416**	.400**	.538**	1.000
CDAvailComponent1	-.308*	-.094	-.017	-.077	-.056
CDAvailComponent2	.035	.139	.084	.172	.182
CDAvailComponent3	.167	.043	.186	-.027	-.074

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The availability of functionalities that enabled maintaining clinical notes, nursing assessments, and advanced directives (termed CDAvailComponent1) had a significant relationship with the hospital's information management capability ($p = -.308$, $p<0.05$). This relationship was also found to be

negative i.e. the availability of these three functionalities seemed to negatively affect the performance of hospitals. These results are discussed further in the next chapter.

Similarly a PCA of the CPOE diffusion measures was performed. It yielded, two distinct components, herein referred to CPOEAvailComponent1 and CPOEAvailComponent2.

CPOEAvailComponent1 was made up of entering medication orders, entering consultants' requests, and entering nursing orders. CPOEAvailComponent2 was made up of ordering lab tests and ordering radiology tests. Table 4.18 below shows the resultant component matrix.

Table 4.18 – PCA matrix of CPOE items

Rotated Component Matrix[a]

Items	Component	
	CPOEAvailComponent1	**CPOEAvailComponent2**
CPOE_OLT		.937
CPOE_ORT		.933
CPOE_EMO	.647	
CPOE_ECR	.854	
CPOE_ENO	.901	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Likewise the items from each component were then summed in order to produce a total score for that component. These total scores were then correlated with the hospital performance measures. The resultant matrix is presented in Table 4.19 below.

Table 4.19 - Correlation Matrix of CPOE Diffusion Components and Performance Measures

	CompInfoMgt	**CompClinEffecPro**	**CompClinEffecTeam**	**CompEconEff**	**CompPatSat**
CPOEAvailComponent1	.160	.081	.014	-.088	-.073
CPOEAvailComponent2	-.070	-.258*	-.126	-.138	-.273*

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

A number of significant relationships were found. CPOEAvailComponent2 was found to have a significant relationship with the clinical efficiency of processes (p = -.273, p<0.05) and with patient satisfaction (p = -.258, p<0.05). These relationships, like the other functionalities that had significant relationships, was also found to be negative.

In summary, Table 4.20 below shows the correlation matrix of the diffusion components and the performance measures.

Table 4.20– correlation matrix of diffusion components and performance variables

		CompInfoMgt	CompClinEffecPro	CompClinEffecTeam	CompEconEff	CompPatSat
Spearman's rho	CompInfoMgt	1.000				
	CompClinEffecPro	.312*	1.000			
	CompClinEffecTeam	.349**	.230	1.000		
	CompEconEff	.253*	.259*	.432**	1.000	
	CompPatSat	.478**	.416**	.400**	.538**	1.000
	CDAvailComponent1	-.308*	-.094	-.017	-.077	-.056
	CDAvailComponent2	.035	.139	.084	.172	.182
	CDAvailComponent3	.167	.043	.186	-.027	-.074
	CPOEAvailComponent1	.160	.081	.014	-.088	-.073
	CPOEAvailComponent2	-.070	-.258*	-.126	-.138	-.273*
	Alt-Diff.ClinDoc	0.086	.185	-.008	-.134	-.180
	Alt-Diff.CPOE	.066	.061	-.174	-.073	-.045

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Alternative measures of diffusion

Correlation analysis was also performed for the alternative measures of diffusion. The availability of clinical documentation as well as the availability of CPOE, as measured by the frequency of use of these functionalities, were found to have no significant relationships with the performance measures. These alternative measures are shown in the preceding table (Table 4.20).

Infusion measures

To measure the infusion of clinical documentation, respondents were asked to indicate the percentage of clinical documentation done electronically. To measure the infusion of CPOE, respondents were asked to indicate the percentage of lab results viewed electronically.

Correlation analysis was performed for these infusion measures as well. Clinical documentation infusion was found to have a significant positive relationship with hospitals' information management. Table 4.21 below shows the summarised correlation matrix between the infusion measures of Clinical documentation (herein referred to as CDInfuse) and Computerised Physician Order Entry (herein referred to as CPOEInfuse).

Table 4.21 – correlation matrix of infusion measures and performance variables

		CompInfoMgt	CompClinEffecPro	CompClinEffecTeam	CompEconEff	CompPatSat
Spearman's rho	CDInfuse	.279*	-.117	-.107	-.215	-.059
	CPOEInfuse	-.035	-.155	.058	.043	-.062

4.6.2 Moderator analysis

Having performed correlations between the diffusion, infusion, and performance measures and as noted in Tables 4.19 and 4.20 that although there were significant relationships between the diffusion of the EMR systems and the performance of the hospital, these relationships were negative, suggesting that the availability of the EMR system was negatively impacting the performance of the hospital, it was necessary to explore whether the identified relationship were moderated by any factors. Specifically, the diffusion of functionalities that enabled hospitals to maintain clinical notes, nursing assessments, and advanced directives (termed CDAvailComponent1) had a significant but negative impact on the hospital's information management capability. Likewise, the diffusion of functionalities that enabled hospitals to order lab tests and radiology tests (termed CPOEAvailComponent2) had a significant but negative effect on the hospital's effectiveness of clinical processes and on patient satisfaction. In an attempt to explore further these unexpected results, three key factors were considered for the moderator analysis, namely whether type of hospital (private or public), location of hospital (rural or urban), or the size of the hospital (small, medium, or large) had any influence on the said relationships. To do this, a subgroup type of regression analysis was performed. Table 4.22 on the next page shows a summary of this regression analysis.

Table 4.22 – Regression Analysis Results

		Size[13]			Kind of Hospital		Location	
Independent Variable	Dependent Variable	Small	Medium	Large	Public	Private	Urban	Rural
		n=26	n=21	n=13	n=40	n=12	n=45	n=17
CDAvailComponent1	CompInfoMgt	.029 p =.755	-.095 p =.151	-.111 **p <0.01**	-.022 p =.659	-.124 **p <0.01**	-.113 **p <0.01**	.085 p =.528
CPOEAvailComponent2	CompClinEffecPro	.035 p =.796	-.409 p =.076	-.216 **p<0.01**	-.175 **p<0.05**	-.134 p = .183	-.133 **p<0.05**	-.588 **p<0.05**
CPOEAvailComponent2	CompPatSat	-.061 p = .354	-.037 p =.780	-.059 p =.077	-.077 p =.125	-.050 p =.139	-.050 p =.061	-.106 p =.497

As noted above, diffusion of clinical documentation in private hospitals were most likely to have a significant effect on information management capability, although negative. In the same manner, diffusion of clinical documentation was significantly related to information management capabilities in hospitals that were in urban areas. Diffusion of clinical documentation in large hospitals also had a significant effect on performance. Likewise the diffusion of CPOE had a significant relationship with performance in large hospitals than in small or medium hospitals. Whilst the diffusion of CPOE also had a negative effect on patient satisfaction, there was no significant difference between the hospitals. Thus the negative effects observed appear to be more pronounced in some contexts than in others. This is discussed further in the next chapter.

4.6.3 Testing the hypotheses

Table 4.23 below summarises the hypotheses developed for this study. Thereafter, the section summarises the results of the hypotheses testing.

Table 4.23 – Summary of hypotheses

	Hypotheses
H1a	"The level of EMR system diffusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."
H1b	"The level of EMR system infusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."

[13] Missing = 2

H2	"Information Management Capability is positively related to the performance of the hospital organisation (clinical processes effectiveness, team process effectiveness, economic efficiency, and patient satisfaction)."
H3a	"The level of EMR system diffusion is positively related to the information management capability of the hospital organisation."
H3b	"The level of EMR system infusion is positively related to the information management capability of the hospital organisation."

The relationship between *diffusion* and *performance*.

Hypothesis 1a stated that

> *"The level of EMR system diffusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."*

Table 4.20 above indicates that only the diffusion of CPOE (CPOEAvailComponent2) has a significant relationship with clinical processes effectiveness ($p<0.05$) and patient satisfaction ($p<0.05$). However, these effects were not in the expected direction and were negative. H1a is therefore not supported.

The relationship between EMR system *infusion* and *performance*.

Hypothesis 1b stated that

> *"The level of EMR system infusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."*

Table 4.20 above indicates that no significant relationship existed between the infusion measures and the performance measures. Therefore H1b is not supported.

The relationship between *information management capability* and *performance*.

Hypothesis 2 stated that

"Information Management Capability is positively related to the performance of the hospital organisation (clinical processes effectiveness, team process effectiveness, economic efficiency, and patient satisfaction)."

Table 4.20 shows that there is a positive and significant relationship between information management capability and the performance of the hospital organisation (clinical processes effectiveness, team process effectiveness, economic efficiency, and patient satisfaction). This positive relationship was found to be significant (clinical process effectiveness, $p<0.01$; team process effectiveness, $p<0.01$; economic efficiency, $p<0.01$; patient satisfaction, $p<0.01$). Hypothesis 2 was supported.

The relationship between EMR system *diffusion* and *information management capability.*

Hypothesis 3a stated that

"The level of EMR system diffusion is positively related to the information management capability of the hospital organisation."

The results in Table 4.20 indicate that there is significant negative relationship between the diffusion of clinical documentation and *information management capability* ($p<0.05$). This is not in the expected direction. Hypothesis 3a was therefore NOT supported.

The relationship between EMR system *infusion* and *information management capability*.

Finally hypothesis 3b stated that

"The level of EMR system infusion is positively related to the information management capability of the hospital organisation."

Table 4.20 above indicates that the infusion of Clinical Documentation has a significant relationship with information management capability. However, the infusion of CPOE does not. Hypothesis 3b is therefore partially supported.

Figure 3 on the next page shows the statistically significant coefficients for the final model. The discussion and interpretation of the findings are discussed in the next chapter.

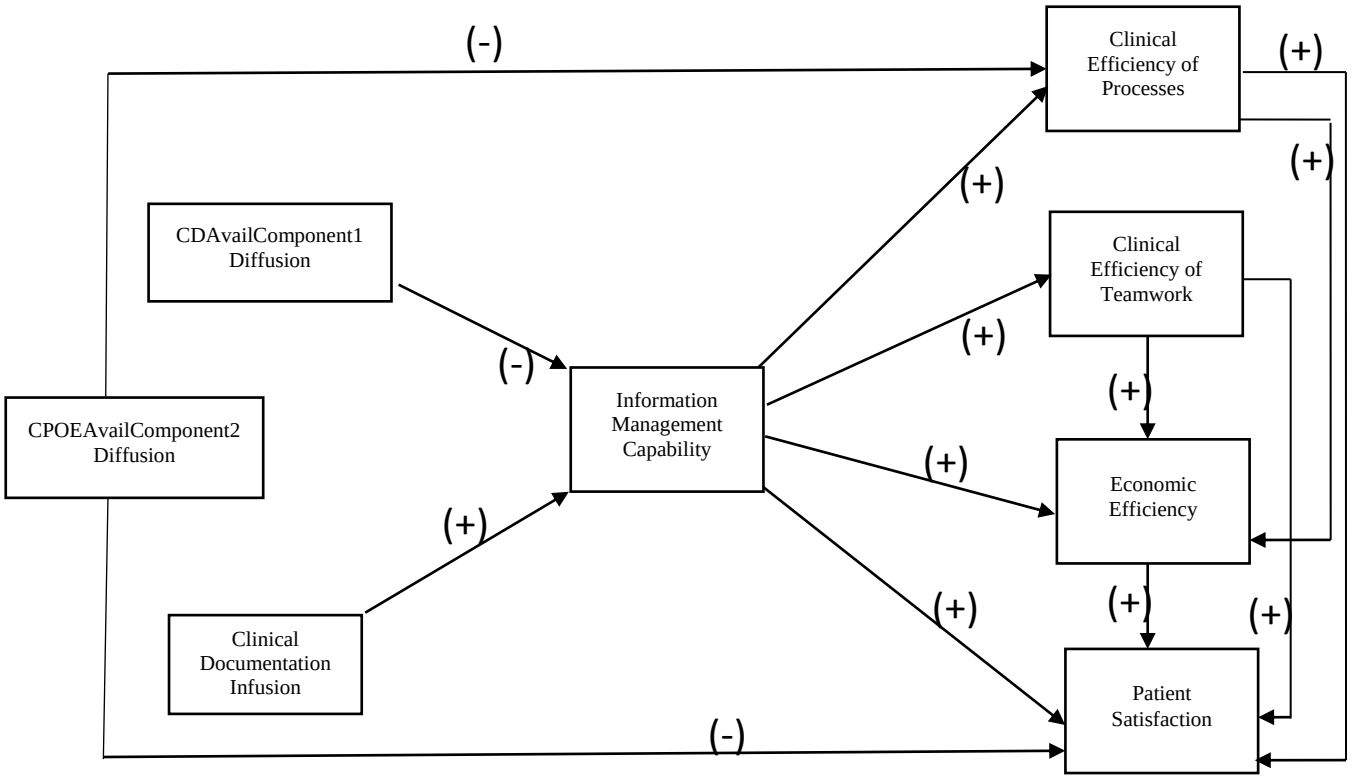


Figure 3: Revised research model showing relationships of study variables (diffusion, infusion, and hospital performance)

4.7 Summary

Two sets of questionnaires were used to collect data. The hospital information systems questionnaire provided data on the diffusion and infusion levels of EMR systems across hospitals in South Africa. This data was used mainly to address the first research objective. The hospital administration questionnaire provided data on the performance measures of hospitals across South Africa. This data was used to address the second research objective.

