FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS IN SOUTH AFRICA

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Thesis presented for the Degree of
DOCTOR OF PHILOSOPHY
in the Department of Information Systems
UNIVERSITY OF CAPE TOWN

November 2009

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for my parents

ACKNOWLEDGEMENTS

This thesis was researched and written over a long period. Significant guidance, support and encouragement throughout the project were provided by my colleague, friend and co-supervisor, Dr Sedick Isaacs. Prof Dewald Roode, my supervisor at UCT, generously contributed his vast experience of doctoral supervision and qualitative research in information systems to ensuring that the sometimes rocky path of the project was negotiated to the end. Sadly, Prof Roode passed away shortly before the finalisation of the thesis. The initial stages of the formal project were greatly enhanced by my participation in the INSAND (INformation Systems for National Development) doctoral programme initiated by Prof Paul Licker.

Colleagues and managers at the Medical Research Council provided a privileged working environment in which it was possible to combine my own research with my commitments to the organisation. The opportunity to reduce my MRC workload over a few months enabled me to complete the thesis writing and is gratefully acknowledged. Sharleen Jackson, Ashley Bess and Barbara Johannesson assisted with fieldwork and provided essential administrative support, and Nita Hanmer contributed her editorial skills and insights to the preparation of a more polished document than I could have produced on my own. The UCT Department of Information Systems provided a collegial environment which enriched and supported the PhD process.

This project would have been impossible without the support and forbearance of my family. The unfailing encouragement of my husband Crain enabled me to continue when completion seemed impossible, and my daughters Carla and Amie provided reason to try to make a contribution.

The fieldwork for the thesis enabled me to understand further the sterling work of colleagues in provincial departments of health and public hospitals in South Africa, often working under difficult conditions to provide health services to mainly poor people. Their generosity in contributing to this project despite heavy service commitments is much appreciated and warmly acknowledged. While errors and misinterpretations remain my own responsibility, I hope that the results of this project contribute both to improving the working environments of these healthcare providers, and to the health of their clients.

Cape Town, November 2009

Factors associated with the successful implementation of Computerised Hospital Information Systems in South Africa

ABSTRACT

A conceptual model of Computerised Hospital Information System (CHIS) use was developed and refined, in order to improve understanding of factors associated with successful CHIS implementation in level 1 and level 2 public sector hospitals in two South African provinces. The study drew on models of information system (IS) success, insights from the HIS evaluation literature and studies of risk factors associated with the implementation of clinical information systems (CISs), in order to synthesise relevant results.

A multi method approach was used to investigate the complex study environment.
Pilot case studies were conducted in three level 2 hospitals in Province 1, in order to understand the use of CHISs in these environments. The major output of this phase was the initial conceptual model of CHIS use, which identified seven factors associated with successful CHIS implementation.
In the second phase of the study, a further case study was conducted at a fourth level 2 hospital in Province 1, and interviews were conducted with three South African CHIS experts. An extended conceptual model of CHIS use was developed on the basis of the data from this phase.
In the third and final phase of the study, a survey of CHIS use was conducted in more than thirty level 1 and level 2 hospitals, in two provinces, using one of three CHISs, in order to validate the conceptual model developed in the previous study phase. The results of the case study informed the refinement of the conceptual model to create the revised conceptual model of CHIS use.

The conceptual model of CHIS use is a major output of this study. The survey results confirmed that the factors of the conceptual model are associated with CHIS success in level 1 and level 2 hospitals in the study provinces, and supported most of the relationships between the factors in the model.

The study provides unique insights into the CHIS implementations in rather poorly resourced environments, thereby contributing to a growing literature on health information system development, implementation and use in developing areas from the perspective of information system success modelling, health information system evaluation, and a developing country context.

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LIST OF ABBREVIATIONS / SPECIAL TERMS

CHIS	Computerised hospital information system
HIS	Health information system
IS	Information system
SA	South Africa / South African
HCS	Healthcare system
SA HCS	South African healthcare system
CHS	Cape Hospitals System
IFIP	International Federation for Information Processing
SAHR	South African Health Review
MOU	Midwife obstetric unit
PAAB	Patient admission and billing system
PADS	Patient admission and discharge system
DHIS	District health information system
HISP	Health Information Systems Programme
LVR	Limited or vulnerable resources
HMIS	Health management information system
ITPOSMO	Information; Technology; Processes; Objectives and values; Staffing and skills; Management systems and structures; and Other resources
INDEHELA	INformatics DEvelopment for HEalth in Africa – collaborative South-South-North research network
NHISSA	National Health Information System for South Africa
OPD	Outpatient Department
superusers	Members of an organisation (not an IS specialist) who are so highly skilled in the use of and knowledgeable about the implemented IS that they provide support and advice

CHAPTER 1 BACKGROUND

1.1 INTRODUCTION

Increasing numbers of computerised hospital information systems (CHISs) are being implemented in public sector hospitals in South Africa, as part of a concerted effort to improve the data available to decision makers at all levels of the South African public healthcare system (Burn and Shongwe, 2004) and at great cost. A proportion of these hospitals is situated in environments with limited access to the resources required to run CHISs, including skilled support personnel for hardware and software, and internal resources in the form of trained personnel in various roles to enable hospitals to obtain maximum benefit from the CHIS. Vulnerability to disruption of services can result from lack of direct access to people with the required skills to support the CHIS software and hardware, since support staff may be based in a central location and have to travel significant distances to reach hospitals which may require their services. Where the required physical infrastructure is available, services can be subject to disruption, sometimes due to lack of resources (including human resources) for maintenance and repair.

The successful implementation of CHISs under these conditions is a particular challenge. Anecdotal evidence from South Africa and references from all over the world indicate that the chance of failure of computerised hospital information systems (CHISs) is high (Heeks *et al.*, 1999; Southon *et al.,* 1999; for example). Since the cost of failure is high in terms of money, time and organisational disruption, it is desirable to reduce the probability of and contain the level of failure as far as possible. The aim of this study is to help increase the chance of successful implementation of CHISs by identifying factors associated with the successful implementation of CHISs in level 1 and level 2 hospitals[1] in South Africa.

[1] A level 1 hospital is 'a facility at which a range of outpatient and inpatient services is offered, mostly within the scope of general medical practitioners. It has a functional operating theatre in which operations are performed regularly under general anaesthesia.'
A level 2 hospital is 'a facility that provides care requiring the intervention of specialists as well as general medical practitioner services. A hospital providing a single specialist service would be classified as a specialised level 2 hospital. A general level 2 hospital should provide and be staffed permanently in at least 4 of the following 6 basic specialties of surgery, medicine, orthopaedics, paediatrics, obstetrics and gynaecology, and psychiatry, plus diagnostic radiology and anaesthetics.'
(Department of Health, 2006)

1.2 DESCRIPTION OF THE SOUTH AFRICAN HEALTHCARE SYSTEM (SA HCS)

1.2.1 Socio-Political factors

The role of CHISs in public hospitals in South Africa has developed and changed as a reflection of

- the changing health policy environment in South Africa, which has resulted in increased emphasis on the role of level 1 and level 2 public sector hospitals since 1994;
- developments in approaches to management of hospitals at both hospital and provincial level, with increased emphasis on effective use of resources;
- cost recovery/income generation from patients able to pay, or for whom costs are covered by third parties, e.g. workmen's compensation/injury on duty (IOD) cases.

1.2.2 South African health policy environment

Prior to the change in the SA political landscape in the 1990s, and specifically the change of government in 1994, the South African Health Care System was characterised largely by an emphasis on tertiary care. As a result, early CHIS activities in the public sector in SA were also focussed in the main on tertiary hospitals. The author's own experience as a member of the project team working on the development of the Cape Hospitals System (CHS), a computerised hospital information system for the level 3 hospitals in the (then) Cape Province of South Africa, at intervals between 1978 and 1992, was that the CHS was similar in scope and design to other early CHISs. A working conference on Hospital Information Systems convened under the auspices of International Federation for Information Processing (IFIP) in Cape Town in 1979 provided an important forum for obtaining information about the status of CHISs internationally at that time, and confirmed that the implementation of CHISs was limited to relatively few hospitals internationally (Ball, 2003).

Post 1994, with a significant policy shift to a primary health care (PHC)-based, integrated public healthcare system, there has been a more holistic policy approach to information and information systems, recognising that CHISs could play an important role in supporting the management of all institutions, including level 1 and level 2 hospitals. The National Health Act (61 of 2003) which was promulgated in part in 2005, and replaced the Health Act (63 of 1977) and several other related Acts, makes specific reference to the co-ordination of a National

Health Information System (section 74) and to provincial responsibilities in respect of health information (section 75). In addition, sections 10 and 13 to 17 of the National Health Act refer to health records. The need for health information and health information systems to support health care services and related activities (including research) is therefore clearly reflected in the National Health Act (Republic of South Africa, 2004).

A comprehensive review of the South African Health Care System since 1994 by Schneider *et al.* (2007) examines factors such as governance and financing; human resources; physical infrastructure; pharmaceutical supply and manufacture; and information systems. The authors of the review make no specific reference to information systems for hospitals. They do note that there have been some improvements in the availability of information to support health system management at national, provincial and local levels over their review period, although 'major challenges to the information system remain' (Schneider *et al.*, 2007, p300). They conclude that, despite significant policy changes and major efforts to implement these changes, progress has been mixed, not least due to the multiple disease burden being faced in the country. Among their specific conclusions is that:

> There has been inadequate investment in key underlying functions such as financing, information systems, infrastructure, human resource development, planning and managerial capacity, and these remain technically weak at all levels of the health sector. (Schneider *et al.*, 2007, p306)

1.2.3 Public sector hospitals in South Africa

Although there have been major changes in public sector healthcare services in South Africa, public sector healthcare facilities still suffer limitations. A study by Von Holdt and Murphy described public sector hospitals as being 'under stress' due to lack of resources and limited real decision-making power for local hospital management, among other factors (Von Holdt and Murphy, 2007). There remain large differences between public and private sector facilities (Schneider *et al.*, 2007, p305).

Thomas *et al.* (2007) conducted an intervention study of maternal health services in a sub-district in South Africa, and noted that the quality of record-keeping in the study clinics, midwife obstetric units (MOUs) and hospitals (level 1 and level 2) was generally poor. They noted that there is a need for the development of a learning culture in organisations for there to be a chance of achieving improvements in the systems which support healthcare services. As in other studies (for example, Jacucci *et al*, 2005), they also noted that there are managers and supervisors in the public healthcare sector in SA who show initiative and make attempts to improve the systems and services in their environments, and that these people need to be supported and given the opportunity to share their experiences and approaches with colleagues (Thomas *et al*., 2007).

1.3 COMPUTERISED INFORMATION SYSTEM SUPPORT FOR LEVEL 1 AND LEVEL 2 HOSPITALS IN SOUTH AFRICA

Increasing numbers of computerised hospital information systems (CHISs) are being implemented in public hospitals in South Africa as part of a concerted effort to improve the data available to decisionmakers at all levels of the South African public healthcare system (Department of Health, 1995; Delaney, 2004). A proportion of these hospitals is situated in environments with limited access to the resources required to run CHISs, including skilled support personnel for hardware and software, and infrastructure such as communication networks. Vulnerability to disruption of services can result from lack of direct access to people with the required skills to support the CHIS software and hardware, since support staff may be based in a central location and have to travel significant distances to reach hospitals which may require their services. Where the required physical infrastructure is available, services can be subject to disruption, sometimes due to lack of resources (including human resources) for maintenance and repair. The successful implementation of CHISs under these conditions is a particular challenge. Level 1 and level 2 hospitals in environments of limited or vulnerable resources, as described, are the focus of this project.

To date, there have been few published evaluations of the CHISs which have been implemented in SA, despite the significant resources required to acquire, implement, maintain and use these systems. However, the results of some of the evaluations which have been conducted (Littlejohns *et al.*, 2003; Mbananga *et al.*,2002), as well as anecdotal evidence, indicate that problems have been and are being experienced with some of the CHISs which have been implemented. For example, the Limpopo Province (previously the Northern Province) Department of Health and Welfare has twice made the decision to replace one CHIS with another, at great cost in monetary and organisational terms (Littlejohns *et al.*, 2003; see text box below). Two of the major reported problems in this environment were system performance and system support, especially in locations remote from the main centres.

In some provinces, system implementation and rollout have taken much longer than anticipated, due to problems with customisation, system performance and change management among others. Since the monetary costs of CHISs are generally high in relation to the available budget and CHIS implementations can require significant organisational change, the implementation of systems which do not meet expectations could have major implications for hospitals such as lack of confidence in system outputs resulting in the use of parallel information systems (see Southon *et al.*, 1999, for example).

In Limpopo province in South Africa, there have been several generations of CHIS in use over the past few decades:

- A locally-developed commercial CHIS was in use in the major tertiary hospital in the province prior to 1994.
- A commercial system was procured for implementation in all public hospitals in the province in 1996. Evaluation of the implementation (Littlejohns *et al.*, 2003; Mbananga *et al.*, 2002) indicated that multiple factors could have contributed to a decision in 2000 to replace the system.
- Following a tender process, a SA CHIS supplier won a 5-year contract to supply a CHIS for implementation in Limpopo hospitals in 2000. No published evaluation of this CHIS is available.
- At the end of the 5-year contract, in 2006, a further tender process was carried out, as a result of which the commercial CHIS procured in 1996 was again selected for implementation in Limpopo hospitals from 2007, at a reported contract value of R261m (Glazier, 2006).
  This contract value (assumed to cover 5 years) needs to be considered in comparison with the overall health budget for the province, which was reported to be R5 831m for the 2006/2007 financial year. The budget for level 1 hospitals for the same period was R1 636m (Day and Gray, 2007, p317). Thus, the average annual cost of this 5-year tender constitutes approximately 0,9% of the province's health budget for 2006/2007.

The aim of this project is to contribute to limiting the risk of CHIS failure by identifying factors which are associated with the successful implementation of CHISs in SA public sector level 1 and level 2 hospitals.

1.3.1 Description of computerised hospital information systems (CHISs)

In its simplest form, a CHIS is used to support the administrative functions of a hospital. The CHIS enables recording of information about each patient (who they are and where they live), and their movements through the hospital (details of admissions to hospital, their movements between locations within the hospital, and discharge from the hospital at the end of their treatment, or details of outpatient visits). A standard record is created for each patient that is updated each time the patient attends the hospital. Basic identifying data on each patient is stored in a Master Patient Index (MPI), which forms the core of the CHIS. Each patient is assigned a unique number that is used to identify all hospital records each time services are received from the hospital. The component of the CHIS which records patient movements is described as the admission/discharge/transfer (ADT) module.

In addition to the MPI and ADT components, CHISs in use in level 1 and level 2 hospitals in South Africa also include a billing module. Data are therefore collected on the financial status of patients to determine the level at which they should be billed; and on the services received to enable accurate accounts to be raised. Information required for the account for each patient includes details of special services used (for example, x-rays or laboratory tests), reason for attending the hospital (a diagnosis or reason for encounter), and any procedures performed (for example, an operation or dispensing of medication). In practice, all the required patient clinical data for billing are not necessarily captured on the CHIS, although typically provision may have been made for doing so on the system.

In terms of computerised hospital-wide information systems (in contrast with personal or departmental systems) the emphasis in South African public sector level 1 and level 2 hospitals has been on support for institutional administration and management, including patient tracking and patient identification. CHIS design has also supported patient billing by making provision for the data required, including some data on diagnoses and interventions, and dispensed medication. However, the extent to which clinical or clinically-related data are recorded in the CHIS is variable, as is reflected in the case study and survey data for this project. In most of the study hospitals, for example, clinical data (including coded diagnoses) were collected, but only for patients for whom itemised bills were required (for example, privately-funded patients).

Coiera (2003) describes a hospital information system as a 'hospital computer system(s) with functions like patient admission and discharge, order entry for laboratory tests or medications, and billing functions'. As described, the CHISs in use in the study hospital did not include order entry. Van der Loo and colleagues (1995), in developing a framework for the evaluation of healthcare information systems (HISs), formulated a useful classification of the health care process. They drew a distinction between care processes – divided into the medical care process and the supporting process – and auxiliary processes, which do not contribute directly to the care process. In terms of this classification, the CHISs typically in use in SA district and regional hospitals support aspects of the supporting process (ADT component) and an auxiliary process (billing).

1.3.2 Selection of CHISs for implementation in public sector district and regional hospitals in South Africa

Public hospitals in South Africa are currently administered at provincial level. Decisions about the acquisition of CHISs are made at provincial level, following a formal tender process, and the same CHIS is therefore implemented at multiple hospitals in a province. All new CHISs acquired for use in the South African public healthcare sector have to conform to a common set of requirements which have been agreed to at national level. While in practice at present there is more than one CHIS in use in some provinces, several provinces (including Limpopo and the Western Cape, for example) have already decided to move towards the implementation of a single CHIS throughout the province, with variations in the scope of implementation depending on the needs of different hospitals. Thus, decision makers are likely to have to take a range of conditions and requirements into account simultaneously in selecting CHISs (Language, 2004; Department of Health and Social Development, 2005).

In practice, the choice of a CHIS in South Africa at present is unlikely to involve the development of new systems. Provinces have made, and are likely to continue to make, choices from among existing systems proposed by potential CHIS suppliers. Apart from commercial suppliers, the CHIS supplier could take the form of a provincial or national health information technology (IT) department, since basic CHISs have been developed locally, for example by provincial IT departments in Gauteng province (called PAAB – patient admission and billing system) and Free State province (called PADS – patient admission and discharge system), to provide 'interim solutions' to CHIS needs. These interim systems are still in use, particularly in environments having limited infrastructure and other resources.
In 2004, Burn and Shongwe reported that

> Estimates suggest that about 40% (or about 150) of public hospitals in the country have some form of electronic patient information system, i.e. a system that collects and presents individual patient information. In the Free State and Gauteng, systems have been locally developed to enable the computerisation of patient information systems in most hospitals, whilst in Limpopo and Western Cape most hospitals have implemented third party privately supplied systems... (Burn and Shongwe, 2004, p36)

The current guidelines defined by the National Health Information System for South Africa (NHISSA) committee for the acquisition of CHISs require that only tenderers who can demonstrate the availability of a comprehensive suite of CHIS modules be considered as CHIS suppliers for provinces. For example, a recent CHIS tender for a provincial department of health included the requirement for the following modules, among others:

- Patient registration & master patient index (MPI)
- Admissions, discharges & transfers (ADT)
- Electronic Patient Record
- Appointment Scheduling
- Bed Management
- Order entry
- Staff Scheduling
- Results reporting
- Laboratory

- Blood transfusion services
- Radiology
- Operating theatre
- Accident & emergency
- Dietary services
- Financial modules, including patient billing.

  (Free State Province Department of Health, 2008)

However, it is the author's opinion that in-house developed applications such as PAAB and PADS could continue to be widely used for the foreseeable future, since ongoing resource constraints could preclude the acquisition and maintenance of more comprehensive CHISs. Alternative approaches to the provision of information system support in hospitals in the Eastern Cape and Mpumalanga provinces, based on the district health information system (DHIS) developed by the Health Information Systems Programme (HISP) have concentrated on providing support for users at hospital or ward level, to ensure effective implementation (Jacucci *et al.*, 2005; Venter *et al.*, 2008).

The development of criteria for the selection of a CHIS is particularly challenging when the same system is being selected for use in both specialist referral hospitals (level 3 hospitals[2]) and in level 1 and level 2 hospitals, since level 1 and level 2 hospitals typically have access to fewer resources for CHIS implementation and maintenance than do the specialist referral hospitals. Current criteria used to inform the selection of CHISs for implementation in public sector hospitals in South Africa do not explicitly address factors which could affect (positively or negatively) the chance of a future successful implementation (Isaacs, 1999).

There are few practical and/or theoretical guidelines available to support decision making about CHISs. One notable exception to this lack of guidelines is the set developed by Heeks *et al.*, who, in a paper on why health information systems succeed or fail, and in subsequent publications, provide an important analysis of factors which have the potential to affect CHIS success (Heeks *et al*., 1999; Heeks, 2006). They use the concept of conception-reality gaps to describe the extent to which the aims of an information system can be matched with the reality of the environment in which it will be implemented. Although Venter (2007) used this framework in analysing HIS implementations in South Africa, there is no available evidence to indicate that these guidelines are likely to be widely used in practice to inform CHIS selection.

[2] A level 3 hospital is 'a facility that provides specialist and sub-specialist care as defined for level 3 services.' Level 3 service are described as 'Services which at some time during the intervention are beyond the normal scope of a specialist and require(d) the input of a registered sub-specialist.'
(Department of Health, 2006)

1.4 LEVEL 1 AND LEVEL 2 HOSPITALS IN SOUTH AFRICA AS ENVIRONMENTS OF LIMITED OR VULNERABLE RESOURCES

The implementation of CHISs in environments with limited access to the resources required to support such systems (skilled personnel, physical infrastructure, finance for maintenance and support, etc) is a particular challenge. Where resources are available, they could also be vulnerable to disruption, as when the single CHIS support person is unavailable for a period without warning. Lack of resources, or the potential for lack of resources (for example, at the end of a donation period or a funded project such as the South African hospital revitalisation project) have to be taken into account, both in the development and implementation phases, and in planning for the sustainability of information systems (Kimaro and Nhampossa, 2005). The case studies conducted for the current study showed that the study hospitals are environments of limited or vulnerable resources (LVR) for CHIS implementation and maintenance (Hanmer, Isaacs and Roode, 2007). A recent study of eight public hospitals in South Africa described the hospitals as institutions under stress, due to lack of personnel and other resources (Von Holdt and Murphy, 2007).

The context examined in this study was that of level 1 and level 2 public sector hospitals in South Africa, which provide both inpatient and outpatient (ambulatory) care. A major objective of the project was to establish whether factors which predict successful or unsuccessful implementation of CHISs in these hospitals are different for well-resourced environments compared with environments of limited or vulnerable resources. Apart from infrastructure and other resources, the scope of the CHIS being implemented in each environment would have to be taken into account. For example, 'success' for a CHIS which supports mainly administrative functions (such as patient tracking and billing) could be significantly different to 'success' for a comprehensive CHIS which supports patient care decision making. As will be discussed in more detail in subsequent chapters, in practice it was found that the study hospitals in the two study provinces (referred to as Province 1 and Province 2) were similar in terms of access to resources, and in the scope of the CHIS implementation.

The requirements for functionality of CHISs for level 3 hospitals have specifically been excluded from the scope of this study, since the requirements for functionality in these environments are likely to be more demanding than those for less specialised hospitals. Although not necessarily true in every case, it is expected that the resources (including human resources) available for CHIS implementation and maintenance are generally likely to be larger and more complex than for less specialised hospitals, but also more likely to be met in tertiary hospitals than elsewhere in the healthcare system (see Figure 1.1). However, while the emphasis in this project is on level 1 and level 2 hospitals, it is hoped that the results will have some relevance for all other hospitals in South Africa.

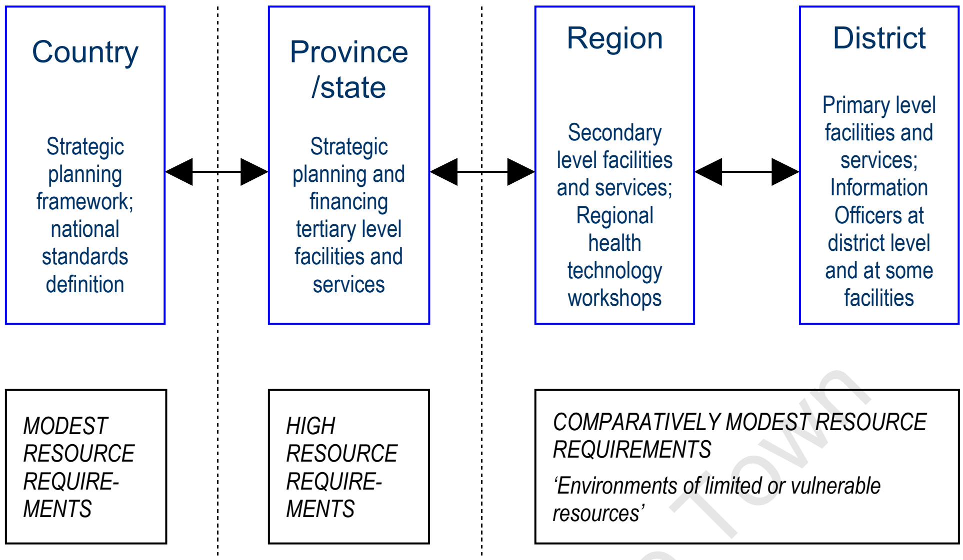

Figure 1.1 Resources for health care services in South Africa

According to the definitions of limited and vulnerable resources used for this project[3], and based on experiences of the study hospitals, it can be argued that all level 1 and level 2 hospitals in the study provinces are environments of limited and/or vulnerable resources. This is particularly true in respect of personnel and personnel-related issues in Province 1, where there are limited

[3] **Limited resources:** Resources which are available, but in quantities which are not sufficient to meet defined system specifications, for example:

- Terminals may not be available at all sites in a hospital specified in the system specification as being required for effective system operation;
- While resources for end user training are available, there are not sufficient to ensure that all end users receive the amount of training indicated in the system specifications;
- Distribution of resources could be variable.

Vulnerable resources: Resources which are available, but access to which cannot be guaranteed at the time when they are required, for reasons which could include the following:

- Resources are available only in limited quantity, for example there may be sufficient terminals available in a hospital to meet normal operational needs, but insufficient on-site backup terminals; OR successful system operation is heavily dependent on the support of a single member of staff of a hospital, but if the person is unavailable the ability of other staff to use the system successfully is compromised.
- Supplies of a resource are subject to disruption, for example an intermittent electricity supply; intermittent access to a wide area network; or intermittent access to system support staff due to their limited numbers.
- Supplies of or access to a resource are subject to delay when required, for example delayed access to system support staff due to their having to travel significant distances to reach a hospital which requires their services.
- The non-availability of the resource is not predictable.
- Resources are unavailable sufficiently often or for long enough on each occasion that it is not possible for the system to perform according to specifications, even if all other required resources are available.

resources available, both internal and external: external resources in the form of personnel who provide system and application support, and internal resources in the form of trained personnel in various roles (at hospital and provincial levels) to enable hospitals to obtain maximum benefit from the CHIS. In discussing the national health management information system (HMIS) in South Africa, which includes hospital information systems, Kumalo (2006) noted several challenges to the availability of reliable health management information in South Africa. One of the aspects highlighted was inadequate investment in the HMIS, resulting in

> (A) shortage of dedicated health information personnel at hospital, sub-district and district level in some provinces. Skills in understanding computer software, data analysis and interpretation are in short supply. Information technology infrastructure and support is inadequate. (Kumalo, 2006, p71)

1.5 IDENTIFICATION OF PROJECT FOCUS AND RESEARCH CONTRIBUTION

The implementation of a CHIS in a hospital has major implications for that organisation. Due to the cost and other resource implications, it is very hard to reverse decisions about CHIS selection and implementation once they have been made. One mechanism for reducing the risk attached to the acquisition of CHISs, especially for use in environments of limited or vulnerable resources, would be to provide decision makers with a framework for assessing and, hopefully, limiting the risk attached to the potential solutions being considered. The potential 'risk-limiting' factors could include organisational issues, such as work flows; or staff education about the necessity for accurate patient records (see Heeks *et al.*, 1999 and Southon *et al.*, 2003, for example).

There is a general lack of 'gold standards' against which to measure the performance of CHISs in hospitals, in order to decide how successful or unsuccessful implementations are (Van der Meijden *et al.*, 2003). This is related to the more general problem of describing, explaining and measuring information system (IS) success (DeLone and McLean, 2003; Ballantine *et al.*, 1998; and Seddon, 1997). Therefore, the assessment of CHIS success had to be addressed before factors associated with the risk of lack of success could be identified. A conceptual model of CHIS use was developed, validated and refined as part of this study.

Theories, models and frameworks related to IS and HIS success, implementation and use have been reported in the literature, as described further in Chapters 2 and 3. However, few investigators have specifically addressed issues of importance in environments of limited or vulnerable resources, such as infrastructure problems, and lack of skilled personnel to support CHISs and to ensure effective use of CHISs. Little theoretical and modelling work has related to CHISs such as those typically used in level 1 and level 2 hospitals in developing areas (district and regional/provincial public hospitals in South Africa), namely CHISs which include only admission/discharge/transfer (ADT) (i.e patient administration) and billing modules, and therefore make provision for only limited clinical data. Most of the studies identified to date refer to clinical information systems, or the clinical components of health information systems (for example Aarts *et al.,* 2004*;* Van der Meijden *et al.*, 2003). In practice, the CHISs in this study are generally not directly used by clinical staff, especially doctors, although they may use reports generated by the CHIS. Authors such as Braa and Hedberg (2002) include such systems in their definition of health **management** information systems (HMIS).

In practice, many public sector level 1 and level 2 hospitals have only limited or vulnerable access to the resources required for CHIS implementation and maintenance. This study focuses on such hospitals, on the assumption that it is more difficult to implement CHISs successfully in such environments than in well-resourced environments, and because they reflect the reality in many developing areas.

One indicator of CHIS success is the extent to which the outputs of CHISs are used (or not used), as described in the DeLone and McLean model of IS success, for example (DeLone and McLean, 2003). Of particular interest for this project is the extent to which the CHIS outputs are used by hospital- and provincial-level managers to support their planning for and management of hospitals. This project therefore concentrated on the assessment of CHIS success from the perspective of healthcare managers at hospital and provincial levels, in environments of limited or vulnerable resources.

Against this background, the following problem statement was proposed.

> ***There is a need to provide support for decision makers to reduce the risk of lack of success in the acquisition and implementation of CHISs for level 1and level 2 hospitals in South Africa through the identification of factors associated with CHIS success in these environments.***

Thus, the aim of this project is to identify factors which can easily be used in practice to assess CHIS success, and to assess the potential for CHIS success in a particular setting.

The research objectives identified for this project were:

- to contribute to the identification of factors associated with CHIS success in LVR environments;
- to identify relationships between factors associated with CHIS success, and the relative significance of the identified factors;
- to contribute to the identification of and explanations for risks associated with HIS implementation, especially in LVR environments;

- to contribute to theory building and modelling of HIS success, as reflected in the IS success literature, and to a lesser extent in the HIS success and HIS evaluation literature.

The specific objectives for the case studies and for the survey of hospitals are discussed in Chapters 4 and 5 (case studies), and 6 (survey).

The results of this project were aimed at contributing to the following research domains, as discussed further in the review of the literature in the next Chapter (Chapter 2):

- HIS evaluation
- IS success and failure
- risk factors associated with HIS implementation
- hospital information systems
- people, organisational and social aspects of HIS implementation, including context issues
- models and modelling related to HIS success.

1.6 THESIS OVERVIEW

A combination of methods was used to respond to the problem statement, including case studies of CHIS use at level 2 hospitals; a survey of CHIS use at level 1 and level 2 hospitals in two South African provinces; interviews with South African CHIS experts; and several iterations of the development of a conceptual model of CHIS use. A diagram of the study process is shown in Figure 1.2.

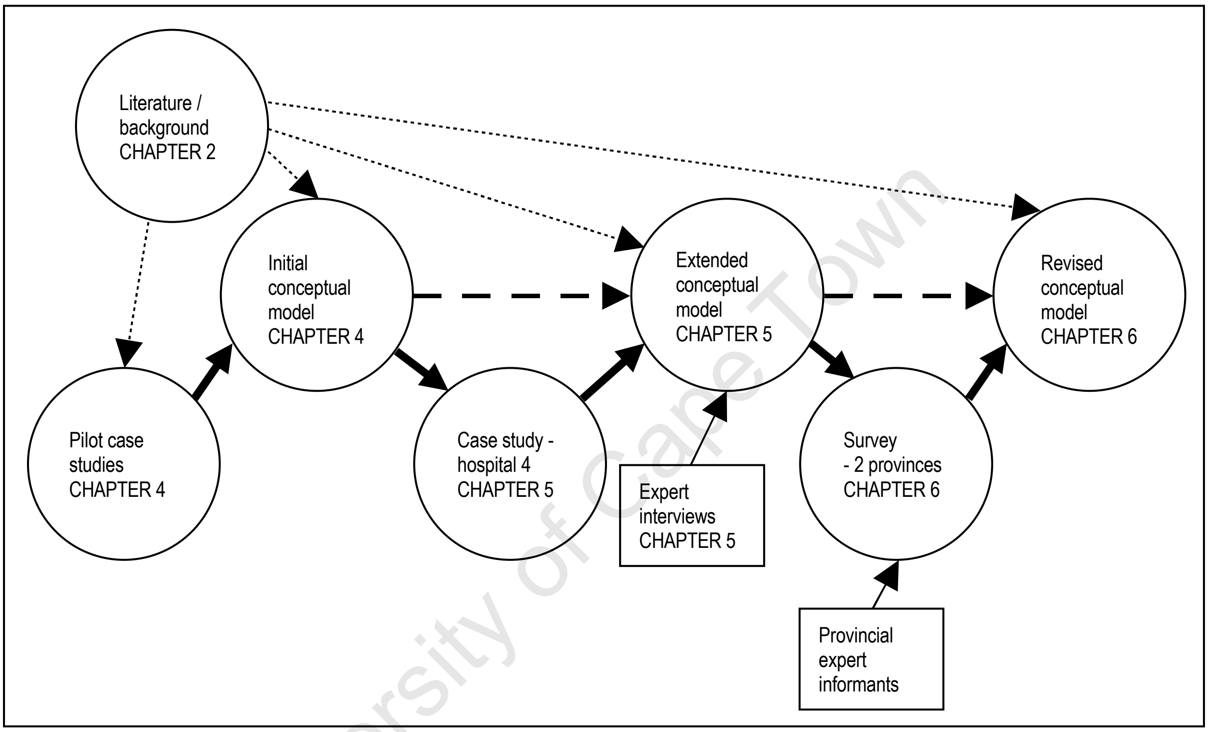

Figure 1.2 Diagram of the study process

Following the background to the study in Chapter 1, including a description of the context of the study, a review of the wide range of related literature, including information system (IS) success and health information system (HIS) evaluation, is reported in Chapter 2.

A detailed description of and motivation for the design of the study is given in Chapter 3.

Chapter 4 describes the first of three cycles of data collection and analysis, followed by the development or updating of the conceptual model of CHIS use which is a key output of this project. Pilot case studies were conducted at three level 2 hospitals in province 1 to gain an understanding of CHIS use in those environments. An initial conceptual model of CHIS use was developed in order to describe the factors associated with CHIS use identified in the pilot case studies.

Using the initial conceptual model as a framework, a case study was conducted at a fourth level 2 hospital in province 1. The case study, interviews with three expert informants, and the resulting enhancement of the conceptual model (to form the extended conceptual model of CHIS use) are described in Chapter 5.

A survey of CHIS use in level 1 and level 2 hospitals in two South African provinces is described in Chapter 6. The survey was developed to test the applicability of the extended conceptual model developed in the previous phase, and the model was reviewed in the light of the survey results.

In Chapter 7, the final chapter of this thesis, the findings and conclusions of the whole study are discussed and reviewed, and recommendations are made for further work based on the results of and insights gained from the study.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

A study of computerised hospital information systems is by definition multi-disciplinary, drawing at least on the fields of information systems and health informatics. Taking the aspects of assessment of 'success', and environments of limited resources into account, further potential sources of relevant literature are indicated.

While there is less emphasis in the literature now on hospital information systems than there has been in the past, hospitals, and the information systems required to support hospital activities, remain a significant and essential component of healthcare systems, in South Africa and elsewhere. As Haux noted in an address analysing the past, present and future of health information systems, the emphasis in health informatics has shifted from hospital information systems, in the 1980s, to a much broader view of health information systems (in scope and geography), still including hospital information systems, at present (Haux, 2006). In South Africa in 2008, the implementation and maintenance of computerised hospital information systems (CHISs) continue to present challenges to healthcare providers in hospitals, and to those responsible for supporting such implementations.

There are few practical and/or theoretical guidelines available to support decision-making about CHISs that have been identified in the literature. One notable exception to this lack of guidelines is the set developed by Heeks *et al.*, who, in a paper on why health information systems succeed or fail, provide an important analysis of factors which have the potential to affect CHIS success (Heeks *et al.*, 1999). They use the concept of conception-reality gaps to describe the extent to which the aims of an information system can be matched with the reality of the environment in which it will be implemented. In a later paper, Heeks (2006) discusses the 'Information; Technology; Processes; Objectives and values; Staffing and skills; Management systems and structures; and Other resources' (ITPOSMO) model reported in the 1999 paper in more detail.

The literature on information system (IS) success and health information system (HIS) evaluation has provided the major theoretical basis for this project. The IS success literature reflects an approach to theory development that is based largely on analysis of relevant empirical studies, with the work of DeLone and McLean (1992; 2003) forming the basis for much further theory development.

In the HIS domain, much of the work has been based on qualitative case studies, in some cases supported and/or supplemented by lessons from the IS success literature, with an emphasis on the organisational aspects of HIS implementation (for example, Aarts *et al.*,2004; Lorenzi and Riley, 2003). A critical premise on which this work is based is that the organisational and social factors related to the implementation of IS, and CHIS in particular, are at least as important and demanding as the technical aspects. The literature related to organisational and social factors that affect CHIS implementation is therefore essential to this project and has been included in this review.

There are multiple strands of literature related to the evaluation of HISs which are relevant to this project. They include

- IS success
- Evaluation of HISs, including
    - evaluation of clinical information systems
    - assessment/evaluation of the extent of HIS success or failure
    - analyses of HIS success relevant to evaluation of CHIS success in district and regional hospitals in developing countries
- Health technology assessment: assessment of HISs as a health technology.

There is the potential for lessons to be learned from the literature in these multiple areas, as is reflected in the rest of this chapter. Ongoing review of these multiple strands of relevant literature to date (end 2008) has not revealed work which is similar in scope and geographic location to this project.

In the following sections, relevant literature from the following domains is reviewed:

- Hospital information systems;
- People, organisational and social aspects of CHIS implementation;
- Models and modelling of IS in general, and HIS in particular;
- IS, HIS and CHIS success;
- HIS evaluation; and
- IS, HIS and CHIS context.

2.2 HOSPITAL INFORMATION SYSTEMS

2.2.1 Computerised information systems in hospitals

Hospitals, as highly complex environments, that are heavily dependent on information to ensure their operation, have been sites of computerised IS implementations since the very early years of computerisation. Thus, in 1984, Reichertz, one of the doyens of health informatics, did a review of 20 years of hospital information system implementations (1984 paper republished as Reichertz, 2006), and highlighted some of the seminal work on computerised hospital information systems which remains relevant today. For example, he noted that information systems in hospitals need to support both the management of hospital activities from an organisational perspective and the management of care from a patient perspective, in order to improve the quality of services being provided. In Reichertz's description, the 'hospital information system' provided 'a central data structure and a means for communication', which included recording of patient admissions, transfers and discharges to provide the core of the patient record. At that stage (1984), he noted that the emphasis in early CHISs had been on the hospital management component, but that the patient management component of CHISs was becoming relatively more important. As described in chapter 1, CHISs have been in use in South Africa since the 1970s. The results from the current study provide a picture of CHIS use in level 1 and level 2 hospitals in two South African provinces which reflects the early component of Reichertz's description of CHIS implementations: CHISs that support hospital administrative functions to varying degrees, but provide little if any support to the patient clinical management component of hospital activities.

There were few references in the literature surveyed which focussed on CHISs similar to those in use in the study hospitals: commercial systems, deployed over many hospitals, having limited scope. Reports on surveys of the status of what they referred to as clinical information technology in hospitals by Jaana *et al.* (2005) reflected situations somewhat similar to those of the study hospitals: community hospitals, which could be compared to level 1 and level 2 hospitals in South Africa, using commercial systems (but not a common system across multiple hospitals). Their study provided a rich picture of the status of computerisation in hospitals in the state of Iowa in the US, and in two Canadian provinces. Ward *et al.* conducted a further study in Iowa, which compared the situations in urban and rural hospitals in the state, indicating that the study also provided information about 'electronic medical record "readiness"' in the study environment (Ward *et al.*, 2006). In view of current plans in South Africa to launch a national electronic health record (eHR.za) (Khotu and Cabuko, 2006), a study of the nature undertaken by the author and reported on in this thesis could prove useful in guiding planning for future implementation.

The economic aspects of the CHISs in hospitals have not been investigated in the current study. However, given the high cost of implementing CHISs in all public sector hospitals in provinces, as is the case in the two study provinces, there would be merit in undertaking economic analyses of these (and similar) implementations. In a recent extensive analysis of the available literature, the authors contest the assertion that the economic benefits of HIS implementation in hospitals cannot be demonstrated (Meyer and Degoulet, 2008). They argue for an econometric approach, and a careful selection of variables, noting for example that in the hospital IS environment, the time before positive return can be demonstrated is likely to be of the order of years, and that the period could vary depending on the hospital organisation (for-profit and not-for-profit hospitals cannot be analysed together, for example). The studies referenced by Meyer and Degoulet refer to hospitals in the US, France, and other European countries. Studies for hospitals in a developing country such as South Africa could make an important contribution to this aspect of the HIS literature.

While there is limited reference in the literature to CHISs of similar scope to those which are the focus of this study, many of the clinical information systems, such as computerised provider order entry (CPOE) systems, which are referenced in the literature are implemented in hospitals. The outputs from research teams such as the physician order entry team (POET) based at Oregon Health & Science University in the US (Ash *et al.*, 2008; Ash *et al.*, 2005); Westbrook *et al.* in Australia (Westbrook *et al.*, 2007); and groups in Europe (for example Brender *et al.*, 2006; Aarts *et al.*, 2004) are therefore relevant to the development of understanding of CHIS implementations in South African hospitals.

In relation to CHISs in hospitals in developing countries, the literature too is limited. Venter (2007) recently reported on a project to improve the availability of data to support hospital management in Mpumalanga province in South Africa through the use of custom-designed spreadsheets, rather than a more comprehensive CHIS. Jacucci *et al.* (2005) and Shaw (2007) report on efforts to improve the use of information for management in level 1 hospitals in the Eastern Cape province of South Africa through support for users and adaptation of software originally developed to support district health service management (i.e., a similar organisational context, and different approach to CHIS acquisition, in comparison with the hospitals included in the current study). Tiihonen *et al.* (2006) examine context factors that affect HIS implementation in multiple environments, including level 1 hospitals, in Southern Africa. As part of the ‘Informatics Development for Health in Africa’ (INDEHELA)-methods project, Nigerian and Finnish colleagues in the 1990s developed guidelines for the development of appropriate hospital information systems, based on the experience of the development of the 'Made In Nigeria Primary and Hospital Information System' (MINPHIS), a HIS which is still being rolled out in Nigeria (Soriyan *et al.*, 2007; Soriyan *et al.*, 1999).

Apart from reporting on experiences with the development and implementation of HISs, providing important lessons which could be applied in other settings, many of these papers also reflect on collaborations between researchers and practitioners, sometimes across countries and continents, providing further valuable insights that could inform other collaborations which are a feature of many HIS projects, also in developing environments.

2.2.2 Integration and interoperability between information systems in hospitals

An important theme arising from references about computerised information systems in hospitals was that of integration between disparate information systems in use within hospitals: Reichertz (2006) noted the need for improved integration between various information systems in hospitals with the hospital information system providing the core database and communication functions. Winter *et al.* (2003) developed their 3LGM^2 tool for modelling hospital information systems as a mechanism for supporting and ensuring effective interoperability for the multiple components of hospital information systems, both manual and computerised. In their econometric study of healthcare information technology investments, Meyer and Degoulet (2008) argue that the chance of obtaining a positive return on investment is positively associated with the level of integration.