Results suggest that South African hospitals are making progress in as far as having basic EMR systems in place. However they are still lagging behind in implementing comprehensive EMR systems. The results have shown that the availability of EMR systems is not as significant to the hospital's performance as the comprehensive embedding of the technology to the hospital's processes – what we have defined as infusion. The study results show that infusion has a positive effect on performance.

The following chapter presents a discussion and interpretations of the findings.

5 Chapter 5 – Discussion of findings

5.1 Introduction

This chapter will first discuss the results of the descriptive aspect of this study. Thereafter, the chapter discusses the results of tests of hypotheses and research model and the implications of the findings. In doing so, the chapter reflects on literature in an attempt to explain the results. Finally, based on the results, an improved model is suggested.

Research objective 1

The first research objective was to describe the current state of EMR systems in the hospitals of South Africa. To achieve this objective, two key research questions were formulated. These are discussed further below.

5.2 What is the current state of EMR systems diffusion in the hospitals of South Africa?

The diffusion of an information technology is seen by the extent of its availability (Li and Collier, 2000). Ash (1997) has defined diffusion as the extent to which the information technology's use has spread across the organisation. These definitions of diffusion are consistent with Rogers classical definition, who defines diffusion as "the process by which an innovation is communicated through certain channels over time among members of a social system" (Rogers, 1995 pg.5). This study sought to find out how diffused EMR systems are across the hospitals of South Africa.

Results suggest that South African hospitals are making progress towards deploying basic EMR systems. Less than a quarter do not have basic EMR systems. The rest of hospitals have these systems available within their hospitals, albeit at varying diffusion levels. This is encouraging as it suggests both private and public hospitals have invested in this hospital technology. Specifically, 37% have lowly diffused basic EMR systems, 25% have moderately diffused their basic EMR systems while a 14% have highly diffused basic EMR systems. Chart 1 presented a summary of the diffusion levels of the three modules that make up a basic EMR system. As noted in Chart 1, CPOE was one of the highly diffused modules with 36% of hospitals reporting that they had CPOE available in all relevant clinical units. This finding was consistent with other literature such as Kaushal et al. (2003) and Poissant et al. (2005) who also found in their systematic review of literature, that CPOE were the most prevalent hospital information systems.

While South African hospitals, both private and public have made investments in basic EMR systems, the picture is somewhat bleak when one looks at hospitals with comprehensive EMR systems. Comprehensive EMR systems have more functionalities that support more hospital processes. A very low 17% had highly diffused comprehensive EMR systems within their hospitals while 10% had moderately diffused comprehensive EMR systems. 9% had lowly diffused comprehensive EMR systems. As mentioned earlier, a large number of SA hospitals (61%) do not have comprehensive EMR systems available at their hospitals. This suggests a lot of work still needs to be done to encourage hospitals to invest more in making comprehensive EMR systems available across hospitals.

5.3 What is the current state of EMR systems infusion in the hospitals of South Africa?

Administrative Support was found to be the most infused module in hospitals as 60% of responding hospitals had this module moderately and highly infused. Only 32% did not have their inpatient and outpatient administrative processes being supported by this technology.

CPOE and Decision Support modules remain the least infused. 86% of hospitals did not have their processes related to CPOE supported by their CPOE module. Likewise 81% of hospitals had 0% of their staff using decision support module for activities supported by the decision support module.

The results do suggest most hospitals are not effectively using the system functionalities that their EMR systems provide. While the researcher acknowledges that the issue of use of technology and how to measure actual use remains a key challenge for researchers, it is evident from the reported usage levels that most hospitals are not using EMR systems for a major part of their processes. The key processes that seem to be well embedded onto the technology are those related to the administrative aspect of the hospital setting, such as Administrative Support functionalities that help in the inpatient and outpatient administrative processes such as billing, as well as Results Viewing functionalities which help in the viewing of lab reports amongst other things. Hospitals still need to do more to encourage their staff to use the functionalities available to support not only the administrative processes but also their clinical processes.

Research objective 2

The second research objective was to assess the extent to which the diffusion and infusion of EMR systems impacts the performance of hospitals in South Africa. In tackling this second objective, two key research questions were formulated. These are discussed further on the next page.

5.4 What are the direct effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction?

Hospital performance remains a critical issue. A number of prior studies have used multiple dimensions to capture the complex performance outcomes of hospital organisations. These studies have been highlighted in Table 2A, appendix and discussed as part of the literature review in Chapter 2.

Drawing on these works, this study conceptualised hospital performance as consisting of four dimensions, namely economic efficiency, clinical effectiveness, patient safety, and patient satisfaction. During the model testing patient safety fell away as it cross-loaded with all the other dimensions. Additionally, clinical effectiveness broke into two variables, subsequently called clinical effectiveness of processes and clinical effectiveness of teamwork.

This study sought to examine, among other things, the impact of EMR diffusion and EMR infusion on hospital performance. To do this, five hypotheses were proposed. These were, in tabular form:

	Hypotheses	*Outcome*
H1a	"The level of EMR system diffusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."	Not supported
H1b	"The level of EMR system infusion is positively related to the performance of the hospital organisation (economic efficiency, clinical effectiveness, patient safety, and patient satisfaction)."	Not supported
H2	"Information Management Capability is positively related to the performance of the hospital organisation (clinical processes effectiveness, team process effectiveness, economic efficiency, and patient satisfaction)."	Supported
H3a	"The level of EMR system diffusion is positively related to the information management capability of the hospital organisation."	Not supported
H3b	"The level of EMR system infusion is positively related to the information management capability of the hospital organisation."	Supported

The following section addresses the specific hypotheses and results thereof.

5.4.1 Diffusion and Hospital Performance

The resource-based view of the firm suggests that valuable and advantage creating firm-level resources result in improved organisational performance. In the IT context, it has been theorized that IT resources can be advantage creating and associated with improved performance outcomes. This is because the overall cost of capturing and disseminating information is reduced. Likewise the

organisation's ability to control and safeguard the data as a resource is enhanced. This suggests that a consistent development of the information technology will enhance business performance (Ross et al. 1996). Kraemer et al. (2006) also suggest that IT diffusion will lead to positive impacts on the performance of a firm. The overall cost of capturing and disseminating information is reduced. Likewise the organisation's ability to control and safeguard the data as a resource is enhanced (Zuboff 1985, Laudon and Laudon, 2008). In this study, the diffusion of EMR systems was hypothesised to be positively related to hospital performance. Although results showed that there was a significant relationship between the diffusion of EMR systems and hospital performance, this hypothesised positive relationship was however not supported. Instead, diffusion was found to be negatively related to two key hospital performance dimensions, namely the effectiveness of clinical processes and patient satisfaction. Thus EMR systems might actually detract from rather than contribute to key performance outcomes. Hospital IT systems have often been criticized for interfering with clinical practice and detracting from the clinician-patient interaction. This study confirms the possibility that such effects might occur.

The results imply that certain types of hospitals may not get the positive effects the IS&T are supposed to provide for organisations in general. To explore what factors might account for these negative effects, certain moderators were tested. It was found that the size, the location, and the type of hospital had an effect on the type of impact that the diffusion of the EMR system had on hospital performance. For example, public hospitals seem to benefit more than private hospitals. In the South African context, public hospitals are often criticized for poorer performance with the country's two tier public/private system of healthcare. Public hospitals appear to benefit from EMR solutions which may substitute in such contexts for poorer administrative capacity and constrained clinical resources. Smaller as opposed to larger hospitals also seem to benefit from the use of EMR systems. This suggests that the EMR technology can be made more available and its use more enforceable in smaller hospitals than in larger hospitals. Future research is needed to continue to understand why this important relationship is negative under certain conditions and based to certain hospital characteristics. The diffusion of EMR systems into hospital contexts are not necessarily a solution to performance challenges.

5.4.2 Infusion and Hospital Performance

Studies such as Zhu et al. (2006) and Kraemer et al. (2006) show that organisations who have institutionalised technology within their business activities achieve more benefits from the technology. Other researchers such as Lenhart et al. (2000) also note that hospital organisations in

particular that have fully functional EMR systems supporting their processes achieved reduced administrative costs and less patient errors.

This study had therefore hypothesised that the infusion of EMR systems was positively related to hospital performance. This hypothesis was also not supported. While the results supported that there was a significant relationship between the infusion of EMR systems and hospital performance, this relationship was found to be negative, moderated by the size of hospital (small, medium or large), the type of hospital (private or public) as well as the location of the hospital (urban or rural). Infusion of EMR systems in private hospitals had a negative relationship with performance, and EMR systems infusion in large hospitals was also negatively related to performance. Likewise hospitals in urban areas had EMR systems infusion negatively affecting their performance.

These results may suggest a number of things. They may suggest EMR systems infusion is beneficial under certain conditions and in selected contexts, whilst detracting from performance in others. In other words, certain factors moderate the impact of EMR systems infusion on hospital performance, therefore suggesting that embedding hospital processes into the EMR systems might be beneficial for certain types of hospitals and not for others. As this study's scope did not include an in-depth assessment of this, it has been recommended as future research possibilities.

5.5 What are the indirect effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction, through improved information management capabilities?

Ravichandran and Lertwongsatien (2005) and Zhang (2006) suggest that information systems and technologies will influence certain organisational capabilities, which in turn affect performance. This study has hypothesised that one capability that these IS&T will influence is a hospital's information management capability. This information management capability is seen as a core capability in hospitals as hospitals are information intensive dealing with large volumes of patient data. Mithas et al. (2011) have defined this capability as the ability to provide data and information to users with the appropriate levels of accuracy, timeliness, reliability, security, confidentiality, connectivity, and access. Patient data, such as patients' medical history, is an integral part of the care giving process. As such hospitals rely on their capability to collect, store, update, retrieve and share their patient data with the relevant healthcare providers to perform.

This study had hypothesised that this information management capability is positively related to hospital performance. Findings supported this hypothesis. The findings are consistent with prior research that the ability to manage information leads to a number of benefits, such as reduced costs, improved communications among stakeholders involved in the care delivery to the patient, patient satisfaction, as well as an improvement in patient safety through reduced patient errors.

5.5.1 Diffusion and Information Management Capability

The study hypothesised that the level of diffusion of EMR systems is positively related to the information management capability. Diffused EMR systems were expected to lead to better information management capability, as diffused EMR systems enable organisational members to share and disseminate information easier. They also enable quicker and cost-efficient communications (Miller and Tucker, 2009). Diffused EMR systems lead to patient data becoming available as and when it is needed.

This study found a negative relationship between EMR diffusion and information management capability except among smaller, rural, and public hospitals where the effect was positive. This suggests that EMR diffusion is necessary for improved information management only under certain conditions, whilst in other contexts EMR systems might actually detract from performance. For example, large urban hospitals may already be invested in established practices for handling patient and clinical records. EMR systems may not been seen to add value and might actually obstruct some traditional clinical practices.

Likewise, on the other hand, public hospitals which have been traditionally criticized for poorer practices, and where continuity of care records are severely lacking, are likely to benefit more from EMR systems than private hospitals who are already invested in EMR systems. The hypothesised relationship was therefore not supported. Future research would do well to find out the underlying reasons for this effect.

5.5.2 Infusion and Information Management Capability

This study also hypothesised that the level of infusion of the EMR system is positively related to the hospital's information management capability. Infusion of EMR systems was defined as the extent to which the EMR system has been comprehensively embedded into the hospitals' processes leads to enhanced information management capability. If used frequently, EMR systems are theorized to improve how the hospital captures, stores, updates, retrieves, and disseminates patient information among healthcare givers. The more the hospital processes and activities are being supported by the EMR system, the more enhanced its information management capability was expected to be. The

results showed that indeed this relationship was significant and also positive, hence the hypothesised relationship was supported. Hospitals that comprehensively embedded the EMR system within their processes are able to enhance their ability to manage clinical and patient information.

These results are significant because they support what a number of research scholars have found in that it is not just the availability of the technology (diffusion) that impacts performance but rather the comprehensive use of it (infusion). By embedding the technology within their processes, organisations create a situation where their organisational members need to use the technology to perform their routine activities, and as such benefit from the technology. Hospital organisations do well to have the systems made available across their units but for them to achieve significant benefits, they need to ensure that the technology is comprehensively embedded within their processes, such that a large percentage of the activities they do is supported by the technology.

5.6 Revised model

The results of the study led to a revised model of the impacts of diffusion and infusion of EMR systems on hospital performance. As can be noted on the revised diagram below, patient safety construct was dropped and clinical effectiveness was split into two dimensions – clinical effectiveness of processes and clinical effectiveness of teamwork. The model confirms the significant role played by information management capability in driving hospital performance. Moreover, it illustrates that infusion is important to an enhanced information management capability.

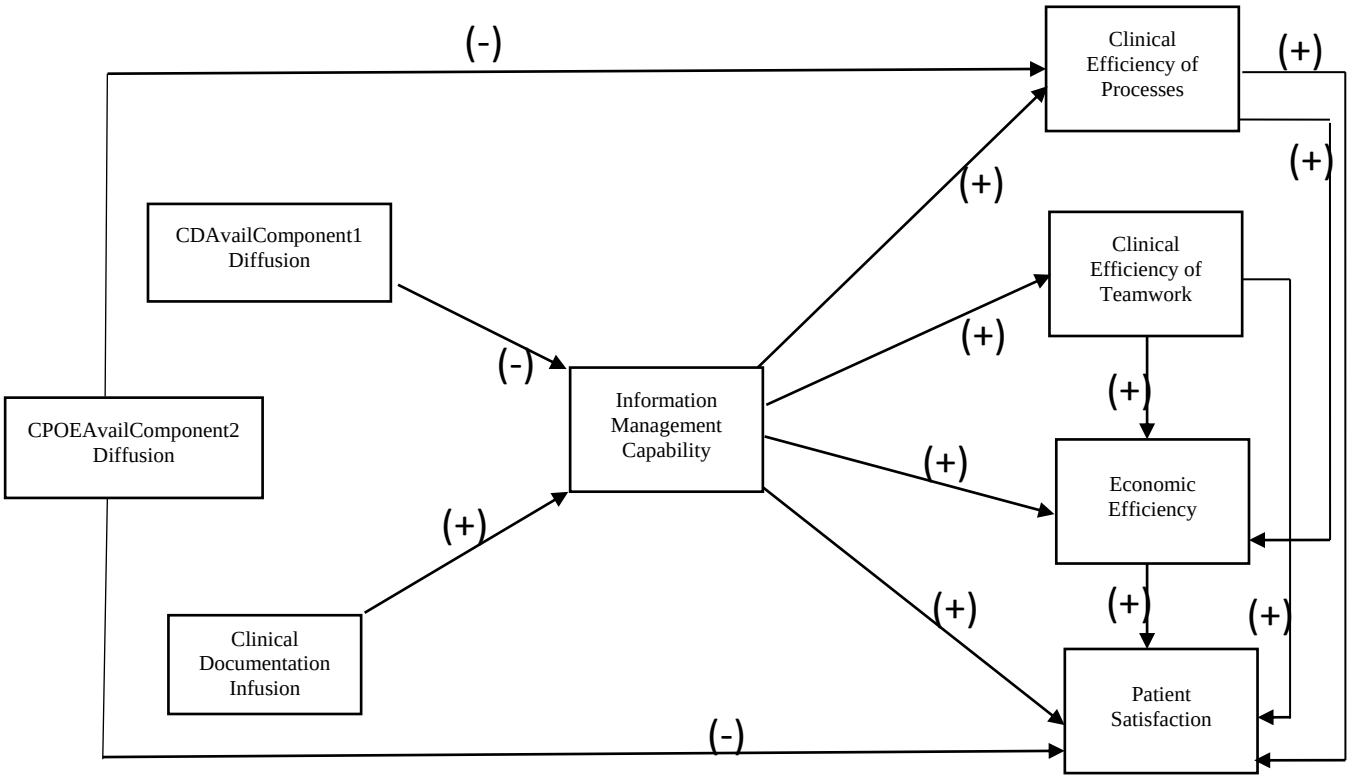


Figure 4: Revised model

5.7 Conclusion

Five hypotheses were proposed for this study. Of these, only two were supported. While results showed a significant relationship between the diffusion of the EMR systems and hospital performance, this relationship was found to be negative, suggesting that although this diffusion of EMR systems has a significant effect on hospital performance, this effect may not be the expected or desired effect. Large hospitals, private hospitals, hospitals in urban areas did not positively benefit from diffusing their EMR systems across their hospitals.

The hospital's information management capability was found to be positively related to the performance of the hospital. In this study it was found to significantly impact the economic efficiency of the hospital, the clinical effectiveness of processes and teamwork processes, and the reported patient satisfaction. These results are consistent with the resource-based view of the firm that suggest that IS&T, as a resource, have a significant impact on certain core capabilities that will in turn influence the performance of the organisation. Hospitals therefore do well to consider this capability as critical. Their ability to capture, store, retrieve, and share clinical and patient information with care-givers is an important competency as it significantly impacts a considerable number of hospital performance indicators.

6 Chapter 6 – Summary and conclusion

6.1 Introduction

This cross-sectional quantitative study was aimed at assessing the impact of IS&T in hospital organisations. This last chapter summarises the research work done to address the study's research questions and objectives. It summarises key findings and the implications of these findings for hospital organisations. The contribution of the study to existing knowledge is also highlighted. Lastly this chapter will also highlight the study's limitations and propose opportunities for future research.

6.2 Research questions revisited

The study set out to address two main research objectives, namely to describe the current state of EMR systems in the hospitals of South Africa and to assess the extent to which the diffusion and infusion of EMR systems impacts the performance of hospitals in South Africa.

To address the first objective, two research questions were developed.

1. What is the current state of EMR systems diffusion in hospitals of South Africa?
2. What is the current state of EMR systems infusion in hospitals of South Africa?

The results collected revealed that South African hospitals were moving towards the basic requirements of EMR systems as 14% had basic EMR systems highly diffused. A quarter (25%) of hospitals had moderately diffused EMR systems within their hospitals and 37% had basic EMR systems available in at least one clinical unit. Only twenty-five[14] percent of hospitals did not have basic EMR systems in place.

On the other hand 19% of hospitals had highly diffused comprehensive EMR system, with 10% having moderately diffused comprehensive systems. 9% of hospitals had comprehensive EMR systems available in at least one clinical unit. A sizeable 61% of hospitals did not have comprehensive EMR systems in place.

However, other functionalities of direct data entry, such as patients' ability to view their medical records electronically as well as updating patient demographics remain a high potential area of use.

Although calculating an overall infusion score was not possible due to the varying number of hospitals that were actually able to report on the extent of processes supported by the EMR system, specific module results show that only the Administrative Support module was highly infused in more than half of the hospitals. The Administrative Support module enables hospitals to perform administrative processes such as registering patients, billing, and handling other financial issues. This high level of infusion is not surprising as many hospitals in South Africa have a centralised administrative support function (Ruxwana et al. 2010).

[14] Due to rounding off figures do not equal 100% but 101

Likewise the results reflected that the Computerised Physician Order Entry (CPOE) module was the least infused module. Again these results are consistent with prior studies which also showed that although CPOE tend to be highly diffused i.e. available, their use by clinical practitioners to support their processes is low.

The second objective was addressed through two research questions.

1. What are the direct effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction?
2. What are the indirect effects of EMR systems diffusion and infusion on hospitals' economic efficiency, clinical effectiveness, patient safety, and patient satisfaction, through improved clinical and patient information management capabilities?

Results revealed that diffusion of EMR systems had a surprising negative effect on hospital performance. However, moderator analysis revealed that the effect is negative for hospitals that are private, large, and / or in urban areas.

The infusion of EMR systems, on the other hand, did not have any direct effects on hospital performance.

With respect to the second research question, results showed that the infusion of EMR systems has significant positive effects on hospital performance by influencing the hospital's information management capability. The effect of diffusion on information management capability was moderated such that the effect was negative for private, large, and urban-based hospitals.

6.3 Key implications of findings

The study has shown that the availability of EMR systems, as well as their infusion, has an impact on performance. Therefore public hospitals, as well as small hospitals, and hospitals in rural areas need to embed their EMR systems within their processes to see impacts on performance.

Further research is needed to understand why EMR systems may be having a negative effect on large hospitals, private hospitals, and hospitals in the urban areas. One possible explanation, as mentioned in the previous chapter, could be that larger hospitals may have processes that have been in place for longer which enable staff to work-around EMR systems.

The results also highlight an important competency that hospitals need to acknowledge and enhance; that of clinical and patient information management. The hospital's ability to collect, store, retrieve, and disseminate patient information has a significant effect on performance. Hospitals need to consider how best IS&T can enhance this capability, as it has a significant impact on performance. This study found that EMR infusion as opposed to diffusion is important here i.e. the infusion of EMR

systems had a positive effect on the hospital's information management capability to manage its information. Hospitals should therefore take steps to encourage the use of EMR systems within their hospitals. This remains a very difficult issue as other researchers such as Blumenthal and Tavenner (2010) have also noted that even incentives provided by governments do not necessarily translate to meaningful use of EMR systems, as the systems themselves have to evolve and mature to meet real-world challenges that are taking place in the hospital settings. However, research such as this study, is showing where the impacts are and hospitals do well in focusing where there is evidence of benefits. Eder and Igbaria (2001) suggests among other things, a strong management communication that a technology be used. While this study has not looked at the management attitude towards EMR systems, it is worth mentioning that the least infused functionalities are those that need to be used by clinicians, whilst the most infused are the ones used for administrative functions. As mentioned earlier, it would seem either clinicians have a greater need for information systems that will support their interaction with patients than they need information systems that will provide them with their practice guidelines and alerts, or hospitals are investing more in systems that relate to patients than in decision support systems that are focused on their clinicians. More research is needed to find out why clinicians may not be using the systems.

Overall, the results suggest that the hospital's ability to collect, store, retrieve and disseminate patient information across the hospital is an important capability. They suggest that this capability has a significant effect on several hospital performance indicators, whereas the availability of IS&T across the hospital has an impact on some hospital performance indicators. Likewise, the comprehensive embedding of technology into hospital processes, termed infusion, has a significant impact by impacting this information management capability. Hospitals must therefore consider how best to use IS&T to enhance this capability.

The section discusses the key contributions that this study makes.

6.4 Contributions of the study

The study makes the following contributions;

6.4.1 Contribution to theory

This study has empirically tested the effects of EMR systems on hospital performance. Results thereof provide further evidence of IS&T impacts on organisational performance and on core competencies. Consequently, the study suggests a parsimonious model for assessing EMR systems' impacts on performance.

The study also integrates a number of constructs into this parsimonious model. These constructs are borrowed from the diffusion theory, the resource-based view of the firm theory, and organisational

theories. Specifically, the study has adapted the concepts of diffusion from Ash (1997) and Zmud and Apple (1992) and has operationalised these concepts. Future studies can further examine the operationalisation of these concepts.

Drawing from the resource-based view of the firm, the study found that effects on organisational competencies can be moderated by among other things the size of the organisation, its location, and its ownership status. Therefore a contingent resource-based view theory is needed.

6.4.2 Contribution to practice

Importantly, this study highlights a significant organisational capability termed information management capability, as the link between the diffusion and infusion of EMR systems and hospital performance.

The study has also provided a set of measures that hospitals looking to evaluate and track their progress with regards to the diffusion and infusion of their EMR systems can use. More over the study results showed that EMR systems can be more beneficial for small or medium hospitals than they could be for large hospitals.

Thirdly, the study has provided key indicators that can be used to assess information management capability.

6.4.3 Contribution to context

The study also provides insights on the diffusion and infusion levels of EMR systems in South African hospitals. Past studies such as the Robert Wood Johnson Foundation Report (2009), have lamented the unavailability of data relating to EMR systems in South African hospitals. This study contributes significantly to this scarce information. Specifically, it established that the current state of comprehensive EMR systems diffusion is relatively low, while on the other hand hospitals have made some meaningful investments into basic EMR systems. The study also established that the current state of EMR infusion is generally low, with administrative processes such as patient billing being the major hospital activities that are well supported by EMR systems.

Also, it highlights that the effects of EMR diffusion and infusion vary across the two-tier public/private system operating in South Africa with EMR system diffusion found more important to driving the performance of under-resourced public than private hospitals.

The next section highlights some of the limitations of this study.

6.5 Limitations of this study

This was a correlational study which is cross-sectional and as such the responses were obtained at one point in time. This presents a limitation for the establishment of causality because temporal precedence cannot be confirmed.

This cross-sectional nature of the study also presents a limitation as there was a significant time gap between data gathering and eventual publication of the results. Given certain aspects of the phenomenon that was being explored (availability and use of EMR systems), this time gap may be important. As such, the actual levels of availability and use may have now shifted.

Secondly, this study was restricted to sampling private and public hospitals whose details were publicly available and therefore the results may not necessarily be generalised to all hospitals, especially private hospitals who may not be members of HASA. Likewise, it cannot be generalised to all hospitals who did not respond. Due to a network problem with one of the private hospital groups, a number of questionnaires could not be matched. This also limited the sample size available for testing the study's research model.

Thirdly, there is a possibility of subjective responses by key informants. Although this was partially addressed by splitting the questionnaire and using multiple respondents to reduce common method bias, data collected from self-reports tend to be subjective, compared to objective data. This is much the case in subjective measures such as patient satisfaction, whose data was gathered from the organisation rather than from the patients themselves.

Finally, given that participation in the study was voluntary, there may have been a self-selection bias where only a certain type of organisations responded e.g. those that are performing well, as such not all the population is analysed.

Having looked at the limitations of the study, the next section discusses recommendations for future research.

6.6 Future research recommendations

Future researchers may consider replicating the study in different contexts. As this study focused on private and public hospitals in South Africa, it is recommended that future research considers replicating the study in a different context, such as a developed country.

Furthermore, studies specific to the private sector or to the public sector are recommended. As highlighted earlier, the conceptualization of hospital performance has been varied and these two sectors may have different interpretations which may be explored further in sector-specific studies.

This study also presents a revised theoretical model which future researchers may empirically test.

A longitudinal study is also recommended to counter one of the limitations of this study. Such a study would provide more insights especially on the impacts of diffusion and infusion. Given that these two phenomena are processes that evolve over time, with their levels dynamically changing within the organisation, it would be interesting to see how these changes in levels over time affect performance. Such a study would be helpful in the assessment of EMR systems impacts on hospital performance.

Future research may also target a larger response rate, especially matched responses. Although this exercise can be strenuous, matched questionnaires do eliminate a number of biases which single respondent questionnaires may not adequately address.

A qualitative study would be useful to examine the underlying reasons behinds the negative effects observed between some of the independent variables and performance. This could further enrich our understanding of how EMR systems come to influence hospital performance and the conditions under which EMR systems are most likely to benefit adopting hospitals.

Future research can also critically analyse and explore the clinical and patient information management construct. Future research could look at how it has been conceptualised and measured, as the results from this study suggest this capability is a key link between IS&T and hospital performance.