The extent of integration between different applications in use was a focus of the surveys of clinical information technology in hospitals in Canada and the state of Iowa in the US referred to in the previous section (Jaana *et al.*, 2005; Paré and Sicotte, 2001). The authors of both papers highlight the importance of promoting integration between information systems to gain the most benefit possible from the implementations.

Two further papers examined the integration between multiple information systems in use in hospitals in Norway (Ellingsen and Monteiro, 2003), and in two national databases in Belgium (Ceratti *et al.*, 2007). Ellingson and Monteiro (2003) examined the issue of integration (or not) between multiple information systems in use in hospitals in the context of the implementation of a standardised Electronic Patient Record (EPR) system in hospitals in Norway. They attempted to identify types of non-integration, and the potential effects of such non-integration on the way in which clinicians work and, ultimately, on how patients are cared for. They argue that non-integration is not necessarily detrimental, citing examples where redundancy of information (particular data elements being available from more than one source) enabled clinicians to continue work even though certain required data elements were not available on one system due to technical difficulties with integration of data, because the same data elements were available on another system. The paper provides a useful framework for the analysis of non-integration between systems, with one major problem being identified, namely inconsistencies between data elements where the same or closely related data elements are present in more than one information system but could have conflicting values. Under such circumstances, the challenge is to decide which version of a data element is the correct one, and the bases on which to make such decisions. In the study an assumption is made that one of the information systems is the correct one, and therefore other systems need to be aligned with it in terms of redundant or closely-related data elements.

In their comparison of data about diagnoses in a national medical database and treatment data in a national billing database in Belgium, Ceratti *et al.* (2007) observed some significant discrepancies. They note that they worked on the assumption that the billing database was correct, although this was not necessarily the case. They make a recommendation that further studies that compare the contents of multiple overlapping databases, also with reference to patient files if possible, could provide further useful insights into the real quality of the data in the various databases.

In the current study, the emphasis was on investigating the **use** of the CHIS (described by Reichertz in 1984 as being the system which provided the core of the patient record and communication across the hospital (Reichertz, 2006)), rather than on integration between multiple information systems (computerised and manual) in use in each institution. However, the issue of integration is important at hospital level, since it is the hospital personnel who have to cope with multiple systems in use, and there were multiple information systems in use in the study hospitals. In all the hospitals included in this study, there were multiple manual and computerised information systems in use, as in most hospitals. In the case study hospitals, it was the nursing systems (daily ward reports on patients in hospital, for example) that were viewed as being the most accurate by clinical and managerial personnel (as discussed in Chapters 4 and 5). This situation was also reflected in the survey of hospitals (described in Chapter 6). This issue is addressed further in Chapter 7.

2.3 PEOPLE, ORGANISATIONAL AND SOCIAL ASPECTS OF CHIS IMPLEMENTATION

In contrast with earlier years of IS research, it is now (2008) a well-established and well-accepted idea that it is necessary to examine both social and technical aspects of HIS development, implementation and use, especially when conducting some form of evaluation. Considering the implementation of computerised ISs in the healthcare environment, this is especially important. Kaplan and Shaw (2004), who are established researchers in this domain, conducted a comprehensive review of the evaluation literature to assess the extent to which people, organisational and social issues were being taken into account in evaluation studies. They found a wide range of studies reporting the use of a wide range of methods to reflect these aspects of HIS implementation, and the evaluation of HIS implementations. One of the outputs of their study was a set of recommendations for future research in order to develop the practice of evaluation of HISs, while at the same time ensuring high quality evaluation research.

In an analysis of 'insights' related to HIS success, Berg (2001) highlights the difficulty of predicting HIS success due to the complexity of health care and health care organisations. He distinguishes between 'primary' health care functions (i.e., those related directly to patient care, and therefore carried out, and documented, by doctors, nurses and other clinical personnel) and 'secondary' health care functions (i.e., those related to supporting patient care, such as management of various aspects of the services provided, and of the organisation as a whole). He proposes that the implementation of HISs be carried out within a clear framework, but that the framework also provides the opportunity for learning from the experiences of the implementation to identify potential for improving the functioning of the health care organisation and, if necessary, revising the expectation of what constitutes 'success' of the HIS implementation. In terms of this analysis, the CHISs in use in the study hospitals, in their forms at the time of the study data collection, related very largely to 'secondary' or support functions. Berg's analysis is relevant in these environments, highlighting as it does the need for the potential for organisational change to ensure optimal usefulness of the CHIS to support patient care – the most important function of any health care organisation.

The Health Information Systems Programme (HISP) action research project, which started in the development of a pilot district health information system (DHIS) in the Western Cape province in South Africa, and continues to develop in scope and geographical reach, is a strong example of HIS development and implementation (also in hospitals) that is firmly grounded in the need to take account of the context in which HISs are implemented (for example, Shaw, 2007; Jacucci *et al.*, 2005; Braa and Hedberg, 2002). Similarly, in the INDEHELA project, people, organisational and social issues are a core consideration in reflecting on requirements for, and development and implementation of, CHISs in developing environments (Soriyan *et al.*, 2007; Korpela *et al.*, 2004).

Examples of projects in developed environments in which people, organisational and social issues are central to research and practice include those reported by Ash *et al.* (2008); Chiasson *et al.* (2007); and Westbrook *et al.* (2007). The paper by Ash *et al*. which highlights the role of 'special people' in the implementation of HISs has reminded other researchers of the multiple essential roles of people in HIS implementation (Ash *et al.*, 2003).

2.4 MODELS AND MODELLING

Models have been developed by numerous authors to facilitate the conceptualisation of the complex domain of health information systems, drawing from a wide range of sources and approaches.

The IS success literature includes the DeLone and McLean model of IS success (2003; 1992), which has formed the basis of other models, such as those of Ballantine *et al.* (1998) and Seddon (1997). In the HIS domain, the relatively few authors who have referenced this work include Mohd.Yusof *et al.* (2008); Mshana (2004); Turunen (2003); and Van der Meijden *et al.* (2003).

Turunen and Mshana, both working in Finland, developed frameworks for the evaluation of HISs that draw on a wide range of models, including models from the IS success literature. Mshana applied his framework to the Tanzanian health management information system (Mshana, 2004; Turunen, 2003). Further work from Finland includes the 'two times four' framework for HIS analysis developed by Korpela *et al.* (2001), which has been extensively used in projects of the INDEHELA network, for example as reported by Soriyan *et al.* (2007). A more recent framework for analysis with specific emphasis on context-related factors has been reported by the same group (Tiihonen *et al.*, 2006).

Recent work in HIS evaluation has proposed models that address the fit between factors associated with success or failure of information systems in organisations. Mohd.Yusof *et al.* (2008) describe the development and testing of an evaluation framework for health information systems which incorporates human, organisation, and technology-fit factors (HOT-fit). The framework which they develop is based on the DeLone and Mclean model of IS success and the MIT90s IT-Organisation Fit Model of Scott-Morton. Both these models were developed for the general IT environment, but the authors quote from the literature and demonstrate from their work that the models are applicable in the health IS environment, with appropriate modification (Mohd.Yusof *et al.,* 2008). The authors provide extensive motivation for the inclusion of the multiple factors in the model, based on the literature, and provide a compelling argument for the model. However, the analysis based on the case study is somewhat unsatisfactory, possibly because the model includes so many factors that it is difficult to deal with them all. This approach to model development is somewhat similar to that used in the development of the conceptual model of CHIS use in the current study.

Ammenwerth *et al.* (2006) present an alternative version of models that address the fit between factors associated with success or failure of the adoption of clinical information systems, in this case. Their 'Fit between Individuals, Task and Technology' (FITT) framework is convincingly presented as a practical mechanism for analysing – and addressing – problems related to the fit between the three aspects of 'IT introduction' (as they describe it). The inclusion of groups of individuals in the category 'individuals' in the framework is somewhat confusing, but does clarify the focus on 'human' or 'people' issues, as described and analysed by other authors. The authors make a case for identifying 'task' as a specific component of their framework (in contrast to 'organisation', which is a broader concept, for example), since it provides a clear mechanism for identifying problems associated with the tasks that people are required to perform (nursing process documentation, in their case example), independent of whether or not these tasks are computerised. One further important aspect of this work is the identification of a feedback loop between 'actors' and 'fit', since the situation can change as 'fit' issues are addressed or change (due to changes in the environment, such as changes in personnel or changes in policy related to the environment).

The usefulness of approaches which highlight the fit between different factors is that they can provide pointers to issues that have to be addressed in order to deal with problems being experienced – while also providing the opportunity to highlight those issues which are not possible to change, for example, at the level of an individual hospital.

A contrasting approach to 'fit' is that of Heeks *et al.*, who have identified conception-reality gaps in multiple dimensions such as 'information', 'technology' and 'personnel' as being risk factors for success (Heeks *et al.*, 1999; Heeks, 2006). This model has been developed as a tool for analysing the potential for success, or guiding efforts to improve the potential for success of HISs. It has been applied in a study by Venter *et al.* in hospitals in South Africa and Zambia, for example (Venter *et al.*, 2008). Kouroubali used the Heeks model in combination with structuration theory to examine outcomes of HIS implementation, using primary health care clinics in Greece in a case study (Kouroubali, 2002).

As will be discussed in the next section, modelling has been one of the approaches used in the analysis of factors associated with IS and HIS success. Some of the models referred to in this review are discussed in more detail in Section 3.4.3 in relation to the approach to modelling used in this study.

2.5 IS, HIS AND CHIS SUCCESS

Because the definition of 'success' (and, by implication, of 'failure') of CHISs in particular and HISs in general are so complex, their definition remains a challenge. This is reflected in the literature. More generally, the definition and measurement or assessment of IS success, especially taking into account the relationships between ISs and the organisations in which they are deployed, continues to be a subject of study. Thus, as for other aspects of this study, there is a wide range of potentially useful literature.

DeLone and McLean (D&M) first published their model of IS success in 1992 (DeLone and McLean, 1992). Their paper remains one of the key references in IS success literature. The 3-D model of IS success developed by Ballantine *et al.* (1998) is one of many based partially on the work of D&M. A review and update of the D&M model by the original authors after ten years, based on a wide-ranging review of the literature related to IS success, concludes that this model remains largely valid (DeLone and McLean, 2003). It is worth noting that the D&M review reflects none of the work related to HIS success in the review period. D&M postulate in their revised model (DeLone and McLean, 2003) that IS success can be described in terms of information quality, system quality, service quality, the extent to which the IS is used (or there is an intention to use it), the degree of user satisfaction with the IS and the net benefits to an organisation of the use of the IS (see figure 3.2). The model does not specifically address the context in which an IS is being implemented, but the authors note that context must be taken into account in any analysis.

Literature searches to date (2008) indicate that there are few studies of CHIS success and failure which refer to the general IS success literature in defining the theoretical frameworks for their analyses, though there are exceptions, such as Hebert (1998) and Coombs *et al.* (1999) in their studies of patient care information systems and community (health) information systems respectively. Mshana (2004) drew extensively on this literature in his development of a multidimensional model for HMIS evaluation. Van der Meijden *et al.* (2003) analysed reports on thirty-three evaluation studies of Inpatient Clinical Information Systems, using the 1992 version of the D&M model of IS success as a framework for their analysis. They found the D&M model to reflect many of the factors describing HIS success examined in the studies. However, they also identified factors not covered by the D&M model, especially in the case of failures. These factors related to system development, the implementation process and the culture and characteristics of the organisation.

Heeks, Mundy and Salazar (1999) reviewed a wide range of studies of computerised health information systems in order to derive the seven dimensions of the ITPOSMO model (see figure 3.3). Their model also provides insights into predictors of health information system success. They identified the transfer of a system designed for the private sector into the public sector as a material risk factor for failure. Disparities between countries, especially those between developed and developing countries, were also identified as being a significant risk factor. In a further analysis of the literature, and based on experiences of applying the ITPOSMO model, Heeks also highlighted the importance of ‘improvisation’ as a mechanism for reducing the conception-reality gaps inherent in any HIS implementation (Heeks, 2006). A different approach is used by Otieno *et al.*, who have proposed a composite index for benchmarking electronic medical record systems in hospitals, based on a case study in 20 Japanese hospitals, using four of the dimensions from the DeLone and McLean model of IS success and drawing on a wide range of IS and CHIS success literature (Otieno *et al.*, 2008). Thompson (2002) and Braa and Hedberg (2000) provide examples of the application of an action research approach to the analysis of HIS implementations, and attempts to facilitate improvements in the level of success of such implementations.

Two Delphi studies of factors associated with HIS success and failure have provided further resources for related work (Paré *et al.*, 2008; Brender *et al.*, 2006). Brender *et al.* identified 110 success factors and 27 failure criteria, rated quantitatively for several system types, including administrative systems (such as the CHISs in use in the hospitals in the current study). Their proposed definitions of ‘success’ and ‘failure’ are examined further in later chapters (Brender *et al.*, 2006). Paré *et al.* examined risk factors for success of clinical information systems in Canada, so their results may not be directly applicable in the hospitals included in the current study.

Chaisson *et al.* (2007) examined the application of theories and methods of the Information Systems domain to the analysis of the use of IT in healthcare. This paper provides a useful overview of the fields and approaches, and underlines the approach used in this study of applying a modelling approach to the analysis of the use of CHISs in level 1 and level 2 hospitals in South Africa. As in many other papers in this literature review, the emphasis is more on clinical systems than on the administrative systems that are the focus of the current CHIS success study. The authors’ further comment that models ‘can complement existing MI research in elaborating and publicly displaying theoretical influences in particular studies, and across numerous studies’ and that ‘[m]odeling techniques can also be used to support the exchange of theoretical and empirical knowledge across MI studies’ provides useful pointers to the potential for further application and generalisation of the results of the current study across a wider area of application (Chiasson *et al*., 2007, pS95).

2.6 HIS EVALUATION

Guise and Kuhn undertook a review of the status of health information systems in which participants also highlighted the need for 'continuing and increased rigorous evaluation of HIS interventions, in order to increase the scientific usefulness of the findings' (Guise and Kuhn, 2003, p111). Other authors such as Littlejohns *et al.* (2003) and Southon *et al.* (1999) have also highlighted this issue. The current study aims to contribute to this process by identifying factors to be taken into account in evaluating CHISs in the environment of level 1 and level 2 hospitals, especially in developing countries.

The IMIA yearbook 2006 focussed on 'Assessing Information Technologies for Health', thus highlighting the importance of evaluation of health information systems (Haux and Kulikowski (eds), 2006). In one of the key contributions to this Yearbook, Talmon presented a survey of the field in which he highlights the need for evaluation studies, especially 'to accompany the large scale implementations of ICT in health care that are currently taking place in many countries around the world' (Talmon, 2006, p11). In tracing the history of HIS evaluation studies, Talmon notes that recent studies have tended to be based on the socio-technical approach, in which the social context in which systems are used is explicitly taken into account – as is the case in the current CHIS success study.
Specific recommendations for action in relation to evaluation are specified:

- develop good implementation practice
- develop an experience base of implementation of ICT in health care
- set up a surveillance system for unintended effects
- build an evidence base of best evaluation practice
- develop guidelines for proper reporting of evaluation studies
- education of clinicians and decision makers. (Talmon, 2006, p11)

One of the comments related to development of good implementation practice is especially relevant to the current study:

> The socio-technical approach should not only try to determine whether an implementation was successful or not. It should also contribute to developing the theory and good practice for successful implementations. (Talmon, 2006, p14)

In proposing the building of an evidence base of best practice, Talmon notes the need to develop 'an overview of both quantitative and qualitative methods for evaluation' to facilitate the choice of appropriate methods for future evaluation studies (Talmon, 2006, p14).

Following the technical/organisation/people framework, Rigby, also writing in the IMIA yearbook 2006, reviews publications related to the evaluation of health information systems, and makes a strong case for including provision for evaluation studies linked to all HIS implementations. He too provides a useful framework for evaluation studies, noting that there are three 'depths' of evaluation which attempt to answer the following questions (for technical/user/organisational aspects of the HIS): 'Does it work? With what results? With what outcomes?' (Rigby, 2006, p117). Apart from surveying the work in the field of HIS evaluation, Rigby also quotes from the Declaration of Innsbruck on HIS evaluation, which includes specific recommendations about the implementation of evaluation studies. The recommendations highlight the need to carry out and publish evaluation case studies, which then have the potential for 'appropriate' translation to different settings (Rigby, 2006).

Chaudhry *et al.* (2006) undertook a formal systematic review of the literature to identify evidence of effects of the implementation of health IT (HIT) on quality, efficiency and cost of health care. The review concentrated on quantitative evidence. (It therefore excluded more than 450 reports on descriptive quantitative and qualitative studies of the effects of HIT implementations, which might have included HIS implementations in developing countries as well.) 257 studies reported between 1995 and 2004 met the defined requirements for the review. The review focuses very largely on clinical systems, i.e. decision support systems, electronic health records (EHRs) and CPOE (which are not mutually exclusive). Noting that 25% of the papers came from established, well-reported and -evaluated systems at four 'benchmark institutions', the authors identified the need for more studies of commercial system implementations, such as CHISs in the current study, in contrast with the in-house developed systems on which there are more reports. They also noted that generalisability is a major limitation of the literature reviewed.

Reports of reviews of CHIS implementations in developing areas reflect a similar bias, in that the emphasis appears to be on custom-developed software, rather than on commercially available software packages (see, for example, Shaw, 2007; Soriyan *et al.*, 2007)

2.7 IS, HIS, CHIS CONTEXT

Context is especially significant in environments of limited or vulnerable resources (LVR), and therefore needs to be taken explicitly into account in the selection of CHISs, and in the analysis of CHIS use.

2.7.1 Limited or vulnerable resources

One of the basic premises of the current study is that the context in which a HIS is implemented is a crucial factor in the potential for its success, especially in environments of limited or vulnerable resources (LVR environments, as defined in the previous chapter). Therefore, the intention in this study was for the context of limited and vulnerable resources to be incorporated into any model developed in the study.

The model of HIS implementation developed by Korpela *et al.* for the INDEHELA-methods project (see Korpela *et al.*, 2004, for example), the ITPOSMO model of Heeks *et al.* (1999), and the IS success model of Ballantine *et al.* (1998) are among the models reviewed to date which specifically take account of context, although none of them specifically addresses the issue of limited and vulnerable resources for IS and HIS implementation and use. The INDEHELA-context project is aimed at comparing experiences between developing and developed environments (Korpela *et al.*, 2004). Braa and Hedberg (2000) and Shaw (2005), among others, report on the HISP project, which specifically addresses approaches to IS development that aim to ensure sustainability of systems in developing environments, with limited infrastructure and other resources, and thus also takes specific account of the LVR context.

The author's conceptual model of CHIS use developed in this study incorporates resources as a factor both explicitly ('availability and allocation of resources') and implicitly (for example, in relation to system performance (linked to resources for system support, access to equipment, access to bandwidth, etc.), and knowledge and understanding of CHIS (linked to resources for training)) (Hanmer, Roode and Isaacs, 2007).

Resource availability is incorporated in the 'bowl' model of HIS context of Tiihonen *et al.* (2006) in terms of 'infrastructure', 'economy' (finances) and 'human resources'. Braa *et al.* (2004) analyse requirements for HIS sustainability across developing countries, taking account of scarcity of resources among other factors, and Piotti and Macome (2007) highlight the need for multiple changing context factors to be taken into account in planning for the implementation of ICT (information and communication technology) to support healthcare in Mozambique. Jayasuriya (1999) proposed a contextualist framework for analysing health services in the Philippines, concluding that 'organisational, environmental and cultural issues' must be taken into account, especially in transferring information systems from one environment to another.

2.7.2 Sustainability of HIS

Sustainability of HISs refers to the ability of local personnel and their institutions to maintain a system after the implementers have handed it over to the institution. This is a significant problem, especially in LVR environments, where the required resources (including finance, people and infrastructure), and knowledge and understanding of the HIS, may not be available at institutional (hospital) level. The lack of appropriately skilled personnel of the healthcare system (HCS) to maintain the HIS in-house once it has been developed and/or supplied has been the focus of several studies. Braa *et al.* (2004) examine this issue in the light of experiences of implementing the HISP district health information system in LVR environments in several developing countries, including South Africa and propose the establishment of 'networks of action' to limit the effects of lack of sufficient skilled human resources.

Kimaro and Nhampossa (2005) analyse factors relating to unsustainability of HIS in Tanzania and Mozambique, including the issue of skilled human resources. Other factors identified include limitations in infrastructure and equipment (networks and PCs for example) and the form of the relationships between donors (who have been the major funders of HIS in the two countries), the ministries of health, and the HIS developers. In the South African context, the analogous relationships are those between the provincial departments of health, who fund the acquisition of CHISs for public sector hospitals; hospital personnel, who typically have limited or no input to decision-making about the choice of the CHIS in use; and the CHIS suppliers, who are required to adapt their systems to meet the needs of the provincial departments of health to whom the systems are supplied. The contractual relationships between the CHIS suppliers and suppliers of other resources such as IT infrastructure, and the provincial departments of health, which have not been explicitly addressed in other models and descriptions, have been identified in the current study as a specific factor associated with success or lack of success of CHISs for this project because contractual difficulties can have a detrimental effect on the functioning of CHISs at hospital level. 'Organisational and contractual mechanisms' is one of the factors in the extended conceptual model of CHIS use developed in this study, as discussed in Section 5.5.

Kimaro (2006) discusses human resource development as a critical component of ensuring sustainability of ICT-based HISs, and reports extensively on the case of implementing an information system (HISP) designed to facilitate reporting on key management indicators at facility level, and providing for aggregation to reflect the multiple levels of the health care services in the country. This is a useful analysis for the current project even though the scope of the HIS being analysed is different, because it relates to an environment of limited and vulnerable resources (LVR), especially in relation to human resources. In the current study environment, there are clear limitations in sustained availability of human resources able to interact with the CHIS beyond simply using it in the way they have been taught. Kimaro proposes a carefully planned and co-ordinated education process, involving higher learning institutions, the related government agencies (mainly departments of health at various levels) and funders (likely a combination of government and donors in the South African environment) to ensure that HIS users and managers develop the skills required to use information and information systems to support health care services. The development and availability of skilled human resources is reflected in the factor 'knowledge and understanding of CHIS' in the conceptual model of CHIS use developed in this study.

2.8 LITERATURE REVIEW - DISCUSSION

This review of the available literature has shown that there is a wide range of work which is relevant to this study. The study has drawn from these multiple disciplines and approaches, and synthesised the resulting insights and lessons, to help to achieve the project aims. In the process, it is hoped that other researchers in both IS and HIS will be made aware of the rich resources which could support and inform the necessarily multidisciplinary nature of work in the IS evaluation and modelling domains. Authors such as Chiasson *et al.* (2007) have also identified the need to draw lessons from the IS research domain and apply them in HIS research, and there is growing evidence from the literature that this is taking place, even if on a small scale. However, from the literature review, it appears that much less transfer from the HIS domain to the IS domain has taken place than in the other direction.

In order to further ensure that the best possible use was made of the opportunity to work in the highly complex environment of hospitals across two provinces, using three different CHISs, this study followed a multi-method approach, by applying both interpretivist and positivist approaches to the analysis of the available qualitative and quantitative data, as described in Chapter 3. Thus, the current CHIS success study has drawn on a wide range of experiences from the literature to inform the analysis of the complex problem of how hospitals use CHISs.

This review of related literature demonstrates that there are lessons to be learned from the published literature about problems and positive experiences in the implementation of CHISs in both LVR and relatively well-resourced environments (for example, Gauld, 2007; Jacucci *et al.*, 2005; Southon *et al.*, 1999). However, Gauld (2007) and others also note that lessons from literature and experience seem to be ignored in at least some of the CHIS selection and implementation experiences reported in the literature. The dissemination of the results of this study beyond academic publication should contribute to the process of applying 'known' lessons or approaches in the selection and implementation of CHISs and other ISs in organisations.

Drawing further on the literature, the following chapter describes the design of the study and the theoretical basis for this work.

CHAPTER 3 RESEARCH DESIGN, APPROACH AND THEORETICAL UNDERPINNING

3.1 INTRODUCTION

The literature review has provided an overview of the diverse work related to success of information systems (IS) in general, and computerised health information systems (CHISs) in particular. In order to develop a coherent project, lessons from the literature and from the CHIS implementation experiences in South Africa, have to be synthesised to inform the identification of factors associated with CHIS use in South Africa. In this chapter, an argument is made for the development of a new model to describe CHIS use in South African level 1 and level 2 public sector hospitals[1]; the research design and approach for the study are described; the theoretical background is explained; and the ethical issues which had to be taken into account in the study are described.

3.2 MOTIVATION FOR A NEW FRAMEWORK FOR CHIS IMPLEMENTATION

The problem statement for this study has been formulated as follows:

> There is a need to provide support for decision-makers to reduce the risk of lack of success in the acquisition and implementation of computerised hospital information systems (CHISs) for level 1 and level 2 hospitals in South Africa through the identification of factors associated with CHIS success in these environments.

The aim for the complete study is the identification of factors which can easily be used in practice to assess CHIS success, and to assess the potential for CHIS success in a particular setting. As described in Section 1.5, the measurement of IS success in general, and HIS success more specifically, is a challenge which has been addressed in multiple studies. In their revised IS success model, DeLone and McLean (2003) identify the extent to which the IS is used (or there is an intention to use it) as being one of the factors related to IS success. LeRouge *et al.* (2007) have extended the DeLone and McLean concept of system use by analysing use quality as a factor in IS success. Of particular interest for this project is the extent to which the CHIS

[1] Level 1 and level 2 hospitals are described as district and regional or secondary hospitals, respectively, in province 1 (the province in which the case studies were conducted, and in which a survey was conducted). In province 2 (in which a survey of hospitals was conducted), level 1 hospitals are described as district hospitals, and level 2 hospitals are described as provincial hospitals.

outputs are used by hospital-level managers to support their planning for and management of hospitals. The conceptual model developed in this project describes factors associated with CHIS use, since one essential component of CHIS success is that the system, or its outputs, should be used by the intended users.

A new framework in the form of a conceptual model of CHIS use is developed in this study, based on relevant theoretical background and the results of case studies and survey, to support decision-making about CHIS acquisition and implementation in South African level 1 and level 2 hospitals. This framework takes into account the context in which the CHISs are implemented (environments of limited or vulnerable resources such as skilled personnel and infrastructure; and CHISs of limited scope, i.e., ADT and billing). The initial conceptual model of CHIS use is described in Chapter 4 and model revisions are described in Chapters 5 and 6. The analysis of the data from this study also attempts to examine the relative importance of the factors affecting CHIS success or failure, and make proposals for overcoming or coping with at least some of the effects of limited or vulnerable resources on CHIS implementation and use.

A combination of techniques is used in this project, namely case studies and an empirical study in the form of a survey of South African level 1 and level 2 hospitals to test and refine the conceptual model, as described in the following sections.

3.3 RESEARCH DESIGN

3.3.1 Components of the research study

The study process is described graphically in Figure 3.1.

Pilot case studies were conducted at three level 2 hospitals in Province 1. At these hospitals, the use of an administrative CHIS (SystemA), which covers ADT and billing functions, was well-established at the time of the case studies.
The purpose of these case studies was to determine how CHIS success was described, and how the level or extent of CHIS success was assessed, in the study hospitals.
These pilot case studies are described in Chapter 4.

A conceptual model of CHIS use was developed based on the results of the pilot case studies; the literature on IS success and failure; and the literature on HIS success and failure.
This **initial conceptual model of CHIS use** is described in Chapter 4, Section 4.2.

A more detailed case study was conducted in a fourth level 2 hospital in Province 1, which also used the SystemA CHIS. This hospital was selected because it is much further (approximately 400km) from the urban centre in which the CHIS supplier is based than was the case for the pilot case study hospitals. The aim of this case study was to build on the results of the pilot case studies in order to test and, if necessary, extend the initial conceptual model. The initial conceptual model of CHIS use provided the framework for this case study.
The more detailed case study is described in Chapter 5, Section 5.2, and the findings are described in Chapter 5, Section 5.4.

The key output of the detailed case study was the revision of the conceptual model to form an **extended conceptual model of CHIS use**, based on the case study results, further review of the literature and interviews with HIS experts to obtain a perspective on provincial-level factors associated with CHIS success.
The extended conceptual model is described in Chapter 5, Section 5.5.

A survey was conducted of CHIS implementations in level 1 and level 2 hospitals in two South African provinces in order to supplement the data from the case studies with data from a cross-section of hospitals.

The aim of the survey was to further refine the extended conceptual model and to determine the relative significance of the factors identified as being associated with success or lack of success in CHIS implementation in the hospitals surveyed.
The survey is described in Chapter 6, Sections 6.2 and 6.3, and the findings are described in Chapter 6, Section 6.4.

The final version of the conceptual model of CHIS use for this project was developed based on the results of the survey.
The final version of the conceptual model, the **revised conceptual model of CHIS use**, is described and discussed in Chapter 6, Section 6.5.

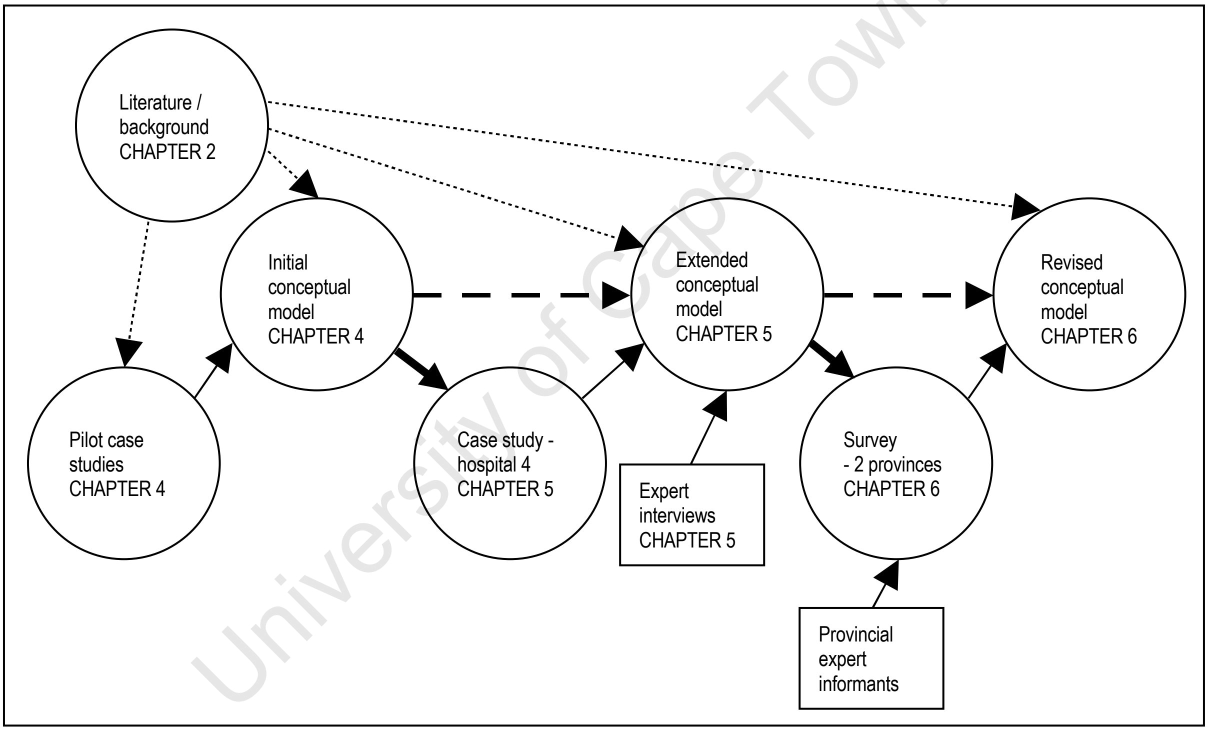

Figure 3.1 Diagram of the study process

3.3.2 Research approach

Two contrasting approaches (positivist and interpretivist) have typically been used in the analysis of the effects of the implementation of information systems in organisations. Much of the literature on IS success seems to reflect the positivist approach, in which attempts are made to demonstrate the validity of theories of IS success, or the need to modify such theories, based on empirical studies of comparatively large numbers of cases (for example, studies reviewed in DeLone and McLean, 2003).

The theoretical work relating to HIS success and failure identified to date has generally been based on an interpretivist approach, in which the aim is to deepen understanding of the social and other factors which contribute to the experience of implementing HISs in different environments. In an interpretivist approach, the aim is to develop an understanding of the relationships between an organisation (a level 1 or level 2 hospital, in this study), the people in that organisation, and the information system (the CHIS, in this study). The idea is not to test an outside view of the interaction between these elements of an environment, but to develop an understanding of the environment from the perspective of those within it (such as hospital personnel). The aim of some HIS studies has been to develop or extend theories which provide a framework in which to interpret results (for example, Thompson, 2002; Braa and Hedberg, 2000). Two more recent studies of factors influencing the success of HISs have taken the form of Delphi studies (Paré *et al.*, 2008; Brender *et al.*, 2006). The interpretivist approach is appropriate to investigating CHIS success or failure because the highly complex nature of the environment being studied makes it difficult to predict outcomes of activities.

This study used the opportunity to combine positivist and interpretivist approaches by using in-depth case studies to identify and examine the factors which affect the success or failure of CHISs in the environment of level 1 and level 2 public sector hospitals (a largely interpretivist approach), in combination with a survey of a large number of these organisations in an attempt to explain similarities and differences in the experiences of CHIS implementation across the organisations (a largely positivist approach). The combination of interpretivist and positivist approaches has been advocated by authors such as Roode, 2003; Lee, 1991; and Kaplan and Duchon, 1988; so that the strengths of each approach can be combined to enrich the analysis of a particular domain.

Plummer (2001) proposes that a structured-case approach could be useful in analysing the organisational aspects of health information system development and implementation, and building (supporting) theory. She proposes the iterative development of a conceptual model of the situation, based on the applicable theories from the literature, personal experience, inputs from key informants, and the results from the case studies as they become available. Riedl *et al.* (2007) used this structured-case approach to investigate the success factors for e-government initiatives, and identified process effectiveness, process efficiency, resource efficiency and motivation efficiency as components of e-government success. The process of development of a conceptual model of CHIS use in this project reflects Plummer's structured-case approach (Plummer, 2001): The initial conceptual model was developed on the basis of results of the three pilot case studies; models and approaches from the IS and HIS literature; and personal experience of the author. This conceptual model i informed the main case study (at hospital H4) for this project. The initial conceptual model was extended and further developed on the basis of the results of the case study, interviews with key informants and further literature review, and the updated ('extended') conceptual model was then used as the basis for the survey component of the project, as described in Chapters 5 and 6.

The broad framework for the methodological approach used in this study is a reflection of the complexity of the issues being addressed: the **socio-technical approach** to HIS studies, as described by Berg and others (Westbrook *et al.*, 2007; Aarts *et al.*, 2004; Berg, 2001), is based on the premise that the implementation of information systems, such as CHISs, results in a complex interaction between the organisation (as the environment in which the CHIS is implemented), including the people involved in implementing and using the CHIS; and the CHIS itself – the application software, as well as the supporting hardware and system software; i.e., the social and technical aspects of the implementation.

This approach is consistent with the intention in this study to examine the implementation of CHISs in the specific context of level 1 and level 2 public sector hospitals in a developing country, based on the premise that access to the resources required for CHIS implementation in these environments is limited and vulnerable. The socio-technical approach provides a mechanism for the incorporation of the context issues in the study design and analysis.

The CHISs in use in the study hospitals mainly support patient administrative functions (patient registration, admission/discharge/transfer and billing). [A pharmacy module to support dispensing of patient medicine was in use in one of the survey hospitals (D24), and implementation of a pharmacy module was planned in one case study hospital (H4), but this component of the CHIS implementations was not addressed in this project in any detail.] Most published HIS studies identified in this project refer to clinical information systems, such as computerised physician order entry (CPOE) systems, which are based on the patient administration components of the system, but then make specific provision for supporting aspects of clinical work. The lack of published studies of administrative CHISs such as those in use in the study hospitals appears to imply that the technical and organisational issues related to a CHIS implementation like those at the study hospitals are relatively trivial. However, the report of a study of a South African hospital in the Eastern Cape Province from Jacucci *et al.* (2005) and the report on a CHIS implementation in Limpopo Province (Littlejohns *et al.*, 2003) highlight the challenges experienced with the implementation of similar CHISs in those environments.

3.3.3 Research methods

The interpretivist component of the current project provided the opportunity to examine the use of a specific CHIS through case studies in three hospitals (the pilot case studies) in order to improve understanding of factors which influence the potential for CHIS success or failure.

Once factors associated with CHIS success or failure had been identified, they were incorporated in the initial conceptual model of CHIS use (as described in Chapter 4). This initial conceptual model then provided the framework for the subsequent (fourth) case study, as described in Chapter 5.

Based on the findings from the fourth case study, and additional insights from the literature and from interviews with HIS experts, the conceptual model was revised to develop an 'extended conceptual model of CHIS use' (see Chapter 5).

The aim of the third methodological component of the study was to validate the extended conceptual model by conducting a survey of CHIS use in a larger number of hospitals – level 1 and level 2 hospitals in two South African provinces. Survey respondents were asked questions designed to confirm (or not) the factors affecting CHIS success, and the relationships between them. These factors had been identified from the case studies, the expert interviews, and the review of the literature. This largely positivist approach was supplemented by a small interpretivist component of the survey, since respondents were also asked a few open-ended questions designed to obtain information on additional factors which they believed affected CHIS success in the study environments.

(a) Multiple methods

The argument has been made in the previous section for using a variety of methods, in order to maximise the chance of identifying factors associated with CHIS success in hospitals.

Westbrook *et al.* (2007) are also following a multi-method approach in a multi-year study of the implementation of a commercial CPOE system in a single Australian hospital, describing the analysis of the effects of this implementation as a 'wicked' problem, requiring multiple methods of investigation in order to gain the best possible understanding of the process. Gagnon *et al.* (2008) plan to follow a multi-method approach to examining the decision-making processes related to e-Health implementation in Quebec, Canada, in an effort to support an effective decision-making process in that environment.

Ragin (1999) clarified the distinction between case-oriented and variable-oriented research strategies, noting that

> The case-oriented strategy is centrally concerned with making sense of a relatively small number of cases … selected because they are theoretically significant in some way. The variable-oriented strategy is centrally concerned with the problem of assessing the relationship between aspects of cases across a large sample of "observations", usually with the goal of specifying general patterns that hold for a population. (Ragin, 1999, pp1137-1138)

He noted further that the approach to producing results from evidence differs between the two strategies:

> In case-oriented research, the aim of a study is to gain an understanding of factors associated with a particular outcome ('factors associated with CHIS success in South African hospitals' in the current study), using multiple cases to improve understanding of the outcome.

Cases are thus chosen in such a way as to provide the opportunity to broaden understanding, rather than on the basis of statistical sampling in order to ensure representativeness of a particular class of cases. In the case of the current study, therefore, the emphasis in the case studies was on identifying factors associated with CHIS success. In variable-oriented research, on the other hand, Ragin (1999) notes that the emphasis is on the variables, rather than on cases, and the aim is to explain differences in outcome linked to differences in associated variables. Thus, in the survey component of the current project, part of the aim was to 'determine the relative significance of the factors identified as being associated with success or lack of success', and one of the objectives was 'to identify differences between hospitals/groups of hospitals in respect of factors associated with success or lack of success'. Rephrased, the questions being addressed were: 'Do the factors differ?' and/or 'Does the (relative) weighting of the factors differ?' across categories of hospitals and/or categories of users within hospitals.

The case studies and discussions with expert informants were expected to yield mainly qualitative data about opinions of the CHISs in use in the study environments. The survey was designed to collect quantitative data, based as far as possible on a 5-point scale to order opinions, and thus facilitate statistical analysis. The design of the questionnaires also made provision for recording qualitative data, both through open-ended questions and by making provision for respondents to comment on issues raised in the questionnaires if they wished. An important point made by both Ragin (1999) and Yin (1999) is that both case studies and surveys can yield qualitative and/or quantitative data. While the case studies and the expert interviews for this project made only limited use of quantitative data, the survey yielded a combination of qualitative and quantitative data.

(b) Case study

The use of case studies in examining HIS implementations is well established (for example, as reported by Mohd.Yusof *et al.*, 2008; Aarts *et al.*, 2004; Littlejohns *et al.*, 2003; Southon *et al.*, 1999).

In practice, the pilot case studies and the main case study (at hospital H4) resulted in the identification of factors associated with (effective) CHIS use, rather than the more general concept of CHIS success. The description of the relationship between these factors was formalised in the development and refinement of a conceptual model of CHIS use, as described in Chapters 4, 5 and 6. The case study at hospital H4, described in more detail in Chapter 5, differed from the pilot case studies at hospitals H1, H2 and H3: the pilot case studies were largely exploratory in nature, with an interview guide to provide structure to interviews with users, but no defined expectations about outputs, as described in Chapter 4, Section 4.2. The H4 case study was aimed at investigating the applicability of the initial conceptual model of CHIS use while also clarifying information gained in the pilot case studies.

RK Yin has written iconic books and papers on case studies, including a paper in which he makes recommendations for enhancing the quality of case studies in health services research (Yin, 1999). The paper provides guidelines for researchers and evaluators of case study-based projects to help ensure that the results of case studies are valid and useful. Since the CHIS success study can be classified within the category 'health services research', Yin's paper provided a useful framework for describing and reviewing the methodology for the case study at hospital H4:

Among the issues identified by Yin (1999) as being associated with high quality case studies are the following:

- The cases need to be clearly defined --- including clear definitions in terms of time --- since cases can change over time. Although the pilot case studies and the main case study were carried out at different times (pilot case studies in 2003 and 2004, and H4 case study in 2006), the CHIS in use at all the case study hospitals, and the organisational framework within which the CHIS was operating at the case study hospitals, had not changed markedly during this period.
- Case studies 'should contain some operational framework' even if they are exploratory (Yin, 1999, p1215). For the pilot case studies in this CHIS success study, the framework was provided by the interview framework which was used in all the case studies, and the key IS success models identified by that stage: DeLone and McLean, 2003; Heeks *et al.*, 1999; and Ballantine *et al.* ,1998. The initial conceptual model of CHIS use and the same interview framework (as used in the pilot case studies) provided the operational framework for the main case study conducted at hospital H4.
- Yin proposed that, in order to strengthen the argument arising from the case study, data 'investigators may want to put serious effort into identifying and collecting data to support or reject plausible rivals, that is, rival explanations from either a logical or empirical standpoint' (Yin, 1999, p1217). While this factor was not explicitly addressed in the case studies, the discussion of competing conceptual and other models related to CHIS success (in Section 3.4, for example) does address this point to some extent.
- Yin also notes that the necessary process of triangulation of evidence 'occurs as data collection proceeds … and is not the same as the triangulation that later occurs when findings are being interpreted' (Yin, 1999, p1218). He comments further that triangulation must be a specific component of the case study protocol. The use of a common interview framework across all the case studies in this CHIS success study ensured that a core of similar data was being collected across the case study hospitals. Since the initial conceptual model of CHIS use developed from the findings of the pilot case studies was used as the framework for the H4 case study, the H4 case study was, by definition, an attempt at triangulation of data across the cases.

(c) Survey

The aim of the survey of level 1 and level 2 public sector hospitals in two provinces was to gain an understanding of the CHIS implementations in a large number of hospitals (between 50 and 60), to find out whether the extended conceptual model of CHIS use could be applied in these environments, and to find out whether any additional factors associated with CHIS success in the study hospitals could be identified. While the primary aim of the survey was not to obtain information about the CHIS itself in each hospital, questions were included about the functioning of the CHIS, relating to the factor 'CHIS performance' in the conceptual model of CHIS use. The survey was also designed to confirm that the factors included in the conceptual model of CHIS use do apply in a wider set of hospitals, and to find out whether the relationships described in the conceptual model could be identified from the survey data. Several hypotheses related to the factors in the conceptual model were defined for investigation through the survey, as described in chapter 6, section 6.2.5. Multiple categories of hospital users were also identified for the survey so that opinions about factors associated with CHIS success or lack of success could be compared across categories of users.

There was no evidence from the available literature that other surveys of similar scope had been conducted either in South Africa or elsewhere. A series of papers related to surveys of the status of clinical information technology in hospitals in Canada and the US focussed on different aspects of HIS use in these hospitals: Jaana *et al.* conducted a survey of clinical information technology in hospitals in the state of Iowa in the US and in two provinces in Canada (Jaana *et al.*, 2005), building on an earlier study of what the authors describe as 'information technology sophistication' in Canadian hospitals (Paré and Sicotte, 2001). They investigated the status of computerisation in the study hospitals, as well as the extent of integration between different applications. A later study (Ward *et al.*, 2006) examined variations in clinical information system availability and use between urban and rural hospitals in the same US state (Iowa). The current CHIS success survey focussed on the use of the CHIS in the study hospitals, rather than on the interaction and/or integration between multiple information systems in use in the study hospitals --- although this could be a valuable focus of future studies in South African hospitals and other South African healthcare facilities.

(d) Generalisation of results

A further contrast between case studies and surveys is the approach to generalisation. Yin argues that 'hypotheses and theory' should be the basis of generalisation from case studies (Yin, 1999, p1212). In this study, multiple cases (three level 2 hospitals in Province 1, using the

SystemA CHIS) were studied to obtain an understanding of the use of CHISs in hospitals of the type which were the focus of the project, leading to the development of an initial conceptual model of CHIS use. This conceptual model then provided the starting theory for the next phase of the study: a fourth case study selected to inform further elaboration of the conceptual model, as described in the previous section. The potential for limited generalisation of the results of the case study (in the form of the extended conceptual model of CHIS use) was examined in the survey, which covered level 1 and level 2 hospitals in two South African provinces (Province 1 and Province 2), each using one of three CHISs (including SystemA). The potential for generalisation of the survey results is discussed in Chapter 7, Section 7.2.2.

3.3.4 Methodologies for data collection

Three major approaches to data gathering were used in the current study:

(a) case studies of hospitals, using observation and semi-structured interviews;

(b) semi-structured interviews and discussions with selected expert informants to obtain information from a provincial perspective; and

(c) a survey of hospitals, using questionnaires administered either by an interviewer or self-completed by the respondents.

(a) Data collection

Data collection for the case studies is described in Sections 4.2.1 and Section 5.2.5, and in Annexure D (Protocol for case study).

Data for the case studies were collected mainly through interviews and discussions with CHIS users and through observation of the use of the CHIS by hospital personnel. Members of hospital management, who would be expected to use outputs from the CHIS rather than being direct users of the CHIS, were also interviewed, as were clinical personnel at hospital H4. The outline questionnaire attached as Annexure E was used to guide the interviews.

Interviews and observations for the pilot case studies (at hospitals H1, H2 and H3) were recorded in the form of written notes taken by the researcher, which were later transcribed electronically by the researcher. As described in Section 5.2.5, all interviews at hospital H4 were recorded in the form of written notes taken by the researcher, and some of the interviews were audio recorded, with the permission of the interviewee. The written notes were later transcribed electronically by the researcher. The audio recordings were partially transcribed by the researcher, to complement the written notes.

Expert interviews were held to provide a provincial-level perspective, as described in Section 5.3. The interviews were recorded by the researcher in the form of written notes.

Data collection for the survey is described in Sections 6.2.5 and 6.2.6, and in Annexures F (Survey protocol) and J (Data collection for Province 1 and Province 2). Questionnaires were completed either by the researcher, a second interviewer, or by the respondents themselves. All data were captured electronically by a research assistant and reviewed by the researcher to ensure that the data had been captured accurately.

(b) Data validity and reliability

As far as possible in a study of this kind, data validity and reliability were taken into account in the study design. The use of a combination of methods: case studies, expert interviews and survey, was aimed at providing multiple, complementary, views of CHIS use in hospitals.

The pilot case studies at hospitals H1, H2 and H3 were exploratory and intended to provide an initial overview of factors associated with CHIS success in these environments. All data collection was done by the researcher, making it possible to consolidate the understanding of the environment from one hospital to the next. At each hospital, there were multiple informants, so the information obtained was not dependent on a single source and the validity could therefore be tested by comparing the information received from the different respondents within and between hospitals. For the main case study at hospital H4, all data collection was again done by the researcher, and was based on multiple interviews, against the background gained from the pilot case studies. The use of the outline questionnaire to guide interviews provided as much consistency between interviews as is possible when conducting semi-structured interviews.

Data obtained from the case studies were also compared with information from the literature, and with relevant inputs from the expert interviewees.

The surveys were designed to build on the data obtained from the case studies by extending the data sources across additional hospitals, additional CHISs and an additional province. The use of more structured questionnaires than for the case studies was intended to ensure consistency of data collection from the multiple informants. Data collection was done by the researcher and an assistant, and in some cases the questionnaires were self completed, as described in Section 6.2.6. It was difficult to test validity of data due to the dependence on the informants providing the data. As far as possible, multiple informants were used from each hospital, but this was not possible in all cases.

3.3.5 Methodologies for data analysis

Data analysis for the pilot case studies is described in Sections 4.2.5 and 4.2.6. Since this was an exploratory phase of the project, the major aim of the data analysis was to link the data obtained to the themes represented by the factors of the DeLone and McLean model of IS success (DeLone and McLean, 2003), and to identify any additional themes emerging from the data. This process was achieved by multiple reviews of the notes on the interviews and the observations at the case study hospitals. The development of a conceptual model of CHIS use provided a mechanism for summarising the data from the pilot case studies, as described in Section 4.3.

Data analysis for the main case study at hospital H4 is discussed in Section 5.4.1. The initial conceptual model developed from the pilot case study results provided the lens through which the results of the main case study were analysed. The data from the case study were therefore initially reviewed in terms of the factors of the initial conceptual model of CHIS use. Further analysis of relationships between factors in the conceptual model informed the extension of the conceptual model, as described in Sections 5.4.2 and 5.5.

For the survey, data analysis was focussed on testing hypotheses derived from the extended conceptual model of CHIS use developed from the case studies. The data analysis approach for the survey is discussed in Section 6.3.

Thus, the data analysis throughout this study was focussed on the development of successive versions of the conceptual model of CHIS use, as described in Figure 3.1. In practice, there were several iterations of the conceptual model of CHIS use, but the major versions are discussed Chapters 4, 5 and 6.

3.4 THEORETICAL UNDERPINNING

The initial theoretical underpinning for this project was provided in the main by theories and models of IS success, most notably that of DeLone and McLean (2003), and approaches to modelling and analysing factors associated with HIS success, as described in section 3.3. The author's own conceptual model of CHIS use, developed iteratively during this study, provided the framework for the analysis and interpretation of data from the detailed case study and the survey.

3.4.1 Related theories and models

Since CHIS selection, implementation and use take place in complex environments, theories and approaches from multiple disciplines could be applicable. Authors such as Despont-Gros *et al.* (2005); Mshana (2004); Kukafka *et al.* (2003); Van der Meijden *et al.* (2003); and Kaplan (2001) have demonstrated approaches to combining theories from multiple disciplines in order to address the multitude of factors which could influence the successful implementation of health information systems.

The literature on IS success and CHIS evaluation has provided the major theoretical basis for this project. The IS success literature has reflected an approach to theory development which is based largely on analysis of relevant empirical studies, with the work of DeLone and McLean (1992 and 2003) forming the basis for much further theory development, but also being used as the framework for analysing results of studies (as indicated in DeLone and McLean, 2003; and Van der Meijden *et al.*, 2003).

In the HIS domain, much of the work has been based on qualitative case studies, in some cases supported and/or supplemented by lessons from the IS success literature. However, Heeks *et al.* (1999) developed a model to describe factors affecting success and failure of health information systems based on a large literature survey, as did Despont-Gros *et al.* (2005). Examples of qualitative studies include those by Aarts *et al.* (2004), who conducted a detailed analysis of the implementation of a computerised physician order entry system in one hospital, using three different theoretical approaches; and the study reported by Southon *et al.* (1999), in which they examined a single case of HIS failure, involving multiple hospitals, in great depth.

The HIS literature seldom refers to the development of 'theories' of HIS success, implementation and/or use, referring more often to the development of 'models' or 'frameworks' in describing the same process. Thus, models and frameworks have been developed, sometimes based on theories of IS success or human-computer interaction, or specific theoretical approaches such as actor-network theory (ANT), activity theory or structuration theory (for example Tiihonen *et al.*, 2006; Despont-Gros *et al.*, 2005; Korpela *et al.*, 2004; and Braa and Hedberg, 2002). In some cases, results are reported in terms of the analysis of the applicability of particular theoretical approaches in the HIS domain, rather than as extensions of the theories or new theories. In other cases, the models or frameworks developed to describe and explain the phenomenon being examined, for example the development, implementation or use of HISs in particular environments, could then be used as a basis for further related analyses.

This project follows the approach of examining existing models for applicability in the study environment, and then making modifications as necessary to develop a new framework. The development of a conceptual model of CHIS use on the basis of the results of preliminary case studies, as described in Chapter 4, reflects this approach.

3.4.2 Success as a concept

Despite many references to IS and HIS success and failure, success as a concept continues to be very difficult to describe. In a comprehensive literature review of determinants of success of inpatient clinical information systems, Van der Meijden *et al.* (2003) found no specific definitions of success in the literature. They noted the use of models to describe or predict success rather than formal definitions. Models such as those of DeLone and McLean (1992 and 2003) aim to provide a description of the factors which contribute to or affect IS success. Heeks *et al.* (1999) identify factors which can be associated with a potential for HIS success or failure. Van der Meijden and colleagues (2003) used the DeLone and McLean framework as the basis for the analysis of their results. They found that the DeLone and McLean model applied in many of the studies but that, especially in cases of HIS failure, the model did not identify all the contributing factors. As will be described in Chapter 4, limitations identified in the DeLone and McLean model, and other models, resulted in the development of the initial conceptual model of CHIS use in this study.

Brender *et al.* (2006) reported on a Delphi study of success factors and failure criteria, which was conducted among participants in a conference on factors influencing HIS success and failure held in 2004. One interesting aspect of this study is that the following definition for success was provided:

Success' for a Health Informatics application means that a combination of the following aspects are more or less fulfilled for the IT-based solution:

- It is widely acknowledged and used in daily practice; users are willing to contribute to improvements
- It fulfils the role and tasks it was planned for in the environment where it is used and for those users who are using it
- It supports good medical practice, and hence benefits the patient
- It benefits the healthcare organisation and the conditions of work for its personnel, or at least a significant proportion of them, without penalizing the other ones or, similarly, without hampering other significant aspects
- It can easily be upgraded to cope with the evolution of healthcare technology and practice as well as to manage emerging demands. (Brender *et al.*, 2006, p129).

The following definition of failure was given:

> Failure of a health informatics application is either due to the non-fulfilment of the defined success aspect or a set of specific criteria that - if present - more or less guarantees failure to achieve one's goals. (Brender *et al.*, 2006, p129).

These definitions, and the success and failure factors described in this study, will be addressed further in the discussion of results of this project.

3.4.3 Theories and models of success

The IS success and related literature (for example, DeLone and McLean, 1992 and 2003; Ballantine *et al.*, 1998) reports on the development of models and theories of IS success, IS use, IS acceptance, and IS implementation, with an emphasis on the identification of factors which influence IS success and failure, the extent of IS use, etc. The updated DeLone and McLean model (DeLone and McLean, 2003) is shown in Figure 3.2. Implicitly or explicitly, this literature appears to refer to computerised information systems, rather than to information systems in general. This literature is relevant for this project because the focus of the project is on (CHISs).

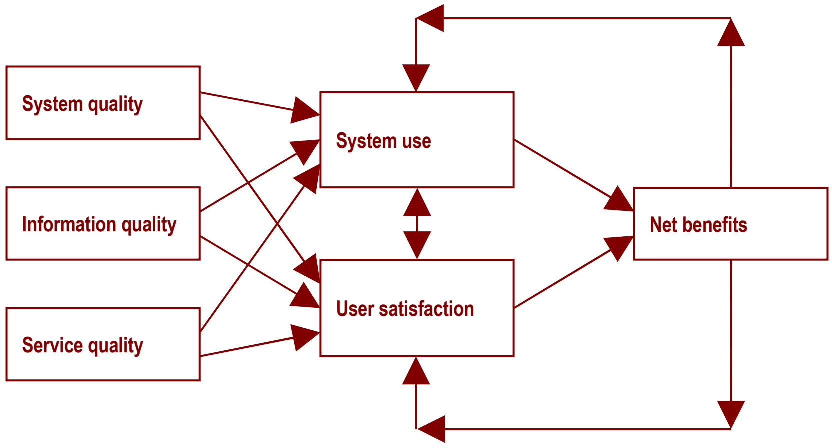

Figure 3.2 Model of IS success (from DeLone and McLean, 2003)

Related theories of diffusion of technology, such as the Technology Acceptance Model (Davis and Venkatesh, 1996; Davis, 1989) and Rogers' Theory of Diffusion of Innovation (Rogers, 1995; quoted in Paré and Trudel, 2007) have been applied in a wide range of situations, and to a wide range of technologies (for example Brown (2002) in relation to the use of web technologies by disadvantaged students in South Africa; and Paré and Trudel (2007) reporting on knowledge barriers to the adoption of Picture ArChiving Systems (PACS)).

Few specific models related to HIS success have been identified in the literature to date. The ITPOSMO model of design-reality gaps, shown in Figure 3.3, was developed by Heeks *et al.* (1999) and discussed further by Heeks (2006). They identified seven dimensions along which such gaps can arise, thereby constituting the risk of failure for a proposed information system: Information; Technology; Processes; Objectives and values; Staffing and skills; Management systems and structures; and Other resources. In discussing a model of the implementation of an order entry system in a hospital in the Netherlands, Aarts and colleagues noted the importance of fit between an information system and the underlying organisational model (Aarts *et al.*, 2004). Mohd.Yusof *et al.* (2008) also address the issue of fit in the HOT-fit model, which provides an evaluation framework for HISs based on Human, Organisation and Technology factors (see Figure 3.4).

Some of the work on success of HIS is reflected in the literature on evaluation of HIS (for example Mohd.Yusof *et al.*, 2008; Brender *et al.*, 2006; Odhiamo-Otieno, 2005; Ammenwerth and de Keizer, 2004; Lorenzi and Riley, 2003; Kaplan, 2001; Hanmer, 1999; Southon *et al.*, 1999; Van Gennip and Bakker, 1995). The emphasis in much of this evaluation literature is on the organisational aspects of HIS implementation, including the essential role of people as system users and system managers, and is therefore very relevant to this study.

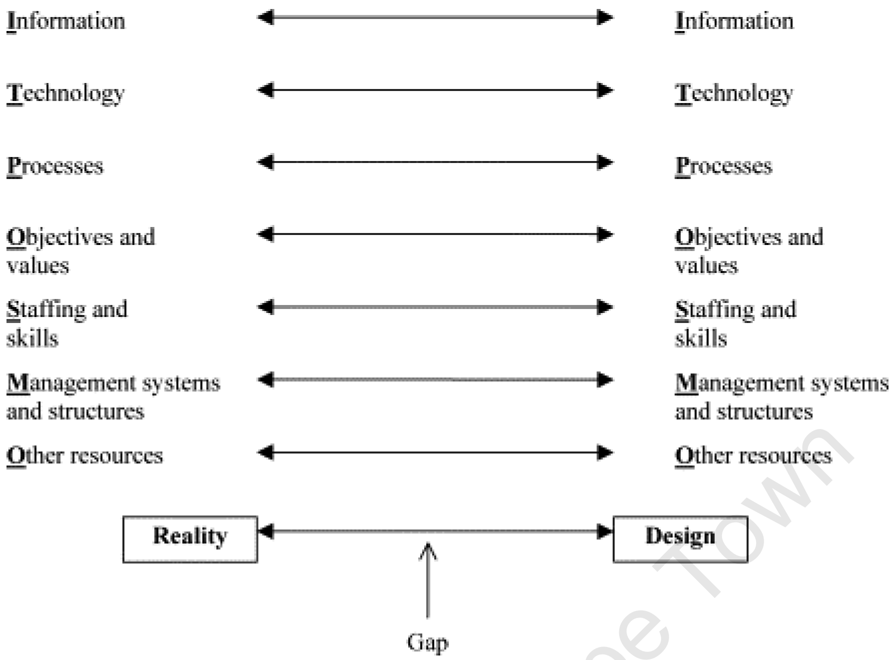

Figure 3.3 ITPOSMO dimensions of health information system design-reality gaps (from Heeks, 2006, p129)

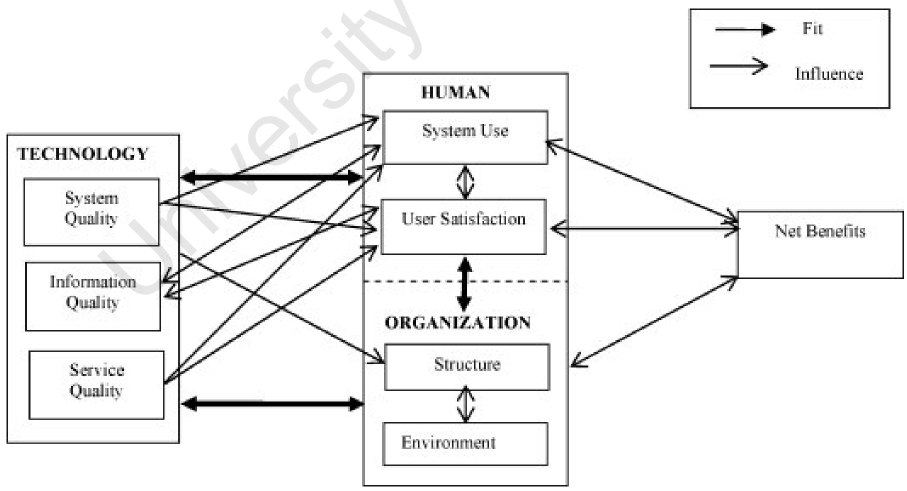

Figure 3.4 HOT-fit model (from Mohd.Yusof *et al.*,2008)

The process of development and refinement of a conceptual model of CHIS use, which formed part of the theoretical basis of this study, is described in the following section.

3.4.4 Conceptual model of CHIS use

The first phase of this project consisted of a pilot study in the form of case studies (the pilot case studies) in three South African level 2 hospitals. The aim of this pilot study was to gain an understanding of how CHIS users view the concept of CHIS success. The DeLone and McLean (D&M) model of IS success (DeLone and McLean, 2003) was used as the framework for the initial analysis of results from the pilot case studies (as described in Chapter 4, Section 4.2.5). While the D&M model provided a useful framework for the analysis (in that all the factors of the D&M model were identifiable in the data from the pilot case studies), the D&M model does not make explicit allowance for the analysis of the organisational issues which were shown to have a major impact on the experience of CHIS implementation in the study hospitals. These factors include the availability of the resources required for CHIS implementation and maintenance, and the role of the management at hospital level in ensuring the availability of such resources and in influencing user attitudes to the CHIS. The D&M model also does not take specific account of the context in which the CHIS has been implemented, for example the fact that the CHIS in use at hospital level is selected at provincial level.

Due to these identified limitations of the D&M model and the lack of an alternative model which addressed all these limitations, an initial conceptual model of CHIS use was developed, based on the results of the pilot study at three hospitals and theoretical models reviewed by that stage (2003), including DeLone and McLean, 2003; Ballantine *et al.,* 1998; and Heeks *et al.*, 1999; and the author's own background knowledge of CHIS implementations. The aim of this initial conceptual model was to clarify those issues identified during the case studies which have the potential for explaining differences between the experiences of CHIS implementation in the three hospitals. This initial conceptual model, which provided the 'starting theory' for the rest of the project, is described in detail in Chapter 4. Once the initial conceptual model had been developed, it was used as the framework for the subsequent, more detailed, case study, and continued to be developed and expanded as data became available from subsequent phases of the project, as shown in Figure 3.1.

Since the conceptual model could (strongly) be supported from the literature, it is argued that it is justified to use it as the starting theory for the rest of the project. Thus, the initial conceptual model of CHIS use (described in Chapter 4) fulfilled the role of the theoretical underpinning for the subsequent analyses, thereby effectively following the structured-case approach described by Plummer (2001). A similar approach was described by Mohd.Yusof *et al.* (2008), who followed an iterative process between case studies and model development in the development of their HOT-fit model for HIS evaluation.

3.5 ETHICAL CONSIDERATIONS

The Ethics Committee of the Medical Research Council approved this project, including the case study and the survey (protocol EC06-013). **A copy of the letter of approval from the MRC Ethics Committee is attached as Annexure A.**

The major ethical considerations rest on the confidential handling of the data on CHIS use gathered during the case study and survey, as described in the project proposal. Negative consequences are not anticipated provided that confidentiality is maintained.

Written permission to conduct this study was obtained from the relevant provincial health authorities, and from the heads of each of the case study hospitals (hospital H1 to H4). Letters were written to each survey hospital requesting permission to conduct the survey.

Patient confidentiality was not a concern in this project, since there was no contact with patients or patient records.

The focus of this project was not on individual hospitals or members of hospital staff. In order to preserve the confidentiality of participants, no interviewees or individual hospitals have been identified in any reports.

This project has resulted in comments about the potential and actual success of the implementation of specific CHISs at specific hospitals, although this was not the focus of the project. Apart from maintaining confidentiality about the identities of project informants, therefore, it has been necessary to maintain confidentiality about the hospitals involved in the study. In this way, confidentiality about the actual CHISs in use in the study hospitals should also be maintained in reporting on this project outside the study provinces.

The text of a letter to the institution requesting permission to conduct a survey is attached as Annexure B.
An information sheet in the form of a letter to potential interviewees for the survey is attached as Annexure C.

The next chapter describes the first of three phases of data collection and conceptual model development: the pilot case studies, and the development of the initial conceptual model of CHIS use.

CHAPTER 4 PILOT STUDY AND INITIAL CONCEPTUAL MODEL

4.1 INTRODUCTION

A conceptual model of CHIS use provides the theoretical underpinning for the main case study and the subsequent survey of hospitals, which together provided the bulk of the input data for this project. The presentation of this initial conceptual model of CHIS use in this chapter is preceded by a description of the pilot case studies on which it is based. .

This rest of this chapter describes the pilot case studies; the initial analysis of the results of the pilot case studies, based mainly on the D&M model (DeLone and McLean, 2003); and the development of the initial conceptual model of CHIS use, which formed the basis for the subsequent phases of this study.

4.2 PILOT STUDY OF CHIS SUCCESS

4.2.1 The pilot case studies

Case studies were conducted at three public sector level 2 hospitals in Province 1 between May 2003 and April 2004.
The objectives of these case studies were

- to describe and analyse the effects on the hospitals of the CHIS implementation;
- to identify those factors which are associated with perceptions of the success or lack of success of the CHIS implementation; and
- to identify those factors which could be associated with the success or lack of success of the CHIS implementation.

A combination of observation of the CHIS in use and semi-structured interviews with representatives of hospital management (clinical, nursing and/or administrative), specialist information management personnel (if any), case managers responsible for co-ordinating services for any private patients in the hospitals, and CHIS end users was used to obtain data for the study. A standard set of questions was used as a guide for all interviews. Four interviews were conducted at hospital H1, six interviews were conducted at hospital H2, and three interviews were conducted at hospital H3. The case study protocol and the interview guide were made available to the management of the study hospitals in advance. Written notes were made of all interviews, and during observation and informal discussions.
A description of the data collection for the case studies is given in Table 4.1.
A list of the interviewees is given in Table 4.2.

Study hospitals were selected on the basis of accessibility to the author, and in order to obtain a set of results which is broadly representative of conditions in district and regional hospitals in South Africa in which a CHIS has been implemented. Two of the three study hospitals (H1 and H2) are general level 2 hospitals, each with approximately 300 beds, and providing 24-hour trauma and emergency services; the third (H3) is a level 2 specialist maternity hospital with approximately 200 beds[1]. The study hospitals have similar management structures: a clinician as the head of the top management team, with the most senior members of the administrative and nursing structures forming the balance of the team. Two of the hospitals (H1 and H3) are situated in a major metropolitan centre, and the third (H2) is in an urban area approximately 100 km from the metropolitan centre.

[1] H1 has subsequently been reclassified as a level 1 hospital.

Pilot case study 1 (H1) (May and June 2003)	**Pilot case study 2 (H2)** (September to November 2003)	**Pilot case study 3 (H3)** (April 2004)
- A combination of observation, informal discussion, and semi-structured interviews based on a questionnaire devised for the study.	- A combination of observation, informal discussion, and semi-structured interviews based on a questionnaire devised for the study.	- A combination of observation, informal discussion, and semi-structured interviews based on a questionnaire devised for the study.
- Observation of CHIS use by admissions staff during both day (07h00 – 19h00) and night (19h00 – 07h00) shifts. Admissions staff in the trauma/emergency reception area of the hospital are on duty 24 hours per day. - Informal discussions with admissions staff during observation.	- Observation of CHIS use by admissions staff during day shift. Admissions staff in the trauma/emergency reception area of the hospital are on duty 24 hours per day. - Informal discussions with admissions staff during observation.	- Observation of CHIS use by admissions staff during day (07h00 – 19h00) and night (19h00 – 07h00) shifts. Admissions staff in the inpatient admission section of the hospital are on duty 24 hours per day. - Informal discussions with admissions staff during observation.
- Interviews with all members of the senior management team, and with the head of the hospital fees section, who is also the supervisor of all admissions staff (4 formal interviews).	- Interviews with the medical superintendent, the head of the hospital fees section, the case manager, the information clerk, a senior admissions officer, and the manager of the hospital revitalisation project (6 formal interviews).	- Interviews with the medical superintendent, the nursing service manager responsible for the outpatient service, and the case manager (3 formal interviews). - Discussion with the trainer for the new CHIS due for implementation shortly after the case study. - The information clerk was not available at the time of the visits.

Table 4.1 Data collection for the pilot case studies

Hospital	Interview	Interviewee
H1	I1	Assistant Director: Administration (Hospital manager)
	I2	Head: Fees office
	I3	Senior Medical Superintendent
	I4	Assistant Director: Nursing services
H2	I5	Senior Medical Superintendent
	I6	Case manager
	I7	Head: Fees office
	I8	Admissions officer
	I9	Information clerk
	I10	Manager: hospital revitalisation project
H3	I11	Senior Medical Superintendent
	I12	Nursing service manager: Outpatient Department OPD
	I13	Case manager

Table 4.2 Interviewees for the pilot case studies

4.2.2 The CHIS in use at the pilot case study hospitals

All study hospitals were using the same CHIS (SystemA) with the same scope, and the CHIS had been in use at each hospital without major changes for at least six months. The system implementation was therefore regarded as having reached stability in all the hospitals.

The CHIS in use in the pilot case study hospitals is a commercial system which has been modified as necessary to meet local requirements, for example for billing of public patients. The limited scope of the implementation, i.e., ADT (admission/discharge/transfer) and billing, for both inpatients and outpatients (ambulatory patients), is typical of the scope of the CHISs in use in many level 2 public sector hospitals in the country. The CHIS allows for the collection of a limited amount of clinical data (for example coded diagnoses and procedures can be recorded on discharge) in support of the billing function. Since an important aim of the implementation of CHISs is to support improved revenue collection, especially in those hospitals which provide services to private patients, the billing component of the CHIS is important for the hospitals. This CHIS has the potential to provide a core set of standard management information for the hospitals, an important factor in an environment in which there is increasing emphasis on using information for management. While these systems are regarded as being 'interim', since the aim is to implement more comprehensive CHISs in all South African hospitals, it is likely that similar systems will continue to be used in many hospitals for the foreseeable future, mainly due to lack of financial resources for the acquisition of more extensive systems (Department of Health, 1999; Department of Health, 2004; Louw and Hanmer, 2002).

Van der Loo *et al.* (1995), in developing a framework for HIS evaluation, formulated a useful classification of the health care process. They draw a distinction between care processes – divided into the medical care process and the supporting process – and auxiliary processes, which do not contribute directly to the care process. In terms of this classification, the CHISs typically in use in South African district and regional hospitals support aspects of the supporting process (ADT component) and an auxiliary process (billing). In their Delphi study of success and failure factors, Brender *et al.* (2006) distinguished between different categories of HISs, including administrative, clinical and decision support systems. In terms of their classification, the CHISs in use in the pilot case study hospitals are administrative systems.

4.2.3 The pilot case study hospitals

The study hospitals were found to be very similar in terms of management structure, available infrastructure for the services they provide, and support for the CHIS. Each of the study hospitals is headed by a clinician: the medical superintendent. The senior management team consists of the medical superintendent, the hospital manager (the most senior administrator), and the most senior nursing services manager. At night and over weekends, the duty nursing services manager is the only member of the hospital management on site.

All the study hospitals are situated in urban areas, and the fact that H2 is not in a large metropolitan area did not seem to account for any significant differences between the three hospitals.

A summary description of the pilot case study hospitals is given in Table 4.3.

Pilot case study 1 (H1)	Pilot case study 2 (H2)	Pilot case study 3 (H3)
A regional (level 2) urban public sector hospital: - inpatient, outpatient and emergency services - internal medicine, general surgery, paediatrics and gynaecology - approximately 300 beds - mainly public patients; few private patients	A regional (level 2) public sector hospital located in a large town: - inpatient, outpatient and emergency services - internal medicine, general surgery, paediatrics and gynaecology and obstetrics - approximately 300 beds - mainly public patients; - increasing number of private patients, in separate wards.	A regional (level 2) urban public sector hospital: - inpatient, outpatient and emergency services - gynaecology and obstetrics - approximately 200 beds - mainly public patients; - increasing numbers of private patients, in separate wards for non-emergency care
Data input and output for the CHIS - workstations in main reception areas, and in the hospital fees office. - workstation in the offices of the most senior administrative and nursing managers - installation of workstations in wards, which could be used for data entry to the CHIS, is planned.	Data input and output for the CHIS - workstations in main reception areas, and in the hospital fees office. - workstations in the offices of the most senior administrative and nursing managers, the case manager and the information clerk - installation of workstations in wards, which could be used for data entry to the CHIS, is planned.	Data input and output for the CHIS - workstations in main reception areas, the obstetric admissions ward, and in the hospital fees office. - workstations in the offices of senior managers, the case manager and the information clerk.

Table 4.3. Description of pilot case study hospitals

The hospitals were also found to be similar in terms of management attitudes to the role of information for management. However, a major difference between the hospitals was found to

be the approach to resource allocation for information management, with two of the three hospital managers having assigned a specific full-time staff member to this function.
A description of the information management functions is given in table 4.4.

Pilot case study 1 (H1)	Pilot case study 2 (H2)	Pilot case study 3 (H3)
The information management (IM) function was shared between several staff members, including the hospital manager, who was acting as the designated information officer (IO) for the hospital.	An information clerk, reporting directly to the medical superintendent, was responsible for compiling management statistical reports from the CHIS and other sources, for example the finance section. These reports were used in all management meetings.	An information clerk, reporting directly to the medical superintendent, was responsible for compiling management statistical reports from the CHIS and other sources, for example the clinical information system and the finance section. These reports were used in all management meetings.
There was no specific review of CHIS input data for accuracy and completeness since the person assigned to this function had been moved to another function.	The information clerk and a designated member of the fees office staff were responsible for ensuring that patient records on the CHIS were complete and accurate, for example by checking the CHIS records against the reports on patients in wards compiled by the nursing staff. This checking was carried out on a daily basis, but not over weekends or public holidays.	The information clerk and the case manager were responsible for ensuring that patient records on the CHIS were complete and accurate, for example by checking the CHIS records against the reports on patients in wards compiled by the nursing staff. This checking was carried out on a daily basis, but not over weekends or public holidays.
There was no case manager at this hospital, since there were few private patients treated here.	The case manager was responsible for information management for all private patients, including coding of clinical details to enable accurate billing.	The case manager was responsible for information management for all private patients, including coding of clinical details to enable accurate billing.

Table 4.4 Summary of information management (IM) functions

4.2.4 Overview of experiences of CHIS use and CHIS usefulness in the pilot case study hospitals-

Comparisons between the hospitals in order to identify similarities and differences between the environments and the experiences of implementing the CHIS provided a rich picture of the use of the CHIS in the hospitals, and the perceptions of users about the CHIS.

The experience at all hospitals was that the CHIS was generally stable and reliable. Since CHIS hardware and software support were only available during office hours (although all the study hospitals provide 24-hour emergency services), delays had been experienced when problems had arisen outside office hours. Delays had also been experienced due to limited availability of software support personnel, even during office hours.

There was concern at all the hospitals about the quality and completeness of the data being input to the CHIS.

All the hospital managers interviewed were clearly aware of the importance of information as a resource for decision-making, and practical efforts were being made to use data from the CHIS in combination with data from other information systems to support management decision-making. However, some managers were also concerned that they had only a limited understanding of the potential capabilities of the CHIS and few, if any, opportunities to gain a better understanding of the CHIS. Due to the limited collection of clinical data via the CHIS, the available clinical data was not used at all by clinical and nursing personnel.

There were plans at all the pilot case study hospitals to extend the usefulness of the CHIS by installing terminals in wards. It was hoped that the ability to collect data about patient movements and patient status on discharge at ward level would improve the completeness of patient data on the CHIS.

The most striking differences between the hospitals were in management approaches to the allocation of resources for ensuring data quality and completeness in the CHIS, and the extent of reliance on data from the CHIS for reporting within and beyond each hospital.

4.2.5 Analysis of results of the pilot case studies using the D&M model of IS success

Results of the case studies were reviewed in terms of the major components of IS success identified in the D&M model (DeLone and McLean, 2003), i.e. information quality, system quality, service quality, intention to use/use, user satisfaction and net benefits (see figure 4.1), in order to determine the extent to which this model is applicable to the study, and to identify issues which could be addressed in future studies. The influence of the organisational context on CHIS success was also examined, since no analysis would be complete without taking the effect of the environment in which it operates into account.

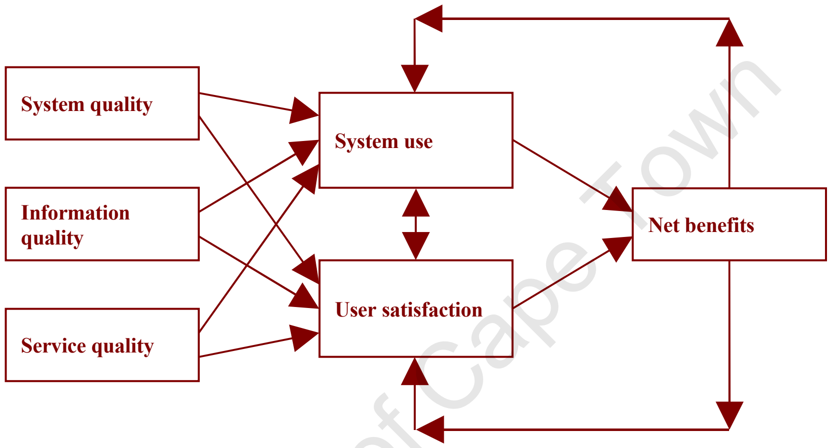

Figure 4.1 Model of IS success (from DeLone and McLean, 2003)

(a) Information quality

In simple terms, 'information quality' in the D&M model refers to the quality of the information obtained from the system. As applied to the case studies, this factor therefore refers to the quality of the data included in any outputs from the CHIS, which is a reflection of the accuracy and completeness of the input data.

(i) Approaches to ensuring information quality

A striking difference between the organisations was reflected in the approach to ensuring completeness and accuracy of data within the CHIS. In all hospitals there was a stated commitment by the management to ensure accuracy of the data in the CHIS. However, different approaches were used in practice, as illustrated by the following examples:

- More staff time was assigned to the functions necessary to ensure accuracy of data within the CHIS in H2 and H3 (approximately 1,5 full-time equivalents (FTEs) each) than in H1 (less than 0,5 FTEs). In H2 and H3 one person had been assigned full time to collation of statistics and preparation of reports for management, with the responsible person reporting to the head of the hospital. In these hospitals, other staff members contribute to the data analysis function as part of their other management functions, for example through case managers. Data management is only a part-time function in H1, shared in practice between several people in supervisory and management positions.

- Although the CHIS was designed to provide real-time information on the movements of patients through the hospitals, and to enable the generation of a comprehensive daily report on patients in the hospital and those who had been admitted and discharged, none of the hospitals used the midnight state report generated by the CHIS as the primary basis for daily management decision-making:
  - Midnight state reports were not generated from the CHIS in any of the hospitals over weekends or on public holidays, when there were no administrative staff on duty except in the emergency admissions sections.
  - In H2 and H3, the CHIS midnight state report was not used at all for daily planning and management: decision-making was based on the manual ward reports on patient movements generated by the nursing staff. In H1, the CHIS report was generated after midnight on weekdays, and was used in conjunction with the daily nursing ward reports, when available, to support daily management decision-making. Over weekends, it was reported that the daily nursing ward reports formed the basis of management decision-making.
  - In H1, CHIS daily reports were generated on the day following the actual patient movements, from Sunday to Thursday, and on the following Monday for movements which had taken place on Friday and Saturday. It was reported by the hospital manager that the daily nursing reports were correlated with the daily CHIS records to ensure that a common, correct set of data was defined in time for the next weekly management meeting. Thus, data from 8 to 14 days before was examined at each weekly meeting.
  - Data checking and reconciliation were carried out in the Fees department of H1, in both the Admissions and Fees departments in H2, and by the case manager and the information clerk in H3.
- Data from multiple sources, including the CHIS, were collated and combined for weekly and monthly reporting at all the pilot case study hospitals:
  - At H2 and H3, the daily nursing ward reports were correlated with the daily CHIS records to ensure that a single, definitive set of ADT data was compiled and used for weekly and monthly reporting and decision-making. At H2, the

CHIS record was updated, if necessary, on the basis of the combined set of data. It is not known whether the CHIS was specifically updated at H3. For H1, it seemed that at least two sets of ADT data (administrative and nursing) were retained, and the CHIS records were not updated retrospectively.

- In H2 the data from the CHIS was regarded as the primary source of that data for management purposes, while in H1 data from multiple sources, including data collected manually by the nursing department in the hospital, was used for management purposes. In H3 a combination of data sources was used, and the CHIS did not appear to be regarded as a primary source of data on admissions, discharges and transfers for the institution. The medical superintendent of H3 noted in the interview that he '(did) not care where the statistics came from, as long as they reflect accurately what has been happening in the hospital'.

(ii) Quality of input data

The quality of output information is largely dependent on the quality of the data input, although it could also be affected by the information system itself – if a system does not provide the required analysis of the input data, for example, or the analysis is erroneous for some reason, this would have an effect on the quality of the output information.

All the interviewees for this study underlined and understood the need for accurate input data for there to be any chance of obtaining accurate output from the CHIS, and recognised that mechanisms (and the required resources) needed to be put in place to ensure accurate and complete data input. As is the case for many CHISs, the staff responsible for data input were largely different to those who use the outputs from the system, and sometimes reported to different components of management, such as administrative and nursing staff. The multiple reporting structures require careful management to ensure that the CHIS functions optimally. An example encountered in H1 reflects this dilemma:

> One of the required processes for the CHIS is that a daily reconciliation of the patients physically in a ward is carried out against the patients recorded on the CHIS as being in that ward. The nursing staff were responsible for carrying out the reconciliation, and then recording required changes on the CHIS by writing amendments on the computer printout of the list of patients in the ward. Admissions staff were then responsible for updating the information on the CHIS. However, it was reported in interviews with both the nursing manager and the admissions staff that required changes recorded by nursing staff were

not always reflected on the ward lists received for review on a subsequent day. Since the data inputs and the physical reconciliation were done in different locations and at different times, it had reportedly been difficult to determine the reason for requested updates not being reflected in the CHIS. Possible explanations include failure to update the required information by the admissions staff; an error in the manual update by nursing staff; or an error in the CHIS software.

User training is a critical component of ensuring information quality. All users observed and/or interviewed in this case study had received training for using the CHIS (for staff required to use the CHIS directly for data input and/or to obtain reports). From observation, end users appeared confident using the CHIS, and understood the components of the CHIS to which they had access. Management staff interviewed who did not use the CHIS directly had been given information on the capabilities of the CHIS and the reports available from the CHIS. However, several of the managers interviewed indicated that a more thorough orientation would have been useful because they were aware that they did not understand all the components of the CHIS and, hence, all the information potentially available from the CHIS.

While the CHIS does allow for certain quality checks on input, accuracy cannot be guaranteed. For example, at H1, when data on all discharges for the day was entered on the CHIS by the admissions clerks on night duty, a standard time of discharge (21h30 – prior to the finalisation of data input after 22h00, in preparation for the midnight processing) was used for all patients, irrespective of when during the day they had actually been discharged. This would have rendered any detailed calculations of length of stay inaccurate, but should not have affected length of stay calculations based only on the dates of admission and discharge. (However, incorrect recording of the discharge time could have had other ramifications, for example if problems arose with a patient after discharge, and the time of discharge from the hospital became a point of medico legal dispute.) It was not possible to ascertain whether this practice was the result of a decision taken by hospital management or a mechanism developed by the end users to facilitate their own work, since the time of discharge was not always specifically recorded in the component of the patient paper record available to the admissions clerks at the time of data input.

(iii) Allocation of resources to ensure quality of information

At all the study hospitals, the necessity for ensuring that data in the CHIS was accurate and complete, and therefore a correct representation of the actual situation, was well recognised by the management and those responsible for providing reports for management use. However, the extent to which this requirement was recognised by those responsible for data entry seemed to be variable. This could be a reflection of the quality and scope of their training, but this aspect could not be verified since a review of user training was beyond the scope of this study.

Those using the outputs from the system recognised the need for comprehensive checking to ensure that the best possible data quality was achieved within the constraints of the environment. The general perception (for example from the medical superintendent at H2 and the nursing manager at H1) seemed to be that data quality in the CHIS was not optimal and that this factor limited the usefulness of the CHIS to them.

Differences in experience and approach between the three hospitals were reflected in the approaches of staff in the three hospitals to ensuring quality of data. At H2 and H3 this function was deemed to be so important that specific hospital resources had been allocated to assist in achieving this aim, in the form of information clerks who reported directly to the medical superintendents. In H1 there was no evidence of a similar dedicated effort to achieve the integration of data from several sources to form a single coherent data set for the hospital, using internal resources. Members of the H1 management team were of the opinion that additional resources, particularly staff resources, would have to be provided to the hospital by the provincial health authorities to enable the achievement of satisfactory data quality in the CHIS.

In H2 staff interviewed indicated that the appropriate organisational arrangements were in place to ensure that a trustworthy set of data about the hospital could be made available for both internal (within the hospital) and external (at provincial level) reporting and decision-making, although not all identified problems had been solved. At H1 there was a lack of satisfaction with aspects of the CHIS related to the quality and trustworthiness of the data, and a feeling that little could be done within the organisation without additional resources. In H3, where two computerised information systems were being used in parallel, perceptions of data quality seemed to be influenced by perceptions of the CHIS itself. Staff who had been familiar with the clinical information system already in use prior to the implementation of the CHIS were sceptical of the potential for obtaining data of good quality from the CHIS. However, the case manager, a comparatively new member of staff, saw great potential benefit from the CHIS for her functions and was concerned that other staff, including those responsible for feeding data into the system, were not as concerned as they could be about ensuring data quality because they did not understand the use of the data elsewhere in the organisation.