It is also recommended that future research look at how hospital performance is conceptualised. This study had initially employed four performance indicators but further analysis led to another indicator (clinical effectiveness of teamwork). This highlights the complicated nature of assessing hospital performance as it suggests there can be other measures of performance. There is a need to continuously explore how hospital performance can be conceptualised and measured.

Future research could also look at other IS&T factors that have a significant influence on the hospital's information management capability. While this study focused on only two aspects, namely the diffusion and infusion of a specific type of IS&T, namely EMR systems, future research could consider other types of IS&T as well as aspects related to information systems and technologies e.g. the compatibility of the technology with clinical and administrative work practices.

6.7 Conclusion

This study contributes to the literature on the current state of the use of hospital IT systems in South Africa and their impacts on hospital performance. This study used diffusion theory, the resource-based view of the firm, and organisational theories to develop and empirically test a model that assessed the impact of EMR systems on hospital performance.

South African hospitals have some way to go in ensuring that their EMR systems are used. While they have made progress in diffusing basic EMR systems, their infusion into hospital processes remains a challenge. While widespread diffusion may not benefit all types of hospitals, results suggest that greater levels of infusion of EMR systems are necessary before South African hospitals can benefit from improved performance. Hospitals need to continuously seek ways of ensuring that their EMR systems are used as this enhances the hospital's ability to capture, store, and disseminate vital patient and clinical information, in the process positively impacting their performance.

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Appendix A – Performance Measures

Table A1 showing performance dimensions measured in previous studies.

Source	Tool	Constructs
Veillard et al. (2005) World Health Organization (Europe)	Performance Assessment Tool for Quality Improvement in Hospitals (PATH)	1.Clinical Effectiveness 2.Efficiency 3.Staff Orientation 4.Reponsiveness 5.Governance 6.Patient Safety 7.Patient Centeredness
Fottler (1987)	Conceptual Framework on Healthcare Organisation Performance	1.Productivity 2.Cost Efficiency 3.Clinical Quality 4.Patient Satisfaction 5.Employee Attitudes and Behaviour 5.Adaptability and Survival 6.Financial Outcomes
Bryan et al. (1998)	Conceptual Framework for Restructuring Outcomes	1.Patient Satisfaction 2.Practice Environment 3.Clinical Measures of Quality 4.Cost of Care / Length of Stay
Harber (1998)	The Balanced Scorecard	1.Patient Satisfaction 2.Team Member Motivation and Satisfaction 3.Accessibility and Responsiveness 4.Productivity and Utilization Management 5.Financial Performance 6.Community Health Leadership 7.Enrivonmental Leadership
Trinh and O'Conner (2002)	Simplified Model of Environmental and Organizational Characteristics, and Strategic Change on Performance	1.Market Share 2.Operational Efficiency 3.Financial Performance
Australian Council on Healthcare Standards	ACHS	1.Clinical Effectiveness 2.Safety 3.Efficiency
Quality Indicator Project - USA	QIP	1.Clinical Effectiveness 2.Efficiency 3.Patient Centeredness 4.Safety

Table A2 – Multiple dimensions of hospital performance.

Source	Example of measure
Powell and Dent-Micallef (1997)	Over the past 3 years, we have been more profitable than our competitors. (1 – 5 Strongly agree to Strongly Disagree)
Raju and Lonial (2001)	In general, our hospital's past 3 years performance rates (1 =very low 5=very high)
Narver and Slater (1990)	Compared to your competitor, how would you rate your return on investment
Jaworki and Kohli (1993)	Overall performance relative to competitors (5 point scale: poor to excellent)
Armstrong and Sambamurthy (1999)	How would you evaluate your firm's performance in applying IT to support each of the following business strategies relative to other firms in your own industry (1 -10 scale)

Appendix B

Table B1 – Summary of public hospitals across South African provinces.

Province	**Number of hospitals**	**Province**	**Number of hospitals**	**Province**	**Number of hospitals**
Eastern Cape	**92**	KwaZulu - Natal	**71**	Northern Cape	**27**
Free State	**32**	Limpopo	**43**	North-West	**28**
Gauteng	**31**	Mpumalanga	**33**	Western Cape	**43**

Appendix C - Summary of comments from Pilot Test

Pilot- Test Participants	Comments
1.Private hospital	Part A. Scales: Fully implemented across ALL units. Must qualify ALL because some units do not need the systems e.g. HR, Finance, and some clinical departments. Part A. Scales: Although fully implemented (fully available) paper documents still being used e.g. for discussions. Qualify replaced paper. Part A. Scales: consider situation where resources are available but the functionality will not be made available e.g. Patients having access to medical records. Part A. Scales: consider scale to capture where functionality is not in place and respondent is not aware whether it is being considered / not considered for implementation. Part A. Q2. Qualify Results viewing (b) and Reporting (h). Although linked to Q1, results viewing can be lab results, or radiology results Part A. Q4. Most (name of hospital) hospitals call it HIS, not EMR systems. Consider sticking to computerised systems. Part A. Q4 and 5: May not know, unless they ask around. Part B Scales : for some departments the systems are Fully implemented but have not yet replaced paper (meaning they are available for use but doctors / nurses still print out hard copies for discussions). Consider a scale to capture that.
2.Public Hospital 1	Part A. Scales: Consider situation where it is fully implemented (to mean fully available) but not being used. Part A. Scales: Consider Not in Place scale for where respondent is not aware whether it is being considered /not considered for implementation. Part A Administrative Support part b. Some are supported whilst others are not. Part B: Consider situation where the systems are fully implemented but they have not replaced paper (Meaning fully available for use but hard copies still printed out of the system for use). Part C : Consider including scale to capture not in place (without "Not considering to make available") Part C: Telemedicine. Distinguish it from Tele-health. Tele-health is the most common term in government systems.
3.Public Hospital 2	Part A. Scales: Consider fully implemented but not being used. Part A. Scales: Consider Available rather than fully implemented. Fully implemented means replaced paper, which may not be the case. (use same scale as Part C) Part A. Q2 Consider scale to capture not available Part B. Scales: Consider Fully Implemented but (i.) not used or (ii.) not yet replaced paper). **NOTE : Fully implemented means fully available**

Appendix D – Public Hospital Administrator Questionnaire



TITLE

THE CURRENT STATE OF ELECTRONIC MEDICAL RECORD SYSTEMS AND THEIR IMPACTS ON THE PERFORMANCE OF HOSPITALS IN SOUTH AFRICA

HOSPITAL ADMINISTRATION

QUESTIONNAIRE

Directions: Please complete the questionnaire by placing a tick in the box that most closely represents your organisation's position

PART A: GENERAL INFORMATION ABOUT YOUR ORGANISATION

1. What is your job title

☐ Chief Executive / General Manager ☐ Hospital Administrator ☐ Chief Medical Officer ☐ Operations Head

☐ Matron ☐ Unit Manager ☐ Other (please specify) _____

2. For how many years have you been with this hospital? years

3. What type of ownership structure is in place?

☐ Provincially aided ☐ Public Hospital ☐ Private Public Partnership

☐ Other (please specify)

4. What kind of facility is your organisation?

☐ First Level Hospital (no ICU) ☐ Second Level Hospital (at least one specialty unit) ☐ Second Level Hospital (at least 5 specialty units)

☐ District Hospital ☐ Specialised Hospital (e.g. Rehab, Psychiatric, T.B) ☐ Academic / Teaching Hospital

☐ Provincial Hospital ☐ Other (please specify)

5. Approximately how many employees (both clinical and non-clinical/ administrative) are directly employed at your hospital?
Please Select employees

6. For how many years has your facility been operating? years

7. What is the approximate number of physicians in your facility? Please Select physicians

8. What is the approximate number of nurses in your facility? _____nurses

9. What is the approximate number of inpatient / acute care beds? _____beds

10. What is the approximate number of outpatient visits per day? _____visits

11. Which approach(es) does your facility take towards coordinating the delivery of care? (Place an X next to as many as appropriate)

☐ Case Management ☐ Multidisciplinary Teams ☐ Disease Management Programs

☐ Other (please specify)

12. Where is your facility situated?

☐ Eastern Cape ☐ Gauteng ☐ Western Cape ☐ North West

☐ Free State ☐ Limpopo ☐ Kwazulu-Natal ☐ Mpumalanga

☐ Northern Cape

13. Is your facility in an urban or rural Community?

☐ Urban ☐ Rural

PART B. ORGANISATIONAL PERFORMANCE

This section explores your facility's performance across a number of key indicators.

1. **Please indicate (by placing a tick) the extent to which you agree / disagree with each of the following statements**

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
Our facility performs very well at capturing clinical data	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at capturing patient details (e.g. demographics)	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at ensuring access to patient information anytime anywhere	☐	☐	☐	☐	☐	☐	☐
Sharing of patient information across internal departments is performed very well in our facility	☐	☐	☐	☐	☐	☐	☐
Sharing of patient information with external facilities is performed very well in our facility	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at protecting patient data from unauthorised access	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at protecting patient data from inappropriate use	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at maintaining a comprehensive audit trail of clinical data	☐	☐	☐	☐	☐	☐	☐
Our facility has very good administrative workflow processes	☐	☐	☐	☐	☐	☐	☐
Overall, we are satisfied with our information management processes	☐	☐	☐	☐	☐	☐	☐
Our Electronic Medical Record systems adequately support our clinical workflow	☐	☐	☐	☐	☐	☐	☐
Our Electronic Medical Record systems align well with our processes	☐	☐	☐	☐	☐	☐	☐
We are generally satisfied with the support provided by our Electronic Medical Record systems	☐	☐	☐	☐	☐	☐	☐
Our facility almost always meets its patient care treatment goals	☐	☐	☐	☐	☐	☐	☐
Given the severity of the patients we treat, our facility's patients experience very good outcomes	☐	☐	☐	☐	☐	☐	☐
Our facility does a good job applying the most available technology to patient care needs	☐	☐	☐	☐	☐	☐	☐
Our facility's clinical units function well together as a team	☐	☐	☐	☐	☐	☐	☐
Our facility is very good at responding to emergency situations	☐	☐	☐	☐	☐	☐	☐
Overall, we are satisfied with our clinical effectiveness	☐	☐	☐	☐	☐	☐	☐
We are satisfied that the expended **physician** time per patient visit is neither too high nor too low.	☐	☐	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
We are satisfied that the expended **nursing** time per patient visit is neither too high nor too low.	☐	☐	☐	☐	☐	☐	☐
We are satisfied with the total payroll expenditure for all personnel (excluding physicians) per patient visit	☐	☐	☐	☐	☐	☐	☐
We are satisfied with the current total cost to the facility of an average patient visit.	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average revenue per bed	☐	☐	☐	☐	☐	☐	☐
Overall, our financial performance is very good	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average wait times (time between patient arriving and being attended by physician)	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average length of stay (time from admission to discharge)	☐	☐	☐	☐	☐	☐	☐
Our procedures and systems are good at preventing errors from happening	☐	☐	☐	☐	☐	☐	☐
We have fewer preventable falls, infections, or medical errors than do similar private hospital facilities	☐	☐	☐	☐	☐	☐	☐
Facility units work well together to provide the best care for patients	☐	☐	☐	☐	☐	☐	☐
Facility units do not coordinate well with each other	☐	☐	☐	☐	☐	☐	☐
Overall, we are meeting our patient safety goals	☐	☐	☐	☐	☐	☐	☐
Our patients are very satisfied with the medical care we provide	☐	☐	☐	☐	☐	☐	☐
We are very satisfied with the service we provide to our patients	☐	☐	☐	☐	☐	☐	☐
The care our patients receive is just about perfect	☐	☐	☐	☐	☐	☐	☐
There are things about the medical care our patients receive that could be better	☐	☐	☐	☐	☐	☐	☐
Overall, we meet our goals for patient satisfaction	☐	☐	☐	☐	☐	☐	☐

THANK YOU FOR YOUR TIME AND YOUR PARTICIPATION IN THIS STUDY

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Appendix E – Private Hospital's Administrator questionnaire



TITLE

THE CURRENT STATE OF ELECTRONIC MEDICAL RECORD SYSTEMS AND THEIR IMPACTS ON THE PERFORMANCE OF HOSPITALS IN SOUTH AFRICA

HOSPITAL ADMINISTRATION

QUESTIONNAIRE

Directions: Please complete the questionnaire by placing a tick in the box that most closely represents your organisation's position

PART A: GENERAL INFORMATION ABOUT YOUR ORGANISATION

1. What is your job title

☐ Chief Executive / General Manager ☐ Hospital Administrator ☐ Chief Medical Officer ☐ Operations Head

☐ Matron ☐ Unit Manager ☐ Other (please specify)_____

2. What type of ownership structure is in place?

☐ Independent Facility ☐ Part of a Public Listed Group ☐ Part of a non-listed Group

☐ Other (please specify)

3. What kind of facility is your organisation?

☐ First Level Hospital (no ICU) ☐ Second Level Hospital (at least one specialty unit) ☐ Second Level Hospital (at least 5 specialty units)

☐ Tertiary Hospital ☐ Specialised Hospital (e.g. Rehab, Psychiatric, T.B) ☐ Academic / Teaching Hospital

☐ Day Clinic ☐ Other (please specify)

4. Approximately how many employees (both clinical and non-clinical/ administrative) are directly employed at your facility (this refers to your facility and not to your Holding Group)? Please Select employees

5. For how many years has your facility been operating? years

6. What is the approximate number of physicians in your facility? Please Select physicians

7. What is the approximate number of nurses in your facility? _____ nurses

8. What is the approximate number of inpatient / acute care beds? _____ beds

9. What is the approximate number of outpatient visits per day? _____ visits

10. Which approach(es) does your facility take towards coordinating the delivery of care? (Place an X next to as many as appropriate)

☐ Case Management ☐ Multidisciplinary Teams ☐ Disease Management Programs

☐ Other (please specify)

11. Where is your facility situated?

☐ Eastern Cape ☐ Gauteng ☐ Western Cape ☐ North West

☐ Free State ☐ Limpopo ☐ Kwazulu-Natal ☐ Mpumalanga

☐ Northern Cape

12. Is your facility in an urban or rural Community?

☐ Urban ☐ Rural

PART B. ORGANISATIONAL PERFORMANCE

This section explores your facility's performance across a number of key indicators.