(b) System quality

While information systems are not necessarily computerised, system quality in the D&M model does refer to the computerised component of the information system being examined. The extent to which the computerised IS meets specifications, and how well those specifications relate to the requirements defined by users and potential users, are among the issues to be taken into account (DeLone and McLean, 2003).

System quality in the context of this project refers to the functioning of the CHIS in terms of factors such as reliability, response times and availability. On the basis of the information available from observation and interviews, the CHIS generally functioned well, with an estimated system availability of close to 100%. Several of the users interviewed referred to one occasion during the previous year when the CHIS had been unavailable for a period of longer than 24 hours. This was the only serious instance of general unplanned system unavailability reported.

The extent to which the CHIS met the user requirements specification was difficult to assess in this study, since the users and managers interviewed and observed had not been involved in the specification of user requirements for the system. Interviewees did refer to requirements for changes to the CHIS, some of which had been formally requested, and were reported to be awaiting implementation by the CHIS supplier. The process of updating the CHIS was not investigated in this study.

Overall, there seemed to be no major problems being experienced with the quality of the system as implemented at the study hospitals from the perspective of the users interviewed and observed, although specific (different) problems had been noted at both H1 and H2 . System quality was judged to be acceptable by the interviewees and the personnel observed during the case study. If there had been major problems, the potential for success in this CHIS implementation would have been severely compromised. For example, a report on a CHIS implementation in the Limpopo province of South Africa indicated that ‘problems arose because of inadequate infrastructure as well as with the functioning and implementation of the system' (Littlejohns *et al.*, 2003).

Although the CHIS seemed to be functioning well at the pilot study hospitals, the full scope and functionality of the system did not appear to be well understood by users at the hospitals. Personnel using outputs from the CHIS in all the study hospitals referred to required functions which were not provided in the reports available to them or directly on the system. In at least some cases, the author was of the opinion that the functionality could be made available, but that the hospital personnel were not aware of what was possible. It was not possible to check during the case studies whether the required functions could be made available.

Responses to questions about the capability of the application software during some interviews indicated that hospital staff were unaware of any but the most basic functions and outputs of the CHIS, and were therefore unable to assess the potential usefulness of components of the CHIS not in use in their organisations at that stage. From the available information, it also appeared that staff were largely dependent on the CHIS supplier for information on the capabilities of the CHIS application – a further source of vulnerability for the hospitals.

(c) Service quality

Service quality refers to the extent, timeliness and quality of the system support available to users of the IS. This dimension was added to the latest version of D&M model (originally published in 1992, and updated in 2003) and is highly relevant for this study.

In the context of the CHIS studied, service quality relates mainly to the level and timing of support provided for both the software application and system hardware and software. Lack of resources for such support impacts negatively on the potential for successful implementation.

(i) Resources for CHIS support

The pilot case study hospitals had limited resources in terms of support for the CHIS. There was no support available on site for either hardware or software at any of the hospitals. All hospitals were dependent on staff of the CHIS supplier and the provincial IT services for software and hardware support respectively. System support was provided by staff of the provincial administration for hardware and system software, and by staff of the CHIS supplier for the application software. Site system support visits were requested by logging requests at the call centre of the provincial administration and response time was dependent on the schedule of the responsible staff. Users mentioned that the system support staff were responsible for hospitals sometimes hundreds of kilometres apart, which accounted for some of the delays experienced in responses to emergency calls. The number of support staff serving one hospital had been increased not long before the commencement of the study (during 2003), resulting in some reported improvement in responsiveness to calls for support. Users observed in H1 and H2 were able to replace paper or labels in printers and resolve basic paper jams, either themselves or with assistance from a colleague, but it seemed that any other problems were being referred to the call centre.

No on site or telephonic support was available outside weekday office hours, over weekends or on public holidays. Since all the study hospitals provide 24-hour emergency services, this lack of support for the CHIS out of office hours meant that the hospitals were especially vulnerable to system breakdowns at these times.

(ii) Hardware infrastructure

A further source of vulnerability is the limited hardware infrastructure available at the hospitals. All the study hospitals had a limited number of terminals available, situated in administrative areas and in patient reception areas, including points via which patients are admitted after hours. A member of staff encountered in H1 during a site visit noted a shortage of terminals, saying that she ‘had to go to a place where a terminal (was) not in use’ in order to ensure that all patients expected for appointments were registered on the CHIS. At H1 and H2 staff noted that there were plans to have terminals installed in ward areas within months of the discussion.

There were no spare terminals or printers available to the hospitals, either on site or in a central pool. If a piece of hardware required repair, there was a gap in the system infrastructure at the hospital concerned until the repair had been completed – a process that reportedly could take months if the problem were serious or if a replacement were required. At H1 admissions staff reported that a faulty terminal had been removed two weeks prior to our discussion and had not yet been returned.

(iii) System availability

In the study environment software and hardware were reportedly largely available when required, with the exception of the single major software breakdown referred to previously and specific instances of hardware breakdowns. However, the reported lack of round-the-clock system support, and unacceptable delays in the response to and resolution of hardware and system software faults, did reflect significant problems with service quality. While system availability (a reflection of both system and service quality) was adversely affected by these problems, the overall reportedly high level of reliability of both hardware and software meant that system availability was generally high.

The timing of planned system unavailability also has the potential to disrupt hospital activities. The author experienced this problem first hand during a site visit to H3:

> The hospital had been informed that the system would be unavailable for at least four hours for a major software upgrade. The planned upgrade was implemented on a weekday morning, starting at 08h00, and was completed after 12h00. Hospital admissions staff had planned for this disruption by reporting for work earlier than usual, registering planned inpatient admissions in advance, and requesting outpatients to arrive for the morning clinics as early as possible so that visits could be recorded on the CHIS before 08h00. Arrangements were also made for manual recording of patient data where necessary. Despite these arrangements, hospital activities were disrupted, and many patients experienced longer delays than usual with admission procedures and as they moved between outpatient services.

The author could not ascertain whether hospital staff had been consulted about the timing of this software upgrade, which took place during the busiest period of the day for hospital administration. In the author's previous experience at another public hospital, major upgrades were planned for Sunday mornings, when there were no scheduled inpatient admissions or outpatient clinics, and the busiest periods for the emergency services (Friday and Saturday evenings) were over.

(d) System use

In their discussion of this component of their model, DeLone and McLean indicate that 'usage measures should capture the richness of use as a system phenomenon including the nature, level and appropriateness of use' (DeLone and McLean, 2003). The use of the CHISs in this study reflects a combination of voluntary and involuntary uses, and would therefore require a range of usage measures, only a few of which are reflected in this report. In this discussion, the term 'effective use' is used to underline the idea that mere use of a system is not on its own a sufficient measure of its success.

In the case of public sector hospitals in South Africa, all hospitals in particular categories within a province (for example, level 1 and/or level 2 hospitals) would use the same CHIS to ensure compatibility between hospitals and to benefit from the economies of scale associated with large-scale implementation of a common system. Thus the use of the specific CHIS in the study hospitals is not voluntary. CHIS selection is done at provincial level, and some of the activity statistics for the hospital are derived directly from the CHIS at provincial level. A further example is given by Littlejohns *et al*. (2003) who describe the implementation of a single CHIS in all public hospitals in the Limpopo province of South Africa.

In the context of the level 2 hospitals in this pilot study, effective use can be described in different ways, depending on the role of the user in relation to the CHIS. For users who are required to use the CHIS as part of their jobs, such as reception clerks who are required to record details of patients and patient visits on the CHIS, or fees office staff who are required to prepare patient accounts based on data from the system, CHIS use in itself cannot be used as an indication of effective use. However, it would be valid to gauge whether the system is being used correctly by such staff members. Measures of correct use would include an assessment of the completeness and accuracy of the data entered into the CHIS, and the ability of these users to obtain outputs in the form of standard printed reports from the system. The admissions staff observed during the pilot study at all the study hospitals seemed to be very familiar with the functions which they were required to perform. However, staff in other sections of the hospital who were required to use the data input by these users expressed some reservations about the accuracy and completeness of the data (for example the medical superintendents, the fees office staff at H1 and H2, and the case manager at H3).

A potentially more variable measure of CHIS use is provided by the indirect users of the system: members of management at various levels who would not be expected to use the CHIS directly, but could receive reports from the CHIS intended to support their decision-making functions. These users were not required to use the CHIS output and could therefore be classified as system users by choice. The extent to which managers did use system outputs could be regarded as both a reflection of their understanding of the system scope and the available outputs (aspects of 'system quality' in the D&M model), and of their confidence in the quality of the information available from the system ('information quality' in the D&M model).

In the pilot case study hospitals, members of the management teams were interviewed in order to gain an understanding of their information needs and problems. With one exception, the members of this group did not use the CHIS directly, either in order to obtain reports or to follow up specific problems. The exception was one manager who fulfilled some of the functions of an information officer for the hospital (H1) in the absence of a person dedicated to this function. The impression gained from these interviews was that hospital managers did not use the CHIS as extensively as they could (either directly or indirectly). Concerns about both system quality and information quality were expressed by the interviewees. The concern about information quality was highlighted by the fact that a key function of the CHIS, the ability to produce the midnight state, a standard operational report on hospital status and functioning, was not being used routinely by management.

Use of CHIS output by clinicians was not investigated in the pilot case studies.

(e) User satisfaction

The degree of user satisfaction with the CHIS was considered from several perspectives, including the acceptability of system performance; the extent to which the capabilities of the CHIS were used and understood; and the perceptions of users, and hospital management in particular, about the validity and reliability of system content and outputs. The attitude of users is a key element in determining whether the potential of a CHIS is realised.

System performance was generally regarded as being acceptable by end users and managers. The major areas of concern noted by interviewees and other staff were the lack of round-the-clock system support and unacceptable delays in the response to and resolution of hardware and system software faults (related to 'service quality' and 'system quality' in the D&M model).

Managers expressed definite concerns about information quality and the extent of their understanding of the capabilities of the CHIS (the medical superintendents at H1 and H2, and the nursing manager interviewed at H1). Several of the interviewees at each hospital specifically indicated a desire to know more about the capabilities of the CHIS in order to make better use of the system (the managers at H1 and H2, and the case managers at H2 and H3). As a result, the reported degree of satisfaction with the reporting component of the CHIS among these interviewees was not high, although it was also recognised by the members of management interviewed that the problems being experienced were more likely to be related to organisational limitations than to problems with the CHIS itself. The issue of organisational limitations is not specifically addressed in the D&M model, but needs to be considered as part of the analysis of the context in which the CHIS is being used.

(f) Net benefits

Interviewees were asked to identify aspects of the CHIS which supported (or did not support) their work, and aspects of the CHIS which they did and did not like. Their responses are interpreted here as reflecting their perceptions of the net benefits of the CHIS for them.

Factors which were identified as being of benefit by interviewees included the following:

- the availability of printed patient labels for use on paper records, laboratory specimens, etc;
- the ability to check back on records of individual patients for both existing patients and patients who had left the hospital;
- an improved ability to monitor the income from patient fees and to follow up patients in default of fee payment, resulting in improved levels of revenue collection for the hospital (details were not investigated in this study);
- the ability to monitor and review the activities of staff members involved in data input to the CHIS;
- the potential to provide ad hoc reports to answer queries from hospital management, provincial management, and persons external to the health service, including politicians and visitors from other health jurisdictions.

These benefits are largely consistent with the scope of the CHIS as implemented at the study hospitals.

However, it was striking that none of the interviewees identified the availability of standard management reports on hospital activities, including automated midnight state reporting, as benefits of the implementation of the CHIS. As indicated in the preceding analysis, these core functions were not perceived by members of hospital management to be functioning reliably and were therefore not used as the definitive sources of this information in the study hospitals.

The organisational context, which is not specifically addressed in the D&M model, was shown in the pilot case studies to be an essential factor to be taken into account in considering CHIS success, as discussed in the next section.

4.2.6 Review of the analysis of the results of the pilot case studies using the D&M model

(a) Organisational context

The D&M model of IS success does not include organisational context as a factor. However, this factor proved to be important in the pilot case studies, as shown in this section.

The context in which the CHIS had been implemented in the study hospitals was dominated by the limitations in the availability of the resources required to ensure the successful implementation of the information system. Although the design of the CHIS in use in the study hospitals had been geared to the needs of these hospitals, and there were very few problems reported with the system itself, other factors contributed to the difficulties experienced in implementing the CHIS successfully in the study hospitals. Problems were identified with the level of system support and availability of system hardware (exacerbated when hardware breakdowns occurred) in all the hospitals. Limitations in knowledge of the operation and scope of the CHIS were identified by hospital personnel as limiting the effective use of the CHIS in their environments. These limitations were common to all the hospitals in this study.

One approach to facilitating optimal use of the CHIS would be to ensure that at least one staff member in each hospital develops a comprehensive, detailed, understanding of the CHIS, in order to act as an effective liaison person between system development/maintenance staff (employees of the company which supplies the CHIS in the case of the study hospitals) and hospital management and other staff. This 'superuser' function has been identified in many studies as being an essential component of effective CHIS implementation and use. For example, Ash *et al.* (2003) have reported on a study of the importance of 'special people', including superusers, in the implementation of a computerised physician order entry system. There was no evidence in any of the pilot case study hospitals of identified superusers, although interviewees such as the case managers at H2 and H3 had the potential to fulfil this function.

In all the study hospitals it was evident that the members of hospital management were committed to ensuring the successful operation of their organisations to ensure the best possible care for their patients, despite limitations in their environments. However, differences in attitude to the CHIS (in terms of the potential of the CHIS to support their own activities and those of their organisations) were clearly reflected in the approaches to those aspects of information system success under their direct control. These differences, most obviously in relation to resource allocation to ensure the effective operation of the CHIS in the hospital and the use (or not) of the outputs from the CHIS, have been highlighted in the analysis. The differences in attitude to the CHIS of the hospital managers in the three hospitals in this study (especially the three medical superintendents) were clearly reflected in the differences in the experiences of the three hospitals in implementing the CHIS. This was the most striking single outcome of this study and highlights the crucial role of hospital management in the successful implementation of CHISs.

(b) Applicability of the DeLone and McLean model for assessing the potential for CHIS success

The D&M model of IS success provided a useful framework for the analysis of some of the data from this study. The factors identified in the D&M model could clearly be identified in the data gathered during the case studies. More data was obtained related to information quality and service quality than for the other factors in the model; a reflection of the major areas of concern about the CHIS in the study hospitals. The model facilitated an analysis of the issues affecting use of the system by different groups of end users, with an important distinction having to be drawn between those users for whom system use is required as part of their jobs, and those for whom use of the system is optional. While benefits of using the CHIS were identified in this study, there were also potential benefits which were not being realised, particularly to support management functions. The analysis of the factors identified in the D&M model contributing to CHIS success provided a mechanism for identifying actions which could be taken to increase the benefits derived from the use of the system in the study environment.

The focus of the D&M model is on describing IS success and the analysis using this model has indicated that the model could be applied to describing CHIS success in the study environment. However, the D&M model does not address organisational issues such as availability of resources to support IS implementation, user training and education; and management of the IS implementation. These organisational issues are a reflection of the context in which the CHIS implementation is taking place, and can have a major impact on the success (or not) of the implementation, as demonstrated in this study. DeLone and McLean describe the factors identified in their model as being 'necessary but not sufficient' to ensure IS success (DeLone and McLean, 2003) They specifically excluded the context from the scope of their model, noting that it is up to those applying the model to take the context into account. The context is so crucial to the success or failure of CHIS implementations that it should be specifically addressed in any future model developed to describe CHIS success, as has been done by Ballantine *et al.* (1998), for example.

An initial conceptual model of CHIS use at hospital level was developed

- to address the limitations identified in using the D&M model in the context of the current study; and
- to reflect the insights gained from other models and from the pilot case studies.

This model is described in the following section.

4.3 INITIAL CONCEPTUAL MODEL OF CHIS USE

An initial conceptual model of CHIS use at hospital level was developed, based on the results of the pilot case studies and theoretical models reviewed to date, including those of DeLone and McLean (2003), Ballantine *et al.* (1998) and Heeks *et al.* (1999). The aim of this conceptual model was to clarify those issues identified during the case studies that have the potential for explaining differences between the experiences of CHIS implementation in the three case study hospitals. The initial conceptual model provided the framework for subsequent data analysis through a further case study and the hospitals survey, as described in Chapters 5 and 6.

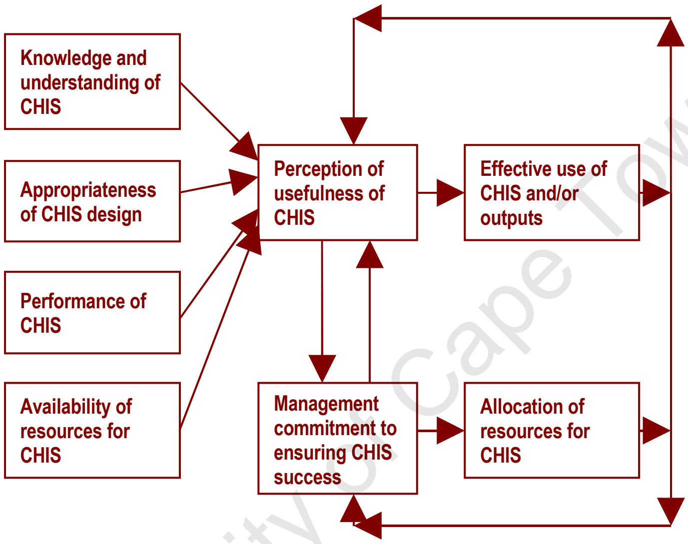

Figure 4.2 – Initial conceptual model of CHIS use

The model is based on the premise that user perception of the usefulness of a CHIS is a key determinant of whether or not the system will be used effectively (see Figure 4.2). Factors which affect user perceptions of the usefulness of the CHIS have been identified as

- knowledge and understanding of the CHIS;
- appropriateness of CHIS design;
- CHIS performance; and
- availability of resources for CHIS.

The context in which the CHIS has been implemented is reflected by including 'management commitment to ensuring CHIS success' as a component of the model. Allocation of resources for implementation, training and maintenance of the system is modelled as the main indicator of management commitment prior to and during system implementation. The allocation of further resources for system development would be a reflection of ongoing management commitment to the use and development of the system.

The components of this initial conceptual model of CHIS use are presented in the following sections.

4.3.1 Knowledge and understanding of CHIS

One of the key issues highlighted by interviewees during the pilot case studies was the quality of the input data and, hence, the quality of the information which could be made available from the CHIS, in the form of reports on aspects of hospital activity (for example, summaries of patient movements over a period, or calculation of indicators such as average length of stay (ALOS)), or on individual patients (e.g. patient billing history and status)). Rather than including information quality as a separate factor in this initial conceptual model (as in the D&M model), it was decided to broaden the concept to 'knowledge and understanding of the CHIS' in order to group several concepts related to the people associated with the CHIS in use in a hospital:

- quality of data input to the CHIS as a reflection of end users' understanding of the use of the data elsewhere in the hospital;
- lack of hospital management understanding of the scope and functionality of the CHIS at case study hospitals;
- lack of CHIS support at hospital level; and
- limited scope of CHIS training for hospital staff.

(a) Quality of input data

The quality of data input to a CHIS could be regarded as a function of the end users' understanding of the way in which the input data are used during the patient contact with the hospital – if end users understood the significance of the data, they would be more likely to make an effort to ensure accuracy and completeness of the data input than if they did not have this understanding.

The case manager at H3 made specific mention during the interview with her of the need for staff to understand the use of the CHIS throughout the hospital, indicating that she wished that her colleagues had a better understanding of the use elsewhere in the hospital of the data which they input. She was of the opinion that, if users had a good understanding of how the input data were used, they would make more effort to ensure that it was accurate. In her contribution to the hospital's annual report for 2003 (the year prior to the case study period) she wrote that her plans for 2004 included the following functions, which could be directly supported by the CHIS: 'Assist (hospital H3) nursing staff to fully understand … the importance of charging patients and ICD 10 coding. Getting them committed to (hospital H3) revenue collection.' (Hospital H3 2003 Annual Report, p76).

A nursing manager in the outpatient department (OPD) at H3 indicated that she had not been given information on the reason for the implementation of the CHIS before the time, and had therefore been sceptical of the need for staff in OPD to use it. Once she had some understanding of the CHIS, she was able to motivate for its use (Interview I12).

(b) Management knowledge and understanding of CHIS

Members of management at the pilot case study hospitals expressed a need to understand the scope and functionality of the CHIS in order to use it more effectively. In particular, the head of H1, who had been in that position for only a few months at the time of the interview, and the nursing services manager interviewed at H1 both noted that they were not aware of the capabilities of the CHIS and therefore felt unable to use it optimally.

(c) CHIS support at hospital level

The need for some self-sufficiency in relation to the operation, supervision and management of the CHIS within a hospital became clear during the pilot case studies. All the pilot case study hospitals (H1, H2 and H3) were entirely dependent on external people for CHIS support beyond very basic functions such as replacing printer cartridges or explaining how to access patient information using CHIS. At all the hospitals, it was not possible to identify a person who was responsible for ensuring that the CHIS was operating correctly, and that queries and problems were being followed up.

The case manager at H3 noted that, when she had repeatedly asked questions of the CHIS supplier personnel, they had indicated that she was the first person at the hospital who seemed to be taking an interest in the capabilities of the CHIS. This was an interesting observation, because the nursing manager at H1, for example, had gained the impression that it would be difficult to obtain information about the system from the CHIS supplier personnel.

The issue of CHIS support at hospital level is directly linked to CHIS training for hospital staff, as discussed in the following section.

(d) CHIS training for hospital staff

The level of training on the use and capabilities of the CHIS available and provided to end users; staff of departments which use information from the CHIS (for example, fees/revenue; and inpatient and outpatient administration); and hospital management seemed to be rather limited, from the information gleaned during site visits and interviews at the case study hospitals.

From observation of and informal discussions with end users at all the case study hospitals, it was clear that they were competent in performing the CHIS functions associated with their jobs (for example, patient admission and billing) and confident in their ability to do so. However, they did not seem to have much understanding of the functionality of the CHIS beyond their sphere of practice.

Of the people interviewed, the case manager at H3 and the information clerk and fees office clerk at H2 seemed to have the best overall understanding of the CHIS functionality from a hospital perspective. At none of the hospitals was there evidence of a person or persons who informally acted as a hub of information and support about the CHIS in the absence of a person on the staff who had been designated to act in that role.

Improved knowledge and understanding of the CHIS in the pilot case study hospitals could have contributed to an improved level of use and usefulness of the CHIS in these environments, including an improvement in the quality of the information drawn from the CHIS (in terms of accuracy and completeness). This factor in the initial conceptual model of CHIS use is related to the 'information quality' dimension of the D&M model (DeLone and McLean, 2003), the 'staffing and skills' dimension of the ITPOSMO model of design-reality gaps (Heeks *et al.*, 1999), and the components of the 3-D model of IS success of Ballantine and colleagues (1998) related to user skills.

4.3.2 Appropriateness of CHIS design

The D&M model does not explicitly address the fit between the design of an information system and the requirements of the organisation in which it is being used. This is a crucial component of the potential for success of a CHIS, as indicated in the ITPOSMO model of design-reality gaps of Heeks and colleagues (1999), in which large gaps between the existing situation and the assumptions in the IS design for factors such as ‘processes’ and ‘objectives and values’ are identified as risk factors. Ballantine *et al.* (1998) refer to the Strategy-Style-Structure-Status-Culture fit as a component of the ‘integration filter’ between the Deployment of an IS in an environment, and the Delivery of the expected outputs and benefits of the IS implementation, in their 3-D model of IS success. Braa and Hedberg (2002) underline the importance of developing information systems which meet the needs of the potential users, and take account of the environments in which the IS would have to function, in their analysis of the development and implementation of another HIS in use in South Africa: the District Health Information System (DHIS), developed and supported by the health information systems programme (HISP). The human-organisation-technology-fit (HOT-fit) model of Mohd.Yusof and colleagues (2007) highlights the need for an effective fit between these three aspects of the implementation of an information system in a particular environment. The appropriateness of the CHIS design is therefore a factor which takes account of the relationship between the CHIS and the context in which it is implemented. In the case of the study environment, an environment of limited and vulnerable resources, it is especially important that the context be taken into account.

It was difficult to obtain the opinion of hospital personnel on the appropriateness of the design of the CHIS in use in their environments since most of those interviewed did not have experience of other CHISs (the exception being people in H3, where there was experience of use of a clinical information system in the ward areas).
One specific factor on which the issue of appropriateness of design was addressed during the pilot case studies, was in relation to CHIS support for patient billing. Interviewees and discussants generally were of the opinion that the functionality of the CHIS accurately reflected the requirements of the hospitals to bill public sector patients and to record payments and outstanding accounts (interviews I2 at H1; I6 at H2; and I13 at H3). In the South African public health care sector, patients are classified on the basis of income into one of four categories, and the fees payable are determined by this classification (Department of Health, 2008). Since public sector hospitals are required to report on revenue collection (in relation to fees payable by patients), this billing function was important for the hospitals.

The factor ‘appropriateness of CHIS design’ was also included in the model to reflect the selection process for CHISs in the study environment (selection at provincial level for categories of hospitals, for example all level 1 and level 2 hospitals, or all public sector hospitals); and anecdotal evidence that other CHISs in use in SA do not handle aspects of billing effectively, or have required specific modification to meet these requirements. These aspects were addressed further in subsequent phases of the project.

4.3.3 Performance of CHIS

CHIS performance is similar to ‘system quality’ in the D&M model (DeLone and McLean, 2003), as described earlier (Section 4.2.5(b)), and is related to the factor ‘technology’ in the model of Heeks *et al.* (1999). If the CHIS did not perform the required functions, it would be very difficult to achieve a successful implementation. In terms of the analysis by Brender *et al.* (2006) of factors associated with HIS success or failure, this factor would be classified as a failure criterion because failure to perform implies that a successful implementation cannot be achieved. This factor is particularly significant in situations where performance specifications are not achieved.

In the pilot case study hospitals, few problems with the performance of the CHIS in use were reported: observation during fieldwork supported the view of the CHIS as generally stable and responsive. Interviewees reported high availability of the CHIS and generally good response times, although one interviewee (H2, I7) indicated that ‘speed is more of a problem (than system availability)’ and an end user at H3 indicated that slow response times sometimes caused delays. Two potential problems with the software were noted during fieldwork and interviews:

At H1, there was an indication that updates on patient movements made by ward staff on printed lists, and then input by the admissions personnel, were not always correctly reflected on subsequent reports. As described previously in the discussion of ‘information quality – quality of input data’ (Section 4.2.5(a)), it had not yet been determined whether there was a problem with the software.

The problem encountered at H2 (as reported by both the senior admissions officer and the information clerk) was that the CHIS was unable to reconcile the system-generated patient numbers for some patients treated at the community clinic linked to the hospital (where a separate set of patient numbers was used), and who were subsequently admitted to the hospital (and therefore should have received a new patient number).

This factor will be discussed further in relation to the results of the surveys (Section 6.4.3), where the CHIS in some hospitals did not perform according to specifications, for example in relation to system availability and response times.

4.3.4 Availability of resources for CHIS

Availability of a wide range of resources (including networks, electricity, computer equipment, software and skilled personnel) is required to support the implementation and ongoing use of a CHIS. In limited and vulnerable resource (LVR) environments, the required resources are either in short supply, and/or are vulnerable to disruption. The pilot case study hospitals were LVR environments in the sense that barely enough hardware was available for the CHIS and there was an absence of skilled personnel to support the CHIS implementation. Thus, at H1, there was a report of a terminal having been taken away for repairs (with no replacement provided) and having been away for more than two weeks at the time of the discussion with admissions staff. At all the pilot case study hospitals, CHIS support was provided by the CHIS supplier (for the CHIS software) and by the provincial IT services (for hardware and system software) via a call centre. No services were available outside office hours despite the fact that all the hospitals provided 24-hour emergency and inpatient services.

'Availability of resources' was included as a factor in the initial conceptual model for CHIS use to highlight the importance of access to resources in LVR environments. In the HIS and IS literature, availability of the required resources, especially infrastructure resources such as hardware, stable power and networks with sufficient bandwidth, is assumed and therefore not specifically discussed as a factor affecting IS use. This assumption cannot be made in LVR environments, and therefore the issue of access to resources has to be taken into account explicitly in planning for CHIS implementation and ongoing operation. Although not identified as a separate factor in the D&M model of IS success (DeLone and McLean, 2003), availability of resources is linked to the factors 'service quality', 'system quality' and 'information quality' in that model. In the ITPOSMO model of Heeks *et al.* (1999) the related factors 'staffing and skills' and 'other resources' are identified, and 'resources' and 'support and maintenance services' are among the factors identified in the 3-D model of IS success (Ballantine *et al.*, 1998).

4.3.5 Perception of usefulness

The attitude of users is reflected in their perception of the usefulness of a system for them. If users believe that a CHIS is useful for them, they will make an effort to ensure that the system works and will use the outputs from the system. Conversely, if there is a perception that a CHIS is not useful, there will be little or no commitment by users to ensuring that the system is used correctly and outputs from the system will not necessarily be used, especially when similar information can be obtained from other sources.

In H3 the CHIS had been implemented against the wishes of hospital management and was due to be replaced within a year of its implementation. Members of the staff interviewed and observed (with one exception: the case manager) were not convinced of the need for the CHIS, and had little understanding of its functionality beyond their own sphere of work, for example patient registration or hospital fees. A specialised (but outdated) computerised obstetric information system, which supported the clinical work of the hospital, had already been in use in some wards for more than a decade. This was not integrated with the CHIS although they had overlapping functions, such as registering patient identification details and patient movements through the ward. Staff were therefore required to record certain data twice. From informal discussions during the fieldwork, it was clear that these staff members regarded the implementation of the CHIS as an additional workload; and they tended to spend more time and effort updating the clinical system than on the CHIS. The impression gained from the staff of this hospital who were familiar with both systems was that they did not perceive the CHIS to be of use for them and therefore felt no obligation to ensure its effective use. Comments in the H3 annual report for the year prior to the case study also reflected these concerns[2].

The experience in H1 indicated that management staff viewed the CHIS as being of only limited use, since the system outputs reflecting patient movements through the hospital often did not match those from the manual system used by the nursing staff for daily reporting to nursing management according to the interviewees. A negative cycle was threatening to become established, with management staff not trusting the system outputs and therefore demonstrating insufficient commitment to ensuring quality and completeness of the data in the CHIS, resulting in continuing inaccuracies in the system outputs.

[2] The hospital medical superintendent noted in his report that: ‘An additional factor has been “IT overload”. Six new information systems are currently being implemented … While there is considerable merit in each of these, there is a huge amount of training involved in each, with massive disruption to normal service delivery.’ (Hospital H3 Annual Report, 2003, p12).

At H2, some of the users were enthusiastic about the potential of the CHIS to support their work, having already experienced the benefits of system use such as effective collection of fees from private patients being treated at the hospital. Staff who were required to provide input to the weekly management meetings (the statistics/information clerk and the project manager for a hospital redevelopment project, in particular) were well aware that data from the CHIS were used in assessing the work of the hospital by the provincial management and therefore felt a particular commitment to ensuring that data were complete and accurate.

The case managers at H2 and H3, who were responsible for ensuring that fees were collected for private patients, were particularly enthusiastic about the potential of the system to provide the data required to enable them to ensure that accurate accounts were raised. They were frustrated by the limited understanding of some of their colleagues about the need for accurate and complete data input, and by limitations in their own understanding of the functionality of the CHIS. They were looking for ways of improving CHIS use to improve the benefits gained from the system.

The 'perception of usefulness' component of this conceptual model is a key component of the 'user satisfaction' component of the DeLone and McLean model (2003), as discussed in Section 4.2.5(e).

4.3.6 Effective use of CHIS and/or outputs

One measure of the effectiveness of a CHIS is whether it is used effectively. DeLone and McLean (2003) employ the concepts of 'use' and 'intention to use', leading to the achievement of 'net benefits' from the system to describe IS success. Heeks *et al.*(1999) have identified information needs of the users as one of the dimensions along which a mismatch between the design of a health care information system and the reality of the environment in which it is implemented could occur. If the information needs of users are not met by the system, it is unlikely to be effectively used, and therefore could not be regarded as a success.

In the context of the level 2 hospitals in this pilot study, effective use can be described in different ways, depending on the role of the user in relation to the CHIS. For users who are required to use the CHIS as part of their jobs, such as reception clerks who are required to record details of patients and patient visits on the CHIS, or fees office staff who are required to prepare patient accounts based on data from the system, CHIS use in itself cannot be used as an indication of effective use. However, it would be valid to gauge whether the system is being used correctly by such staff members. Measures of correct use would include an assessment of the completeness and accuracy of the data entered into the CHIS, and the ability of these users to obtain outputs in the form of standard printed reports from the system.

The reception staff observed during the pilot study at all the study hospitals appeared to be very familiar with the functions which they were required to perform. However, staff in other sections of the hospital who were required to use the data input by these users expressed some reservations about the accuracy and completeness of the data. This aspect of system use requires further investigation in subsequent case studies.

A potentially more variable measure of CHIS use is provided by the indirect users of the system: members of management at various levels who would not be expected to use the CHIS directly, but who would receive reports from the CHIS intended to support their decision-making functions. These users are not obliged to use the CHIS output, and can therefore be classified as system users by choice.

In the pilot case study hospitals, members of the management teams were interviewed to gain an understanding of their information needs and problems. With one exception at one hospital, none of the members of this group used the CHIS directly to obtain reports or to follow up specific problems. The exception was one manager who fulfilled some of the functions of an information officer for the hospital in the absence of a person dedicated to this function.

Although the CHIS was designed to generate a daily midnight state report, this CHIS-generated report was not the primary source of data on patient movements at any of the study hospitals. The primary source of data for daily management decision-making at all the pilot case study hospitals was the daily report on patient movements and status prepared by the nursing staff. At one hospital, the midnight state generated by the CHIS was used in conjunction with the nursing reports only on weekdays, since the CHIS midnight state was not produced on weekends and public holidays. At a second hospital, the CHIS was updated to ensure that it provided the definitive historical patient movement data for the hospital.

Use of CHIS output by clinicians was not investigated in the pilot study.

4.3.7 Management commitment to ensuring CHIS success and allocation (by hospital management) of resources for CHIS

The context in which the CHIS has been implemented is reflected by including ‘management commitment to ensuring CHIS success’ as a component of the model. This factor is similar to the organisation factor ‘structure’ in the HOT-fit model (Mohd.Yusof *et al.*, 2008) and the factor ‘management systems and structures’ in the ITPOSMO model (Heeks *et al.*, 1999).

‘Allocation of resources for CHIS’ for implementation, user training, and maintenance of the system was modelled as the main indicator of management commitment prior to and during system implementation. The allocation of further resources for system development would be a reflection of ongoing management commitment to the use and development of the system.

The allocation of hospital resources to support the CHIS implementation was included in this initial conceptual model to reflect one of the significant findings of the pilot case studies: that one of the key differences between the pilot case study hospitals was in the extent to which the hospital management allocated resources to ensure that the contents of the CHIS were an accurate reflection of the hospital activities and that the CHIS was effectively used. The allocation of resources for the CHIS in the pilot case study hospitals also reflected the allocation of resources for information management in general in the respective hospitals:

> The medical superintendents of two of the hospitals (H2 and H3) had assigned specific responsibility for the preparation of management reports, based on data from the CHIS and from other systems, to full-time clerks responsible directly to them. At H1 the responsibility for preparation of management reports was divided among members of the management team, and the staff member responsible for reception and fees office staff (the head of the fees office). At this hospital, the hospital manager, the most senior administrative staff member, was responsible for the final collation of hospital reports required by the provincial department of health.

Comparing the pilot study hospitals, the degree of user satisfaction with the CHIS appeared to correlate directly with the allocation of personnel time to ensure accuracy and completeness of the data on the CHIS. At the hospital at which there was no full-time person responsible for data management (H1), there was the greatest degree of dissatisfaction with the CHIS, and the impression gained was that there was little management commitment to CHIS success in practice.

> In interviews with both the hospital manager and the head of the fees office at H1, they indicated that ‘the province’ should allocate resources to support the CHIS since the hospital was unable to do so.

This factor ('allocation of hospital resources') is referred to again in the analysis of results of the surveys where, despite formal allocation of personnel to CHIS support and management functions in terms of the hospital staff organogram, in some study hospitals an additional staff member had been seconded to the function of 'system controller' for the CHIS.

In a later version of this conceptual model, the two factors related to 'resources for CHIS' have been combined into a single factor: 'availability and allocation of resources' (see Chapter 5, Section 5.5).

4.3.8 Discussion of the initial conceptual model of CHIS use

(a) Relationship between the user and management components of the model

'Management commitment' influences 'perception of usefulness' in this model. Since 'perception of usefulness' reflects user attitude to the CHIS, this link provides a connection between management and user attitudes to the CHIS.

'User perception of usefulness' could persuade management to commit resources to ensure the effective operation of the CHIS. This could also reflect the attitude of members of hospital management who use the CHIS (either directly or indirectly, via CHIS reports). This direction of influence is reflected in the model by having a two-way arrow between these two components of the model.

(b) Comment on the model

During related interviews with key informants outside the case study hospitals, all comments related to CHIS use at hospital level could be assigned to one of the factors identified in this conceptual model.

The model provided the framework for the detailed case study for this project, by highlighting issues to be investigated in order to clarify and expand the information gained from the pilot case studies. As described in later sections, the initial conceptual model has been modified and extended on the basis of the results from detailed case study, interviews with key informants, further literature review, and the analysis of data gathered during the survey. Further attention is given in future analysis to the factors in the conceptual model related to the allocation and availability of resources to support the CHIS implementation.

4.4 SUMMARY

Pilot case studies at three hospitals, and the development of an initial conceptual model of CHIS use based largely on the results of these studies, have been presented in this chapter. Using what Plummer (2001) described as a structured-case approach, this conceptual model provided the framework for the next phase of the project: the case study of a fourth level 2 hospital; interviews with key informants; and a resulting review of the conceptual model; as described in Chapter 5.

CHAPTER 5 CASE STUDY AND MODEL ENHANCEMENT

5.1 INTRODUCTION

The analysis of results from several phases in this project will form the basis of this Chapter, starting with a discussion of the results from the case study at hospital H4. These case study results, combined with the data from the interviews with experts provide the input for a further discussion of the conceptual model of CHIS use – an extended conceptual model of CHIS use.

The extended conceptual model will provide the lens for the analysis and interpretation of data from the hospital survey, and the conceptual model will then be revisited in the light of the outcomes of the analysis of the survey results (Chapter 6).

5.2 THE CASE STUDY

5.2.1 Aim and objectives

The aim of this study is to build on the results of the preliminary case studies, in order to validate and, if necessary, extend the conceptual model.

The objectives of this case study are

- to describe and analyse the effects on the hospital of CHIS implementation
- to identify those factors which are associated with perceptions of the success or lack of success of the implementation, and
- to identify those factors which could have been associated with the success or lack of success of the implementation
- to inform the refinement of a conceptual model of CHIS use.

5.2.2 Overview

Since the aim of successive cases in a qualitative study like this is to extend and provide richness to the information gleaned from earlier studies, this case study was designed to complement the preliminary case studies. This case study was conducted in a regional level 2 hospital approximately 400km from Cape Town, in order to assess the effect on the operation of the CHIS in a hospital which is so far from the support centre for both system software and hardware that the distance could affect the success of the CHIS implementation.

The scope of this study was further extended to examine the use of the CHIS (either directly or through the use of reports from the system) to support the work of clinical managers in the hospital, that is clinicians responsible for the management of clinical services such as surgery, internal medicine or obstetrics and gynaecology. An attempt was made to understand how clinical data which could be recorded in the CHIS was analysed in the hospital. This issue was not addressed in the preliminary case studies.

Input was obtained from the perspective of the CHIS supplier through an interview and a published statement, and from publicly available information on the CHIS, to supplement information from hospital personnel. Interviews were also held with two CHIS experts from outside the study hospitals to obtain a broad perspective of CHIS implementation in South Africa, as described in Section 5.3.

Combined with the results of the preliminary case studies, it was expected that this additional case study would provide sufficient data to enable the development of a valid framework for describing CHIS success. In the unlikely event that sufficient information could not be obtained from a single detailed case study, an additional case study could be undertaken. However, this proved not to be necessary.

The protocol for the detailed case study is attached as Annexure D.
An outline of the questions that were covered in the interviews with hospital personnel is attached as Annexure E.

5.2.3 The study hospital

The study hospital is classified as a level 2 (regional) hospital, with 265 inpatient beds. Approximately 250 000 outpatient visits and 60 000 inpatient days of treatment are recorded annually. The hospital is located approximately 400 km from the major metropolitan centre of the province, and is a public sector hospital under the control of the Department of Health of Province 1. Services provided by the hospital include

- obstetrics and gynaecology
- general medicine / family medicine
- general surgery
- orthopaedic surgery
- paediatrics
- psychiatry
- anaesthetics
- trauma.

The hospital provides 24-hour emergency services to a population of approximately 550 000, covering an area of 6 200 square kilometres.

Historically, the hospital would largely have served those classified white in the area, since it is located in what would previously have been an area designated for white occupation. Since 1994, all public hospitals have been integrated, and serve all who qualify to access the services on medical grounds. According to the policy governing access to level 2 hospitals, all people accessing such hospitals for the first time must have been referred by a clinic or district hospital, or by a private practitioner, and arrangements for such referrals must have been made with the hospital. The exception is for emergency cases, although every effort is made to ensure that people requiring treatment for minor conditions are not treated at level 2 hospitals (Republic of South Africa, 2004. National Health Act, Act 61 of 2003).

The hospital was part of the national government's programme of revitalisation for hospitals, and therefore had received funding for capital works (a major renovation and expansion of this hospital) and for organisational development (Hospital H4, Interview I1). Of significance from the perspective of resources available to the hospital is the decision by hospital management to use some of the funds available for organisational development to appoint an information manager at senior level to support the hospital management in particular. This appointment was initially made on contract and was then successfully converted to a permanent post on the hospital establishment. The hospital management had also taken the decision to acquire an additional module of the CHIS (pharmacy management) to support patient care services. This module had not yet been implemented at the time of the hospital visits (September 2006).

Although relatively well resourced in comparison with some other public sector level 1 and level 2 hospitals due to its inclusion in the revitalisation programme, this study hospital, like those included in the preliminary case studies, was found to be an environment of limited or vulnerable resources (LVR) for CHIS implementation and maintenance (Hanmer *et al.* 2007). The head of the hospital indicated that clinical personnel, and particularly medical personnel, were in short supply, since it was difficult to attract personnel to the hospital (Hospital H4, Interview I1). A recent study of eight public sector hospitals in South Africa described the hospitals as institutions under stress, due to lack of personnel and other resources (Von Holdt and Murphy, 2007). That study included two level 3 (specialist) hospitals, and six level 2 hospitals in Gauteng, KwaZulu-Natal and North West provinces.

5.2.4 The CHIS in use at the study hospital

In the South African public healthcare sector, decisions about CHIS selection for the hospitals in a province are made at provincial level. CHIS contract administration, as well as allocation of resources for CHIS implementation and maintenance, also take place at provincial level. The primary aim of this process is to ensure consistency and interoperability between CHIS implementations and to facilitate the deployment of related personnel across a province.

However, this also means that, in practice, hospital staff are unlikely to have any direct input into the choice of a CHIS, but are required to use and manage and maintain the chosen CHIS at hospital level. This is similar to the situation in New South Wales, Australia, described by Southon and colleagues (Southon *et al.*, 1999), where common selection criteria were developed for all the public hospitals in one State.

The same CHIS (SystemA) used in the pilot case study hospitals (H1, H2 and H3) was in use in this study hospital (H4). As at the pilot case study hospitals, the CHIS in use at the study hospital was limited in scope: patient registration and master patient index (MPI); admission, discharge and transfer (ADT), including mainly administrative data; and patient billing. It therefore made provision for limited data on diagnosis (coded in ICD-10) and some treatments. Two of the major functions of the CHIS at the hospital were to support patient administration, including the tracking of patient files, and to support revenue collection from patient billing. The CHIS was therefore used in conjunction with other manual and computerised information systems to provide the information necessary to support the management of the study hospital. Since the CHIS made only limited provision for the capture of clinical data, and the clinical data collected did not cover all patients, the CHIS data were used only to a limited extent by clinical personnel at the hospital.

Provision is made in the CHIS for the data elements required for standard hospital management reporting, including such indicators as patient length of stay (LOS) and hospital bed occupancy. A major challenge in practice is to reconcile data for patients from multiple sources, including the CHIS, the patient record (manual at the study hospital), and clinical records held by nursing and medical personnel. This issue is discussed further in Chapter 7.

One of the key items on which all public hospitals are required to report to the provincial Department of Health is revenue from patient billing. SystemA, the CHIS in use in this case study hospital, included a billing module tailored to reflect the billing mechanisms used, and provided the functionality required to make it possible for patient payments and the status of patient accounts to be tracked. The CHIS is the major source of data required for billing, for both public and private patients. Hospital management and administrative personnel therefore rely on the data in the CHIS to be reliable enough to support the whole hospital revenue collection process.

5.2.5 Data collection

Data collection took place over two visits of two days each during August and September 2006. A combination of observation of the CHIS in use, and semi-structured interviews with representatives of hospital management (clinical, nursing and/or administrative), specialist information management personnel, case managers responsible for co-ordinating services for any private patients in the hospitals, and CHIS end users was used to obtain data for the study. A standard set of questions was used as a guide for all interviews (see Annexure E). Ten interviews were conducted at the study hospital. Audio recordings were made of five of the interviews. Written notes were taken of all interviews, with more extensive notes for those interviews for which audio recordings were not made. A description of the interviewees is provided in Table 5.1.

Permission to contact hospitals was first obtained from the Provincial Department of Health, and then arrangements for hospital visits and for interviews with personnel were made through the office of the Head of the Hospital: the Senior Medical Superintendent, who was also one of the interviewees.

The focus of the data collection at hospital H4 was on the interviews. From the initial interview with the head of the hospital and the interview with the supervisor of the CHIS end users, it was ascertained that the CHIS was used very similarly to the way in which it was used at the pilot case study hospitals. It was therefore not necessary to carry out extensive observation of the use of the CHIS in the hospital. In addition, the wide range of interviews conducted at the hospital made it possible to obtain a good understanding of how the CHIS was being used in that environment.

A one-hour reportback session and discussion was held at the end of the second visit with most of the people who had been interviewed, at the request of the Senior Medical Superintendent. The discussion provided a useful opportunity to obtain feedback and clarification on the very preliminary findings presented to the hospital, and for members of the hospital staff (mainly at management level) to gain an understanding of the use of the CHIS by some of their colleagues.

Data obtained from the case study were complemented by insights on CHIS implementation and sustainability gained from interviews with South African HIS experts, as described in the next Section.

	Designation	Comments	Audio Recording
1	Senior Medical Superintendent	Head of hospital	yes
2	Head: Administration		
3	Head: Finance		
4	Head: Patient admissions and billing	Supervisor of end users	
5	Information manager		yes
6	Senior pharmacist	Identified superuser	
7	Case manager		
8	Nursing services manager		yes
9	Head: Clinical services		yes
10	Head: Trauma and family medicine		yes (2 files)
11	Head: General surgery	***No interview due to emergency***	

Table 5.1. Description of interviewees at case study hospital H4

5.3 EXPERT INTERVIEWS AND DISCUSSIONS

While the initial conceptual model of CHIS use developed as an output of the pilot case study phase of this project includes hospital-level factors only, it was necessary also to consider factors at provincial level which could affect CHIS use, since the process for selection of CHISs in the study provinces (for case studies and survey) takes place largely at provincial level. In order to obtain insights into the factors at provincial level related to CHIS use, information was obtained from three CHIS experts:

- Expert 1 (E1) was the chief information officer (CIO) in the Provincial Department of health of a province not included in the case studies or the survey. Following preliminary exchanges of correspondence by email, an interview was conducted on 26 July 2006.
- Expert 2 (E2) was the CEO of a CHIS supplier company based in South Africa, who had also previously informally discussed the thesis topic with the author. A formal interview with this expert was conducted on 11 October 2006.
- Expert 3 (E3) has had extensive experience of CHISs at hospital and provincial level in one of the study provinces, and was a key expert informant for this project. As E3 was one of the supervisors of this project, the author held ongoing discussions with E3 at intervals during the project, including discussions of the development of the conceptual model in its various versions.

Notes were taken during the discussions with experts, and were then reviewed in the light of data emerging from the case study at H4 (conducted during August and September 2006), ongoing review of the literature related to CHISs, and the author's previous experience as a member of the development team for a multi-hospital CHIS and manager of that CHIS at one hospital.

The insights gained from the expert interviews and discussions were combined with results and interpretations from the case study to inform the further development of the conceptual model of CHIS use.

In addition to these expert interviews and discussions, interviews were also conducted with provincial informants in the two provinces in which the survey was undertaken, as described in Chapter 6. The interviews with the provincial informants were intended to inform the surveys in each province by providing an overview of the CHIS implementations in the study hospitals. Those interviews are therefore discussed in the sections dealing with the survey of hospitals.

5.4 CASE STUDY RESULTS

5.4.1 Data analysis

(a) Introduction

Data analysis for the case study of H4 included a detailed review of the interview notes and recordings, in order to identify comments relevant to the factors included in the initial conceptual model of CHIS use developed in the first phase of the project. The author developed partial transcripts of the recorded interviews, which necessitated multiple reviews of the recordings. Since the interviews had been conducted in a combination of English and Afrikaans, the author translated some quotations from Afrikaans to English. Notes developed in preparation for the presentation to the interviewees at the hospital immediately following the second phase of data collection (September 2006) provided a summary of some of the key findings, and the notes on the discussions following the presentation provided further insights on the attitudes and concerns of the interviewees.

Overall, the results of the case study confirmed the results of the pilot case studies, in the sense that the framework provided by the initial conceptual model provided a reasonable framework for the information gained from the case study. The results of the case study are therefore discussed in this Section using the framework of the initial conceptual model of CHIS use developed as an outcome of the pilot case study phase of this project (as described in Chapter 4). The initial conceptual model of CHIS use is therefore included as figure 5.1, for ease of reference. All the interviews refer to the case study hospital (H4) unless otherwise indicated.

Issues identified in addition to the factors in the initial conceptual model (for example the provincial context and the quality of the data in the CHIS) are discussed in Section 5.4.2 of this Chapter. These emerging themes from the data provided pointers for further avenues for analysis of the data and for data collection, for example through the expert interviews, from the literature, and in the survey of hospitals.

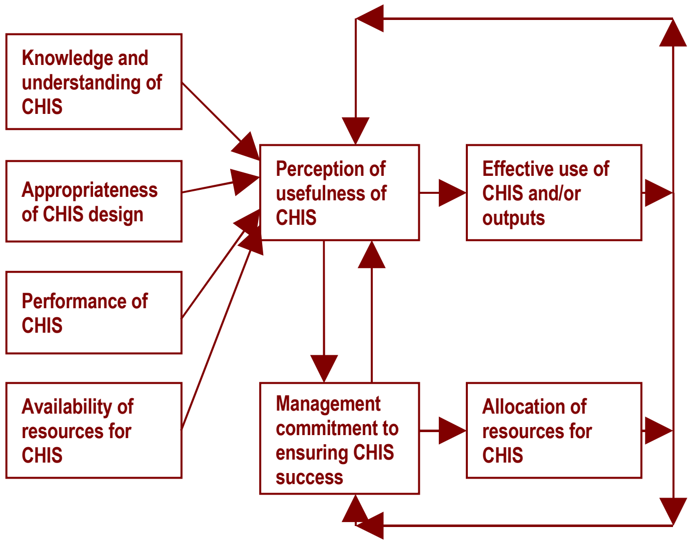

Figure 5.1 Initial conceptual model of CHIS use

(b) Knowledge and understanding of CHIS

As in the pilot case study hospitals, there was a wide divergence of familiarity with the functions and functioning of the CHIS in the study hospital (H4), ranging from a doctor in the trauma unit who commented that 'it could be very useful to have a system like SystemA[1] in this area' (having had experience of using SystemA at another hospital, and being unaware that this was the CHIS in use in the study hospital), to the case manager (Interview I7) and the admissions supervisor (Interview I4) who had developed a detailed understanding of all the CHIS functionality relative to their jobs, and more generally. For example, during the report back session to interviewees, one of the members of management indicated a need for a report on numbers of patients seen after hours, and the admissions supervisor was able to comment that this was a routine report available from the CHIS.

The head of the hospital, the senior medical superintendent, expressed frustration at her limited understanding of the CHIS, indicating that 'it all seems like a well-kept secret' (Interview I1) since there was little information available to her about the CHIS and its functioning. This sentiment was partially echoed by the information manager (Interview I5), indicating that management information for the hospital is sometimes difficult to obtain because 'it is a secret(ive) environment'.

[1] The descriptors SystemA and SystemB are used to describe the two CHISs in use in Province 1 at the time of this study. The CHIS in use in Province 2 at the time of the study is described as SystemC. Note that SystemA was previously used in Province 2.

(c) Appropriateness of CHIS design

This factor relates to the extent to which the needs of CHIS users are met by the system. The pilot case studies at hospitals H1 to H3 had already demonstrated that the available CHIS functionality reflected many of the hospital requirements for record-keeping for individual patients in terms of its scope: patient registration, patient movements through the hospital, and patient billing. In the case of H4, the person responsible for admissions and patient billing (Interview I4) described the CHIS as being 'very user friendly' and that it 'gives what is required'.

For example, none of the interviewees expressed concern about the ability of the CHIS to support the billing functions for public or private patients. The case manager (Interview I7) specifically indicated that she had few problems with the CHIS in relation to billing, provided that the required data had been provided or could be obtained from the patient folder. Problems experienced related to availability of data (for example on medication provided to patients (Interview I7)) rather than on the ability of the CHIS to handle the data.

In order to improve the usefulness of the CHIS for the hospital a decision had been made to acquire two additional components of the CHIS: the pharmacy module (to support dispensing) and an outpatient booking module (to support appointment scheduling). This allocation of additional resources for the CHIS is discussed further in relation to management commitment to CHIS success (Section 5.4.1(g)).

A major area in which the CHIS design was not appropriate for the study hospital was in the lack of support for the clinical functions of the hospital. The clinicians interviewed (Interviews I9 and I10) indicated the need for information related to the treatment of patients during their period in hospital (for example in the trauma unit or as inpatients). The perceived usefulness of the CHIS for clinical (medical and nursing) personnel is discussed further in Section 5.4.1(h)

The information manager (during Interview I5) noted that, by using the existing CHIS optimally, it should be possible to obtain additional benefits from the CHIS without expending too many additional resources. These comments were made in relation to the planned implementation of a new CHIS at the hospital (SystemB), in accordance with the provincial plan to implement the same CHIS at all public hospitals in the province. The information manager was of the opinion that the existing CHIS could continue to be run using limited resources, including using relatively old PCs as terminals. He commented that the resources required for running information systems were often underestimated.

(d) CHIS performance

From observation of the CHIS in use at the hospital, and from the responses of interviewees, it was clear that the CHIS performed well overall. The information manager (Interview I5) indicated that performance of the CHIS and of other computerised information systems in use in the hospital, had improved in terms of response times once the available bandwidth on the hospital network had been increased. He described the CHIS as 'stable and cost-effective', since it was 'cheap on resources' required to keep it running.

None of the interviewees indicated significant problems of CHIS availability, so the impression was gained that availability was generally close to 100%. The head of administration (Interview I2) described the downtime as being 'low', and the person responsible for admissions and hospital billing described the system availability as 100% 'since approximately 2001' (Interview I4).

At H4 the issue of system performance was of particular significance, given the limited availability of resources for system support s (see Section 5.4.1(e)) and the distance from the support base. As it was, the high levels of system performance compensated for the reliance on limited resources for CHIS support available to the hospital. If CHIS performance had been less reliable, this would have been a major factor affecting the use of the CHIS at the hospital. Thus, these results could be interpreted as indicating that the significance of the CHIS performance factor is influenced by the level of CHIS performance – if performance is good (in the opinion of the user), this factor is of less importance to users than if performance is perceived to be poor. This aspect of some form of weighting of factors, at least in relation to each other, is discussed further in Section 5.4.2(b) in terms of relationships between factors in the conceptual model.

(e) Availability of resources

Due to its general reliability, the CHIS was reportedly able to perform well despite the limited availability of resources to support the system. As at the pilot case study hospitals, the hospital was dependent on the CHIS supplier, based approximately 400km away from this hospital, for application software support. IT support was provided by a local person, who also sometimes provided application software support, in telephone consultation with the CHIS supplier (Interview I4). Representatives of the software supplier scheduled visits to the hospital twice a year. Other visits were made if necessary, at the cost of the hospital, as described by the head of the hospital (Interview I1).

One of the key resources required to ensure the effective use of the CHIS was personnel skilled in both the use of the CHIS and with a clear understanding of the needs for information of the hospital users. The information manager (in Interview I5) made the case for the appointment of a few specialist 'consultants' with these skills who should be able to support more than one hospital, once the key reporting mechanisms had been established.

As for CHIS performance, there is a need to investigate further whether this 'resources' factor is more significant when resources are limited than when resources are plentiful. This issue is discussed later in this Chapter when relationships between factors in the conceptual model are reviewed, and in relation to how users cope with environments in which resources are limited.

(f) Allocation of hospital resources for CHIS

One of the key factors which differentiated between the responses of the pilot case study hospitals to the implementation and effective use of the CHIS was in the allocation of hospital resources for this purpose. At this case study hospital (H4) resources from the hospital management quality improvement grant made available to hospitals included in the national hospital revitalisation programme (including hospital H4) had been used to appoint the information manager on contract, to support the hospital management by collating and analysing information from multiple sources (including the CHIS, but not limited to the CHIS) to support management decision-making. The head of the hospital indicated that at the time of the interviews at the hospital, inclusion of an information officer post on the permanent hospital personnel establishment was awaited, following motivation for this to be done (Interview I1).

In contrast to the pilot study hospitals, the management of the study hospital (H4) had also made the decision to acquire additional modules of the CHIS to assist in the effective management of the hospital, i.e. for outpatient appointment scheduling and to support dispensing in the pharmacy (Interviews I1 and I6). The resources for these acquisitions also came from the hospital revitalisation grant for the hospital and were being allocated for this purpose, despite the planned implementation of a new CHIS at the hospital, because the hospital management had decided that the functionality was urgently required and because the implementation date for the new CHIS could not be determined (Interviews I1 and I6).[2]

[2] The H4 case study was carried out during August and September 2006. By May 2008, the SystemB CHIS had not yet been implemented at Hospital H4, according to the provincial project manager for the rollout of SystemB (Interview P3).

(g) Management commitment to CHIS success

The decision to acquire additional modules of the CHIS is a reflection of strong management commitment to CHIS success at the study hospital (H4). Commitment to ensure effective use of information resources at the hospital, including the CHIS, is further reflected in the decision to appoint an information manager, first on contract and then in a permanent post, as described in previous Sections.

However, the lack of a structure or process within the hospital for ensuring that the use of the CHIS is co-ordinated on a hospital-wide basis (as became clear during the reportback session at the hospital) is a reflection of a somewhat ambivalent attitude to the CHIS as a resource for hospital management. This could also be a reflection of the lack of detailed understanding of the CHIS by the senior hospital management, as indicated in the interviews with the head of the hospital (Interview I1), the head of nursing (Interview I8), the information manager (Interview I5), the head of administration (Interview I2) and the head of clinical services (Interview I9).

(h) Perception of usefulness

Perceptions of usefulness varied widely. While those most closely involved in patient administration (including the head of admissions and patient billing (Interview I4) and the case manager (Interview I7)) indicated that the CHIS was a useful tool in their work, the head of the hospital was concerned that the CHIS was not being used optimally. The nursing and medical managers interviewed (Interviews I8, I9 and I10) viewed the CHIS as having very limited usefulness for their functions, since there was only limited clinical data in the CHIS, for a small subset of patients (those paying, especially private patients), and the data were generally only available after discharge.

During the interview with the nursing services manager (Interview I8), she was adamant that, until there was good correlation between the data in the manual ward records and the data in the CHIS; and until the data in the CHIS also reflected requirements for reporting on specific issues such as the National Tertiary Services Grant (NTSG); she would continue to ensure that nursing personnel reported separately to her office, where a separate database of statistics was maintained electronically. Her particular concern was that data in the CHIS could not adequately reflect the clinical disciplines involved in the treatment of patients. She noted that

> It depends on what I am going to use the data for. Because there are certain things for which I will only use the CHIS, even if I do not trust it, because … I need concrete evidence, and my totals must correlate with the CHIS. … Especially for clinical data,

> I go back to my own system … Overall, I will draw totals from the CHIS, but for the sub-totals I come to my own system.

The clinicians interviewed (I9 and I10) also indicated that they used the CHIS only on a limited basis. The head of clinical services (Interview I9) indicated that 'I have access to the CHIS … it is sometimes convenient to look up (administrative data) about a patient … it is not clinical information'. He also noted that 'We have now asked ward clerks to maintain other information on admissions, and discharges and deaths … we have been trying for a long time to gather data for mortality and morbidity (M&M) reviews.' The nursing services manager (Interview I8) noted that 'most doctors also accept these (nursing statistics) since they are consistent with … the data in the books which they have in the departments'.

(i) Use of CHIS / CHIS outputs

From the interviews, it seemed that direct reports from the CHIS were not much used by non-administrative staff. The CHIS was used to obtain information on individual patients, and reports were used by the head of admissions and patient billing, for example, to enable her to check that all patient movement information had been input. The standard midnight state report from the CHIS was used in conjunction with nursing midnight statistics, as at case study hospital H1.

The Information manager (Interview I5) prepared reports from a variety of sources, which were then provided to the clinical and other management personnel. Such reports included information on the use of pharmaceuticals and blood projects by different doctors.

5.4.2 Discussion of case study results

(a) Overview of case study results

The key findings from the case study at hospital H4 are summarised in the table below (Table 5.2) and are discussed in more detail in the sections of this Chapter which follow. The most significant output of the process of analysis of the results of the H4 case study, combined with the inputs from expert informants and further insights from the relevant literature, is the revision and extension of the conceptual model of CHIS use, as described in Section 5.5.

Theme	Comments
The initial conceptual model of CHIS use provided an appropriate lens for the analysis of some of the results of the case study at hospital H4.	The initial model did need modifications, including the combination of the hospital-level factors related to resources, and the addition of provincial-level factors to the conceptual model (see Section 3 for related discussion).
The initial conceptual model did not make explicit allowance for the context of limited and vulnerable resources (LVR).	The resource factors at hospital level do make allowance for reflecting the availability of resources. The addition of the province-level factors provides further scope for reflecting the context of the CHIS implementations at hospital level.
The lack of input about the provincial environment meant that provincial-level factors related to CHIS use at hospital level could not be fully taken into account.	The expert interviews and discussions provided the essential provincial perspective and formed part of the motivation for including provincial-level factors in the revision of the conceptual model of CHIS use (as described in Section 3).
There were differences in perspectives of the CHIS in use in the case study hospital (H4), depending on the respondents' roles in the hospital.	The scope of the CHIS in use was particularly limiting for clinical (nursing and medical) personnel. The limited availability of complete clinical data in the CHIS resulted in nursing and medical personnel using supplementary information systems to support their work and external reporting requirements.
The stability and robustness of the CHIS in use in the case study hospital (H4) contributed to the success of the implementation despite the LVR environment.	However, the lack of structures and processes to ensure the effective use of the CHIS in the hospital could have been a limiting factor in the usefulness of the CHIS to the hospital.
The importance/significance of the factors 'CHIS performance' and 'Availability of resources' in the initial conceptual model seems to be related to the extent to which these factors are perceived to be a problem.	There was little specific mention of CHIS performance at the case study hospital. This could be due to the fact that the performance was acceptable to the users interviewed. Concerns about lack of availability of resources to support the CHIS were expressed at management level, but not specifically by users – perhaps due to the perception that resources were adequate to ensure acceptable performance of the CHIS.

Table 5.2 Main themes from case study at Hospital H4

The initial conceptual model of CHIS use described in Chapter 4 is reproduced below for easy reference in support of the further discussion of results from the case study.

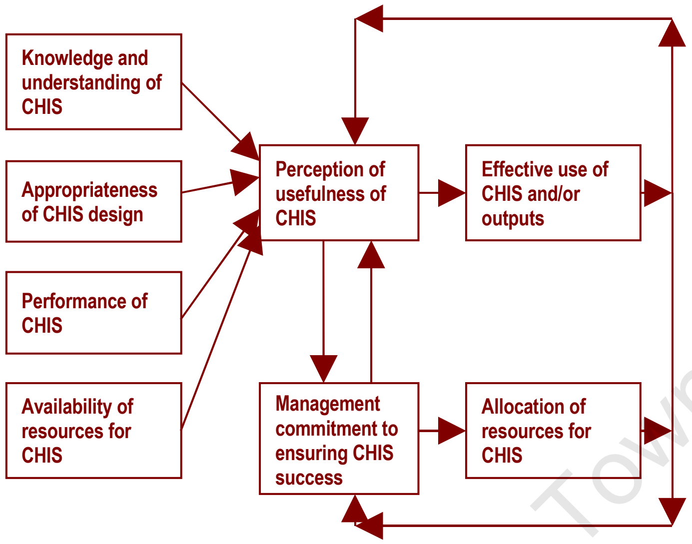

Figure 5.2 – Initial conceptual model of CHIS use

(b) Relationships between factors in the initial conceptual model of CHIS use

The analysis of the data from the case study at hospital H4 in terms of the initial conceptual model of CHIS use addressed each of the factors in the model individually. However, it was not surprising that aspects of the discussions during the interviews could have been 'assigned' to more than one of the factors in the model, thus underlining the interaction between factors.

In this Section, specific relationships between factors in the initial conceptual model of CHIS use will be discussed, starting with relationships between sets of two factors, and followed by more complex relationships between multiple factors in the model.

(i) Knowledge and Understanding -> perception of usefulness

Perception of usefulness of the CHIS at H4 (the case study hospital) was limited by lack of knowledge and understanding of end users or potential end users, particularly among those not required to use the CHIS directly, such as members of the management and clinical teams. The head of the hospital, the senior medical superintendent, noted during the interview (I1) that she felt limited by her lack of understanding of the capabilities of the CHIS, and therefore the system was of limited usefulness for her.

A similar comment was made by one of the clinical managers, who indicated that the system could not provide some management information which would have supported his work (I9). On the other hand, staff with a good understanding of the CHIS capabilities, such as the supervisor of the administrative personnel, viewed the system as being very useful to her, since it was capable of providing all the information which she required, either on line or in the form of reports, to enable her to carry out her functions (I4).

One of the key factors associating ‘knowledge and understanding’ and ‘perception of usefulness’ of the CHIS in the case study at hospital H4 was the quality of the data in the CHIS. In the conceptual model, quality of data is associated with the factor ‘knowledge and understanding’ using the argument that, if people responsible for data collection and data entry on the CHIS understood the use of the data in the hospital to support patient care, they would be more likely to ensure that the data were accurate and complete (part of ‘quality’). From the point of view of the clinical (nursing and medical) managers interviewed at the study hospital, the perception of very limited usefulness of the data in the CHIS was directly linked to the incomplete clinical data available from the CHIS (since clinical data were only collected to support patient billing, and more than 50% of the hospital patients qualified for free service) (Interviews I8 and I9). In addition to the lack of clinical data, there was a clear perception on the part of the nursing services manager that data available on the CHIS related to services within wards were not accurate enough to be useful (Interview I8), thus further limiting the perception of usefulness for this clinical manager.

(ii) Appropriateness of design -> perception of usefulness

Both the nursing services manager and the clinical services manager (Interviews I8 and I9) noted that the CHIS did not provide sufficient detailed information on the clinical services provided to support some of their reporting, such as reporting on the National Tertiary Services Grant (as noted in the previous discussion of perception of usefulness).

In contrast to these perceptions, the head of patient admissions and billing, and the case manager, indicated that the CHIS design was highly appropriate for their requirements, and they therefore regarded it as an essential tool for their work. (Interviews I4 and I7)

From the perception of the pharmacy superuser interviewed and the head of the hospital, the functionality, and hence usefulness, of the CHIS would be greatly enhanced by the planned implementation of the CHIS pharmacy module at the hospital (Interviews I6 and I1).
This could be described in terms of the appropriateness of the design of the CHIS in use at the hospital, rather than the design of the CHIS itself, since the CHIS pharmacy module had already been designed and was already successfully in use at another hospital in Province 1 (hospital D24, one of the survey hospitals, as described in Chapter 6).

(iii) Performance -> perception of usefulness

An explicit relationship between CHIS performance and perception of usefulness was not identified in this case study. A more explicit relationship was underlined later in the project during the survey, when problems of CHIS performance were identified as a factor affecting perception of usefulness – sometimes very strongly, especially in Province 2, where performance was identified by some survey interviewees as a major concern (see Chapter 6).

Thus, performance seems to manifest as an explicit factor affecting perception of usefulness when there are problems or perceived problems, but not, as in this case study, when performance is acceptable to users and managers.

(iv) Availability of resources -> perception of usefulness

As for CHIS performance, availability of resources was not explicitly identified as a factor affecting perception of usefulness at this study hospital. Interviewees indicated that the required resources were generally available, in terms of hardware and software, and in terms of system support. However, the hospital manager did express concern about vulnerability of the hospital due to the physical distance between the hospital and the location from which the CHIS supplier support personnel operated. As discussed previously, if there had been frequent problems experienced with the performance of the CHIS, the usefulness of the CHIS to the hospital users would have been directly affected by the limited availability of resources for system support in particular.

The information manager at the study hospital made an important related point, which was later confirmed by some interviewees in the survey: the CHIS in use (SystemA) had been designed to be 'lean' on resources (for example relatively simple PCs as terminals and limited bandwidth requirements on the LAN, with the ability to run on few terminals if required) and therefore **required** fewer resources than the next generation CHIS due to be implemented in the hospital (SystemB, which had already been implemented in some of the survey hospitals in Province 1). His perception of the usefulness of the CHIS in use (SystemA) was therefore strongly related to resource requirements for CHIS operation: the relatively modest requirements made it more feasible to ensure the availability of required resources at hospital level than for a future CHIS (SystemB, which was already in use at some of the other hospitals in the province) which would require more resources (Interview I5).

The resource requirements for the operation of the CHIS were a reflection of the design of the CHIS, which explicitly took account of the limitations of the environment. This issue was also highlighted by the CHIS supplier representative who was one of the expert interviewees (expert Interview E2). Two interviewees for the survey, both hospital heads, explicitly raised concerns about the cost-effectiveness of the newer CHIS implemented in province 1 (SystemB). This aspect of resource availability and requirements is discussed further in relation to the survey results. While there is great optimism that resource limitations, for example access to bandwidth, are less likely to be a challenge in future, current realities dictate that resource requirements are a factor affecting potential for system effectiveness in many environments.

(v) Perception of usefulness <=> management commitment to success

As with other relationships between factors, the 'strength' of the relationship between perception of usefulness and management commitment to success varied across the study hospital. From the perspective of the pharmacy department superuser, the decision of the hospital management to allocate resources for the acquisition of the CHIS pharmacy module reflected a strong relationship between these factors: management commitment to the success of the CHIS in the pharmacy department of the hospital reflected an understanding that the usefulness of the CHIS for the whole hospital would be improved if information about the medication dispensed to patients were available on the CHIS.

The members of the nursing and clinical management interviewed reflected a negative relationship between management commitment to CHIS success and perception of usefulness: from their perspectives, the CHIS in its current format was of only limited usefulness to their functions and responsibilities, and therefore as managers they did not reflect any feeling of responsibility towards ensuring the success of the CHIS in the hospital (Interviews I8 and I9).

(vi) Management commitment to success -> allocation of resources

Hospital management commitment to CHIS success was strongly reflected in terms of allocation of resources for the acquisition of the CHIS pharmacy module and the intention to support the implementation of the outpatient scheduling component of the CHIS patient administration module already in use at the hospital (Interviews I1, I4, I5).

Hospital management commitment to CHIS success was also strongly reflected in the decision to appoint an information manager on contract from funds associated with the hospital revitalisation project (Interview I1), and further to motivate for the post to become part of the hospital establishment (thus enabling a permanent appointment). While the incumbent of this post had a wider brief than being responsible solely for the CHIS, the appointment of a person with extensive information management skills reflected a commitment to improve information management and information support for the hospital management in particular.

In the case of the nursing services manager (in Interview I8), there was a negative relationship between management commitment to CHIS success and the allocation of resources for the CHIS: she had taken the decision to continue allocating resources to ensure the availability of the information which she required for management and reporting until the CHIS could provide the required data. She maintained a statistics database in her office, based on data provided by the nursing and related administrative personnel at ward level, in parallel with the processes required for the maintenance of the data in the CHIS. In other words, the nursing manager seemed to feel no responsibility for allocating resources to support the CHIS, but rather was allocating resources to support a parallel system of collecting data to support nursing management and reporting.

(vii) Perception of usefulness <=> effective use of CHIS and/or outputs

From the point of view of the admissions supervisor (Interview I4) and the case manager (Interview I7), the CHIS was essential to their work, and provided the outputs which they required for their work. The admissions supervisor in particular gave the impression that her perception of the usefulness of the CHIS was closely related to her ability to use the CHIS and the CHIS outputs effectively. She demonstrated her detailed knowledge of the CHIS during the discussion following the author's feedback to the hospital during the second case study visit, when she was able to inform one of the clinical managers that a report, which he identified as not being available from the CHIS, was in fact already available.

From the point of view of the clinical and nursing managers interviewed, the outputs from the CHIS available to them were not particularly useful, since they were incomplete in terms of clinical data, and did not provide all the categories of reporting which they required. The limited use of the CHIS outputs was influenced, negatively in this case, by the reported perception of usefulness of the system.

The information manager at the study hospital (in Interview I5) was of the opinion that the CHIS could be much more effectively used than was the case at the time of the interview (August 2006) if a concerted effort were made to use all the available capabilities of the CHIS, and to ensure that the data in the CHIS were as accurate as possible. He was thus making a case for the potential for increased usefulness of the CHIS as a result of more effective use of the CHIS and CHIS outputs within the hospital. He in fact went further in suggesting that it might not be necessary to implement a new CHIS in the hospital for some years if the existing CHIS were used to its full potential, noting that 'You can do minor changes to keep a system going … it should be possible to stretch (SystemA) for a further 20 years'. This view was not tested with any other member of the management team at the study hospital, and no similar comments were made in any of the other interviews at this hospital. However, this opinion was partly echoed during an interview at one of the survey hospitals which was due to migrate from SystemA to SystemB: A member of the management of the hospital indicated that they were using the CHIS (SystemA) 'to the fullest' and expressed concern that the new CHIS would not provide sufficient additional functionality to justify the additional cost of implementing and running the new system (hospital D24, Interview I1).

(viii) Effective use of CHIS and/or outputs -> management commitment to success

In the study hospital, since there was no strong evidence of effective use of CHIS outputs by management, there was no strong link identifiable between these factors.

(ix) Allocation of resources -> perception of usefulness (feedback loop)

This relationship was included in the initial conceptual model as a reflection of earlier findings (from the pilot case study) that hospital management allocation of hospital resources for the CHIS could be interpreted (by other personnel in the hospital) as a reflection of hospital management commitment to the CHIS, and hence strengthen their perception of the CHIS as useful for them.

In the case study hospital (hospital H4) the pharmacy superuser interviewed indicated that his perception of the usefulness of the CHIS would directly be influenced by the decision of the hospital management to allocate resources to the acquisition of the CHIS pharmacy module for use in the hospital (Interview I6). However, this relationship between perception of usefulness and allocation of resources by the hospital management was not explicitly indicated in any of the other interviews at the hospital.

(x) Multiple relationships between factors in the initial conceptual model of CHIS use

The importance of user perception of the CHIS was highlighted in the interview with the nursing services manager, for example, in which the reasons for her lack of trust in the CHIS were very clearly expressed: the data were not an accurate reflection of the detail and extent of the activities in the wards, and the CHIS did not provide the functionality to support all the reporting for which she was responsible (Interview I8). This discussion thus clearly highlighted a relationship between 'perception of usefulness of the CHIS' and 'effective use of CHIS and/or outputs', and between 'perception of usefulness', and 'appropriateness of CHIS design' (as reflected in the available management reports from the CHIS) and data quality (included in 'knowledge and understanding of CHIS' in the initial conceptual model).

The relationship between 'knowledge and understanding of the CHIS', 'perception of usefulness' and 'effective use of CHIS and/or outputs' was reflected in the discussion with the head of the hospital (Interview I1), in which she expressed her frustration at not understanding enough about the functionality of the CHIS to enable her to use the system optimally.

(c) Factors associated with CHIS use not specifically included in the initial conceptual model of CHIS use

(i) Quality of data

One issue which arose at multiple stages during the case study (as well as in other phases of the project) was the quality of data, as indicated mainly in terms of the completeness of the data in the CHIS. Many interviewees were well aware of the fact that, unless the data in the CHIS were complete and accurate, it could not be expected that the reports from the CHIS would be an accurate reflection of the activities of the hospital and the hospital clients, i.e. the patients.

In the initial conceptual model the issue of quality of data was included under the factor 'knowledge and understanding', since it was argued that, if end users had sufficient understanding of the CHIS and how it supported the patient care process, they would be more likely to ensure the accuracy and completeness of the data entered into the CHIS. As reflected in the initial conceptual model, some of the interviewees at the case study hospital (H4) also noted that the accuracy and completeness of data in the CHIS was linked to end users' understanding of the significance of the input data for the patient record and to support hospital management processes. For example, the nursing service manager noted that she did not think that 'the people who do it (record patient information) now are as fanatical about (accuracy) as for example we are at management level' (Interview I8).

In both the D&M model of IS success (DeLone and McLean, 2003) and in the HOT-fit evaluation framework (Mohd.Yusof *et al.*, 2008), 'information quality' is included as one of the factors related to IS success. Given the importance of information quality also in the current project, it could be argued that 'information quality' should be included in the conceptual model of CHIS use as a separate factor associated with CHIS use. However, since data quality was explicitly included in the factor 'knowledge and understanding of CHIS' in the initial conceptual model, it was decided not to include information quality as a separate factor in the model.

In order to examine quality of data further, specific questions related to accuracy and completeness of data were included in the survey of hospitals, and discussed during other formal interviews, meetings and informal discussions in relation to this project. Further discussion on data quality is included in the interpretation of findings from the hospital surveys.

(ii) Cost-effectiveness of CHIS

The information manager at the study hospital (H4, Interview I5) referred to the issue of cost effectiveness in comparing the CHIS in use in the study hospital with the replacement CHIS which was being rolled out across the province. He expressed the opinion (as described earlier in the discussions of relationships between factors) that the replacement CHIS (SystemB) would require significantly more resources than the CHIS in use (SystemA), and was concerned that it could be difficult for the hospital to allocate all the required resources for effective implementation of SystemB. This issue was also specifically raised by the medical superintendents at two hospitals in province 1 during the survey (at hospitals already using SystemB, S7 and D5), and by a member of the management team at a third hospital (D24) which was preparing to migrate from SystemA to SystemB.

Since actual costs associated with the implementation of the CHIS in use at the study hospital (and other study hospitals in this project) have not been examined, it was not possible to examine the issue of cost effectiveness any further. However, this is an important issue in relation to availability and allocation of resources, especially in LVR environments, and therefore warrants further investigation in a future study.

The context within which the CHIS was being used in the study hospital, both in relation to the hospital environment, and the environment within which the hospital functions, must be taken into account in this analysis, in order to ensure that as many factors as possible associated with CHIS use are taken into account. This issue is therefore discussed in more detail in the next Section.

(d) Context

(i) Limited or vulnerable resources

The framework within which this study was undertaken was that of a level 2 provincial hospital distant from the urban centre in which the provincial IT services and the CHIS supplier are based. In contrast with the pilot case study hospitals, this study hospital (H4) had a full-time information manager on the staff, with responsibility for working with data from multiple sources in order to provide information to support hospital management, including clinical management. According to information gained during site visits and interviews, there was nobody on the hospital staff with specific responsibility for ensuring the most effective use of the CHIS in the hospital, and there was no spare equipment available, so that in the event of a breakdown, equipment (for example PCs and/or printers) could not be speedily replaced. While arrangements had been made for local support from an IT technician (interviews with admissions supervisor (I4) and information manager (I5)), the hospital was dependent on telephonic support from consultants for the CHIS supplier and support visits by staff of the CHIS supplier approximately twice per year (interviews with information manager (I5) and senior medical superintendent (I1)).

Resources supporting the CHIS implementation were thus indeed both limited and vulnerable. In terms of hardware and software support, available resources were generally adequate, given that the CHIS implementation was stable and therefore external support was reportedly seldom required. In the event of a major problem being experienced, there could definitely be significant delays in support, given a travel time of a few hours at minimum for skilled personnel to reach the hospital, and the lack of backup equipment on site at the hospital. As indicated in the discussion of results, the lack of a clear focal point within the hospital for ensuring the effective use of the available CHIS functionality constitutes a serious vulnerability – which could become more apparent in a situation where problems are being experienced with the CHIS, or when the planned changeover to a new CHIS takes place.

One aspect of access to resources which was not specifically addressed during the case study is the extent to which users (at the study hospital, in this case) ‘make do’ with the available resources. It would have been interesting to probe whether people were actually resigned to working with limited resources, and therefore did not highlight this as an issue because they were not expecting to have access to additional resources. While in the study hospital users were certainly assisted by the fact that they were working with a stable CHIS which was relatively lean in terms of resource requirements, as discussed earlier, none of the interviewees apart from the hospital manager and the information manager expressed major concern about access to resources: the hospital manager (Interview I1) in relation to the vulnerability of the hospital due to distance from the CHIS supplier offices, and the information manager (Interview I5) in relation to the lack of detailed knowledge of the CHIS within the hospital, which could have facilitated more effective use of the CHIS.

(ii) Provincial decision-making about selection and rollout of CHISs

Results from this case study confirmed the fact that hospital personnel felt excluded from decision-making about CHIS selection and implementation. It was not clear from the available information whether there had been specific consultation at the study hospital about the planned changeover to a new CHIS, not only in terms of the functionality of the new system, but also in terms of the projected costs associated with the implementation. The issue of cost was noted as a concern in the discussion with the senior medical superintendent, since support costs (for example for calling out a CHIS consultant in an emergency) had to come from the hospital budget, and were by definition higher than those for a hospital in the urban centre as transport costs would have to be taken into account. As indicated previously, the information manager questioned the wisdom of changing to a new CHIS when all the capabilities of the existing CHIS were not being used.

(iii) Multiple information systems in use

As at other study hospitals, there were multiple information systems in use in the study hospital, in addition to the CHIS. Apart from financial, stock control and pharmacy stock control systems, which are used nationally in the public sector in South Africa, both medical and nursing personnel were collecting data in parallel with data being collected by the CHIS.

The discussion with the nursing services manager (Interview I8) made it very clear that nursing, clerical and computer resources were being used to maintain a set of data about nursing and medical services being provided to patients, in parallel to and partially overlapping with the data being collected via the CHIS. The daily (manual) ward reports to the nursing managers, which provide data on the patients in the ward, including patient movements during a 24-hour period, are a key example of reports which could have been based on printed reports from the CHIS, using available data about admissions, discharges and transfers between wards within the hospital. While the nursing services manager indicated a willingness to stop using a parallel system if the CHIS provided the data which was required by the nursing management, at the required level of accuracy, it was clear from the discussion that there was no feeling of shared responsibility for ensuring that the CHIS was developed appropriately.

One key system which operated completely in parallel to the CHIS, and which would have been very useful if integrated with the CHIS, was the laboratory results reporting system of the national health laboratory service (NHLS). Clinical managers (interviews I9 and I10) highlighted the fact that the laboratory reports included important clinical information, which was reported monthly on CD sent to the hospital. Laboratory results were available on-line at multiple points in the hospital, accessible to clinical staff.

It was not clear from the discussion with the information manager whether attempts were being made to co-ordinate the multiple ISs in use in the hospital, and to streamline the costs and other resources required to maintain multiple ISs at hospital level.

Since the situation of having multiple electronic and manual information systems, overlapping to varying degrees, is common to all the study hospitals, it could be worthwhile in future to investigate mechanisms for improving co-ordination and consolidation between systems, to the benefit of staff and patients and with the further potential benefit of reducing or reallocating resources as a result. The situation of having multiple information systems in use in the hospital setting is discussed further in Chapter 7.

(e) Limitations in the initial conceptual model identified in the discussion of results

(i) Hospital-level factors in the conceptual model of CHIS use

Overall, the initial conceptual model of CHIS success provided a good lens through which to analyse the results of the case study at hospital H4. There were some gaps identified in the interpretation of the results, most notably the lack of a specific factor 'quality of data', and the lack of factors related to the economic aspects of CHIS implementation, such as the cost-effectiveness of the CHIS. The factor 'allocation of (hospital) resources' (strongly linked to 'management commitment to CHIS success' in the model) did not seem to link strongly to the factor 'perception of usefulness' through the feedback loop, as indicated in this version of the conceptual model.

Although the inclusion of an additional factor 'quality of data' was considered, it was decided to continue to include this factor as a component of the factor 'knowledge and understanding of CHIS', as discussed in Section 5.4.1(b) of this Chapter. Since cost effectiveness had not specifically been included in the design of this study as a factor to be investigated, it was decided to include economic aspects of CHIS implementation and use, and especially cost effectiveness, as a component of the factors related to resources. The most important change to the hospital-level factors in the conceptual model was the combination of the two factors related to resources, to form the factor 'availability and allocation of resources', as described in Section 5.5.1 of this Chapter.

(ii) Province-level factors associated with CHIS success

The major limitation identified in the initial conceptual model was the lack of factors which related to the context in which hospitals are operating, since this was one of the stated issues of interest for the project. The major context issue is the fact that decision-making in relation to CHISs takes place at provincial level for the hospitals which are the subject of this project. Related to the decision-making about the choice of CHISs is, by extension, also the decision-making about allocation of resources for ongoing maintenance and support in the form of province-level contracts for CHIS software and hardware, province-level allocation of resources for WANs (where required for the operation of the CHIS), and allocation of resources (or not) for provincial personnel to provide system support. The approach chosen for incorporating the province-level factors associated with CHIS success was to extend the conceptual model to include provincial-level factors, which link to the hospital-level factors in the model, as described in Section 5.5.1 of this Chapter.