1. **Please indicate (by placing a tick) the extent to which you agree / disagree with each of the following statements**

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
Our facility performs very well at capturing clinical data	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at capturing patient details (e.g. demographics)	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at ensuring access to patient information anytime anywhere	☐	☐	☐	☐	☐	☐	☐
Sharing of patient information across internal departments is performed very well in our facility	☐	☐	☐	☐	☐	☐	☐
Sharing of patient information with external facilities is performed very well in our facility	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at protecting patient data from unauthorised access	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at protecting patient data from inappropriate use	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at maintaining a comprehensive audit trail of clinical data	☐	☐	☐	☐	☐	☐	☐
Our facility has very good administrative workflow processes	☐	☐	☐	☐	☐	☐	☐
Overall, we are satisfied with our information management processes	☐	☐	☐	☐	☐	☐	☐
Our Electronic Medical Record systems adequately support our clinical workflow	☐	☐	☐	☐	☐	☐	☐
Our Electronic Medical Record systems align well with our processes	☐	☐	☐	☐	☐	☐	☐
We are generally satisfied with the support provided by our Electronic Medical Record systems	☐	☐	☐	☐	☐	☐	☐
Our facility almost always meets its patient care treatment goals	☐	☐	☐	☐	☐	☐	☐
Given the severity of the patients we treat, our facility's patients experience very good outcomes	☐	☐	☐	☐	☐	☐	☐
Our facility does a good job applying the most available technology to patient care needs	☐	☐	☐	☐	☐	☐	☐
Our facility's clinical units function well together as a team	☐	☐	☐	☐	☐	☐	☐
Our facility is very good at responding to emergency situations	☐	☐	☐	☐	☐	☐	☐
Overall, we are satisfied with our clinical effectiveness	☐	☐	☐	☐	☐	☐	☐
We are satisfied that the expended **physician** time per patient visit is neither too high nor too low.	☐	☐	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
We are satisfied that the expended nursing time per patient visit is neither too high nor too low.	☐	☐	☐	☐	☐	☐	☐
We are satisfied with the total payroll expenditure for all personnel (excluding physicians) per patient visit	☐	☐	☐	☐	☐	☐	☐
We are satisfied with the current total cost to the facility of an average patient visit.	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average revenue per bed	☐	☐	☐	☐	☐	☐	☐
Overall, our financial performance is very good	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average wait times (time between patient arriving and being attended by physician)	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average length of stay (time from admission to discharge)	☐	☐	☐	☐	☐	☐	☐
Our procedures and systems are good at preventing errors from happening	☐	☐	☐	☐	☐	☐	☐
We have fewer preventable falls, infections, or medical errors than do similar private hospital facilities	☐	☐	☐	☐	☐	☐	☐
Facility units work well together to provide the best care for patients	☐	☐	☐	☐	☐	☐	☐
Facility units do not coordinate well with each other	☐	☐	☐	☐	☐	☐	☐
Overall, we are meeting our patient safety goals	☐	☐	☐	☐	☐	☐	☐
Our patients are very satisfied with the medical care we provide	☐	☐	☐	☐	☐	☐	☐
We are very satisfied with the service we provide to our patients	☐	☐	☐	☐	☐	☐	☐
The care our patients receive is just about perfect	☐	☐	☐	☐	☐	☐	☐
There are things about the medical care our patients receive that could be better	☐	☐	☐	☐	☐	☐	☐
Overall, we meet our goals for patient satisfaction	☐	☐	☐	☐	☐	☐	☐

THANK YOU FOR YOUR TIME AND YOUR PARTICIPATION IN THIS STUDY

If you would like to participate in future phases of this study, or receive a copy of the report of this study, please send a separate email message to Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com

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Appendix F – Hospital Information Systems (HIS) Questionnaire



TITLE

THE CURRENT STATE OF ELECTRONIC MEDICAL RECORD SYSTEMS AND THEIR IMPACTS ON THE PERFORMANCE OF HOSPITALS IN SOUTH AFRICA

HOSPITAL INFORMATION SYSTEMS

QUESTIONNAIRE

Directions: Please complete the questionnaire by placing an X in the box you think most closely represents your facility's position.

PART A - ELECTRONIC MEDICAL RECORDS (EMR) AVAILABILITY AND USE

This section asks about the extent to which EMR / Computerised systems are available in your facility's various units to support a number of functions

1. To what extent are computerised systems within your facility available for:

	Available in all relevant clinical units*	Available in a majority of clinical units	Available within at least one but not the majority of clinical units	Already beginning to make available	Planning to make available within a year	Not in Place
Clinical Documentation and Health Data						
a. Maintaining Patient Demographics	☐	☐	☐	☐	☐	☐
b. Maintaining Clinical Notes	☐	☐	☐	☐	☐	☐
c. Maintaining Active Diagnoses	☐	☐	☐	☐	☐	☐
d. Maintaining Current Procedures	☐	☐	☐	☐	☐	☐
e. Maintaining Nursing Assessments	☐	☐	☐	☐	☐	☐
f. Maintaining Problem Lists	☐	☐	☐	☐	☐	☐
g. Maintaining Active Medication Lists	☐	☐	☐	☐	☐	☐
h. Maintaining Discharge Summaries	☐	☐	☐	☐	☐	☐
i. Maintaining Advanced Directives (e.g. DNR)	☐	☐	☐	☐	☐	☐
Results Viewing						
a. Viewing Lab Reports	☐	☐	☐	☐	☐	☐
b. Viewing Radiology Reports	☐	☐	☐	☐	☐	☐
c. Viewing Radiology Images	☐	☐	☐	☐	☐	☐
d. Viewing Diagnostic Test Results (e.g., EKG report, Echo report)	☐	☐	☐	☐	☐	☐
e. Viewing Diagnostic Test Images (e.g., EKG tracing)	☐	☐	☐	☐	☐	☐
f. Viewing Consultant Reports	☐	☐	☐	☐	☐	☐
Computerised Physician Order Entry						
a. Ordering Laboratory Tests	☐	☐	☐	☐	☐	☐
b. Ordering Radiology Tests	☐	☐	☐	☐	☐	☐
c. Entering Medication Orders	☐	☐	☐	☐	☐	☐
d. Entering Consultation Requests	☐	☐	☐	☐	☐	☐
e. Entering Nursing Orders	☐	☐	☐	☐	☐	☐

*All relevant clinical units refers to clinical units that require the functionality, not necessarily all clinical units within the hospital.

	Available in all relevant clinical units*	Available in a majority of clinical units	Available within at least one but not the majority of clinical units	Already beginning to make available	Planning to make available within a year	Not in Place
Decision Support						
a. Providing Clinical Guidelines	☐	☐	☐	☐	☐	☐
b. Providing Clinical Reminders (e.g., pneumovax)	☐	☐	☐	☐	☐	☐
c. Providing Drug Allergy Alerts	☐	☐	☐	☐	☐	☐
d. Providing Drug-Drug Interaction Alerts	☐	☐	☐	☐	☐	☐
e. Providing Drug-Lab Interaction Alerts	☐	☐	☐	☐	☐	☐
f. Providing Drug Dosing Support (e.g., renal dose guidance)	☐	☐	☐	☐	☐	☐
Electronic Communication and Connectivity						
a. Enabling Physician to Physician Communication	☐	☐	☐	☐	☐	☐
b. Enabling Patient to Physician Communication	☐	☐	☐	☐	☐	☐
c. Enabling Facility to External Parties (e.g. Pharmacy, Laboratory, Medical Insurer) Communication	☐	☐	☐	☐	☐	☐
Integrated Patient Support						
a. Supporting Patient education (patient having access to educational material)	☐	☐	☐	☐	☐	☐
b. Supporting Family and informal caregiver education	☐	☐	☐	☐	☐	☐
c. Supporting direct data entry by patient, family, and/or caregiver (e.g. demographics, medical history)	☐	☐	☐	☐	☐	☐
d. Patient Access to medical record (e.g. Viewing of medical record)	☐	☐	☐	☐	☐	☐
Administrative Support						
a. Supporting Inpatient and Outpatient administrative procedures	☐	☐	☐	☐	☐	☐
b. Supporting Scheduling management (for 1 or more of the following; Hospital admissions, Appointments, Surgery / Procedure scheduling)	☐	☐	☐	☐	☐	☐
c. Supporting Payment Determination (Medical Aid, Co-Payment, Cash)	☐	☐	☐	☐	☐	☐
d. Supporting Billings and Claims Management	☐	☐	☐	☐	☐	☐
Reporting						
a. Reporting on Patient safety and quality.	☐	☐	☐	☐	☐	☐
b. Public health reporting	☐	☐	☐	☐	☐	☐
c. Maintaining Disease registries	☐	☐	☐	☐	☐	☐

*All relevant clinical units refers to clinical units that require the functionality, not necessarily all clinical units within the hospital.

2. Please indicate the current frequency of usage of the following functionalities.

	Used All the Time	Often Used	Sometimes Used	Hardly Used	Not Available to be Used	Not Sure
a. Clinical Documentation and Health Data	☐	☐	☐	☐	☐	☐
b. Results Viewing (of Diagnostic test results & test Images; radiology reports & images)	☐	☐	☐	☐	☐	☐
c. Computerised Physician Order Entry	☐	☐	☐	☐	☐	☐
d. Decision Support	☐	☐	☐	☐	☐	☐
e. Electronic Communication and Connectivity	☐	☐	☐	☐	☐	☐
f. Integrated Patient Support	☐	☐	☐	☐	☐	☐
g. Administrative Support	☐	☐	☐	☐	☐	☐
h. Reporting (for Patient Safety and Quality)	☐	☐	☐	☐	☐	☐

3. Please provide your best estimate for…

	0%	1-25%	26-50%	51-75%	76-100%	Don't Know / Not Sure
a. The percentage of patients at your facility for whom *clinical documentation* is written electronically	☐	☐	☐	☐	☐	☐
b. The percentage of patients at your facility for whom lab *results* are viewed electronically	☐	☐	☐	☐	☐	☐
c. The percentage of patients at your facility for whom *physician orders* are entered electronically	☐	☐	☐	☐	☐	☐
d. The percentage of **physicians** at your facilities who use electronic *decision support*	☐	☐	☐	☐	☐	☐
e. The percentage of **nurses** at your facilities who use electronic *decision support*	☐	☐	☐	☐	☐	☐
f. The percentage of **physicians** at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	☐	☐	☐	☐	☐	☐
g. The percentage of **nurses** at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	☐	☐	☐	☐	☐	☐
h. The percentage of patients at your facility performing *direct data entry* electronically	☐	☐	☐	☐	☐	☐
i. The percentage of *inpatient and outpatient administrative procedures* at your facility that are done electronically	☐	☐	☐	☐	☐	☐
j. The percentage of source data used in *public health reporting* that is collected electronically	☐	☐	☐	☐	☐	☐

4. If your facility has implemented any one of the above EMR system functionalities, in what year was it first introduced Please Select

5. How integrated are your EMR systems?

Not Integrated, Separate Modules	☐	Modules are able to share data	☐	Modules share a common interface	☐	Modules are fully integrated into a single facility-wide EMR system	☐

6. Approximately how long, in months, has it taken you to achieve your current level of integration? Please Select

7. To what extend have computerised electronic medical record systems replaced paper within each of the following units / departments?

	Has completely replaced paper	Has replaced paper for the most part	Available and replacing paper in many ways	Available but only replacing paper in some ways	Not implemented	Not Applicable
Emergency Department	☐	☐	☐	☐	☐	☐
ICU	☐	☐	☐	☐	☐	☐
General Medical / Surgical Wards	☐	☐	☐	☐	☐	☐
Specialty Ward - Obstetrics	☐	☐	☐	☐	☐	☐
Specialty Ward - Paediatrics	☐	☐	☐	☐	☐	☐
Other Specialty Wards	☐	☐	☐	☐	☐	☐
Onsite Ambulatory Practices	☐	☐	☐	☐	☐	☐

PART B : OTHER TECHNOLOGIES

This section asks about other technologies within your facility.
To what extent are the following technologies available across your facility?

	Available in all relevant clinical units*	Available in a majority of clinical units	Available within at least one but not the majority of clinical units	Already beginning to make available	Planning to make available within a year	Not in Place
a. Barcoding technology for laboratory specimens	☐	☐	☐	☐	☐	☐
b. Barcoding technology for patient identification	☐	☐	☐	☐	☐	☐
c. Barcoding technology for medication administration	☐	☐	☐	☐	☐	☐
d. I.T applications to control patient flow	☐	☐	☐	☐	☐	☐
e. I.T applications to monitor bed status	☐	☐	☐	☐	☐	☐
f. Telemedicine	☐	☐	☐	☐	☐	☐
g. Radio Frequency ID for tracking equipment	☐	☐	☐	☐	☐	☐
h. Physician use of personal digital assistant (PDA or tablets)	☐	☐	☐	☐	☐	☐
i. Check-in / Check-out or way-finding kiosks for use by patients	☐	☐	☐	☐	☐	☐

*All relevant clinical units refers to clinical units that require the functionality, not necessarily all clinical units within the hospital.