In order to inform the expansion of the initial conceptual model and gain an improved understanding of context factors beyond the level of individual hospitals, interviews were held with CHIS experts operating at provincial level, both within and beyond the study provinces, as described in Sections 5.3 and 5.4.3 While most of the interviewees were working in the public sector with responsibility for various aspects of health information system (HIS) development, management, implementation and support, valuable insights from a different perspective were obtained from an interview with a senior manager in one of the CHIS supplier companies, who had extensive experience of CHIS implementation and support in the South African public healthcare sector.

5.4.3 Supplementary data: Results from the expert interviews and discussions

The formal interviews and ongoing discussions with experts, as described in Section 5.3, provided a relatively small but important input to the development and extension of the conceptual model of CHIS use. During both formal interviews (with E1 and E2) and the discussions with E3, factors related to both hospital and provincial levels were discussed. However, the focus, for the purpose of the development of the conceptual model of CHIS use, was on factors at provincial level which could affect the potential for success of CHIS implementations in the hospitals of interest for this study: level 1 and level 2 public sector hospitals.

For Interview E1, topics identified in advance included:

- definitions/descriptions of CHIS success
- the influence of the extent of local experience of the supplier on the potential for success
- the effect of the scope of the CHIS for the potential for success.

The issue of CHIS scope was not addressed during the interview.

For Interview E2, the major focus was on the contrasts between local and external/foreign CHIS suppliers. The discussion also referred to people and organisational issues affecting the potential for successful CHIS implementations in South African hospitals.

The insights gained from the expert interviews and discussions are discussed in relation to the development of the extended conceptual model of CHIS use, as described in the next Section, rather than being examined in isolation from the model development.

5.5 AN EXTENDED CONCEPTUAL MODEL OF CHIS USE

The initial conceptual model of CHIS use developed on the basis of the pilot case study results identified factors which are associated with CHIS success or lack of success at the level of individual hospitals, as described in Chapter 4. The analysis of the case study results in terms of the initial conceptual model of CHIS use provided a useful way of validating the applicability of the model at hospital level. However, as discussed in Section 5.2.2.4, limitations in the model were identified. On the basis of the results of the final case study (at hospital H4), and taking into account expert inputs, as described in the previous Section, the conceptual model developed in the first phase of the project has been extended to take account of some of the context factors at provincial level which could affect CHIS success (see Figure 5.3). A summary of the factors and sub-factors in the extended conceptual model is given in Table 5.3.

Modifications to the initial conceptual model are described in the following Sections.

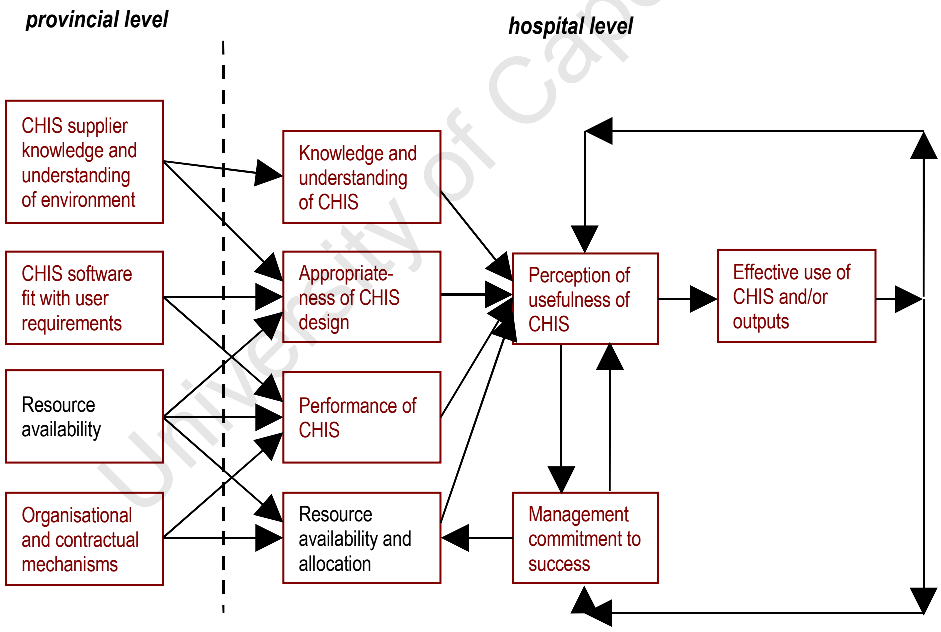

Figure 5.3 Extended conceptual model of CHIS use

Factor	**Sub-factors**
Knowledge and understanding of CHIS	Quality of data in the CHIS
	Training
Appropriateness of CHIS design	Functionality
	Fit
Performance of CHIS	
Resource availability and allocation	Human resource availability and allocation
	Resources for CHIS support
Perception of usefulness of CHIS	Attitude to CHIS
Management commitment to CHIS success	
Effective use of CHIS and/or outputs	Outputs
CHIS supplier knowledge and understanding of environment (P)	
CHIS software fit with user requirements (P)	
Resource availability (P)	
Organisational and contractual mechanisms (P)	

Table 5.3 Factors and sub-factors of the extended conceptual model of CHIS use

5.5.1 Conceptual model of CHIS use at hospital level

The initial conceptual model of CHIS use described in Chapter 4 included two factors related to resources: ‘availability of resources’ for running the CHIS, and ‘allocation of hospital resources’ for running the CHIS and continuing development of the CHIS. A distinction was made between these factors to highlight the significance of the allocation of hospital resources, since this implied that there was recognition by the hospital management that the CHIS could be a useful tool for the hospital.

In order to reflect the significance of availability of resources in the study environment, irrespective of whether they were made available from hospital or provincial resources, the two factors related to resources are now combined into a new factor ‘resource availability and allocation’ at hospital level. A link between the factor ‘management commitment to CHIS success’ and the new factor ‘resource availability and allocation’ highlights the fact that resources for the CHIS are both internal to the hospital and accessed from sources external to the hospital.

The initial conceptual model of CHIS use developed in this project (as described in Chapter 3) incorporated resources as a factor both explicitly (now in the combined factor ‘resource availability and allocation’) and implicitly’ for example in relation to system performance (linked to resources for system support, access to equipment, access to bandwidth, etc), knowledge and understanding of CHIS (linked to resources for training), and ‘design’ (linked to resources for adaptation of the CHIS to meet local user requirements).

Resource availability is incorporated in the ‘bowl’ model of HIS context of Tiihonen *et al.* (2006) in terms of ‘infrastructure’, ‘economy’ (finances) and ‘human resources’. Braa *et al.* (2004) analyse requirements for HIS sustainability across developing countries, taking account of scarcity of resources among other factors, and Piotti and Macome (2007) highlight the need for multiple changing context factors to be taken into account in planning for the implementation of ICT (information and communication technology) to support healthcare in Mozambique. Jayasuriya (1999) proposed a contextualist framework for analysing health services in the Philippines, concluding that ‘organisational, environmental and cultural issues’ must be taken into account, especially in transferring information systems from one environment to another. Jacucci *et al.* (2005) identified the need for resources to ensure the local sustainability of an externally-chosen IS. They found that the effectiveness of this process depends on various factors in the local hospital environment, including some of those identified in the case studies, such as the extent to which internal hospital resources are deployed towards ensuring that the CHIS is effectively used for the benefit of the hospital in the first instance, and knowledge and understanding of the CHIS among hospital personnel.

The availability of hospital resources for implementation, training and maintenance of the CHIS at hospital level is modelled as one of the factors that affect perception of usefulness of the CHIS at hospital level. In terms of this model, available hospital resources are a reflection both of resource availability from provincial level (for example resources available to hospitals for infrastructure and/or application software support in terms of provincial service level agreements with service and system suppliers) and of resource availability at hospital level from hospital resources.

Availability and allocation of hospital resources ('hospital resources') was identified as a separate factor in this conceptual model of CHIS use to reflect differences identified between the case study hospitals, especially in relation to the allocation of hospital personnel to information management (IM) functions. At the three pilot case study hospitals, as described in Chapter 4, there were no dedicated IM personnel with specific responsibility for the CHIS: at one hospital (H1) one of the members of the management team handled IM functions on a part time basis, and at each of the other two pilot case study hospitals (H2 and H3) the responsibility for compiling management statistics had been allocated to a clerk reporting directly to the hospital manager (the senior medical superintendent). At the case study hospital (H4) an information manager had been appointed at senior management level to take overall responsibility for all reporting for the hospital.

Allocation of hospital resources for the extension or further development of the CHIS at the hospital was also included in this factor as a reflection of management commitment to ensuring the ongoing usefulness and use of the CHIS at the hospital. The case study hospital (H4) and one of the pilot case study hospitals (H2) had been included in the national revitalization programme for hospitals, in terms of which additional funding is made available for physical and organizational development of a hospital, typically in a three-year programme. In terms of this programme, it was reported that hospital management have some discretion in terms of allocation of financial resources for organizational development. At the case study hospital, the hospital management made the decision to purchase two additional modules of the CHIS from these additional resources, while they were available (Interviews I1 and I5).

5.5.2 Extended conceptual model of CHIS use: factors at provincial level

The hospital-level factors reflect the CHIS life cycle phases of system implementation and use. Provincial level factors have been included to reflect the provincial role in decision-making about CHIS selection, and preparation for implementation, including the adaptation of the CHIS for use in South African (level 1 and level 2) hospitals, as well as ongoing implementation and maintenance.

The following factors were identified at provincial level (i.e. external to hospital level) as having the potential to affect the success of CHIS implementation:

- CHIS supplier knowledge and understanding of the environment;
- CHIS software fit with user requirements;
- Organisational and contractual mechanisms;
- Resource availability.

The diagram of the extended conceptual model of CHIS use is repeated below as Figure 5.4 to support the discussion of factors at provincial level included in the model.

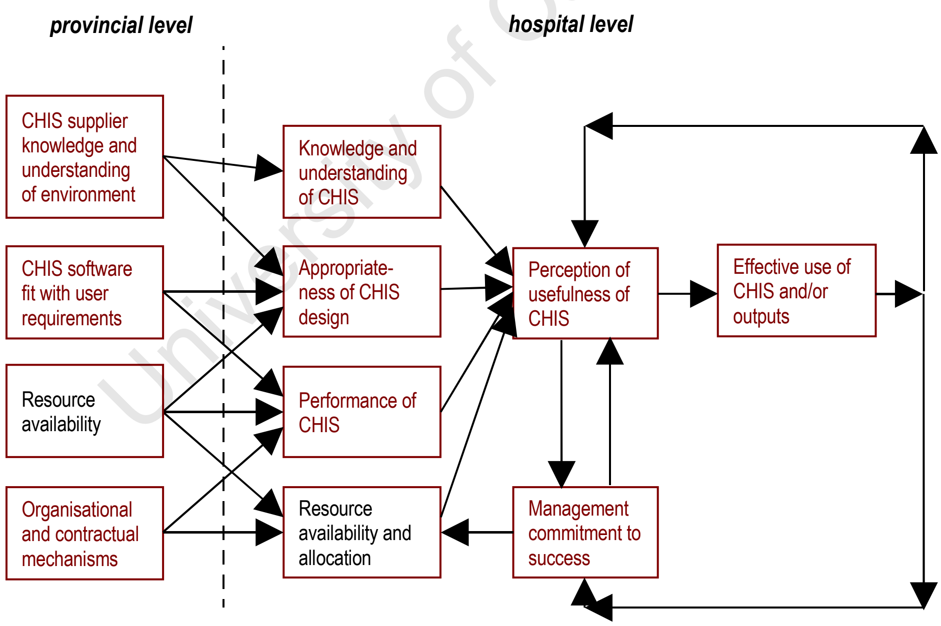

Figure 5.4 Extended conceptual model of CHIS use

(a) CHIS supplier knowledge and understanding of environment

Anecdotal evidence from South Africa suggests that one of the factors which affect the potential for CHIS success in public sector hospitals is knowledge and understanding of the South African public healthcare sector of the CHIS supplier/developer. A representative of a long-term supplier of CHISs in South Africa, for example, has identified applicability (meeting local user requirements), maintainability and cost as being areas in which locally-developed software products are likely to have an edge over products developed outside the country.[3] One of the experts interviewed (E1) was of the opinion that knowledge and understanding of the local environment was more important than local (i.e. within South Africa) development of software. Further discussion of this issue between the author and the third expert (E3) confirmed that 'local knowledge' rather than being 'locally-based' was the key issue, since there had been overseas-based companies with extensive local experience that had developed products which had been closely aligned to the needs of the South African CHIS market. The CHIS supplier representative interviewed (E2) underlined the necessity for local alignment by noting that, in his experience, 'the way hospitals are administered in South Africa is completely different to other countries, in both public and private sectors', due to legislative requirements and the way in which the medical aid industry functions. He noted that 'things that foreign computer systems take for granted, they can't', highlighting the level of computer literacy of CHIS users, the available bandwidth, and the availability of personnel to capture clinical data, as examples.

This factor affecting CHIS use was investigated further in the next phase of this project (i.e. the survey of hospitals).

(b) CHIS software fit with user requirements

Characteristics of the CHIS such as the degree of fit between the CHIS software and user requirement specifications, and between the organisational environment for which the CHIS software was designed and the organisational environment in which it will be implemented can have a major effect on the use of the CHIS at hospital level. Broadly, this factor corresponds to the 'conception-reality gap' between the design of an information system and the potential for that system to meet the needs and capabilities in the (hospital) environment identified by Heeks and colleagues (1999). In the information system use literature, the related concept of task-technology fit has been extensively examined (Mohd.Yusof *et al.,* 2008; Kukafka *et al.,* 2003; Goodhue and Thompson (1995)). In their analysis of the problems which had arisen in a CHIS implementation in the Limpopo province of South Africa, Littlejohns *et al.* (2003) identified the

[3] Interview with Chris Stevenson of Delta 9 reported in ICT World online newsletter, Issue 199, August 2006 (www.ictworld.co.za).

difference between the environment for which a system had originally been designed and the environment in which it was being implemented as one of the factors that complicated the South African implementation. In the Australian case reported by Southon *et al.* (1999) it was these organisational issues which were among the most significant factors leading to the failure of the CHIS implementation.

In the South African environment, expert E1 also noted that extensive resources (paid for in US dollars or another foreign currency if a system is not procured from a local supplier) could be required to modify software to meet local requirements. Expert E2 noted that, as a supplier, their approach was to implement a 'vanilla' (basic) version of the CHIS software, and then modify or provide additional available capabilities to meet additional requirements identified by users, rather than providing a wide array of functions, some of which might not be required by the users. In the case study hospital (H4), the general consensus of the users seemed to be that the CHIS software was well-aligned with user requirements, within the scope of the CHIS. The effort and resources required to match the CHIS software to user requirements at the time of first implementation was not specifically addressed in user interviews at hospital H4.

(c) Organisational and contractual mechanisms

Even allowing for the context factors above, there are still situations in which problems arise with CHIS implementations, which could be due to the fact that organisational and contractual processes have not been established to facilitate and enable the CHIS implementation, including contractual arrangements with CHIS suppliers; policies and standards for CHIS acquisition; and mechanisms for ensuring local sustainability of the CHIS implementations. For example, once the decision has been made to acquire a CHIS, it is necessary for the purchaser organisation (the province, for South African district and regional hospitals) and the user organisation (hospitals in which the CHIS is implemented) to ensure that the contract with the CHIS supplier includes service level agreements and clear guidelines and timeframes for processes such as customisation (application software changes which do not require reprogramming) and adaptation (application software changes which do require reprogramming). This aspect of the acquisition and implementation process is especially crucial in cases where the CHIS supplier is based outside the implementing country and all or some of the software modifications are not being done within the province or the country. Unregulated, the software modification process can result in increased resource requirements due to large costs and long delays.

There were few references to contract issues in the available HIS literature. This could be a reflection of the fact that much of the HIS literature refers to in-house developed software, rather than the procurement of commercial systems. Some exceptions were provided by Gauld (2007), who includes contract issues in his analysis of a New Zealand public hospital HIS project failure; and Southon and colleagues (1999) who referred to differences between users and supplier in the interpretation of the contract in an Australian case study. Littlejohns and colleagues (2003) refer to 'dissonances between the expectations of the commissioner, the producer and the users of the system', in an indirect reference to contract issues in their evaluation of a South African HIS implementation.

From experience, expert E1 noted the need to monitor a contract very carefully to ensure that a South African province was not paying (in US dollars) for software modifications to provide functionality which had been specified in the original contract with the CHIS supplier.

(d) Resource availability at provincial level

In this extended conceptual model of CHIS use, availability of resources for functions such as system adaptation, user training, system maintenance, ensuring the quality of the data in the system, and ongoing development/enhancement of a CHIS are explicitly identified as factors associated with CHIS use. There are two 'resource' factors in the model: resource availability at provincial level, and hospital resource availability and allocation (see figure 5.4). Of particular importance in the study environment is the fact that access to resources is vulnerable, since resources could be subject to disruption (for example due to the resignation of a key member of the support personnel) or termination (for example due to the end of project funding).

Resource availability at provincial level refers to requirements for resources at multiple stages, including resources for the preparation for implementation at hospital level in terms of adaptation of the application software to meet local needs and the provision of the required equipment and infrastructure, and resources for the ongoing maintenance and support of the CHIS after implementation. Availability of resources for the development of skills related to effective CHIS use is a critical component of this factor. In terms of the extended conceptual model for CHIS use, resource availability at provincial level influences not only resource availability at hospital level, but could also influence the performance of the CHIS. The appropriateness of the CHIS design at hospital level is influenced in the sense that CHIS adaptation to meet hospital needs could be limited by lack of access to the resources required to effect the changes. Hence, changes and/or limitations in the availability of resources at provincial level can have major knock-on effects at hospital level.

During the expert interviews and case studies, limitations of resources of various kinds emerged as a recurring theme. Two of the expert interviewees (E1 and E2) interpreted the problem of outstanding CHIS adaptations (i.e. adaptations identified by users as being required prior to system implementation in one or more hospitals) as being due to insufficient resources being made available for this function. E1 commented that there sometimes seemed to be more emphasis on hospitals adapting to the CHIS, rather than the CHIS being adapted to suit the users. Southon and colleagues (1999) also identified the problem of outstanding adaptations as one of the problems leading to the failure of the CHIS implementation which they analysed. Case study hospitals all experienced limitations of resource availability for both hardware and software system support, the most glaring of which is the unavailability of support outside office hours, as has been described. The very limited number of skilled personnel available to provide support for the CHIS implementation at provincial and hospital levels was identified as a concern in all case study hospitals and by all expert interviewees. E2 indicated in the interview that there had been cases where 'reallocations of one or two staff members have had a major effect on the efficiency and effectiveness of hospital administrative processes'.

5.5.3 Discussion

The analysis of the conceptual model of CHIS use in the preceding Sections demonstrates the interpretation of results from the case studies, from targeted interviews and from the literature, through the lens of a model. The model takes account of factors which reflect the context in which CHISs are implemented, recognising that context has a major effect on CHIS implementation and use. Specific analysis of the 'resource' factors affecting CHIS success has highlighted the importance of taking resource factors into account if progress is to be achieved towards the successful implementation of CHISs in LVR environments.

The experiences at the study hospital demonstrate also that it is possible to achieve success in CHIS use despite limitations of resources. For example, the fact that the CHIS has proven to be robust and stable has enabled the hospital to use the system despite the very limited resources available for hardware and software support. Distance from the support services (400 km) was partly offset by the arrangements that had been made for local system support: a local hardware support service provider had been identified, and this service provider also assisted with software problems wherever possible, in telephone consultation with the software support personnel. Jacucci *et al.* (2005) demonstrated how the pooling of skills within the hospital, and strong management support, have made it possible to achieve successful implementation of a different health information system in a rural hospital in the Eastern Cape province in South

Africa. One of the expert interviewees (E1) described a hospital (in a fourth SA province) in which strong management support had offset limitations in the scope and functionality of the locally-implemented CHIS to the point where the CHIS had become an essential management tool in that environment. Further examples of such best practices, and the local factors which contributed to them, were sought in the survey of level 1 and level 2 hospitals.

The following tentative proposals are made for coping with the limitations of resources in many CHIS implementations, based on the results to date of this project:

- Management and end users require the best possible understanding of the capabilities of the CHIS to enable effective use of the available functionality. At all the case study hospitals, members of the management team expressed concern about their own limited understanding of the CHIS and the lack of opportunity to enhance their understanding of the CHIS.
- Management support for and ongoing commitment of resources to the CHIS implementation, and efforts to ensure data quality and consistency in particular, is a key factor in ensuring effective CHIS use within a hospital.
- Appropriate contractual and service level agreements are essential to ensure that ongoing hospital needs are taken into account in CHIS implementations.

The analysis of this extended conceptual model of CHIS use demonstrates that, especially in environments where access to resources is limited or vulnerable, availability and allocation of resources are among the key factors that affect CHIS use. The focus of the next Chapter is on a survey of CHIS user in level 1 and level 2 hospitals in two South African provinces. The analysis of the results of the survey provided further rich data to contribute to modelling of CHIS use in hospitals. That analysis included an assessment of the extent to which the results of this study could be generalised to similar hospitals within and beyond South Africa, and to the implementation of CHISs in hospitals other than the public sector level 2 hospitals which were the focus of the case studies.

CHAPTER 6 SURVEY AND REVIEW OF MODEL

6.1 INTRODUCTION

The outcomes of the third round of data collection and conceptual model review in this study are reported in this chapter, following the pilot case studies and initial model development described in Chapter 4, and the case study and development of an extended conceptual model of computerised hospital information system user (CHIS use), as described in Chapter 5 (see Figure 6.1).

The positivist approach in the survey phase of the study contrasts with and complements the interpretivist approach in the previous phases, with a focus on testing the extended conceptual model, which was developed on the basis of the results of the case studies, inputs from expert informants, the literature and the author's experience of the implementation of CHISs in hospitals in South Africa.

Analysis of the data from more than 30 hospitals in two provinces obtained in this phase of the study provided a rich picture of the use of three different CHISs in level 1 and level 2 hospitals (SystemA and SystemB in Province 1, and SystemC in Province 2), and provided the basis for further refinement of the conceptual model of CHIS use which has formed a major thread of outputs of this study. Data were obtained for 21 hospitals in Province 1 and 13 hospitals in Province 2, although full data sets were not available for all hospitals, as will be discussed.

6.2 SURVEY – RESEARCH SETTING AND DATA COLLECTION

6.2.1 Background

A survey was conducted of CHIS implementations in level 1 and level 2 hospitals in two South African provinces, in order to supplement the data from the case studies with data from a cross Section of level 1 and level 2 hospitals.

The focus of the survey was on obtaining data to support the investigation of factors associated with CHIS success or lack of success from a larger sample of hospitals than in the case studies. The conceptual model was further developed and extended on the basis of the survey results, as described in Section 6.5.

An overview of the survey, the study hospitals, and the data collection process are provided in this Section. The data analysis approach is discussed in Section 6.3. The results and the analysis of results are presented in Section 6.4.

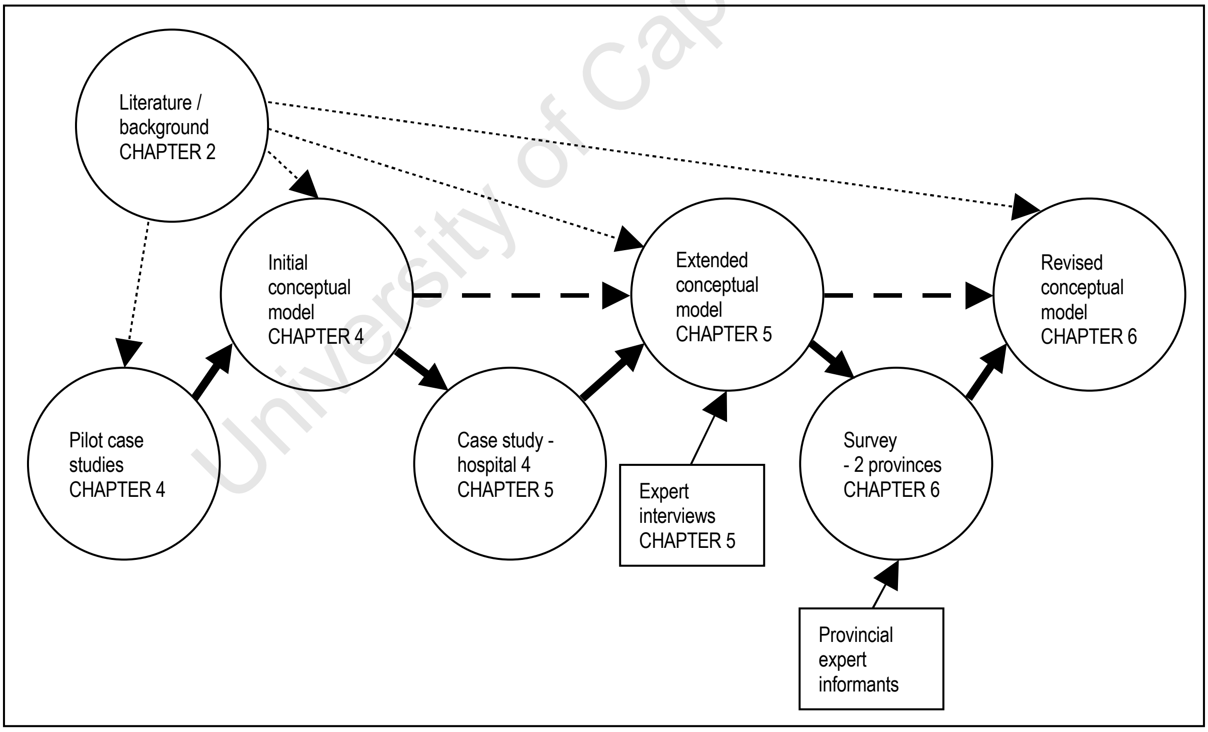

Figure 6.1 Diagram of the study process

6.2.2 Aim and objectives

The conceptual model developed in the first two phases of this study was based on data from case studies in four level 2 hospitals in Province 1 using the SystemA CHIS. The aim of this survey was to test and refine the conceptual model, on the basis of data from additional level 2 hospitals in Province 1, level 1 hospitals in Province 1, and level 1 and level 2 hospitals in Province 2, and to determine the relative significance of the factors identified as being associated with success or lack of success in CHIS implementation in the hospitals surveyed.

The objectives of this survey, as defined in the survey protocol, were

- To identify those factors which are associated with CHIS success
- To identify those factors which could predict CHIS success or lack of success;
- To identify differences between hospitals/groups of hospitals (district and regional; urban and rural, etc) in respect of factors associated with CHIS success or lack of success;
- To provide further data for identifying factors which could predict CHIS success or lack of success.

The aim and objectives are discussed further in Section 6.3, in the context of the analysis of the data obtained from the survey.

The protocol for the survey of hospitals is attached as Annexure F.

6.2.3 Overview

(a) Sampling

All level 1 and level 2 hospitals in the two study provinces were included in the sample, except those level 2 hospitals at which case studies had already been conducted. This sample was chosen to provide a balance between the requirement to obtain data from as wide a range of South African public sector level 1 and level 2 hospitals as possible, and the practicality of conducting surveys on a wide scale.

Approval was sought from the provincial authorities to conduct the survey in Province 1 (where the case studies had been conducted), and in a second province (Province 2) with more rural areas than Province 1, and known to be relatively under-resourced in comparison with Province 1. These provinces were chosen to ensure that the sample used was broadly representative of the range of level 1 and level 2 hospitals in South Africa. There were three different CHISs in use in the study hospitals: SystemA or SystemB in Province 1 hospitals, and SystemC in Province 2 hospitals.

As far as possible, one questionnaire ('the user questionnaire') was completed for each of the following categories of users/hospital personnel at each hospital:

- hospital management
- end users
- information officers and other staff with full-time responsibility for information management, e.g. statistics clerks (whether appointed or seconded to this role)
- case managers for private patients in hospital (if there were designated personnel for this function).

These categories of users were chosen on the basis of the results of the case studies, in order to develop a composite picture of CHIS use at each hospital.

A description of the CHIS implementation at each hospital surveyed was obtained from the hospital manager or another key informant designated by hospital management, using the 'hospital questionnaire'.

The development of the questionnaires is discussed in Section 6.2.5.

(b) Survey administration

Data collection for the survey of CHIS use in level 1 and level 2 hospitals took place in several phases and by multiple mechanisms, once permission had been received from the provincial health authorities in each of the two provinces:

- Interviews by the author with key informants at provincial level, to obtain an understanding of the CHIS from the provincial perspective;
- Site visits by the author to selected hospitals in both provinces, including interviews using the defined questionnaires and/or more general interviews;
- Individual telephone interviews, conducted by the author or one other interviewer;
- Self-completion of questionnaires by hospital personnel.

The provincial perspective provided by the interviews with key informants was essential, both in order to provide context for the interviews and other data collection at hospital level, and because CHIS selection typically takes place at provincial level in the public healthcare sector in South Africa. The interviewees included the health IT manager of Province 2, a senior manager of district hospitals in Province 2, the leader of the SystemB CHIS implementation team in Province 1, and the health IT manager for Province 1 (see Table 6.1).

Interview code	Interviewee role	Province	Interview date/s
P1	Senior manager, district hospitals	2	25 and 28 February 2008
P2	Manager, IT, department of health	2	25 February 2008
P3	Manager, rollout of CHIS SystemB	1	08 May 2008
P4	Director, health IT	1	12 May 2008

Table 6.1 Provincial key informants for survey of hospitals

The hospital site visits provided the opportunity for the author to obtain a clear understanding of the hospital environment, particularly in Province 2, since the author had only limited experience of hospitals in this province gained during short-term assignments in the province more than ten years previously. One of the hospital visits in Province 1 also provided the opportunity for the author and the second interviewer to gain an understanding of the SystemB in use in the hospital, and also for the second interviewer to understand the hospital information system environment in a public sector hospital, with which she was unfamiliar. Other hospital visits by the author provided valuable insight into the activities of level 1 hospitals outside the city environment. Wherever possible, requests from interviewees to be interviewed in person were acceded to. However, it was not possible to visit hospitals more than 50km from the author's office mainly due to time constraints.

Descriptions of the survey hospitals and the CHISs in use in the survey hospitals are given in the next Section.

Two questionnaires were developed: a hospital questionnaire was used to obtain an overall view of the CHIS implementation at a hospital (normally obtained from the person responsible for the CHIS implementation at the hospital); and a user questionnaire, which was completed for each respondent at each hospital. The development of the questionnaires is discussed in Section 6.2.5.

As far as possible, the questionnaires were administered by an interviewer visiting the hospital, or telephonically. All interviews were conducted by appointment, and at the convenience of the interviewee. The user questionnaire was forwarded to each hospital in advance. The interviewers completed the questionnaires on the basis of inputs received from the interviewees at each hospital. Where it was not possible to arrange interviews, or where respondents preferred to complete the questionnaires themselves, self-completed questionnaires were returned to the author. Details of the source of data were recorded (interview by author/interview by second interviewer/self-completed questionnaire).

As described previously (Chapter 3, Section 3.5), ethical approval to conduct this survey was obtained from the MRC Ethics Committee. Prior to conducting the survey at any hospital, a letter was sent to the hospital manager to request permission for the survey, and survey participants were identified by the hospital management. Participants were assured that individuals and individual hospitals would not be identified in any reporting on the project.

6.2.4 The study hospitals and the CHISs in use

The units of analysis for this study were level 1 and level 2 public sector hospitals in two South African provinces, excluding specialised hospitals.

Lists of level 1 and level 2 hospitals were obtained from the websites for each province and confirmed with the provincial key informants (P3 and P2 for Provinces 1 and 2, respectively). All the hospitals included in the survey were using a computerised hospital information system (CHIS), mainly to support administrative functions. For Province 1, information was obtained on which CHIS (SystemA or SystemB) was in use in each hospital. This information was confirmed during data collection at each hospital. A few hospitals indicated that they were not using any CHIS and were excluded from the survey.

(a) The CHISs in use at the study hospitals in Province 1

All the case study hospitals, as described previously, were using a well-established, locally-developed CHIS, which supported patient registration, admission/discharge and transfer of patients, and patient billing (described in this study as SystemA). The same CHIS was in use at one of the level 2 hospitals and most of the level 1 hospitals (18 of 23) included in the survey in Province 1.

Seven of the hospitals included in the survey in Province 1 (two level 2 hospitals and five level 1 hospitals) were using SystemB, a CHIS which was being rolled out throughout the Province, and would in time replace SystemA in all the hospitals in the Province.

A description of SystemB was obtained from the head of the system rollout team for the Province prior to the commencement of the survey phase of this project (interview P3). Further information was obtained during the interviews at study hospitals. The implemented CHIS at the time of the study (the survey phase of this project: June - September 2008) was based on the patient administration module (patient registration; admission/discharge/transfer (ADT)) of the main supplier of the CHIS. A billing module from a different supplier had been integrated with the ADT module. Implementation of a replacement billing module (from a different supplier) was planned. A pharmacy dispensing module from another supplier was also being integrated with the core ADT module in preparation for rollout in the Province.

The supplier of SystemB therefore seemed to be following a 'best of breed' approach to providing the appropriate application software for the users, combining modules from more than one supplier in a single implementation. This approach contrasts with the implementation of SystemA in Province 1, which consisted of integrated modules from a single supplier. From the available information, it was not possible to confirm whether all modules of SystemC, used in Province 2, were from the same supplier.

A key difference between SystemA and SystemB in use in the study hospitals in Province 1 was that SystemB had been designed and implemented to provide a central Master Patient Index (MPI) for the Province, whereas SystemA had only a hospital-level MPI and did not provide the facility for linking patient data from multiple hospitals. Patient identification data on SystemB accessed at hospital level therefore had to be checked against the data held in the central MPI, via the provincial WAN. The 'SystemB' hospitals were therefore dependent on the performance of the WAN and central server, in addition to the performance of the hospital LAN and server.

(b) The CHIS in use at the study hospitals in Province 2

According to interviewees at hospitals, implementation of SystemC, the CHIS in use in the study hospitals in Province 2, had commenced in May 2007, with the patient registration and admission/discharge/transfer components; the billing module had been implemented later, between July 2007 and February 2008, according to survey respondents. The scope of the version of SystemC in use at the time of the survey was generally described as being the first phase of a wider scope of functionality (for example, including pharmacy service support) planned for the future. As with SystemB in Province 1, SystemC was designed to link to a central provincial master patient index (MPI).

Previously, a different CHIS having similar scope (ADT and billing) and supplied by a different supplier (i.e., SystemA), had been in use in Province 2. Many of the interviewees had also used the previous CHIS and were therefore able to make some comparisons between the previous and current CHISs in use in their environments.

6.2.5 Questionnaires

A description of the development of the questionnaires used as the major tool for data collection in this survey of CHIS use in hospitals is given in this Section. It is followed in the next Section by a general discussion of the data collection process, and separate descriptions of data collection in the two Provinces.

The survey was designed to collect a core set of data for each hospital included in the study. Two questionnaires were designed:

(a) The hospital questionnaire was designed to record an overview of the hospital and the core data about the CHIS implementation each study hospital. Data collected included the scope of the CHIS implementation at the hospital, the hospital personnel involved in providing input to the CHIS and those using outputs from the CHIS, and the resources available to the hospital for CHIS hardware and software support.

(b) The user questionnaire was designed to collect data about each respondent's experience of and opinions about the CHIS, and their opinions about the factors associated with CHIS success or lack of success in their hospitals.

(a) Questionnaire design

The questionnaires were designed to collect data related to each of the hospital level factors in the extended conceptual model of CHIS success developed in Chapter 5, Section 5.5. The questionnaires were also designed to collect data on the relationships between the hospital level factors in the extended conceptual model, so that the answers to these questions could then be analysed to establish whether the relationships in the conceptual model were reflected in the survey hospitals.
A diagram of the conceptual model, indicating the relationships between factors which were investigated in the survey results analysis is shown in Figure 6.2.

The factors in the revised conceptual model are listed in Table 6.2.
The relationship between the survey questions and the factors in the revised conceptual model is given in Annexure G.

A list of the hypotheses to be tested in the survey is provided in Table 6.3.

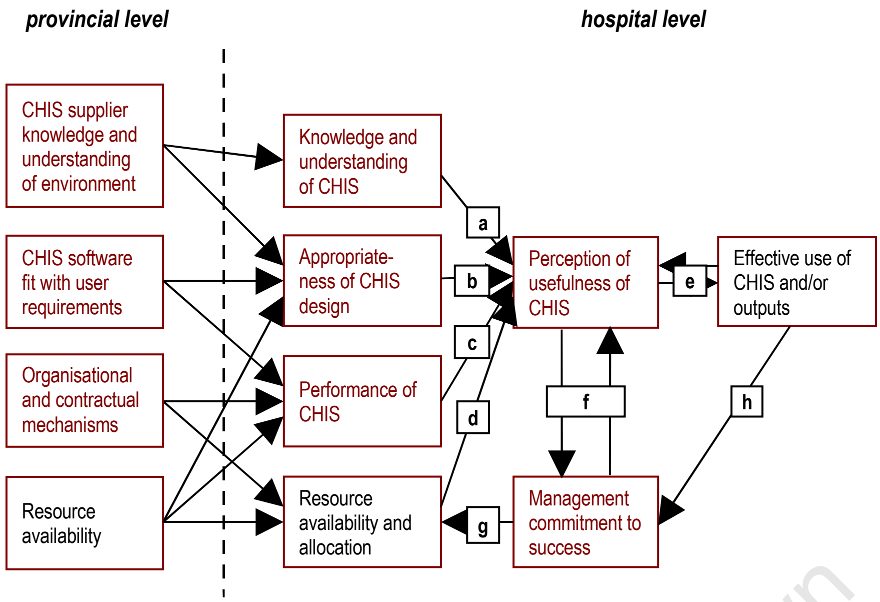

Figure 6.2 Extended conceptual model of CHIS use, identifying relationships (a) to (h) between model factors for analysis

Factor	**Notes**
Knowledge and understanding of CHIS	
Quality of data in the CHIS	A component of 'knowledge and understanding'
Training	Component of 'knowledge and understanding'
Appropriateness of CHIS design	
Functionality	Scope of CHIS; available functions
Fit	Fit between requirements and CHIS functions
Performance of CHIS	
Resource availability and allocation	
Human resource availability and allocation	A component of 'resources' factor
Resources for CHIS support	
Perception of usefulness of CHIS	
Attitude to CHIS	
Management commitment to CHIS success	
Effective use of CHIS and/or outputs	
Outputs	Availability of outputs/reports from CHIS
CHIS supplier knowledge and understanding of environment (P)	
CHIS software fit with user requirements (P)	
Resource availability (P)	
Organisational and contractual mechanisms (P)	
(status of CHIS implementation)	background information
(questions related to the relationships in the conceptual model)	information to assist with assessment of conceptual model

Table 6.2 Factors of the extended conceptual model of CHIS use

(b) Questionnaire piloting

The questionnaires were based on the interview guide that had successfully been used for the case study phases of this project (see Annexure E). The questions used in the case study interviews therefore provided the framework for the development of the questionnaires.

The initial plan for piloting the questionnaires was to administer them to colleagues involved in CHISs in tertiary hospitals, and/or at provincial level, in Province 1. In practice, however, it was decided to obtain inputs from these colleagues about the CHIS implementation in the Province, rather than using the limited available meeting time for questionnaire testing.

It was therefore decided to use the initial interviews in Province 2 (during February 2008) to pilot the questionnaires. One hospital questionnaire and two user questionnaires were completed during this phase of the study, and on the basis of these experiences, it was decided that the questionnaires should be used in their initial format for subsequent data collection.

However, during the first set of hospital interviews in Province 1, it was found that some of the questions in the user questionnaire related to outputs from the CHIS, and the use and usefulness of these outputs, were overlapping and hence caused confusion for the interviewees. This section of the user questionnaire was therefore streamlined, which also reduced the length of the questionnaire. Since these modifications did not change the actual questions posed to interviewees, the data collected from the initial interviews could be captured using the template of the revised questionnaires.

Samples of the final versions of hospital and user questionnaires are attached as Annexures H and I respectively.

Hypotheses related to CHIS success and factors of the conceptual model of CHIS use	Hypothesis number
Knowledge and understanding of the CHIS (among users and hospital management) is associated with CHIS success	(1)
Lack of knowledge and understanding of CHIS is associated with lack of CHIS success	(1a)
Appropriate CHIS design is associated with CHIS success	(2)
Lack of appropriate CHIS design is associated with lack of CHIS success	(2a)
Good CHIS performance is associated with CHIS success	(3)
Poor CHIS performance is associated with lack of CHIS success	(3a)
Availability of resources is associated with CHIS success	(4)
Lack of resources is associated with lack of CHIS success	(4a)
Hospital management commitment to CHIS success is associated with CHIS success	(5)
Lack of hospital management commitment to CHIS success is associated with lack of CHIS success	(5a)
Perception of usefulness of CHIS success is associated with CHIS success	(6)
Lack of perception of usefulness of CHIS is associated with lack of CHIS success	(6a)
Effective use of the CHIS and/or CHIS outputs is associated with CHIS success	(7)
Lack of effective use of the CHIS and/or CHIS outputs is associated with lack of CHIS success	(7a)

Table 6.3 Hypotheses to be tested in survey of hospital respondents (part 1)

Hypotheses related to relationships between factors of the conceptual model of CHIS use	Relationships in the conceptual model
Knowledge and understanding of CHIS are associated with perception of usefulness of CHIS	(a)
Accuracy and completeness of CHIS data are associated with perception of usefulness of CHIS	(a)
Appropriateness of design is associated with perception of usefulness of CHIS	(b)
CHIS performance is associated with perception of usefulness of CHIS	(c)
Availability of resources for CHIS is associated with perception of usefulness of CHIS	(d)
Perception of usefulness of CHIS is associated with effective use of the CHIS and/or CHIS outputs	(e)
Hospital management commitment to CHIS success is associated with perception of usefulness of CHIS	(f)
Hospital management commitment to CHIS success is associated with resource allocation for CHIS	(g)
Effective use of CHIS and/or outputs is associated with hospital management commitment to CHIS success	(h)

Table 6.3 Hypotheses to be tested in survey of hospital respondents (part 2)

6.2.6 Data collection

Permission was received for the provincial surveys in January 2008 for Province 2 and in May 2008 for Province 1. Initial data collection for Province 2 took place in February 2008, and the bulk of the data collection in both Provinces took place between June and October 2008. Summary descriptions of the data sources for Province 1 and Province 2 are given in Tables 6.4 and 6.5 respectively.

Hospital category	Number of hospitals with CHIS	Number of hospitals for which data are available	% hospitals with data	Notes
Level 1 hospitals in survey using SystemA	18	14	78%	
Level 1 hospitals in survey using SystemB	5	4		No data from survey for hospital D22. Hospital D25 (hospital H1 in case studies) was not included in the survey.
Total level 1 hospitals in survey	**23**	**18**	**78%**	
Level 2 hospitals in survey using SystemA	1	1		Hospital S6
Level 2 hospitals in survey using SystemB	2	2		Hospitals S7 and S8
Total level 2 hospitals in Province	5	5		Two level 2 hospitals were included in the case studies: hospitals H2 and H4. Case study hospital H1 was a level 2 hospital at the time of the case study. The fourth case study hospital (H3) is a specialist level 2 hospital.
Total level 2 hospitals in survey	**3**	**3**	**100%**	
Total hospitals in survey	**26**	**21**	**81%**	

Table 6.4 Data collection for Province 1 - summary

Hospital category	Number of hospitals with CHIS	Number of hospitals for which data are available	Number of hospitals for which user questionnaires are available	Number of hospitals for which interview data are available
Level 2 hospitals using SystemC	5	2	1	1
Level 1 hospitals using SystemC	28	11	8	4
Total hospitals in survey	**33**	**13 (40%)**	**9 (27%)**	**5 (15%)**

Table 6.5 Data collection for Province 2 - summary

The primary method of data collection planned for this survey was telephone interviews, using the defined questionnaires, in order to ensure as high a rate of return as possible. This method was selected on the assumption that busy hospital personnel would be unlikely to complete questionnaires mailed to them, due to the many competing calls on their time. In practice, setting up the interviews proved to be a serious challenge, requiring multiple follow-ups by a dedicated research assistant. However, once the interviews had been organised, the interviewees honoured their commitments to be interviewed with very few exceptions, had allocated the required time (normally about one hour, but sometimes longer) for the interview, and responded to questions carefully and candidly. In some cases, interviews were conducted in person at hospitals by the interviewers rather than by telephone (for example at hospitals C2, C7, D5, D24, S6, and S8).