THANK YOU FOR YOUR TIME AND YOUR PARTICIPATION IN THIS STUDY

If you would like to participate in future phases of this study, or receive a copy of the report of this study, please send a separate email message to Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com

Appendix G – Cover letter accompanying Administrator Questionnaire (Private hospitals)

24th May, 2012

Dear *Ms. XXXXXXX– YYYYYY Hospital*

My name is Bheki Gule. I am a Masters Degree student at the University of the Witwatersrand, Johannesburg.

I am conducting a study into the ***current state of Electronic Medical Records (EMR) Systems*** and their ***impact on the performance*** of hospitals of South Africa. As Hospital Manager for YYYYYY Hospital, you are invited to participate in the study by completing the attached questionnaire.

This invitation to participate has been sent to a senior executive in each of the private hospitals registered as members of the Hospital Association of South Africa (HASA). In view of your knowledge, you are best positioned to report on the performance of your hospital and your response will be the most reliable for the purpose of this study.

A corresponding questionnaire has been sent to your hospital's I.T / Operations Manager (Ms. Alphabets Numbers) inviting her to respond on the availability and use of certain EMR system functionalities within your hospital facility.

Results of this study provide empirical evidence to help answer a key strategic question in the healthcare industry - ***whether EMR systems have any effect on hospital performance***; Results will also be relevant to you and will help you to benchmark your practices and your deployment of EMR technology. In appreciation for your contribution, I will provide you with an executive summary of the research results. You also have the opportunity to ***request a confidential report*** that assesses your organisation's EMR availability and usage levels and benchmarks your organisation against the sample.

Participation is voluntary but the success of the study is dependent upon your kind cooperation. If you choose to participate, the included questionnaire will take approximately ***15 minutes*** to complete. You are able to opt out of the survey at any point.

Please note that although each questionnaire is emailed, this will only be used to monitor returns, facilitate certain levels of analysis and to send you a summary of results. Confidentiality is guaranteed. Results will be reported only in aggregate format and neither your name nor that of your organisation will be identified anywhere in the report. All data collected in the study will be kept confidential and will not be used other than for the purposes of the study. A non-disclosure and confidentiality agreement will be provided on request.

This research has been approved unconditionally by the University of Witwatersrand Human Research Ethics Committee. The protocol number is H110930.

Should you have any questions or to receive a copy of the report of this study, please send a separate email message to Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com

Thank you for considering to participate. Your participation is highly appreciated. Completed responses can be submitted through email or by fax to 086-651-7291, preferably by ***Friday the 01st of June 2012***.

Yours Sincerely

Bheki Gule

Bheki S. Gule
Tel: 011 -717-8216
Cell: 071-979-8610
Fax: 086-651-7291

Supervisor: Prof Jason Cohen, 011-717-8164, Jason.Cohen@wits.ac.za

Appendix H – Cover letter accompanying HIS Questionnaire (Private hospitals)

24th May, 2012

Dear Ms CCCCC EEEEE

My name is Bheki Gule. I am a Masters Degree student at the University of the Witwatersrand, Johannesburg, and I am conducting research around the current state of Electronic Medical Records (EMR). More specifically, my research interests lie in the impact of EMRs on the performance of private hospitals in South Africa.

As a senior executive for YYYYYY Hospital, I would like to invite you to participate in the study by completing the attached questionnaire. This invitation to participate has been sent to you in view of your position and your knowledge on the availability and use of certain EMR system functionalities within your hospital.

A corresponding questionnaire is being sent to Ms. XXXXX YYYYYY, the Hospital Manager, inviting her to respond on Hospital YYYYY operations.

Together, your responses will be most invaluable in achieving the purpose of this study.

The results of this study will provide empirical evidence to help answer a key strategic question in the healthcare industry - whether EMR systems have any effect on hospital performance. You may also find that the results prove to be relevant and valuable to you, and may help you benchmark your practices. In appreciation for your contribution, I will provide you with an executive summary of the research results. You also have the opportunity to request a confidential report that assesses your organisation's EMR availability and usage levels and benchmarks your organisation against the sample of HASA members. For example, this report will benchmark your organisation's level of EMR technology usage in a number of processes, such as the percentage of your patients for whom clinical documentation is done electronically.

Your participation is voluntary at all times, and you are free to opt out of the survey at any point. If you choose to participate, the included questionnaire will take approximately 15 minutes to complete.

I would like you to also note that although each questionnaire is emailed, this will only be used to monitor returns, facilitate certain levels of analysis and to send you a summary of results. Confidentiality is guaranteed. This is achieved by results being reported only in aggregate format and neither your name nor that of your organisation will be identified anywhere in the study's reports. All data collected in the study will be kept confidential and will not be used other than for the purposes of the study. A non-disclosure and confidentiality agreement is attached.

This research has been approved unconditionally by the University of Witwatersrand Human Research Ethics Committee. The protocol number is H110930.

Should you have any questions before deciding to participate or should you wish to receive a copy of the report of this study, I would appreciate it if you could please send a separate email message to Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com .

Thank you for considering to participate. Completed responses can be submitted through email or by fax to 086-651-7291, preferably by Friday the 01th of June 2012.

Yours Sincerely

Bheki Gule

Masters by Research Student – Information Systems Division
Wits University, Johannesburg
Tel: 011 -717-8216
Cell: 071-979-8610
Fax: 086-651-7291

Supervisor: Prof Jason Cohen, 011-717-8164, jason.cohen@wits.ac.za Fax: 011-717-8139

Appendix I – Letter requesting Provincial permission to conduct study in a particular Province

Dear _____
Director for Policy Planning and Research

My name is Bheki Gule. I am a Master's Degree student in the Department of Information Systems at the University of the Witwatersrand, Johannesburg.

This introductory letter serves to inform you of a study I am pursuing. This phase of the study aims to assess the *current state of Electronic Medical Records (EMR) Systems* and their *impact on the performance* of hospitals of South Africa. EMR systems are sometimes called computerized hospital information systems, patient information systems; patient health record systems etc.
This phase is largely descriptive, reporting on the availability and use of EMR systems on a set of 8 core functionalities that EMR systems have.

My target respondents are all district, provincial, and tertiary hospitals in the _____Province. Health centres and clinics are excluded in this study.

To collect data I will be using two questionnaires. Both have been attached as part of this research approval request. One questionnaire will be directed to the IT/Operations personnel and will require responses o the availability levels and usage levels of EMR systems on the 8 core functionalities.

The other questionnaire will be directed to hospital administrators that can report on perceived performance against a set of 5 performance measures. The hospital administrators can be anyone in management that can report on perceived performance levels.

Each questionnaire should take not more than *15 minutes* to complete. There will be no added requirements from the hospital as the questionnaires will be printed out by the researcher as well as dropped in and picked up by the researcher.

Participation is voluntary, and there is no loss of benefit whether or not you choose to participate. Respondents can opt out of the survey at any point. There is no requirement to disclose the respondent's name or that of the respondent's hospital. Results will be reported only in aggregate format and neither the respondent's name nor that of their organisation will be identified anywhere in the report. All data collected in the study will be kept confidential and will not be used other than for the purposes of the study.

Aggregate results will be made available as a report to the Provincial Department. These results will be helpful in understanding the *impacts of EMR Systems in the South African context*, as well as help benchmark hospital EMR systems usage levels.

This research has been approved unconditionally by the University of Witwatersrand Human Research Ethics Committee. The protocol number is H130203. The ethics clearance certificate is attached with this request.

You will note that the original request was for the study to be conducted in private hospitals but after the pilot study it was discovered that public hospitals have the same systems as private hospitals, hence the addition of public hospitals into the sample.

Thank you for taking time to review this research request. Your participation as a province is highly appreciated.

Yours Sincerely
Bheki S. Gule

_____
Bheki S. Gule
Tel: 011 -717-8216
Cell: 071-979-8610

Supervisor: Prof Jason Cohen, 011-717-8164, jason.cohen@wits.ac.za

Appendix J – Letter granting permission to conduct study in Gauteng Province

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

BANK OF LISBON BUILDING
37 SAUER STREET JHB
PRIVATE BAG X085
MARSHALLTOWN
Tel: (011) 355 3500
Fax: (011) 355 3675

GAUTENG DEPARTMENT OF HEALTH
RESEARCH PROPOSAL EVALUATION FORM

Researcher Name	Bheki Gule
Researcher's contact details	email: Bheki.Gule@students.wits.ac.za
Institution	University of the Witwatersrand – Faculty of Commerce, LAW AND management
Research Topic	The current state of Electronic Medical Record systems and their impacts on the performance of hospitals in South Africa
Date Received by the Directorate PPR	23/01/2013
Date Received Reviewer	28/01/2013
Final Review Date	02/02/2013
Date Submitted to Director of PPR	04/02/2013
Research Site(s)	All public hospitals and private hospitals in Gauteng
Type of research	Descriptive

CRITERIA	YES	NO	COMMENTS
1. Is this research project within the scope of the Department of Health key policy priorities/directives?	X		
2. Content of Research: ▪ Original work	X		
▪ New facts, ideas	X		
▪ Confirmation of uncertain data	X		
▪ Repetition of known data and consequently of limited importance		X	
▪ Insufficient research information		X	
▪ Confusion of topics/questions		X	
3. Is the title of the research project suitable?	X		
4. Are the objectives of the research project adequate?	X		
5. Could the objectives be limited to better focus on the project's main objective?		X	
6. Writing style			
▪ The text of the proposal is clear	X		

1

CRITERIA	YES	NO	COMMENTS
▪ The references used are relevant, comprehensive and accurate	X		
▪ The spelling and grammar are correct	X		
▪ The language needs improvement		X	
▪ The research proposal needs re-styling and re-writing		X	
7. Are the research methods appropriate to the study?	X		
8. Is data collection method in line with the study design?	X		
9. Does the study have ethical approval? If yes, name the ethics committee.	X		
10. Is the definition and measurement of variables consistent with the scope of the proposal?	X		
11. Is the time frame of the proposal adequate to meet the objectives?	X		
12. Is the method of dissemination of the results of the research project stated?		X	It is recommended that the researchers specify how the results will be shared / disseminated
13. Is any possible conflict of interests clarified?	n/a		
14. Are financial implications and financial support transparent?	x		

SUMMARY OF PROPOSAL

Background

Empirical evidence from recent studies suggests that the diffusion and infusion of EMR systems is limited. In the study of EMR use on US hospitals, found that only 1.5% of the sample of hospitals in the U.S (63% of all hospitals) had fully implemented, comprehensive EMR systems, while only an additional 7.6% had a basic system in one clinical unit (Jha *et al.*, 2009). However, this picture is reflective of developed countries. Little is known about the diffusion and infusion of EMR systems in developing countries. The Robert Wood Johnson Foundation Report, published in 2009, noted that there was little or no information from developing countries in terms of whether EMR systems were in place and the level and extent of adoption. In particular, those researchers indicated their disappointment in their inability to comment on the state of EMR systems adoption in SA. The existence of EMR is acknowledged (rid). but the functionality and extent of the existence and use, is not known. Specifically, the levels of diffusion and infusion of EMR systems in SA hospitals is unknown. Research that identifies the levels of diffusion and infusion will provide a much needed guide to understanding where the healthcare industry is at and how far it needs to go to be at par with other countries. The objectives of this study are the following:

1. To describe the current state of EMR systems in the hospitals of South Africa.

   Sub- objectives

- Assess the current state of Electronic Medical Record systems' diffusion within the hospitals of South Africa.
- Assess the current state of Electronic Medical Record systems' infusion within the hospitals of South Africa.

2. To assess the extent to which the diffusion and infusion of Electronic Medical Record systems impact the performance of hospitals in South Africa.

   Sub-objective

   - Assess the direct effects of Electronic Medical Record systems on the economic efficiency, clinical effectiveness, patient safety and patient satisfaction performance of hospitals in South Africa, as well as their indirect effects through improved information management.

Method

A quantitative survey using structured questionnaire will be conducted using key informants (hospital CEOs, chief administrators) in a sample of hospitals in South Africa. All 34 hospitals in Gauteng province will be targeted. Private sector hospitals will be drawn from the list of 297 members of the Hospital Association of South Africa. Key informants are: hospital CEO, Hospital administrator, Head of Operations, Head of Quality Assurance, Chief Medical Officer, and Chief Information Officer. In addition, there has been little empirical evidence at organizational level analysis on EMR systems effect on hospital performance.

Objectives

1. To describe the current state of EMR systems in the hospitals of South Africa.

   Sub- objectives

   - Assess the current state of Electronic Medical Record systems' diffusion within the hospitals of South Africa.
   - Assess the current state of Electronic Medical Record systems' infusion within the hospitals of South Africa.

2. To assess the extent to which the diffusion and infusion of Electronic Medical Record systems impact the performance of hospitals in South Africa.

   Sub-objective

   - Assess the direct effects of Electronic Medical Record systems on the economic efficiency, clinical effectiveness, patient safety and patient satisfaction performance of hospitals in South Africa, as well as their indirect effects through improved information management.

Benefits

Improve patient safety; support the delivery of effective patient care; facilitate the management of chronic conditions; improve efficiency and feasible to implement.