User questionnaires had been sent to all interviewees in advance, as part of the information about the project. Some interviewees chose to complete the questionnaires themselves, and returned them to the author by mail or by fax. In one case, additional questionnaires were distributed in a hospital by the information officer (hospital C27), and collected on behalf of the author. This support was greatly appreciated. Self-completion of questionnaires was also requested in cases where it proved very difficult to make appointments for telephone interviews, even though interviewees had been identified.

Due to miscommunication with hospital personnel in setting up visits, at two hospitals in Province 1 (D23 and D24) and one in Province 2 (C3), interviews were arranged with groups of key users rather than with individuals. Since the group interview for hospital C3 included senior management personnel, a general set of questions based on the standard questionnaires was used to guide the discussion. Group discussions were also held in two of the hospitals visited in Province 2 during the initial site visits in February 2008. The author conducted all the group interviews.

Information from all these group discussions was used to complete the hospital questionnaire and a single user questionnaire as far as possible, and the remaining information from the discussions was used as part of the background information for the hospital. Data from only two of the group discussions, for hospitals D23 and D24, were used to complete a single user questionnaire for each of these hospitals. The data recorded reflected the consensus of opinion within the group interviewed. This approach was consistent with the approach followed in the data analysis where user data were consolidated per hospital for some aspects of the analysis. Comments from individuals were recorded without attributing them to particular interviewees. This approach was also consistent with the analysis approach for other hospitals, since all comments related to a specific CHIS were analysed together, rather than being attributed to a particular hospital or individual interviewee.

Some of the group discussions/interviews provided an interesting opportunity to hear members of the hospital staff discussing aspects of the CHIS among themselves, highlighting differing perspectives of the CHIS in some cases. At one hospital (S6) two colleagues were interviewed simultaneously, but separate questionnaires were completed to ensure that their differing points of view were reflected.

A more detailed description of the data collection process is given in Annexure J.

6.3 SURVEY – DATA ANALYSIS APPROACH

Following the description of the survey data collection process in the previous Section, the measurement and other issues related to the analysis of the heterogeneous data set obtained from the survey are discussed in this Section.

6.3.1 Plan for analysis

In terms of the planning for this project, a major aim of the survey was to build on the results from the pilot case studies (resulting in the first version of the CHIS use conceptual model) and the major case study (resulting in the extended conceptual model of CHIS use), in order to further refine the conceptual model of CHIS use as a framework for analysing CHIS success (see figure 6.1, which describes the study process).

(a) Analysis strategy

The analysis of the survey results was aimed at investigating the validity of the conceptual model in the survey hospitals (i.e. in additional level 2 hospitals in Province 1; in level 1 hospitals in Province 1; and in level 2 and level 1 hospitals in Province 2), and assessing whether changes in the model would be required (based on the survey results). Therefore, the focus of the analysis was on confirming an association between the factors in the conceptual model and CHIS success; and on analysing the relationships between the factors in the model. A further aim of the analysis of survey results was to investigate the relative significance of the identified factors in the conceptual model. The hypotheses to be considered in the analysis of survey results are shown in Table 6.3 in Section 6.2.5, and a framework for the analysis of survey results is shown in Table 6.6. Due to limitations in the data set, as discussed in subsequent sections, it was not possible to analyse quantitatively any but the simplest relationships between factors of the conceptual model. Where possible, the more complex interrelationships between factors are examined using combinations of quantitative and qualitative data from the survey, but detailed analyses of such interrelationships were beyond the scope of this study.

The intended objectives of this survey were noted in Section 6.2.2. However, some of these objectives had to be modified to take account of the available data from the case studies, and the data collected using the final design of the questionnaires.

The revised objectives of this survey were

- To review the factors of the conceptual model of CHIS use;
- To further investigate relationships between factors of the conceptual model of CHIS use;
- To identify differences between groups of hospitals using the same CHIS (SystemA or SystemB or SystemC) in respect of factors associated with CHIS success or lack of success;
- To provide further data for identifying factors which could help to explain CHIS success or lack of success.

(b) Expected outputs from analysis of survey results

The major expected output from the surveys in two provinces was an analysis of the data from the study in terms of the factors of the extended conceptual model of CHIS use. The analysis would be based on a unique set of data describing the CHIS implementations in the study hospitals, and the perceptions of the respondents related to the CHISs in use in their hospitals. The analysis of the data was aimed at the confirmation and extension of the conceptual model of CHIS use developed in previous phases of the study.

The uniqueness of the data set (and, hence, the results of the analysis) lies in the fact that there are no published studies of similar scope known to the author: CHISs which support mainly administrative and billing functions in public sector level 1 and level 2 hospitals in a developing country. While there is much emphasis in the literature on clinical information systems (for example, Ash *et al.*, 2008; Westbrook *et al.*, 2007; Southon *et al.*, 1999), if the administrative and billing functions which are expected to form the core of future computerised clinical information systems in the study hospitals are not used effectively, the chances of effective use of the functions which support clinical activities are greatly reduced.

The use of interviews to gather much of the survey data (in contrast to self-completed questionnaires) provided the opportunity to develop vignettes describing specific aspects of the CHIS implementations at some of the study hospitals. These provided complementary data to the data from the case studies and the data from the surveys to support the further development of the conceptual model of CHIS use.

As a by-product of this analysis, it was expected that a comprehensive description of the CHIS implementations in Province 1 and Province 2 could form the basis of the reporting to the survey provinces, as required in terms of the agreement between the respective Provinces and the author for the survey to be done in hospitals in the Provinces. While not of direct relevance for this study, this information could be of great value to the provincial personnel involved in CHIS selection, implementation and maintenance.

(c) Framework for discussion of survey results

A framework for the discussion and analysis of the survey results is provided in Table 6.6. The data from the survey were divided into different subsets for the purpose of the analysis:

- data about the CHIS implementations in the study hospitals;
- the respondents' opinions about associations between the factors in the conceptual model, and CHIS success or lack of success;
- descriptions of the CHIS in use:
  - variables linked to the factors in the extended conceptual model of CHIS use
  - the respondents' opinions about the CHIS in use in their environments (related to the factor 'perception of CHIS usefulness' in the conceptual model)
  - the respondents' opinions about how the top management in their hospitals relate to the CHIS (related to the conceptual model factors 'perception of usefulness of CHIS'; 'management commitment to CHIS success'; and 'effective use of CHIS and/or outputs');
- the respondents' opinions about the success of the CHIS in their environment (response to question 29 in the user questionnaire – variable 'successful?').

	Analysis step	Data sources
A	Examine hypotheses about relationships between factors in the conceptual model of CHIS use, and CHIS success:	
a	Discuss results of questions about relationships between model factors and CHIS success/lack of success - link to hypotheses about factors associated with CHIS success or lack of success;	- respondents' assessments of the relevance for CHIS success in their environments of factors in the extended conceptual model of CHIS use; - respondents' assessments of the relevance for **lack** of CHIS success in their environments of factors in the extended conceptual model of CHIS success.
b	Discuss results for each conceptual model factor - compare across CHISs in use as a reflection of differences in success;	- results for variables associated with factors of the conceptual model of CHIS use - non-numeric data related to factors of the extended conceptual model of CHIS use.
c	Link to perceptions of CHIS success (question 29 in user questionnaire);	- analyse respondents' opinions about the relevance for CHIS success of factors in the extended conceptual model of CHIS success, in relation to respondents' opinions about the success of the CHIS in use for their work.
	Describe respondent perceptions of CHIS success.	- respondents' perception of CHIS success for their functions in the hospital, including comments.
B	Examine hypotheses about relationships between factors in the conceptual model of CHIS use.	- analyse relationships in terms of data related to factors in the extended conceptual model of CHIS use.

Table 6.6 Framework for discussion and analysis of survey results

(d) Data analysis approach

In terms of the project plan, similar sets of data from Province 1 and Province 2 were anticipated: similar data collection methods had been planned and the expected sample sizes were similar, as described in Section 6.2.6. In order to facilitate data analysis, it was decided, in consultation with the statistician supervisor for the project and because provinces were so different, that data from the two provinces would be analysed separately, and then compared – thus using Province 2 as a comparison for Province 1. For each province, data were analysed at both the level of respondents in hospitals, and at hospital level, wherever possible and appropriate.

In practice, the data collection experience in the two provinces was very different, despite the same approach being used: initial site visits/interviews by the author, followed by written and telephonic contact to make arrangements for telephonic interviews, followed by telephonic interviews with identified hospital respondents. The sample size obtained in Province 1 was much larger than that obtained for Province 2. Different approaches to data analysis in the two provinces were therefore required.

The samples for the two provinces have been described in Tables 6.4 and 6.5 in the previous section. The Province 1 sample, as described in Table 6.4, included data from 81% of the target group of hospitals, with high representativeness in all hospital sub-categories (level 1 and level 2 hospitals, using SystemA CHIS or SystemB CHIS). Limited statistical analysis of the survey results, as described in Section 6.4, was therefore appropriate.

The Province 2 sample, as described in Table 6.5, covered only 40% of the target group of hospitals, with a limited number of completed questionnaires, and could therefore not be regarded as statistically representative of all CHIS implementations in Province 2, although it did include hospitals from all regions in the Province. As far as possible, available data from questionnaires and interviews were analysed similarly to the data from Province 1. In order to gain as much insight as possible into the available data, data from interviews and a limited number of completed questionnaires were also combined and analysed as an exploratory data set. Statistical representativeness is not regarded as a requirement for exploratory studies, making this an appropriate approach to data analysis for this sample (Pinsonneault and Kraemer (1993) in their analysis of survey research in management information systems).

Due to the limited sample size in relation to the number of variables being considered, it has not been possible to use analytical statistical techniques for data analysis. Therefore, a descriptive approach has been followed to

- describe the results related to the factors in the extended conceptual model of CHIS use, and
- compare and discuss the relationships between model factors as reflected in the survey results.

Much of the quantitative data took the form of weighting on a 5-point scale (strongly disagree, disagree, neutral, agree, strongly agree) or presence or absence of a factor (yes, no, neutral). Where no response had been obtained, this was recorded. Descriptions of the results consisted mainly of summaries of the distribution of responses to questions, with the questions grouped in terms of the factors in the conceptual model to which they related.

Statistical analysis took the form of exploring the cross tabulations, and correlations (bivariate and partial), between variables associated with model factors, in order to examine the strength of the relations between them, as reflected by the data. Quantitative data were analysed using Excel and SPSS version 14.0.

The approach followed in the data analysis was to triangulate data from different sections of the questionnaire in order to understand the internal consistency of the data, and data related to the different factors in the extended conceptual model of CHIS use were compared in order to ascertain whether the data confirmed the relationships in the conceptual model.

As explained in the description of the development of the questionnaires (Section 6.2.5), questions were developed to reflect various aspects of the conceptual model. In order to obtain user opinions, extensive provision was made in the survey for user comments, both in relation to specific questions and in the form of general comments at the end of each questionnaire (both hospital and user questionnaires, as previously described).

(e) Analysis of comments in questionnaires

Since the focus of the analysis was on factors of the conceptual model, comments were coded as far as possible in terms of the factors of the model. Thus, the comments related to the usefulness of the CHIS (questions 25 to 28 in the user questionnaire), the respondents' perceptions of the usefulness of the CHIS (comments on question 29 in the user questionnaire), and the general respondent comments at the end of the user questionnaire (questions 47 to 50 in the user questionnaire) were coded in terms of aspects of the conceptual model. Sub-factors were added to some of the factors in order to reflect the richness of the comments (e.g. the 'CHIS design' factor included sub-factors 'functionality' to reflect comments related to the scope of the CHIS, and 'fit' where respondents specifically referred to the fit between the CHIS in use in their hospital and their needs as users within that hospital) (see Table 6.2 in Section 6.2.5). This 'fit' sub-factor reflects the arguments of authors such as Heeks (2006) and Mohd.Yusof *et al.* (2008) that poor fit between user requirements and the software implemented is a major risk factor for successful implementation of health information systems (HISs). In practice, it was found that most comments and responses could be coded in terms of the factors and sub-factors of the extended conceptual model of CHIS use.

Coding of comments:
In order to ensure that respondent comments had been accurately and reliably coded, subsets of the data were coded by two people:

- The author coded all comments.
- General user comments at the end of the user questionnaire were also coded by the research assistant who captured the data from the questionnaires.
- Subsets of approximately 10% of all other coded comments were independently coded by a colleague with extensive experience of the development and management of CHIS implementations in the public sector.
- Where there were discrepancies in coding between two coders, the coding was reviewed by the author in consultation with one of the thesis supervisors (SI) in order to make a decision about how to code the comments. There was generally good consistency between the coding by multiple coders. Where discrepancies arose, these were due to the fact that some comments could be linked to more than one of the factors in the conceptual model. The best fit between each comment and the code was chosen. In some cases, a single comment was coded to two factors in the model. For example, the comment 'user friendly; no problem; being run down' was coded to 'CHIS design' and 'resources' (hospital S6, interview I1).

Comments related to specific questions, for example performance (questions 2 to 5 in the user questionnaire), user training (questions 6 and 7), and use of the midnight state report (questions 16 and 17) were reviewed to check whether there were comments related to factors other than those being addressed in the related question. If comments related to other factors were identified, these comments were coded appropriately and added to the general comments for that respondent. All the uncoded comments were retained in the project data set, and some of them were used to illustrate aspects of the analysis of the survey data.

6.3.2 Measurability and performance of measures

(a) Analysis approach: combining quantitative and qualitative data

As data collection proceeded, the complexity of the environment became apparent and changes had to be made to the collection process. Due to the uniqueness of this study, it was not possible to predict the type of data which would become available from the study. It was ultimately decided to treat even this phase of the study as an exploratory study, which could hopefully provide guidance for data collection in a future study, to support further refinement of the conceptual model and the understanding of CHIS success.

The data analysis approach also had to take into account the high degree of complexity of the data set derived from the survey, which was a reflection of the complexity of the environments being described and analysed in this study. As in the multi-method design of the study as a whole, a multi-pronged approach was required for the analysis of the data from the survey of hospitals in the two provinces: statistical analysis combined with qualitative analysis of the remaining data.

It was also difficult to formulate questions for the questionnaires which could provide quantitative data related to each of the factors in the extended conceptual model of CHIS success. As indicated previously, the questionnaires included significant opportunities for respondents to add comments to answers to questions, and to provide free text answers to some questions. The data from the survey therefore consisted of a mixture of coded and open responses. Where quantitative data were available, they were analysed as far as possible using statistical methods appropriate to the data, as described in Section 6.4. The open ended responses were coded as far as possible in terms of factors in the conceptual model, or related factors such as characteristics of the CHIS itself, or the hospital being surveyed, as described in Section 6.3.1.

Reporting on the results related to model factors individually, and on relationships between model factors, reflected the nature of the data: a combination of quantitative and qualitative approaches to ensure that the available data were used as fully as possible. Care was taken not to read more into the data than was justified. Wherever possible, data were triangulated with similar data from different sources, as described in the following sections.

(b) Statistical analyses: selection of data

(i) Hospital data and user data

Data were collected from a wide range of CHIS users in both study provinces, including heads of hospitals, information officers, information managers (in Province 2 only) and case managers (in Province 1 only), among others. Due to small numbers, it was difficult to draw general conclusions about categories of users from the available data. Future surveys involving larger groups of respondents in particular categories, such as information officers or heads of hospitals, and dealing with aspects of CHIS implementation of particular interest for each group, could provide valuable insights to guide future CHIS implementation and selection.

In general, data analysis was done by treating all respondents from a province as a single group, in order to work with a reasonable sample size (maximum 48 for Province 1, 24 for Province 2 or 72 for the two provinces combined), depending on the variable, and excluding 'no comment' returns). Since model factors such as performance or CHIS design were likely to vary depending on the CHIS in use, data were also analysed separately for each CHIS in use. Thus, data for Province 1 were also grouped into SystemA users and SystemB users. All users in Province 2 used the same CHIS, i.e., SystemC.

(ii) Hospital data

Since the main unit of analysis for the survey is the hospital, data gathered from multiple respondents for a single hospital were also consolidated, to provide composite values for each data item in the user questionnaire. Where hospital questionnaires had also been completed for a hospital, data from both user and hospital questionnaires could then be combined at hospital level, as appropriate.

Hospital data were combined in such a way as to reflect the overall view of the data from a hospital perspective. Where numeric data were very different among users (for example, values of '-2' and '+1' for different respondents at a hospital for a specific variable), the composite value for the hospital was defined as '0', reflecting a 'neutral' or 'inconsistent' response.

(iii) Identification of variables to be used in statistical analyses

The available numerical data were analysed to find out whether there were statistically significant correlations between variables related to the hospital-level factors in the extended conceptual model of CHIS use.

For some of the model factors ('knowledge and understanding of CHIS', 'appropriateness of CHIS design', 'performance of CHIS' and 'resource availability and allocation'), there were several related variables in the user questionnaire for which numerical data had been collected. The available user data for both provinces related to each factor were cross correlated against each other to establish the strength of the relationships between them, and hence support decisions about which variables to use in the statistical analyses as proxies for the factors in the conceptual model. The variables used in the statistical analyses of data from the questionnaires are described in Table 6.7. **The selection of the variables related to each factor in the conceptual model is described in more detail in Annexure K.**

Factor in the extended conceptual model of CHIS use	Variable used in statistical analysis of model relationships	Question number in User question-naire	Question number in Hospital question-naire
Knowledge and understanding of CHIS			
Quality of data in the CHIS	incomplete?	13	
Training	training	6	
	CHIS knowledge		13
Appropriateness of CHIS design			
Functionality			
Fit	rep not appr	11	
Performance of CHIS	availability factor	from 4	
Resource availability and allocation			
Human resource availability and allocation	all patients (factor for ICD-10 coding)	23d	
Resources for CHIS support			
Perception of usefulness of CHIS	man useful tool	30	
Attitude to CHIS			
Management commitment to CHIS success	man commit	32	
	CHIS meetings		12
Effective use of CHIS and/or outputs	man use	31	
Outputs			
CHIS supplier knowledge & understanding (P)			
CHIS software fit with user requirements (P)			
Resource availability (P)			
Organisational & contractual mechanisms (P)			
(Perception of success of CHIS for user)	**successful?**	**29**	

Table 6.7 Variables related to factors in the extended conceptual model of CHIS use

(c) Statistical analyses: relationships between factors in the extended conceptual model of CHIS use

Due to the nature of the data, statistical analyses were conducted with caution. Bivariate correlations and cross tabulations between the variables related to hospital level factors in the conceptual model were calculated.

Descriptions of the relationships between factors in the extended conceptual model of CHIS use which were analysed are given in Figure 6.3 (repeated in this section for ease of reference) and Table 6.8. The user questionnaire also included a question about the respondents' perception of the success of the CHIS for their work (question 29). The results from this question were correlated with each of the variables (from the user questionnaire) used to represent factors in the conceptual model. The user questionnaire included questions designed to obtain user opinions on the significance of the factors in the conceptual model for CHIS success in their environments. The data from these questions are discussed separately, in Section 6.4.2.

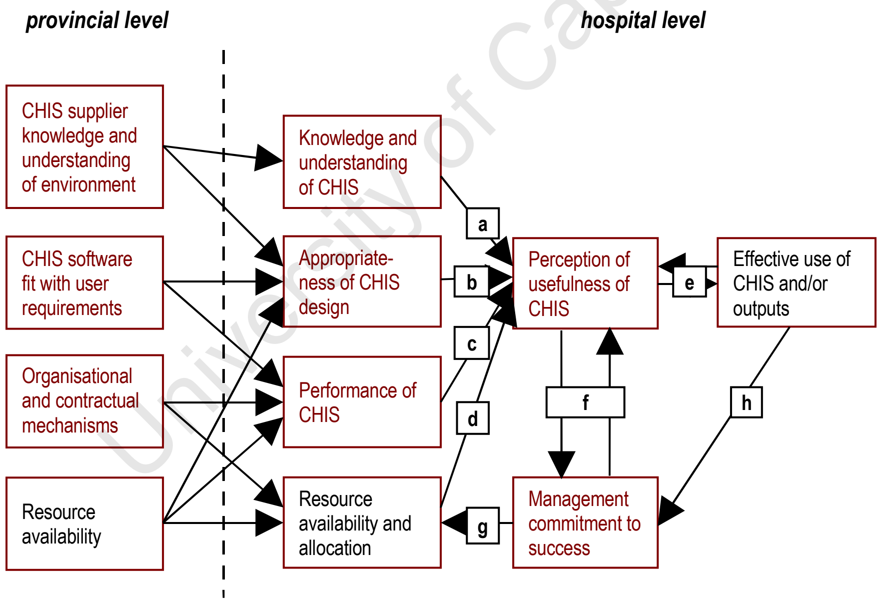

Figure 6.3 Extended conceptual model of CHIS use, identifying relationships (a) to (h) between model factors for analysis

	Relationships between factors in the extended conceptual model of CHIS use			Relationships between related variable(s) analysed statistically		
(a)	**Knowledge and understanding of CHIS**		**Perception of usefulness of CHIS**			
	Quality of data in the CHIS	&	Perception of usefulness of CHIS	incomplete?	&	man useful tool
	Training	&	Perception of usefulness of CHIS	training	&	man useful tool
				CHIS knowledge	&	man useful tool
(b)	**Appropriateness of CHIS design**		**Perception of usefulness of CHIS**			
	Functionality			***[no statistical analysis of this factor]***		
	Fit	&	Perception of usefulness of CHIS	rep not appr	&	man useful tool
(c)	**Performance of CHIS**	**&**	**Perception of usefulness of CHIS**	availability factor	&	man useful tool
(d)	**Resource availability and allocation**		**Perception of usefulness of CHIS**			
	Human resource availability and allocation	&	Perception of usefulness of CHIS	all patients (factor for ICD-10 coding)	&	man useful tool
	Resources for CHIS support			***[no statistical analysis of this factor]***		
(e)	**Perception of usefulness of CHIS**	**&**	**Effective use of CHIS and/ or outputs**	man useful tool	&	man use
(f)	**Management commitment to CHIS success**	**&**	**Perception of usefulness of CHIS**	man commit	&	man useful tool
(g)	**Management commitment to CHIS success**	**&**	**Resource availability and allocation** Human resource availability and allocation	man commit	&	all patients (factor for ICD-10 coding)
(h)	**Effective use of CHIS and/or outputs**	**&**	**Management commitment to CHIS success**	man use	&	man commit
	Perception of success of CHIS for user	**&**	***All variables related to model factors***	*successful?*	&	*multiple variables*

Table 6.8 Relationships between factors in the extended conceptual model of CHIS use, and between related variables

(i) Factors associated with 'perception of usefulness of CHIS'

Conceptual model factors were considered in two groups, reflecting to some extent the available data:

- the 'input' factors, related to CHIS success in the conceptual model (knowledge and understanding, appropriateness, performance, and resource availability and allocation) which reflect characteristics of the information system and the user; and
- the factors related largely to responses to the 'input' factors (perception of usefulness, management commitment, and effective use of CHIS and/or CHIS outputs).

Since this was a hospital survey, specific information related to province-level factors was not collected in the survey.

All the hospital-level factors in the conceptual model link to the factor 'perception of usefulness of CHIS'. In the survey results, relationships between factors in the conceptual model were partially reflected in user responses to their perceptions of the CHIS in use in their hospitals. These results were included in the responses to questions 25 to 32 in the user questionnaire.

Thus, apart from statistical analyses of relationships between variable related to factors in the conceptual model, user responses to questions about their opinions of the CHIS in use in their environments provided useful insights into relationships between factors, as described in Section 6.4.5. These data were also drawn on in the following Sections to illustrate relationships between factors of the extended conceptual model of CHIS use.

(ii) Hospital data

Since the major unit of analysis for this study is a hospital, some statistical analyses were based on hospital-level data. Where data from multiple user questionnaires were available for a hospital, data were consolidated to provide a single set of measures for the hospital, as described in Section 6.3.2(b). Where data were available from only one respondent for a hospital, it was assumed that the data were representative of all hospital users. Although this was not necessarily a valid assumption, this was the best possible assumption on the basis of the available data. Single respondents for hospitals included heads of hospitals or members of the hospital management, or information officers, among others. Since information officers and information managers should have a comprehensive understanding of the CHIS implementation in their hospital, it was assumed that they were able to provide data which was representative of the situation in the hospital.

Hospital questionnaires were analysed only for Province 1, since there were only two hospital questionnaires available for Province 2. For the hospital questionnaires, data were obtained as far as possible from the information officer or information manager or CHIS system controller or system administrator for the hospital, on the assumption that they were able to provide the best overview of the CHIS implementation at the hospital. In practice, the data for 10 of the 16 hospital questionnaires analysed were provided by information officers. Data for the remaining six hospital questionnaires were provided by representatives of hospital management (four respondents), or CHIS user supervisors (two respondents). For Province 2, hospital data were based on the available hospital questionnaires, and available data from interviews and discussions. These data could not be analysed statistically.

While the results from the data did reflect statistically significant relationships between some of the model factors, as will be discussed, they were interpreted with caution due to the limitations of the data sets being analysed. Accordingly, these statistical results were not considered in isolation, but were combined with related quantitative and qualitative data from the survey, also referring to case study results where appropriate.

The survey results are discussed in relation to the extended conceptual model of CHIS use in the following sections.

6.4 RESULTS AND DISCUSSION OF RESULTS

6.4.1 Introduction

(a) Overview of data collection

All level 1 and level 2 hospitals (except the case study hospitals and excluding special hospitals) in the study provinces were surveyed, but no questionnaires were completed if there was no CHIS in use in the hospital. Therefore, the actual sample size was determined by the number of level 1 and level 2 hospitals in the survey provinces in which a computerised hospital information system (CHIS) was in use, as described under 'data collection' in Section 6.2.6.

As also described in Section 6.2.6, survey data collection methods included face-to-face and telephonic interviews, and self-completion of questionnaires. It was not possible to test the accuracy of the self-completed questionnaires directly, but review of the self-completed questionnaires did not reveal obvious differences from the data collected via interview. However, there were few or no recorded comments on the self-completed questionnaires. This could be explained by the lack of opportunity to probe for further information from participants, as was possible in the interviews.

Completed user questionnaires were obtained from 45 respondents at 21 hospitals in Province 1. Hospital questionnaires were completed for 16 of the 21 hospitals from that province. Three of the respondents had responsibility for two hospitals: the information officer (IO) for hospitals D13 and D19, the IO for hospitals D11 and D16, and the medical superintendent for hospitals D11 and D16. The user questionnaire data for these respondents were therefore recorded twice: once for each of the two hospitals in which they worked. Each of these respondents indicated in the survey interviews that their responses applied to both of the hospitals in which they worked. Therefore, the analysis of user data for Province 1 was based on 48 responses at 21 hospitals. Data from completed hospital questionnaires for 16 Province 1 hospitals were included in analyses as appropriate. As indicated in Section 6.2.6, varying amounts of data were collected for approximately 40% of the target hospitals in Province 2: level 1 and level 2 hospitals using the SystemC CHIS. Completed user questionnaires were obtained from 24 respondents at nine Province 2 hospitals.

In the following Sections, data from the user questionnaires for Province 1 and Province 2 are presented.

- Data associated with each of the factors in the extended conceptual model of CHIS use are grouped to facilitate discussion.
- Where data were available for more than one respondent at a hospital, data from the respondents were reviewed in order to understand, and, where possible, resolve any apparent discrepancies in the data sets referring to individual hospitals, and to enable hospital-level analysis.
- The following discussions are based mainly on user-level responses to questions in the user questionnaire. Where results are drawn from the hospital questionnaire, results are given per hospital.
- Since the data set for Province 2 included a set of 12 questionnaires from one hospital (hospital C27), these data are discussed separately as appropriate, and are specifically discussed as a mini case in **Annexure L**.
- Where possible and appropriate, the limited available hospital-level data for Province 2 (mainly from interviews and discussions with hospital personnel) are combined with the data from the user questionnaires.
- Calculations of percentage of positive responses exclude the number of 'no response's (rating value = 9).

(b) Overview of results

An overview of the CHIS implementations at the study hospitals was given in Section 6.2.4. The scope of the CHISs was very similar across the hospitals, covering mainly patient administration functions.

The results in the following sections are grouped to refer to different aspects of CHIS implementations, particularly in relation to hypotheses based on the extended conceptual model of CHIS use, which provided the framework for this component of the study. The hypotheses are listed in Table 6.3.

Factors associated with CHIS success are examined in Section 6.4.2. Despite limitations in the data, which are discussed, it has been possible to demonstrate support from survey respondents for the hypotheses that the hospital-level factors of the extended conceptual model of CHIS use **are** associated with CHIS success. Respondents were asked for their opinions of the success of the CHIS in use in their hospitals for their work. Cross correlations between these responses and the rating values for measures of each of the hospital-level factors in the conceptual model partially supported the hypotheses about the association between CHIS success and the model factors.

Based on the demonstrated support for the hypotheses about the relationship between CHIS success and hospital-level factors of the conceptual model, rating values for measures of the hospital-level factors are compared across CHISs in Section 6.4.3. Overall, the available data indicate that the SystemA CHIS is more successful than either SystemB or SystemC, and that SystemC is less successful than SystemB.

The hypotheses about relationships between hospital-level factors in the extended conceptual model of CHIS use are examined in Section 6.4.4, and further in Section 6.4.5. While support for some of these relationships could be demonstrated from the survey results, other results are less conclusive, as shown in the discussion.

The results derived from the extensive data obtained through the survey are discussed in more detail in the following sections, and in the related Annexures.

6.4.2 Factors associated with CHIS success and lack of success

(a) Factors associated with success and lack of success: User responses

The survey questions discussed in this Section were designed to obtain the respondents' opinions about the association between the **hospital-level** factors in the conceptual model and CHIS success; and between these conceptual model factors and lack of CHIS success. An additional aim of these questions was to obtain user opinions on the relative weighting of the factors in the extended conceptual model of CHIS use in relation to CHIS success.

Questions 33 to 39 in the user questionnaire related to factors associated with CHIS success. Questions 40 to 46 related to factors associated with lack of CHIS success. The factors associated with lack of CHIS success were conceptualised as being the opposite of those associated with success (i.e., lack of knowledge and understanding, inappropriate design, poor performance, etc.).

A summary of the responses obtained to these questions related to the factors in the extended conceptual model of CHIS use, from users in Provinces 1 and 2, is given in the following tables. Further breakdowns of these data, dividing users in terms of the CHIS which they were using, are provided in tables M.1 and M.4 in **Annexure M**.

Respondents appeared to find difficulty dealing with these questions relating to factors associated with success and lack of success, and particular difficulty with factors associated with lack of success. On average, there were 32% nil or neutral user responses to questions 33 to 39 related to CHIS success (see Table 6.9). There were fewer responses to the questions related to factors associated with **lack of** CHIS success than to the questions related to factors associated with CHIS success (average 42% nil or neutral response to questions 40 to 46 related to **lack of** CHIS success), as summarised in Table 6.10. Possible explanations for the difficulties experienced with these questions include the phrasing of the questions, and a lack of general knowledge and experience of CHISs among some of the survey respondents, although conclusive evidence was not obtainable. Difficulties with obtaining answers to these questions were experienced by both interviewers in cases where there was a language barrier due to the questionnaire being in English, and many of the respondents not having English as their first language. [Both interviewers were able to rephrase questions in Afrikaans or translate responses received in Afrikaans if necessary, but were unable to translate as required for those colleagues who did not have Afrikaans or English as their first language.] From the author's experience of administering the survey questionnaires, apart from language difficulties described, these questions also seemed to be difficult to answer for respondents who had limited knowledge of CHISs beyond their specific use of the CHIS in their environments, such as admissions or billing.

Rating value **Factor**	**-2**	**-1**	**(neu-tral) 0**	**1**	**2**	**(no re-sponse) 9**	**TOTAL users**	**Users no response/ neutral**	**+ve or –ve user re-sponse**	**% +ve user re-sponse**
knowledge		1	8	23	25	15	72	23	49	(48) 98%
design		3	6	30	16	17	72	23	49	(46) 94%
performance			8	34	15	15	72	23	49	(49) 100%
resources	1	4	7	31	14	15	72	22	50	(45) 90%
usefulness			8	29	20	15	72	23	49	(49) 100%
commitment		3	8	21	24	16	72	24	48	(45) 94%
use effectively			6	28	21	17	72	23	49	(49) 100%
								Avg 32%	**Avg 68%**	Avg 97%

Table 6.9 Rating values for factors associated with CHIS success – all users all hospitals

Rating value **Factor**	**-2**	**-1**	**(neu-tral) 0**	**1**	**2**	**(no re-sponse) 9**	**TOTAL users**	Users no response/ neutral	+ve or –ve user re-sponse	% +ve user re-sponse
lack knowledge	4	7	8	13	15	25	72	33	39	(28) 72%
lack design	4	8	8	14	11	27	72	35	37	(25) 68%
lack performance	4	10	5	16	13	24	72	29	43	(29) 67%
lack resources	3	9	5	17	15	23	72	28	44	(32) 73%
lack usefulness	4	13	5	11	13	26	72	31	41	(24) 59%
lack commitment	7	13	4	10	14	24	72	28	44	(24) 55%
lack use effectively	4	12	5	15	12	24	72	29	43	(27) 63%
								Avg 42%	**Avg 58%**	Avg 65%

Table 6.10 Rating values for factors associated with LACK OF CHIS success – all users all hospitals

(i) User opinions about relationships between the hospital-level factors in the extended conceptual model of CHIS use, and CHIS success

Although it is necessary to interpret these results with caution, as indicated in the previous paragraphs, some conclusions can be drawn from the available data. Respondents were asked about their opinions of factors associated with success or lack of success in their working environments. Due to the difficulties in interpreting the questions, some respondents could have responded in relation to CHIS implementations in general, and this had to be taken into account in the discussion.

Taking into account the limitations in this data set, as described in this Section, those respondents who did express opinions about the association between the (hospital-level) conceptual model factors and CHIS success in their environments agreed that there was an association between the conceptual model factors and CHIS success: Overall, approximately 97% of the respondents to these questions agreed that the factors in the extended conceptual model of CHIS use are associated with CHIS success, either strongly (rating value = '2') or less strongly (rating value = '1') (see Table 6.9). A few respondents indicated that these factors are not associated with CHIS success. These negative responses could be interpreted as meaning that, in the respondents' environments, these factors were not associated with CHIS success due to their absence or weakness (limited resources, or limited management commitment, for example).

The data for factors associated with lack of CHIS success were more varied (see Table 6.10). Between 11 and 20 respondents disagreed ('2' for 'strongly disagree'; '1' for 'disagree') that lack of one or other of the factors contributed to lack of CHIS success in their environments. In these cases, it could be assumed that there was **no** lack of the factor in the respondent's environment, which is a positive finding. A striking finding from these data for SystemC (the CHIS in use in the Province 2 study hospitals) was that all 13 respondents (i.e., excluding those who were neutral or did not answer the question) agreed that lack of resources **did** contribute to lack of CHIS success in their environment.

Thus, while the survey data on those questions concerning factors being related to lack of success were less conclusive, on average, 65% of the respondents strongly agreed or agreed that lack of each of the factors of the conceptual model could be associated with lack of CHIS success in the hospitals in which they were working.

Overall, the available data do support the inclusion of the hospital-level factors in the conceptual model of CHIS use developed in this study as being factors associated with CHIS success. Therefore, these data support the hypotheses related to the factors in the extended conceptual model of CHIS use (as listed in Table 6.3 part (1)).

The data related to user opinions about factors associated with CHIS success also support the generalisability of the extended conceptual model of CHIS use beyond the case study hospitals (hospitals H1 to H4 in Province 1) to all level 1 and level 2 hospitals in the study provinces, Province 1 and Province 2. The generalisability of the conceptual model developed in this study is further discussed in Chapter 7, Section 7.2.2.

Although the number of respondents for which data are available is limited (average 49 respondents about factors associated with CHIS success and average 42 respondents about factors associated with lack of CHIS success), this is also true of other studies examining the factors associated with CHIS success or failure, such as those of Pare *et al.*, 2008; Brender *et al.*, 2006; and Ash *et al.*, 2005. Future studies which include more respondents would enable stronger conclusions to be drawn.

To enable further investigation of these hypotheses related to CHIS success, these data related to factors associated with CHIS success are discussed in relation to the variable 'perception of CHIS success' from the survey data in the next Section (6.4.2(b)).

(ii) User opinions about the relative weighting of factors associated with CHIS success

The intention behind including the questions about factors associated with CHIS success or lack of success was also to obtain data from the respondents about their relative weighting of these factors. Due to the small number of respondents and the limited variability in the available data, as shown in the summary Tables 6.9 and 6.10, and in the more detailed tables in **Annexure M**, it was not possible to draw any conclusions on a statistical basis about relative weighting of factors from these data.

The results of cross correlation of these data also reflected the difficulty of drawing any conclusions about relative significance of factors. Most of the factors are strongly correlated with each other in terms of these data. Composite tables reflecting the results of cross correlations of these data using SPSS, both per user and per hospital, are provided in **Annexure M**. As for the factors associated with CHIS success, the cross correlation results did not make it possible to draw any conclusions about the relative weighting of conceptual model factors in relation to lack of CHIS success.

Therefore, it was not possible to make any conclusive findings from this subset of the survey data about the relative weighting of the conceptual model factors in relation to CHIS success or lack of success.

There have been reports on other studies designed to obtain opinions about factors associated with HIS success or failure. However, these studies focussed on respondents with extensive experience of HIS development and/or implementation, using methods such as consensus conferences or Delphi studies (Paré *et al.*, 2008; Brender *et al.*, 2006; Ash *et al.*, 2005). In retrospect, it seems to have been optimistic to expect to obtain direct inputs on weighting of factors associated with CHIS success, or lack of success, as part of a survey, from respondents with limited knowledge and/or experience of CHIS implementation and use in South Africa. However, future studies including respondents highly familiar with CHIS development, implementation and management in South Africa could greatly contribute to the developing body of knowledge about factors associated with HIS success. The perspectives of CHIS users, as in the current study, should also be taken into account in further future studies, since their opinions would not necessarily match those of experts, who are unlikely to be direct CHIS users.

(b) 'Perception of CHIS success' ('successful?') and conceptual model factors

The purpose of this component of the analysis was to investigate whether the results of the survey related to the variable 'perception of CHIS success', consolidated at hospital level, supported the conceptual model of CHIS use on a statistical basis.

The variable 'successful?' reflects the responses of users to the statement 'Overall, in terms of my job, the CHIS is a success' (question 29 in the user questionnaire). The rating values of this variable therefore provide the most direct reflection from the survey of the respondents' overall opinions of the CHIS which they were using. [Where there were multiple user responses available for a single hospital, the rating values for this variable were consolidated at hospital level to reflect the most common response. As for other numeric variables in the user questionnaire, a neutral response (rating value = 0) was recorded at hospital level if there was wide variation in user responses.]

One of the assumptions in this study (also supported by results from the literature) is that effective CHIS use is related to CHIS success (as discussed in Chapter 4, Section 4.3.6). Therefore, if the conceptual model is valid, the rating values (and other measures) of the factors of the conceptual model of CHIS use, should be consistent with user perceptions of CHIS success in their working environments. The analysis of cross correlations between the variable reflecting CHIS success ('successful?'), and the variables reflecting factors of the extended conceptual model of CHIS use, was therefore aimed at **exploring** these relationships, based on the available numeric data from the study survey.

A summary of the results at hospital level and at user level of the cross correlations between the variable 'successful?, and the variables representing the factors in the extended conceptual model of CHIS success, is shown in Table 6.11, parts 1 and 2. Details of these results are summarised in Tables N.1 and N.2 in Annexure N.

Overall, while there were some statistically significant cross correlations between the variable 'successful?' and variables representing factors in the conceptual model for some categories of hospitals and users, the results were very varied.

Concep-tual model factors	Related vari-ables	Summary comments on results of cross correlations AT HOSPITAL LEVEL (as listed in Table N.1, Annexure N)	Summary comments on results of cross correlations AT USER LEVEL (as listed in Table N.2, Annexure N)
Knowledge and understanding of CHIS	training	Positive correlations (but not significant) for all hospitals, and for hospitals in Province 1, using SystemA and SystemB. Negative, non-significant, correlation (counter-intuitive) for SystemC.	Positive correlations for all categories. Statistically significant correlations for all users, Province 1 users and SystemA users.
	incom-plete?	Negative correlations for all hospitals, SystemA user hospitals and SystemC user hospitals; significant at 0.05 level for SystemC user hospitals. Near-zero correlation for all Province 1 hospitals, and high positive, but non-significant, correlation (r = .739) (counter-intuitive) for SystemB user hospitals.	Negative correlation for all users. Statistically significant at 0.05 level for SystemC users (r = .621). Near-zero correlations for all Province 1 users and SystemA users. Positive (counter-intuitive) correlation for SystemB users.
Appropriate-ness of design	rep not appr	Negative correlations (but not significant) for all categories, except for SystemC user hospitals. Positive, non-significant, correlation (counter-intuitive) for SystemC user hospitals.	Negative correlations for all categories. Statistically significant correlations for all users (r = -.471; significant at 0.01 level); and for all Province 1 users (r = -.348; significant at 0.05 level).
Performance of CHIS	availabi-lity factor	Statistically significant positive correlation for all hospitals (r = .503; significant at the 0.01 level). Positive, non-significant correlation for SystemC user hospitals (r = .480). Near-zero correlations for all Province 1 hospitals, and for SystemA user hospitals in Province 1. Weak, negative correlation (counter-intuitive) for SystemB user hospitals in Province 1 (r = -.250).	Statistically significant positive correlation for all users (r = .338; significant at the 0.05 level). Positive, non-significant correlation for SystemB and SystemC users. Near-zero correlations for all Province 1 users and for SystemB users. Weak, negative correlation (counter-intuitive) for SystemA users in Province 1 (r = -.161).
Resource availability and allocation	all patients (factor for ICD-10 coding)	No statistically significant correlations; negative for all groups except SystemA users in Province 1. Near-zero correlation between 'perception of success' and 'all patients' for SystemA users. This variable seems not to be a good reflection of resource availability in relation to perception of CHIS success, since the cross correlations for all groups are either counter-intuitive or near zero.	Negative statistically significant correlation for all users (r = -.330; significant at 0.05 level). Negative, non-significant correlations for Province 1 users, and SystemA and SystemC users. Positive, non-significant correlation for SystemB users. This variable seems not to be a good reflection of resource availability in relation to perception of CHIS success, since negative cross correlations for this variable are counter-intuitive.