REVIEWER'S FINAL CONCLUSION

Recommended

Reviewed by

Dr Bridget Ikalafeng, DD: Research and Epidemiology

Date: 11/03/2013

S. le Roux, Director PPR

Date: 12/03/2013

Approved / not approved

Appendix K – Letter granting permission to conduct study in KwaZulu-Natal

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

Health Research & Knowledge Management sub-component
10 – 103 Natalia Building, 330 Langalibalele Street
Private Bag x9051
Pietermaritzburg
3200
Tel.: 033 – 3953189
Fax.: 033 – 394 3782
Email.: hrkm@kznhealth.gov.za
www.kznhealth.gov.za

Reference : HRKM 005/13
Enquiries : Mr X Xaba
Tel : 033 – 395 2805

Dear Mr B. Gule

Subject: Approval of a Research Proposal

1. The research proposal titled **'The current state of electronic medical record (EMR) systems and their impacts on the performance of hospitals in South Africa'** was reviewed by the KwaZulu-Natal Department of Health.

   The proposal is hereby **approved** for research to be undertaken at hospitals in Amajuba, eThekwini, Ugu, UMzinyathi, uMkhanyakude, uThukela, uMgungundlovu districts and Umzimkhulu Psychiatric hospital. Data collection is scheduled for six months.

   NB: The study can be implemented in the other districts once this office receives a letter of support from the District office.

2. You are requested to take note of the following:
   a. Make the necessary arrangement with the identified facility before commencing with your research project.
   b. Provide an interim progress report and final report (electronic and hard copies) when your research is complete.

3. Your final report must be posted to **HEALTH RESEARCH AND KNOWLEDGE MANAGEMENT, 10-102, PRIVATE BAG X9051, PIETERMARITZBURG, 3200** and e-mail an electronic copy to hrkm@kznhealth.gov.za

For any additional information please contact Mr X. Xaba on 033-395 2805.

Yours Sincerely

Dr E Lutge
Chairperson, Health Research Committee
Date: 18/01/2013 .

Appendix L – Cover letter accompanying Administrator Questionnaire (Public Hospitals)

XX March, 2013

Title of Study	: The current state of electronic health records systems and their impacts on the performance of hospitals in South Africa.
Name of Student / researcher	: Bheki S. Gule Department of Information Systems, School of Economics and Business Sciences University of the Witwatersrand, Johannesburg, South Africa. Tel: +2711-717-8216. Mobile: +2771-979-8610. Fax: 086-651-7291 Email : Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com
Name of Supervisor	: Professor Jason Cohen Department of Information Systems, School of Economics and Business Sciences University of the Witwatersrand, Johannesburg, South Africa. Tel: +2711-717-8164. Fax: +2711-717-8139 Email : jason.cohen@ wits.ac.za website : http://www.wits.ac.za/staff/jason.cohen

My name is Bheki Gule. I am a Masters Degree student at the University of the Witwatersrand, Johannesburg.
I am conducting a study that aims to assess the *current state of Electronic Medical Records (EMR) Systems* and their *impact on the performance* of hospitals of South Africa. To do this, I am using a questionnaire that asks about your hospital's demographics and then about the extent to which you agree which some performance related statements.

You are invited to participate in the study by completing the attached questionnaire, which takes about 15 minutes to complete.

The results of this study will help us understand the *impacts of EMR Systems on hospital performance in the South African context*. You may also find the results relevant and valuable to your hospital, and may help you benchmark your practices.

Participation is voluntary, and there is no loss of benefit whether or not you choose to participate. Responses are anonymous and you are not asked to disclose your name nor that of your hospital. Results will be reported only in an aggregate manner. Neither your name nor that of your hospital will be identified anywhere in the report. All data collected in the study will be kept confidential and will not be used other than for the purposes of this research study.

This research has been approved unconditionally by the University of Witwatersrand Human Research Ethics Committee. The protocol number is H130203. It has also been approved by the Provincial Department of Health (see attached letter).

By completing and returning the questionnaire, you acknowledge that you have read this information and have consented to participate in this research, with the knowledge that you are free to withdraw your participation at any time without any risk or loss of benefit.

Yours Sincerely

_____
Bheki S. Gule

Appendix M –Cover letter accompanying Hospital Information Systems Questionnaire (Public)

XX March, 2013

Title of Study	: The current state of electronic health records systems and their impacts on the performance of hospitals in South Africa.
Name of Student / researcher	: Bheki S. Gule Department of Information Systems, School of Economics and Business Sciences University of the Witwatersrand, Johannesburg, South Africa. Tel: +2711-717-8216. Mobile: +2771-979-8610. Fax: 086-651-7291 Email : Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com
Name of Supervisor	: Professor Jason Cohen Department of Information Systems, School of Economics and Business Sciences University of the Witwatersrand, Johannesburg, South Africa. Tel: +2711-717-8164. Fax: +2711-717-8139 Email : jason.cohen@ wits.ac.za website : http://www.wits.ac.za/staff/jason.cohen

My name is Bheki Gule. I am a Masters Degree student at the University of the Witwatersrand, Johannesburg.
I am conducting a study that aims to assess the *current state of Electronic Medical Records (EMR) Systems* and their *impact on the performance* of hospitals of South Africa. To do this, I am using a questionnaire that asks about the availability of certain EMR software functions and the extent to which certain processes are done electronically.

You are invited to participate in the study by completing the attached questionnaire, which takes about 15 minutes to complete.

The results of this study will help us understand the *availability and usage levels of EMR Systems in South African hospitals*. You may also find the results relevant and valuable to your hospital, and may help you benchmark your practices.

Participation is voluntary, and there is no loss of benefit whether or not you choose to participate. Responses are anonymous and you are not asked to disclose your name nor that of your hospital. Results will be reported only in an aggregate manner. Neither your name nor that of your hospital will be identified anywhere in the report. All data collected in the study will be kept confidential and will not be used other than for the purposes of this research study.

This research has been approved unconditionally by the University of Witwatersrand Human Research Ethics Committee. The protocol number is H130203. It has also been approved by the Provincial Department of Health (see attached letter).

By completing and returning the questionnaire, you acknowledge that you have read this information and have consented to participate in this research, with the knowledge that you are free to withdraw your participation at any time without any risk or loss of benefit.

Yours Sincerely

_____
Bheki S. Gule

Appendix N – Private Hospitals Ethical Clearance Certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON MEDICAL)
H110930 Gule

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER H110930**
PROJECT TITLE	The Use and Impact of Electronic Health Records Systems Software in Private Hospitals of South Africa.
INVESTIGATOR(S)	Mr B Gule
SCHOOL/DEPARTMENT	Economics & Business Sciences
DATE CONSIDERED	16 September 2011
DECISION OF THE COMMITTEE	Approved Unconditionally
EXPIRY DATE	30 September 2013

DATE 24 September 2011

CHAIRPERSON
(Professor R Thornton)

cc: Professor J Cohen

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature

11 / Oct / 2011
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix O – Public Hospitals Ethical Clearance Certificate

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON MEDICAL)
R14/49 Gule

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER H130203**
PROJECT TITLE	The current state of electronic health records systems and their impacts on the perormance of public hospitals in South Africa
INVESTIGATOR(S)	Mr BS Gule
SCHOOL/DEPARTMENT	Economic and Business Sciences/Information Systems
DATE CONSIDERED	15/02/2013
DECISION OF THE COMMITTEE	Approved unconditionally
EXPIRY DATE	05/03/2015

DATE 06/03/2013 **CHAIRPERSON** (Professor T Milani)

cc: Supervisor : Professor J Cohen

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature **Date** 07 / 03 / 2013

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix P –Hospital's Administrator questionnaire Coded



TITLE

THE CURRENT STATE OF ELECTRONIC MEDICAL RECORD SYSTEMS AND THEIR IMPACTS ON THE PERFORMANCE OF HOSPITALS IN SOUTH AFRICA

HOSPITAL ADMINISTRATION

QUESTIONNAIRE

Directions: Please complete the questionnaire by placing a tick in the box that most closely represents your organisation's position

PART A: GENERAL INFORMATION ABOUT YOUR ORGANISATION

1. What is your job title

☐ Chief Executive / General Manager ☐ Hospital Administrator ☐ Chief Medical Officer ☐ Operations Head

☐ Matron ☐ Unit Manager ☐ Other (please specify)_____

2. What type of ownership structure is in place?

☐ Independent Facility ☐ Part of a Public Listed Group ☐ Part of a non-listed Group

☐ Other (please specify)

3. What kind of facility is your organisation?

☐ First Level Hospital ☐ Second Level Hospital (at least one specialty) ☐ Second Level Hospital (at least 5 specialty units)

☐ District Hospital ☐ Specialised Hospital (e.g. Rehab, Psychiatric, T.B) ☐ Academic / Teaching Hospital

☐ Day Clinic ☐ Other (please specify)

4. Approximately how many employees (both clinical and non-clinical/ administrative) are directly employed at your facility (this refers to your facility and not to your Holding Group)? Please Select employees

5. For how many years has your facility been operating? years

6. What is the approximate number of physicians in your facility? Please Select physicians

7. What is the approximate number of nurses in your facility? _____ nurses

8. What is the approximate number of inpatient / acute care beds? _____ beds

9. What is the approximate number of outpatient visits per day? _____ visits

10. Which approach(es) does your facility take towards coordinating the delivery of care? (Place an X next to as many as appropriate)

☐ Case Management ☐ Multidisciplinary Teams ☐ Disease Management Programs

☐ Other (please specify)

11. Where is your facility situated?

☐ Eastern Cape ☐ Gauteng ☐ Western Cape ☐ North West

☐ Free State ☐ Limpopo ☐ Kwazulu-Natal ☐ Mpumalanga

☐ Northern Cape

12. Is your facility in an urban or rural Community?

☐ Urban ☐ Rural

PART B. ORGANISATIONAL PERFORMANCE

This section explores your facility's performance across a number of key indicators.

1. **Please indicate (by placing a ti xten ch ee ee ch o following statements**

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
Our facility performs very well at capturing clinical data	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at capturing patient details (e.g. demographics)	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at ensuring access to patient information anytime anywhere	☐	☐	☐	☐	☐	☐	☐
Sharing of patient information across internal departments is performed very well in our facility	☐	☐	☐	☐	☐	☐	☐
Sharing of patient information with external facilities is performed very well in our facility	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at protecting patient data from unauthorised access	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at protecting patient data from inappropriate use	☐	☐	☐	☐	☐	☐	☐
Our facility performs very well at maintaining a comprehensive audit trail of clinical data	☐	☐	☐	☐	☐	☐	☐
Our facility has very good administrative workflow processes	☐	☐	☐	☐	☐	☐	☐
Overall, we are satisfied with our information management processes	☐	☐	☐	☐	☐	☐	☐
Our Electronic Medical Record systems adequately support our clinical workflow	☐	☐	☐	☐	☐	☐	☐
Our Electronic Medical Record systems align well with our processes	☐	☐	☐	☐	☐	☐	☐
We are generally satisfied with the support provided by our Electronic Medical Record systems	☐	☐	☐	☐	☐	☐	☐
Our facility almost always meets its patient care treatment goals	☐	☐	☐	☐	☐	☐	☐
Given the severity of the patients we treat, our facility's patients experience very good outcomes	☐	☐	☐	☐	☐	☐	☐
Our facility does a good job applying the most available technology to patient care needs	☐	☐	☐	☐	☐	☐	☐
Our facility's clinical units function well together as a team	☐	☐	☐	☐	☐	☐	☐
Our facility is very good at responding to emergency situations	☐	☐	☐	☐	☐	☐	☐
Overall, we are satisfied with our clinical effectiveness	☐	☐	☐	☐	☐	☐	☐
We are satisfied that the expended physician time per patient visit is neither too high nor too low.	☐	☐	☐	☐	☐	☐	☐

	1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Neither Agree nor Disagree	5 Somewhat Agree	6 Agree	7 Strongly Agree
We are satisfied that the expended nursing time per patient visit is neither too high nor too low.	☐	☐	☐	☐	☐	☐	☐
We are satisfied with the total payroll expenditure for all personnel (excluding physicians) per patient visit	☐	☐	☐	☐	☐	☐	☐
We are satisfied with the current total cost to the facility of an average patient visit.	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average revenue per bed	☐	☐	☐	☐	☐	☐	☐
Overall, our financial performance is very good	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average wait times (time between patient arriving and being attended by physician)	☐	☐	☐	☐	☐	☐	☐
We are satisfied with our average length of stay (time from admission to discharge)	☐	☐	☐	☐	☐	☐	☐
Our procedures and systems are good at preventing errors from happening	☐	☐	☐	☐	☐	☐	☐
We have fewer preventable falls, infections, or medical errors than do similar private hospital facilities	☐	☐	☐	☐	☐	☐	☐
Facility units work well together to provide the best care for patients	☐	☐	☐	☐	☐	☐	☐
Facility units do not coordinate well with each other	☐	☐	☐	☐	☐	☐	☐
Overall, we are meeting our patient safety goals	☐	☐	☐	☐	☐	☐	☐
Our patients are very satisfied with the medical care we provide	☐	☐	☐	☐	☐	☐	☐
We are very satisfied with the service we provide to our patients	☐	☐	☐	☐	☐	☐	☐
The care our patients receive is just about perfect	☐	☐	☐	☐	☐	☐	☐
There are things about the medical care our patients receive that could be better	☐	☐	☐	☐	☐	☐	☐
Overall, we meet our goals for patient satisfaction	☐	☐	☐	☐	☐	☐	☐

Reverse-coded

THANK YOU FOR YOUR TIME AND YOUR PARTICIPATION IN THIS STUDY

If you would like to participate in future phases of this study, or receive a copy of the report of this study, please send a separate email message to Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com

Responding address: Bheki S. Gule Department of Information Systems. Faculty of Commerce, Law, and Management. School of Economics and Business Sciences. University of the Witwatersrand. Private Bag 3 Braamfontein, Johannesburg. 2050. Fax: 086 651 7291 Email. Bheki.Gule@students.wits.ac.za Supervisor: Prof. Jason Cohen. Email Jason.Cohen@wits.ac.za

Appendix Q – Hospital Information Systems questionnaire Coded



TITLE

THE CURRENT STATE OF ELECTRONIC MEDICAL RECORD SYSTEMS AND THEIR IMPACTS ON THE PERFORMANCE OF HOSPITALS IN SOUTH AFRICA

HOSPITAL INFORMATION SYSTEMS

QUESTIONNAIRE

Directions: Please complete the questionnaire by placing an X in the box you think most closely represents your facility's position.

PART A - ELECTRONIC MEDICAL RECORDS (EMR) AVAILABILITY AND USE

This section asks about the extent to which EMR / Computerised systems are available in your facility's various units to support a number of functions

1. To what extent are computerised systems within your facility available for:

	6 Available in all relevant clinical units*	5 Available in a majority of clinical units	4 Available within at least one but not the majority of clinical units	3 Already beginning to make available	2 Planning to make available within a year	1 Not in Place
Clinical Documentation and Health Data						
a. Maintaining Patient Demographics	☐	☐	☐	☐	☐	☐
b. Maintaining Clinical Notes	☐	☐	☐	☐	☐	☐
c. Maintaining Active Diagnoses	☐	☐	☐	☐	☐	☐
d. Maintaining Current Procedures	☐	☐	☐	☐	☐	☐
e. Maintaining Nursing Assessments	☐	☐	☐	☐	☐	☐
f. Maintaining Problem Lists	☐	☐	☐	☐	☐	☐
g. Maintaining Active Medication Lists	☐	☐	☐	☐	☐	☐
h. Maintaining Discharge Summaries	☐	☐	☐	☐	☐	☐
i. Maintaining Advanced Directives (e.g. DNR)	☐	☐	☐	☐	☐	☐
Results Viewing						
a. Viewing Lab Reports	☐	☐	☐	☐	☐	☐
b. Viewing Radiology Reports	☐	☐	☐	☐	☐	☐
c. Viewing Radiology Images	☐	☐	☐	☐	☐	☐
d. Viewing Diagnostic Test Results (e.g., EKG report, Echo report)	☐	☐	☐	☐	☐	☐
e. Viewing Diagnostic Test Images (e.g., EKG tracing)	☐	☐	☐	☐	☐	☐
f. Viewing Consultant Reports	☐	☐	☐	☐	☐	☐
Computerised Physician Order Entry						
a. Ordering Laboratory Tests	☐	☐	☐	☐	☐	☐
b. Ordering Radiology Tests	☐	☐	☐	☐	☐	☐
c. Entering Medication Orders	☐	☐	☐	☐	☐	☐
d. Entering Consultation Requests	☐	☐	☐	☐	☐	☐
e. Entering Nursing Orders	☐	☐	☐	☐	☐	☐

*All relevant clinical units refers to clinical units that require the functionality, not necessarily all clinical units within the hospital.

	6 Available in all relevant clinical units*	5 Available in a majority of clinical units	4 Available within at least one but not the majority of clinical units	3 Already beginning to make available	2 Planning to make available within a year	1 Not in Place
Decision Support						
a. Providing Clinical Guidelines	☐	☐	☐	☐	☐	☐
b. Providing Clinical Reminders (e.g., pneumovax)	☐	☐	☐	☐	☐	☐
c. Providing Drug Allergy Alerts	☐	☐	☐	☐	☐	☐
d. Providing Drug-Drug Interaction Alerts	☐	☐	☐	☐	☐	☐
e. Providing Drug-Lab Interaction Alerts	☐	☐	☐	☐	☐	☐
f. Providing Drug Dosing Support (e.g., renal dose guidance)	☐	☐	☐	☐	☐	☐
Electronic Communication and Connectivity						
a. Enabling Physician to Physician Communication	☐	☐	☐	☐	☐	☐
b. Enabling Patient to Physician Communication	☐	☐	☐	☐	☐	☐
c. Enabling Facility to External Parties (e.g. Pharmacy, Laboratory, Medical Insurer) Communication	☐	☐	☐	☐	☐	☐
Integrated Patient Support						
a. Supporting Patient education (patient having access to educational material)	☐	☐	☐	☐	☐	☐
b. Supporting Family and informal caregiver education	☐	☐	☐	☐	☐	☐
c. Supporting direct data entry by patient, family, and/or caregiver (e.g. demographics, medical history)	☐	☐	☐	☐	☐	☐
d. Patient Access to medical record (e.g. Viewing of medical record)	☐	☐	☐	☐	☐	☐
Administrative Support						
a. Supporting Inpatient and Outpatient administrative procedures	☐	☐	☐	☐	☐	☐
b. Supporting Scheduling management (for 1 or more of the following; Hospital admissions, Appointments, Surgery / Procedure scheduling)	☐	☐	☐	☐	☐	☐
c. Supporting Payment Determination (Medical Aid, Co-Payment, Cash)	☐	☐	☐	☐	☐	☐
d. Supporting Billings and Claims Management	☐	☐	☐	☐	☐	☐
Reporting						
a. Reporting on Patient safety and quality.	☐	☐	☐	☐	☐	☐
b. Public health reporting	☐	☐	☐	☐	☐	☐
c. Maintaining Disease registries	☐	☐	☐	☐	☐	☐

*All relevant clinical units refers to clinical units that require the functionality, not necessarily all clinical units within the hospital.

2. Please indicate the current frequen[illegible]age of [illegible]owing [illegible]alities	6 Used All the Time	5 Often Used	4 Sometimes Used	3 Hardly Used	2 Not Available to be Used	1 Not Sure
a. Clinical Documentation and Health Data	☐	☐	☐	☐	☐	☐
b. Results Viewing (of Diagnostic test results & test Images; radiology reports & images)	☐	☐	☐	☐	☐	☐
c. Computerised Physician Order Entry	☐	☐	☐	☐	☐	☐
d. Decision Support	☐	☐	☐	☐	☐	☐
e. Electronic Communication and Connectivity	☐	☐	☐	☐	☐	☐
f. Integrated Patient Support	☐	☐	☐	☐	☐	☐
g. Administrative Support	☐	☐	☐	☐	☐	☐
h. Reporting (for Patient Safety and Quality)	☐	☐	☐	☐	☐	☐

3. Please provide your best estimat[illegible]	2 0%	3 1-25%	4 26-50%	5 51-75%	6 76-100%	1 Don't Know / Not Sure
a. The percentage of patients at your facility for whom *clinical documentation* is written electronically	☐	☐	☐	☐	☐	☐
b. The percentage of patients at your facility for whom lab *results* are viewed electronically	☐	☐	☐	☐	☐	☐
c. The percentage of patients at your facility for whom *physician orders* are entered electronically	☐	☐	☐	☐	☐	☐
d. The percentage of physicians at your facilities who use electronic *decision support*	☐	☐	☐	☐	☐	☐
e. The percentage of nurses at your facilities who use electronic *decision support*	☐	☐	☐	☐	☐	☐
f. The percentage of physicians at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	☐	☐	☐	☐	☐	☐
g. The percentage of nurses at your facility who use *electronic communication* (e.g. email, intranet) to communicate with other healthcare providers	☐	☐	☐	☐	☐	☐
h. The percentage of patients at your facility performing *direct data entry* electronically	☐	☐	☐	☐	☐	☐
i. The percentage of *inpatient and outpatient administrative procedures* at your facility that are done electronically	☐	☐	☐	☐	☐	☐
j. The percentage of source data used in *public health reporting* that is collected electronically	☐	☐	☐	☐	☐	☐

4. If your facility has implemented any one of the above EMR system functionalities, in what year was it first introduced Please Select

5. How integrated are you ... tems?

1	2	3	4
Not Integrated, Separate Modules ☐	Modules are able to share data ☐	Modules share a common interface ☐	Modules are fully integrated into a single facility-wide EMR system ☐

6. Approximately how long, in months, has it taken you to achieve your current level of integration? Please Select

7. To what extend have computeris... onic me... ord sy... lac... withi... the... g units / departments?

	6 Has completely replaced paper	5 Has replaced paper for the most part	4 Available and replacing paper in many ways	3 Available but only replacing paper in some ways	2 Not implemented	1 Not Applicable
Emergency Department	☐	☐	☐	☐	☐	☐
ICU	☐	☐	☐	☐	☐	☐
General Medical / Surgical Wards	☐	☐	☐	☐	☐	☐
Specialty Ward - Obstetrics	☐	☐	☐	☐	☐	☐
Specialty Ward - Paediatrics	☐	☐	☐	☐	☐	☐
Other Specialty Wards	☐	☐	☐	☐	☐	☐
Onsite Ambulatory Practices	☐	☐	☐	☐	☐	☐

PART B : OTHER TECHNOLOGIES

This section asks about other tec... ies wit... r faci...
To what extent are the following... ogies... e ac... r faci...

	6 Available in all relevant clinical units*	5 Available in a majority of clinical units	4 Available within at least one but not the majority of clinical units	3 Already beginning to make available	2 Planning to make available within a year	1 Not in Place
a. Barcoding technology for laboratory specimens	☐	☐	☐	☐	☐	☐
b. Barcoding technology for patient identification	☐	☐	☐	☐	☐	☐
c. Barcoding technology for medication administration	☐	☐	☐	☐	☐	☐
d. I.T applications to control patient flow	☐	☐	☐	☐	☐	☐
e. I.T applications to monitor bed status	☐	☐	☐	☐	☐	☐
f. Telemedicine	☐	☐	☐	☐	☐	☐
g. Radio Frequency ID for tracking equipment	☐	☐	☐	☐	☐	☐
h. Physician use of personal digital assistant (PDA or tablets)	☐	☐	☐	☐	☐	☐
i. Check-in / Check-out or way-finding kiosks for use by patients	☐	☐	☐	☐	☐	☐

*All relevant clinical units refers to clinical units that require the functionality, not necessarily all clinical units within the hospital.

THANK YOU FOR YOUR TIME AND YOUR PARTICIPATION IN THIS STUDY

If you would like to participate in future phases of this study, or receive a copy of the report of this study, please send a separate email message to Bheki.Gule@students.wits.ac.za or bhekigule@gmail.com

Appendix R – Correlation matrix of independent variables' items and performance measures

	CD_MPD	CD_MCN	CD_MAD	CD_MCP	CD_MNA	CD_MPL	CD_MAML	CD_MDS	CD_MAdDi	CPOE_OLT	CPOE_ORT	CPOE_EMO	CPOE_ECR	CPOE_ENO	CDInfu	CPOE Infu	Comp Info Mgt	Comp ClinEffec Pro	Comp ClinEffec Team	Comp EconEff	CompPat Sat
CD_MPD	1																				
CD_MCN	0.222	1																			
CD_MAD	0.135	.264*	1																		
CD_MCP	0.121	.287*	.635**	1																	
CD_MNA	-0.055	.440**	.438**	.463**	1																
CD_MPL	.335**	.485**	0.198	0.2	.395**	1															
CD_MAML	0	0.081	.380**	0.175	.332**	0.094	1														
CD_MDS	.567**	0.134	-0.044	-0.09	0.057	.328**	0.074	1													
CD_MAdDi	0.087	.365**	.360**	.363**	.638**	.404**	.391**	0.199	1												
CPOE_OLT	.366**	0.184	-0.099	0.033	0.109	.305*	0.121	.552**	0.225	1											
CPOE_ORT	.360**	0.208	-0.08	0.056	0.125	.256*	0.028	.637**	0.243	.817**	1										
CPOE_EMO	0.173	.309*	0.205	0.11	.382**	.289*	.545**	0.122	.487**	.339**	.338**	1									
CPOE_ECR	0.121	.437**	.437**	.435**	.562**	.423**	0.214	0.12	.657**	0.171	0.191	.501**	1								
CPOE_ENO	0.181	.320*	.320*	.317*	.444**	.418**	.360**	0.213	.749**	.288*	.274*	.650**	.809**	1							
CDInfu	0.118	0.159	0.159	0.04	.413**	0.118	.419**	0.193	0.196	0.208	0.135	.331*	0.142	0.093	1						
CPOEInfu	0.143	0.188	0.173	0.184	.301*	0.114	0.132	0.201	.347**	.272*	.277*	0.159	.308*	0.25	.377**	1					
CompInfoMgt	0.108	-0.222	-0.03	-0.11	-0.171	-0.137	0.073	0.209	-0.203	0.171	0.14	-0.059	-0.141	-0.125	.279*	-0.117	1				
CompClinEffecPro	0.109	-0.057	0.05	0.097	-0.147	-0.041	0.019	-0.039	-.338**	0.098	0.064	-.254*	-.351**	-.290*	-0.035	-0.155	.312*	1			
CompClinEffecTeam	0.125	0.089	0.117	0.197	-0.069	0.031	-0.068	0.224	-0.037	-0.01	0.066	-0.13	0.142	0.07	-0.107	0.058	.349**	0.23	1		
CompEconEff	0.043	0.008	.260*	.306*	-0.063	-0.011	-0.046	-0.075	-0.069	-0.05	-0.097	-0.139	0.062	-0.046	-0.215	0.043	.253*	.259*	.432**	1	
CompPatSat	-0.085	-0.005	0.223	0.244	-0.052	-0.117	-0.018	-0.06	-0.183	-0.067	-0.067	-.274*	-0.054	-0.132	-0.059	-0.062	.478**	.416**	.400**	.538**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).