Table 6.11 Summary of results of statistical analyses: 'perception of CHIS success' and variables related to conceptual model factors – hospital and user levels (part 1)

Concep-tual model factors	**Related vari-ables**	**Summary comments on results of cross correlations AT HOSPITAL LEVEL** **(as listed in Table N.1, Annexure N)**	**Summary comments on results of cross correlations AT USER LEVEL** **(as listed in Table N.2, Annexure N)**
Perception of usefulness of CHIS	man useful tool	Positive correlations for all hospitals (r = .379; significant at the 0.05 level), and for SystemC user hospitals (r = .587; not statistically significant). Near zero for SystemA user hospitals and zero for all Province 1 hospitals. Negative correlation (r = -.707; not statistically significant) for SystemB user hospitals in Province 1.	Positive correlations for all categories, apart from SystemB users. Statistically significant correlation for SystemA users (r = .495; significant at 0.05 level). Negative correlation (r = -.292; not statistically significant) for SystemB users in Province 1.
Management commitment to CHIS success	man commit	No statistically significant correlations; negative (counter intuitive) for all hospitals, and SystemB and SystemC user hospitals. The positive correlations for Province 1 hospitals and for SystemA user hospitals in Province 1 are weak (r = .143 and r = .258 respectively). This variable seems not to be a good reflection of management commitment to CHIS success in relation to perception of CHIS success, since the cross correlations for all groups are either counter-intuitive or weak.	Statistically significant correlations for all users (r = .557; significant at 0.01 level); Province 1 users (r = .374; significant at 0.05 level); SystemA users (r = .570; significant at 0.01 level). Non-significant positive correlation for SystemC users. Zero correlation for SystemB users. The statistical relationships between ‘successful?’ and ‘man commit’ are generally much stronger at user level than at hospital level.
Effective use of CHIS and/ or outputs	man use	Statistically significant correlations for all hospitals (r = .581; significant at the 0.01 level) and for SystemC user hospitals (r = .797; significant at the 0.05 level). Zero correlation for all hospitals in Province 1, and weak positive correlation for SystemA users in Province 1. Negative correlation (counter-intuitive) (r = -.525) for SystemB user hospitals in Province 1. The statistical relationships between ‘successful?’ and ‘man use’ are generally much stronger at hospital level than at user level.	Non-significant positive correlation for SystemA users. Near-zero correlation for Province 1 users. Statistically significant negative correlation (counter-intuitive) for SystemC users. (r = -.615; significant at 0.05 level). Negative correlations for all users, Province 1 users; and SystemB users. Most correlations are counter-intuitive or weak.

Table 6.11 Summary of results of statistical analyses: ‘perception of CHIS success’ and variables related to conceptual model factors – hospital and user levels (part 2)

At hospital level, there were statistically significant correlations between ‘successful?’ and the variables ‘incomplete’; ‘availability factor’; ‘man useful tool’; and ‘man use’ for one or more categories of hospitals. These variables are linked to the conceptual model factors ‘quality of data’ (sub-factor of ‘knowledge and understanding of CHIS’); ‘performance of CHIS’; ‘perception of usefulness of CHIS’; and ‘effective use of CHIS and/or outputs’; respectively. At user level, there were statistically significant correlations between ‘successful?’ and the variables representing each of the model factors, for some categories of users. However, the statistically significant correlation between ‘successful?’ and ‘man use’ was negative, and therefore counter-intuitive.

At hospital level, the data analysis also yielded a number of counter-intuitive results for SystemC hospital users (for ‘successful?’ and the variables ‘training’ and ‘rep not appr’) and for SystemB hospital users (for ‘successful?’ and the variables ‘incomplete’; ‘availability factor’; ‘man useful tool’; and ‘man use’). The pattern of the correlations between the variable ‘successful?’ and ‘incomplete?’; ‘availability factor’; ‘man useful tool’ and ‘man use’ was similar: strong or relatively strong correlations for all user hospitals, and for SystemC user hospitals; weak or near zero correlations for Province 1 hospitals, and for SystemA user hospitals in Province 1; and counter-intuitive results for SystemB user hospitals in Province 1. The results of the cross correlations between ‘successful?’ and ‘all patients’, and between ‘successful?’ and ‘man commit’, were so varied that no conclusions could be drawn. However, the cross correlations between ‘successful?’ and ‘man commit’ were generally positive, including several statistically significant correlations.

There were fewer counter-intuitive results of cross correlations at user level than at hospital level. There were fewer counter-intuitive results for SystemC users than at hospital level, but the pattern of counter-intuitive results for SystemB users continued. The large number of counter-intuitive results for SystemB could be due to the fact that positive rating values were reported for the variable ‘successful?’ by all respondents in this category (14 users at six hospitals). Excluding the counter-intuitive results for SystemB users, the results of the cross correlations between ‘successful?’, and the variables ‘training’, ‘incomplete?’, ‘rep not appr’ ‘man useful tool’ and ‘man commit’ supported the corresponding relationships in the extended conceptual model of CHIS use. The correlations between ‘successful’ and ‘man use’ were counter-intuitive or weak, in contrast to the strong correlations between these variables at hospital level. As for the hospital-level analyses, these results did not support a relationship between ‘successful?’ and ‘all patients’, representing the factor ‘resource availability and allocation’ in the extended conceptual model of CHIS use. Results for the variables related to the conceptual model factor ‘resource availability and allocation’are discussed further in Section 6.4.5(e).

The statistically significant cross correlation between ‘successful?’ and ‘man use’ for all hospitals, and for Province 2 hospitals using SystemC, could be interpreted as implying that ‘man use’ could be used as a proxy for ‘perception of CHIS success’ at this level of analysis (i.e. all hospitals, or hospitals using SystemC). However, this strong cross correlation is not reflected for other groupings of hospitals or users, and some correlations are negative, and therefore counter-intuitive.

The hypotheses that the factors of the conceptual model are associated with CHIS success are thus largely supported by these cross correlations. Related results from the analysis of responses to questions about the association between the conceptual model factors and CHIS success, which were discussed in the previous Section (Section 6.4.2(a)), indicated that most respondents supported the hypotheses which indicate associations between the factors of the extended conceptual model of CHIS use, and CHIS success.

6.4.3 Results – Province 1 and Province 2: variables associated with factors of the extended conceptual model of CHIS use

The identification of numeric measures to reflect the hospital level factors in the conceptual model of CHIS was described in Section 6.3.2.

Following the argument that the factors in the conceptual model are associated with CHIS success, the percentage of positive rating values for the variables representing these factors provides an indication of level of success. Therefore, the rating values were analysed, mainly at user level, for each of the variables used to reflect the hospital-level factors of the extended conceptual model of CHIS use. For the variable ‘all patients’, which reflects the resource allocation for ICD-10 coding from patient records, rating values were analysed at hospital level.

For the purposes of comparison, the ‘percentage of positive responses’ was calculated for each variable, for each category of users. The ‘positive responses’ reflect all responses which reflect a positive response in terms of CHIS use. Thus, for the variable ‘training’, the positive responses are reflected in rating values of ‘1’ or ‘2’. For the variable ‘incomplete’, the positive responses are reflected in rating values of ‘-1’ or ‘-2’, since negative values for this variable indicate that the respondents agreed (rating value = -1) or strongly agreed (rating value = -2) that the data in the CHIS **were** complete. The percentage of positive repsonses was calculated using the total number of responses to the question as the denominator (i.e., excluding the number of ‘no response’s (rating value = 9)).

A summary of the percentage positive rating values for the variables used to represent hospital-level factors in the extended conceptual model of CHIS use is presented in Table 6.12. The percentages of positive rating values for SystemA are higher than for SystemB or SystemC for all the measures of the conceptual model factors, other than ‘all patients’. The percentages of positive rating values for ‘incomplete?’ and “man useful tool’ for SystemB and SystemC are rather similar (46% and 47%; and 60% and 64%; respectively). The percentages of positive rating values for ‘all patients’ - a measure for the conceptual model factor ‘availability and allocation of resources’ - follow an opposite trend: SystemC positive rating values were much larger than those for SystemA and SystemB.

Conceptual model factor	Variable used to measure factor	Province 1	SystemA	SystemB	System C Province 2
Knowledge and understanding of CHIS	training		92%	85%	65%
	incomplete?		68%	46%	47%
Appropriateness of CHIS design	rep not appr		84%	69%	33%
Performance of CHIS	coded % availability		100%	68%	41%
Availability and allocation of resources (per hospital)	all patients	***33%***	***38%***	***20%***	***71%***
Perception of usefulness of CHIS	man useful tool	79%	89%	60%	64%
Management commitment to CHIS success	man commit	88%	93%	80%	42%
Effective use of CHIS and/or outputs	man use	64%	75%	43%	33%

Table 6.12 Summary of % positive responses for measures of conceptual model factors

Apart from the data for 'all patients', these data for percentage positive rating values show that the survey respondents regarded SystemA as being more successful than either SystemB or SystemC, and that the two Province 1 implementations (SystemA and SystemB) were viewed as being more successful than the SystemC implementations in Province 2.

This pattern is repeated in the user responses to question 29 in the user questionnaire: 'Overall, in terms of my job, the CHIS is a success', as shown in table Table 6.13. All but one of the respondents among the SystemA users, and all the SystemB users, who responded to this question agreed or strongly agreed that the CHIS was a success in their jobs, while only 37% of SystemC user respondents shared this opinion.

	CHIS ID			
Count of 'successful?'	**SystemA**	**SystemB**	**SystemC**	**TOTALS**
2	12	7		19
1	14	7	7	28
0	1		8	9
-1			2	2
-2			2	2
9	6	1	5	12
TOTALS	33	15	24	72
% positive	***96%***	***100%***	***37%***	
% most positive	***44%***	***50%***	***0%***	

Table 6.13 Rating values for the variable 'successful?'

These results are discussed further in Sections 6.4.5(d) and 6.4.5(e).

A more detailed presentation and discussion of the results for measurement of variables associated with factors of the extended conceptual model of CHIS use is included in Annexure O.

The available survey data related to the conceptual model factor ‘Perception of usefulness of CHIS’ include values for a range of numeric and non-numeric variables. These results are discussed in more detail in Section 6.4.5(e).

The data for the variable ‘all patients‘, which has been used in the statistical analyses as a measure of the conceptual model factor ‘Availability and allocation of resources’, reflect a different pattern than for the other variables in this analysis. The other survey data related to this conceptual model factor also reflect the seemingly anomalous situation which was identified during the survey: that access to resources does not necessarily translate into successful implementation, as discussed further in Section 6.4.5(e).

6.4.4 Statistical analysis of survey results: relationships in the conceptual model

Eight relationships between factors in the extended conceptual model of CHIS use were analysed, reflecting the relationships between factors in the extended conceptual model of CHIS use, as described in Figure 6.2 in Section 6.2.5. The results of the cross correlations between measures reflecting the conceptual model factors are described in Table 6.14, parts 1 and 2, and discussed in the rest of this section. In some cases, more than one variable was used as a measure for the conceptual model factor, as indicated in the table. Correlation coefficients which are significant at the 0.01 level are marked '**', and results which are significant at the 0.05 level are marked '*'. The limited number of statistically significant cross correlations could in part be explained by the small number of cases in some groups (especially for SystemB and SystemC users and hospitals).

A summary description of the results of the statistical analyses, including cross correlations and cross tabulations between measures reflecting the factors in the conceptual model is given in Table 6.15.

Pearson correlation coefficient Data category	'training' & 'man useful tool' (relation-ship (a))	'incom-plete' & 'man useful tool' (relation-ship (a))	'know-ledge' & 'man useful tool' (relation-ship (a))	'rep not appr' & 'man useful tool' (relation-ship (b))	'availa-bility factor' & 'man useful tool' (relation-ship (c))	'all patients' and 'man useful tool' (relation-ship (d))
hospital data: Provinces 1 and 2	.064	-.398*	---	-.106)	.332	.116
hospital data: Province 1	-.013	-.365	.117	-.182	.263	.359
hospital data: Province 1, SystemA	-.201	-.385	.245	-.106	.018	.213
hospital data: Province 1, SystemB	-.408	-.522	-.167	.000	.000	.612
hospital data: Province 2 (all users of SystemC).	-.127	-.488	---	.482	.000	-.200
user data: Provinces 1 and 2	*.091*	*-.193*			*.236*	
user data: Province 1	*.070*	*-.316*			*.222*	
user data: Province 1, SystemA	*.056*	*-.643***			*-.196*	
user data: Province 1, SystemB	*-.183*	*.129*			*.020*	
user data: Province 2 (all users of SystemC)	*.010*	*.396*			*-.129*	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 6.14 Results of cross correlations between measures of factors of the extended conceptual model of CHIS use (part 1)

Pearson correlation coefficient Data category	'man use' & 'man useful tool' (relation-ship (e))	'man commit' & 'man useful tool' (relation-ship (f))	'man commit' & 'all patients' (relation-ship (g))	'man commit' & 'man use' (relation-ship (h))
hospital data: Provinces 1 & 2	.538**	.300	.168	.227
hospital data: Province 1	.461*	.619**	.062	.548*
hospital data: SystemA	.000	.419	-.239	.285
hospital data: SystemB	.928**	.707	.408	.525
hospital data: Province 2 (all users of SystemC).	.483	-.267	.316	-.075
user data: Provinces 1 and 2	*.450***		*-.200*	
user data: Province 1	*.629***		*-.049*	
user data: SystemA	*.283*		*-.258*	
user data: SystemB	*.708***		*.535*	
user data: Province 2 (all users of SystemC)	*.121*		*-.111*	

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 6.14 Results of cross correlations between measures of factors of the extended conceptual model of CHIS use (part 2)

(i) Relationships between 'input' factors and 'perception of usefulness of CHIS' (relationships (a), (b), and (c)

There were some statistically significant correlations between the variables 'man useful tool' (reflecting respondents' perceptions of management's view of the CHIS as a useful tool) and 'incomplete?' (reflecting respondents' assessment of the quality of data in the CHIS). The negative correlation reflects the respondents' opinions that **complete** data are associated with a positive perception of usefulness of the CHIS.

The relationships between the characteristics of users and the CHIS and perception of usefulness of the CHIS (relationships (a) to (c)) were generally not strongly supported by the results of the cross correlations. However, the data from cross tabulations between the rating values of these variables did support these relationships.

These data are discussed further, in combination with non-numeric data from the survey, in Section 6.4.5(e).

(ii) Relationships involving 'resource availability and allocation' (relationships (d) and (g))

Overall, positive, but not statistically significant, cross correlations were shown between 'all patients' (reflecting resource availability for ICD-10 coding) and 'man commit' (relationship (g)). Only a weak cross correlation between 'all patients' and 'perception of usefulness of CHIS' (relationship (d)) was demonstrated.

Further analysis in combination with non-numeric data for this key relationship in the conceptual model is discussed in Section 6.4.5(e).

(iii) Relationships involving 'management commitment to CHIS success', 'effective use of CHIS and/or outputs' and 'perception of usefulness of CHIS' (relationships (e), (f) and (h))

Strong, but not necessarily statistically significant, relationships were demonstrated for the measures for these three relationships for most groups of respondents. Where cross correlations were counterintuitive, cross tabulations did reflect positive relationships between these variables, as expected in terms of the conceptual model.

The measures used for these conceptual model factors at hospital level all related to the respondents' perceptions of hospital management attitudes to and use of the CHIS at a hospital. The cross correlations between these variables were generally stronger than those for other conceptual model relationships, reflecting support for the relationships in the model. In a future study, more detailed comparisons between the answers to these questions by different groups of respondents could provide interesting insights into differences in perception of the CHIS between groups of hospital personnel.

The results of these statistical analyses are discussed in more detail in Annexure P.
As appropriate, these results are discussed in combination with other related data from the survey in Section 6.4.5(e).

	Relationships between factors in the extended conceptual model of CHIS use	Relationships between related variable(s) analysed statistically	Summary of results of statistical analyses
(a)	**Knowledge and understanding of CHIS** & **Perception of usefulness of CHIS**	incomplete? & man useful tool	- Some statistically significant corrrelations
		training & man useful tool	- Weak, sometimes negative correlations; crosstabs more consistent with model
		CHIS knowledge & man useful tool	- Weak, sometimes negative correlations; crosstabs more consistent with model
(b)	**Appropriateness of CHIS design** **& Perception of usefulness of CHIS**	rep not appr & man useful tool	- Not supported by statistical analysis - ??require a different variable for ‘appropriateness’ - But note user comments re. CHIS (+ve and –ve)
(c)	**Performance of CHIS** **& Perception of usefulness of CHIS**	availability factor & man useful tool	- Strong relationship not reflected in statistical analyses - But note user comments re. CHIS (-ve) - Stronger correlation with ‘success’ in some groups
(d)	**Resource availability and allocation** **& Perception of usefulness of CHIS**	all patients (factor for ICD-10 coding) & man useful tool	- Non-significant/weak relationship reflected; - Require combination with other data
(e)	**Perception of usefulness of CHIS** **& Effective use of CHIS and/or outputs**	man useful tool & man use	- Relatively strong correlation; - Values are based on respondents’ perceptions
(f)	**Management commitment to CHIS success** **& Perception of usefulness of CHIS**	man commit & man useful tool	- Relatively strong correlation, except for SystemA - Crosstabs for SystemA ‘positive’
(g)	**Management commitment to CHIS success** **& Resource availability and allocation**	man commit & all patients (factor for ICD-10 coding)	- Positive but not strong relationships, except for SystemA (negative) - Positive for SystemA in crosstabs
		man commit & availability factor	- Relatively strong correlations, including statistically significant correlation for Province 1 hospitals, and some groups at user level
(h)	**Effective use of CHIS and/or outputs** **& Management commitment to CHIS success**	man use & man commit	- Positive; strong for Province 1 users - Close to zero for Province 2
		man use & CHIS meetings	- Inconclusive; results for Province 1 only

Table 6.15 Summary of results of statistical analyses: variables related to conceptual model factors

6.4.5 Survey – discussion of results

(a) Overview

The aim of this survey was to test and refine the extended conceptual model of CHIS use developed following the case study phase of the study. A further aim was to determine the relative significance of the factors identified as being associated with CHIS success.

Data from the survey of level 1 and level 2 hospitals in the study provinces were analysed separately, to enable comparisons to be made between the two provinces. Within Province 1, data from hospitals using SystemA and SystemB were also analysed separately, to enable comparison between the implementation experiences with the two CHISs. Thus, the data analysis spanned three CHISs in use, and two provinces.

The data from the survey were analysed from two perspectives:

- testing of hypotheses related to the relationships between the factors in the extended conceptual model of CHIS use, and CHIS success (as discussed in Section 6.4.2); and
- testing of hypotheses related to the relationships among factors in the extended conceptual model of CHIS success, as discussed in Sections 6.4.3 and 6.4.4.

The presentation and analysis of results in the previous Sections focussed largely on the results of analysis of the numeric data from the survey. In this Section, the available numeric and non-numeric data from the survey are discussed under the following headings:

- measures for factors in the extended conceptual model of CHIS use (sub-section (b));
- factors of the extended conceptual model of CHIS use as factors associated with CHIS success (sub-section (c));
- comparisons of CHIS success between provinces and CHISs in use, in relation to factors of the extended conceptual model of CHIS use (sub-section (d));
- relationships among factors of the extended conceptual model of CHIS use (sub-section (e));
- provincial level factors in the extended conceptual model of CHIS use (sub-section (f)).

Following the same process as in previous phases of this project, the results of the survey, as discussed in this Section, form the basis of the final review of the conceptual model of CHIS use in Section 6.5).

(b) Measures for factors in the extended conceptual model of CHIS use

Since it was not possible to measure them directly in the survey, measures in the survey questionnaires had to be defined for factors in the extended conceptual model of CHIS use, as described in Section 6.3.2. The measures chosen consisted of a combination of numeric variables (as shown in table 6.7 in Section 6.3.2(b)), and uncoded responses, some of which were coded in terms of factors of the extended conceptual model to facilitate analysis.

Selected numeric variables related to factors of the extended conceptual model were used in the statistical analyses of relationships among model factors; and between model factors and measures of CHIS success, as described in Sections 6.4.2; 6.4.3; and 6.4.4. Thus, the numeric variables were used as proxies for factors in the extended conceptual model in the statistical analyses. The extent to which these variables accurately reflected the model factors was difficult to assess definitively. If large-scale surveys related to CHIS implementation and use were to be conducted, in South Africa or elsewhere, in future, extensive validation of measures, following the example of other studies, such as that of Paré and Sicotte (2001), would help to ensure reliability of results,.

An important set of measures was provided by the responses to questions in the user questionnaire designed to obtain the opinions of the respondents about the association between factors of the extended conceptual model and CHIS success or lack of success; the success of the CHIS which they were using in terms of their jobs; and their perceptions of the opinions of their hospital management about the CHIS in use in their respective hospitals. The responses to these questions provided valuable insights into user opinions, especially about the validity of the factors in the extended conceptual model of CHIS use, as described in Sections 6.4.2 and 6.4.3.

(c) Factors in the extended conceptual model of CHIS use as factors associated with CHIS success

Evidence from the survey data provided overall support for an association between the hospital-level factors in the extended conceptual model of CHIS use, and CHIS success (as described in Section 6.4.2). This made it possible to conclude that the hospital-level factors in the extended conceptual model of CHIS use, developed mainly on the basis of the insights gained from the case studies (conducted in level 2 hospitals in Province 1, using SystemA), were also applicable in the survey hospitals: level 1 and level 2 hospitals in Province 1 and Province 2, using three different CHISs between them (SystemA and SystemB in Province 1; and SystemC in Province 2).

An attempt was made in the data analysis to weight the factors which could contribute to CHIS success or lack of success, in order to identify the most significant factors which affect CHIS success, as described in Section 6.4.2(a). This was intended as a precursor to identifying key factors which could predict CHIS success or failure. Although it was not possible to define relative weightings for the factors of the conceptual model, and a further study would be required for this to be done, analysis of other survey data does provide some pointers to weighting of factors.

Not surprisingly, if the CHIS was not perceived to be available when required, and performing according to specification, respondents expressed concerns. A review of the comments made by respondents about the CHISs in their environments, and the comments related to perception of usefulness of the CHISs, indicates that poor performance was a major problem in some environments, as described previously, with power supply problems being mentioned at several hospitals in Province 1 and Province 2, and lack of patient identification label printing capabilities being highlighted at hospitals C6 and C21, for example. Discussions with survey respondents also referred to problems related to system design, for example the problems experienced at hospital C21 because the billing module had not adequately been tailored to meet local needs (**see Annexure L**). Therefore, it can be argued that the available data provide some support for the argument that 'performance of CHIS' and 'appropriateness of CHIS design' are key factors related to the potential for CHIS success.

(d) Comparisons of success of CHISs in use in terms of factors of the extended conceptual model of CHIS use

(i) Comparisons between CHISs in use in the study hospitals

Following the argument in previous Sections that the hospital-level factors in the conceptual model of CHIS use **are** associated with CHIS success, the data from the survey related to each of the conceptual model factors were compared for the three CHISs in use in the study hospitals. While comparison between the three CHIS implementations can be justified in terms of the available data, it would not be appropriate to make a judgement about the absolute level of success of these implementations on the basis of the available data: respondents' opinions were obtained, rather than absolute measures of aspects such as response times or system availability. The sample sizes were also rather small; with the largest sample available for SystemA hospitals (see Section 6.2.6 for a discussion of data collection for the survey). Data from 15 of the 19 hospitals using SystemA (79%) were included in the survey. The sample size for SystemB implementations was of necessity small, since there had only been a small number of implementations at the time of the study – six of the seven potential cases were included in the survey. The sample size for SystemC implementations reflected 40% of the potential sample size: statistical data for nine hospitals could be analysed (representing 27% of the target of 33 hospitals), and data from interviews were available for a further four hospitals.

On the basis of the analysis of the data from respondents used to reflect each of the conceptual model factors at hospital level, as discussed in Section 6.4.3 and summarised in Table 6.12, the SystemA implementation was the most successful of the three CHIS implementations represented in this study, and the SystemB implementation was generally more successful that the SystemC implementation. Results for measures related to the conceptual model factor 'Availability and allocation of resources', which show an opposite trend, are discussed separately in Section 6.4.5(e).

Comparisons between sets of hospitals were made in terms of the CHISs in use and, by implication, between the two provinces, because different CHISs were in use in the two study provinces. Consideration of the two provinces separately could also be justified by the fact that the province is the unit of decision-making in terms of selection of CHISs for use in level 1 and level 2 hospitals, and also the level at which decisions are made about the CHIS implementation approach to be used, and the allocation of resources to support the CHIS implementation. This includes resource allocation for network infrastructure across provinces, the provision of call centre facilities in both study provinces, and decisions about staffing for CHIS support on hospital organograms; as discussed previously. Overall, the Province 1 implementations were more successful than the Province 2 implementations, in terms of the available data.

The SystemA implementations at most of the study hospitals (case study and survey hospitals) were very well established, and there seemed to be a general perception among respondents that the SystemA CHIS had been tailored over the years to meet the requirements of the hospitals. Despite infrastructure limitations, users were generally satisfied with the performance of the CHIS in their environments. The results from the survey confirmed the impression gained during the case studies, of a CHIS with limited scope, which performed according to expectations. Additional functions required of a CHIS were not investigated in the survey.

The SystemB and SystemC implementations were relatively recent, as described in Section 6.2.4. They were of similar scope at the time of the study, and both made provision for links between the hospitals and central provincial Master Patient Indexes. One significant difference between the two CHIS implementations was that, in Province 1, the rollout of SystemB was being conducted one hospital at a time, with extensive preparation at both hospital and provincial level, as described by the provincial informants (see Section 6.2.3). In Province 2, SystemC had been rolled out to all hospitals in the Province within a few weeks, according to provincial informants. This rollout pattern was confirmed by hospital respondents, who indicated that SystemC had been implemented between May and June 2007. Experiences in other environments (for example, as discussed by Littlejohns *et al.*, 2003; Southon *et al., 1999;* and Heeks *et al.*, 1999) have shown that the simultaneous or near-simultaneous implementation of complex information systems, such as CHISs, places great strain on resources, and limits the potential for success. The fact that only seven (7) of the 19 SystemC respondents indicated that they agreed with the statement that the CHIS was a success in terms of their work, in contrast with all the SystemB respondents (n = 14) agreeing or strongly agreeing with this statement, highlights the differences in the implementation experiences between the two CHISs, as described in Section 6.4.3.

Despite the necessary cautions expressed about these results, they do reflect a trend of differences between the three CHIS implementations in the two study provinces. There are multiple potential explanations for these differences, some of which have been discussed. Further work will be required to examine possible causes of the differences in experience across the CHISs and between provinces in more detail. Proposals for practical and research responses to these results are made in Chapter 7.

(ii) Comparisons between other groups of respondents

Comparisons between groups of respondents, for example information officers and information managers; hospital senior managers; or CHIS billing module users; were considered. However, this level of analysis was not pursued since the sample sizes were small; and the hospital was the main unit of analysis in this survey. In future studies, it could be useful to consider the perspectives of different groups of users and other hospital personnel, since they could differ in significant respects, as also indicated in the data from 12 respondents at hospital C27 in this study (as described in **Annexure L**).

(e) Relationships among factors in the extended conceptual model of CHIS use

Results of analyses of data related to factors in the extended conceptual model of CHIS use, and relationships between factors in the conceptual model, have been presented in Sections 6.4.2 and 6.4.3. Further discussion related to two aspects of these sets of results is presented in this Section:

- Relationships between 'perception of usefulness of the CHIS' and other factors of the conceptual model; and
- Data related to 'resource availability and allocation'.

(i) Perception of usefulness of CHIS

This factor of the extended conceptual model of CHIS use is linked to all other hospital-level factors in the model, reflecting the strong influence of perceptions on users' attitudes to CHISs. As discussed previously, the variable 'man useful tool' was used as a measure of 'perception of usefulness of CHIS' in the statistical analyses, and there were few statistically significant cross correlations between 'man useful tool' and measures of other factors in the conceptual model. The only statistically significant cross correlations were those between 'man useful tool', and 'incomplete?', which was used as a measure of the quality of the data in the CHIS.

In addition to this numeric measure, respondents were asked a series of questions about the CHIS which they were using. The uncoded responses to these questions were coded in terms of factors of the conceptual model, yielding a set of approximately 300 coded comments from all the users who responded to these questions. In addition, users were asked to add general comments on the CHIS in use at the end of the survey questionnaire. These comments were also coded, and linked to factors of the conceptual model as far as possible.

The coded comments linked to positive perceptions of usefulness of the CHIS related mainly to the model factors 'appropriateness of CHIS design' (approximately 50% of coded comments); 'knowledge and understanding of the CHIS'; 'CHIS performance'; and CHIS outputs (a sub-factor of 'effective use of CHIS and/or outputs'). Approximately 70% of the more than 200 coded comments (excluding 'CHIS outputs') related to factors directly linked to the implementation of the CHIS, and confirmed relationships between these factors and 'perception of usefulness'. For the coded comments linked to negative perceptions of usefulness of the CHIS (fewer than 100 coded comments), the majority of comments were related to 'CHIS performance' and 'appropriateness of CHIS design', thus supporting a relationship between poor CHIS performance and/or design, and a perception that the CHIS is not useful.

Very few coded comments (fewer than 10 in total) related to the factor 'resource availability and allocation'. Data related to this factor in the extended conceptual model are discussed in the next sub-Section.

Combining all available data related to 'perception of usefulness of CHIS', it can be claimed that the relationships between 'perception of usefulness of CHIS', on the one hand, and factors related to the CHIS implementation ('knowledge and understanding of the CHIS' by users; 'CHIS performance' and 'appropriateness of CHIS design'), on the other hand, **are** supported by the available data from the survey.

(ii) Resource availability and allocation

Statistical analyses for the relationship between 'all patients', the measure for statistical analyses related to 'resource availability and allocation', and 'man useful tool'; and between 'all patients' and 'man commit' resulted in weak or counter-intuitive cross correlations, although the cross tabulations between these measures were generally positive. The cross correlations between 'all patients' and 'successful?' were either near zero or counter-intuitive, and the comparison of the rating values for 'all patients' for the different CHISs indicated that the system which performed most poorly in terms of most other measures (SystemC) had 71% positive ratings, compared with an average of 33% positive ratings for the Province 1 CHISs (SystemA and SystemB). These statistical analyses therefore had to be combined with other data related to the conceptual model factor 'resource availability and allocation'.

An unexpected finding from the cross correlations between measures for the factors in the conceptual model was that there were statistically significant correlations for four different groups of respondents between 'man commit' and 'availability factor', suggesting a strong relationship between the model factors 'management commitment to CHIS success' and 'CHIS performance' – a relationship which is not reflected in the extended conceptual model of CHIS use. However, if the variable 'availability factor' were considered also as a measure of 'resource availability and allocation', these results would support an existing relationship in the conceptual model - relationship (g). This argument is made because the performance of the CHIS in terms of system availability is strongly linked to availability of resources, such as electricity or after hours system support.

An important component of the conceptual model factor ‘resource availability and allocation’ is the availability of the required human resources to support the CHIS implementation at hospital level. The personnel arrangements for information management at hospital level in the two study provinces were rather different: The organogram for posts related to the CHIS at Province 1 hospitals makes provision for Information Officers at each hospital, and a case management function (full- or part time), which includes responsibility for ICD-10 coding for fee-paying patients. In a few hospitals, there was an expectation that clinical staff would code patient diagnoses (at hospital S7, for example) – the activity reflected in the measure ‘all patients’. For Province 2 hospitals, the organogram includes an information management function at management level, as well as software and hardware support staff. Respondents reported that clinical and/or senior ward administrative staff were responsible for ICD-10 coding. There were no case managers on the staff of any of the study hospitals in Province 2.

At hospitals in both provinces, there were references to a ‘system administrator’ or a ‘system controller’, with overall responsibility for aspects of the CHIS implementation in the hospital. In some cases, the system administrator was not the hospital Information Officer (as might have been expected) but a superuser from the hospital administration or admissions section. These people therefore had a pivotal role in ensuring CHIS success in their environment. At one of the Province 2 hospitals (C2, interview I2)), it was reported that the system administrator (a seconded position at that hospital) did not report to the Information Manager, which caused difficulties of control and co-ordination. In general, the impression was gained that there was provision for more information management staff at Province 2 hospitals than in Province 1 hospitals. However, several respondents from Province 2 also expressed concern about a lack of ward clerks, who were responsible for CHIS data collection at ward level, including the registration of details of patient discharges.

Although there were major differences in the organograms in the two provinces, the arrangements for system support appeared to be similar: during office hours, queries were referred to the information officer, a superuser in the section (for example, admissions or fees) or to external personnel responsible for application software or hardware support. After hours, calls were logged at call centres in both provinces, although in some cases, application software support staff were contacted directly.

There were several questions in the user and hospital questionnaires related to availability of human and other resources to support the CHIS implementation at hospital level. However, it was difficult to gain an overall impression of the relationship between human resource requirements and availability at hospital level because there were no specific questions about human resource requirements.
A specific study examining human resource aspects of CHIS implementations will be required to obtain a better understanding of the situation in level 1 and level 2 hospitals.

It is worth noting that, as was found at the case study hospitals, limited CHIS support available at hospital level and from external personnel (department of health staff at provincial or local level, or staff of the CHIS supplier) was not highlighted by most users as a major problem.

Further details related to the collection and analysis of data related to relationships among factors of the conceptual model are included in **Annexure O and Annexure P**.

(f) Provincial-level factors in the extended conceptual model of CHIS use

Provincial-level factors were included in the extended conceptual model of CHIS use on the basis of information obtained from provincial-level informants, supported by insights from the literature, as described in Chapter 5, Section 5.5.2. These factors were considered important in order to take account of the context in which the study hospitals functioned, in relation to the selection, acquisition and implementation of CHISs in level 1 and level 2 hospitals in the study provinces.

The survey of hospitals was designed mainly to obtain data related to the conceptual model factors at hospital level. Since hospital-level staff were unlikely to have been involved in CHIS selection or resource allocation at provincial level, as described previously in Section 1.3.2, it was not expected that hospital respondents would be in a position to provide data related to the conceptual model factors at provincial level, i.e., 'CHIS supplier knowledge and understanding of environment'; 'CHIS software fit with user requirements'; 'Resource availability' (at provincial level); and 'organisational and contractual mechanisms'. Thus, although provincial-level factors associated with CHIS success in level 1 and level 2 hospitals in South Africa had been identified, they were not specifically investigated further in the survey phase of the project.

As indicated in the discussion of the survey results (in previous sub-sections of the current Section (6.4.5)), there were some references to provincial-level factors, which highlighted the association between the experiences at hospital level, and the organisational relationships within the provincial hospital services, in the study hospitals. For example, the discussions with the respondents at hospital C21 highlighted the negative effect of decisions made at provincial level about accepting the version of the CHIS in use at the hospital on the ability of the hospital CHIS users to work effectively.

The provincial level factors are discussed further in relation to the revision of the conceptual model of CHIS use, in Section 6.5.2.

(g) Recommendations arising from the survey results

The survey was not primarily aimed at deriving practical recommendations for provinces and hospitals. However, the inputs received, and the analysis of the inputs, did yield information which could be of potential use in practice.

The following recommendations are made on the basis of the results obtained from the survey:

- The factors associated with CHIS success identified in this study should be taken into account in making decisions about the selection and development of CHISs for use in level 1 and level 2 hospitals in South Africa;
- The results of the comparisons between the CHISs in terms of the conceptual model of CHIS use indicate large differences in the experiences of CHIS users, and could indicate areas for improvement. These results will be provided directly to the study provinces.
- The responsible managers need to ensure that the CHIS performs according to specifications in all hospitals. Poor CHIS performance was a serious cause of frustration and concern among respondents. System availability of at least 99% is required for effective operation in environments which provide continuous service. Lack of system support outside office hours was widely identified as a problem.
- The responsible managers need to ensure that CHIS suppliers update systems so that they meet the agreed specifications in all hospitals, especially in terms of adaptation to local requirements.

- Ongoing training and education of hospital and provincial staff is essential, to enable them to use the available CHIS functionality as effectively as possible.

6.5 CONCEPTUAL MODEL REVISITED

The survey of level 1 and level 2 hospitals described in the previous Sections focussed on the hospital-level component of the conceptual model of CHIS use developed in this study. Therefore, the hospital-level components of the conceptual model are considered first in reviewing the conceptual model, and provincial-level factors of the conceptual model are considered separately, in Section 6.5.2.

6.5.1 Hospital level factors and relationships of the extended conceptual model of CHIS use

(a) Overview of survey results

As discussed in Section 6.4.2, the results of the survey supported the inclusion of the hospital-level factors in the conceptual model of CHIS use, as factors associated with CHIS success. The results of cross correlations and cross tabulations between the variable ‘perception of CHIS success’, and the quantitative measures of the factors of the extended conceptual model, generally supported this conclusion, except for the measures for the conceptual model factors ‘resource availability and allocation’ and ‘management commitment to CHIS success’ (as described in Table 6.11).

Considering the relationships between hospital-level factors in the extended conceptual model of CHIS use, as discussed in Section 6.4.5(e) and summarised in Table 6.15, the strength of the relationships in statistical terms, and in combination with qualitative data from the survey, was variable, but generally supported the relationships in the extended conceptual model. The results included some statistically significant cross correlations; some strong but not statistically significant correlations; and relationships which could be demonstrated taking into account a combination of quantitative and qualitative data.

(b) Resources to support CHIS implementation

The two conceptual model relationships related to ‘resource availability and allocation’, i.e., relationship (d) – the relationship between ‘all patients’ and ‘man useful tool’ in the quantitative analysis – and relationship (g) – the relationship between ‘all patients’ and ‘man commit’ in the quantitative analysis – could not be clearly supported, even when combined with qualitative data from the survey.

As discussed in Section 6.4.5(e), the extensive available data related to human resources reflected differences between the two study provinces, but the effect of the differences was hard to interpret. While the available evidence indicated that extensive human resources were allocated to CHIS support at hospital level in Province 2, and relatively few resources were allocated to CHIS support at hospital level in Province 1, this did not seem to contribute to improved CHIS performance in Province 2. Available infrastructure resources were similar for SystemB and SystemC, both of which required linking to provincial master patient indexes (MPI) via WAN, and enabled CHIS access in administrative and clinical areas of the user hospitals, as described in Sections 6.2.4 and 6.4.1. SystemA implementations were generally more modest than for SystemB and SystemC, with limited numbers of terminals available in administrative and management areas, and no link to a provincial MPI required.

Thus, while the inclusion of the factor 'resource availability and allocation' in the conceptual model of CHIS use could be confirmed on the basis of the data from the survey, it has not been possible to confirm the relationships between this factor and other factors of the extended conceptual model of CHIS use, from the available survey data. Further work focussed on the relationship between resource availability and allocation and CHIS success would be required to obtain more conclusive results, also taking into account aspects such as resource requirements for CHIS implementation; the fit between resource requirements and resource availability – before, during and after implementation; and the effect of additional CHIS resource allocation from within the pool of resources available to hospital management.

However, on the basis of the combined data from the case studies and from the survey, and the discussion and interpretation of these data, the relationships between the factor 'resource availability and allocation' and other hospital-level factors in the extended conceptual model of CHIS use should be retained in the revised conceptual model of CHIS use discussed in Section 6.5.4.

(c) Knowledge and understanding of CHIS: data quality and training

The sub-factors, 'quality of data in the CHIS' and 'training', were identified in relation to the conceptual model factor 'knowledge and understanding of CHIS'. These sub-factors represent two important aspects of CHIS knowledge and understanding, and were reflected in separate numeric measures in the survey. The numeric measure used for data quality was 'incomplete?' reflecting respondents' assessments of the completeness of the data in the CHIS at the hospitals in which they worked. Two numeric measures were used for 'training': the variable 'training' reflected users' opinions of the quality of CHIS user training in their hospitals; and the variable 'CHIS knowledge' (from the hospital questionnaire) reflected the hospital respondents' opinions about the general level of knowledge of the CHIS in their hospitals. The statistical analysis of the relationship (a) in the extended conceptual model of CHIS use reflected strong (including statistically significant) relationships between the variable 'incomplete?' and 'man useful tool'. There were only weak statistical relationships between the variables 'training' and 'man useful tool'; and between 'CHIS knowledge', and 'man useful tool' (see Table 6.11).

These results again gave rise to a consideration of the possibility of including 'data quality' as a separate factor in the conceptual model (see discussion in Section 5.4.2(a) about factors in the extended conceptual model of CHIS use). As was decided for the extended conceptual model, the current, broad factor 'knowledge and understanding of CHIS among hospital staff' was retained, rather than increasing the number of factors by splitting this factor into two. Both 'quality of data in the CHIS', which is a reflection of knowledge and understanding; and 'training', which should contribute to improved knowledge and understanding of the CHIS, are essential components of this factor.

6.5.2 Provincial level factors and relationships in the extended conceptual model of CHIS use

Three options for reviewing the extended conceptual model of CHIS use in relation to provincial-level factors were considered:

- the removal of the provincial-level factors from the conceptual model; or
- the retention of provincial-level factors in the conceptual model, in the same form as in the extended conceptual model of CHIS use; or
- the retention of provincial-level factors in the conceptual model in a different form than in the extended conceptual model of CHIS use.

The removal of provincial-level factors from the conceptual model was not considered, since evidence has been obtained during this project, from expert interviews, from provincial-level informants, and from the study hospitals (case studies and surveys), that provincial-level factors do affect CHIS use in the study hospitals.

The retention of provincial-level factors in the conceptual model in the same form as in the extended conceptual model of CHIS use developed in the previous phase of this project (as described in Chapter 5, Section 5.5.2) could not be conclusively justified on the basis of the survey results. In particular, there was no intention or provision in the survey phase of this study to examine the provincial-level factors themselves, or their relationships with other factors in the extended conceptual model of CHIS use.

The third option, of retaining provincial-level factors but in a different form, has been adopted: Due to the limited evidence gathered for the provincial-level factors in the extended conceptual model of CHIS use, the specific provincial-level factors are not included separately in the revised conceptual model of CHIS use presented as an output of this study. Rather, a general factor ‘provincial-level factors’ is used to replace the four separate provincial-level factors in the extended conceptual model of CHIS use. The inclusion of this factor makes it possible to identify that there are provincial-level factors which are associated with CHIS use in the study hospitals, but takes account of the fact that further work is required to determine the nature of the relationships between the provincial- and hospital-level factors in the conceptual model (and in relation to the implementation of CHISs in level 1 and level 2 hospitals). In order to reflect the provincial-level factors identified in the extended conceptual model of CHIS use, these factors are included as sub-factors of the general factor: ‘provincial-level factors’.

The revised conceptual model of CHIS use is discussed in Section 6.5.4.

In future, it would be useful to undertake a specific study of the approaches followed in the acquisition and implementation of CHISs, in order to understand how they affect the potential for success of the implementations. The provincial-level factors identified for the extended conceptual model of CHIS use could provide a useful input for such work. The potential for this further work is discussed in Chapter 7, Section 7.3.3.

6.5.3 Factors associated with CHIS success: comparisons with other studies

Several studies have identified factors associated with HIS success or failure, or risk factors for HIS implementations, have already been referred to in this study. Some of the results are discussed below, in relation to factors associated with CHIS success.

(a) Delphi studies

The Brender *et al.* Delphi study (Brender *et al.,* 2006) of factors associated with HIS success or failure yielded extensive lists of success factors and failure criteria, grouped into similar categories or dimensions. The international group of experts who participated in this study were also asked to rate the importance of these factors for different categories of HISs, including administrative systems, which are similar in scope to the CHISs in the current study.

Paré *et al.* (2008) conducted a Delphi study among 21 health informatics experts in Canada, in order to identify risk factors associated with clinical information systems (CIS) success. Based on the IS and the HI literature, these authors identified more than twenty risk factors for CIS success – which could be regarded as the converse of factors associated with CIS success. This study obtained the experts' opinions about which factors are risk factors for CIS success, and about their perception of the relative importance of these factors. Comparisons between these results and the factors of the conceptual model of CHIS use are made with care, since the current study does not refer to **clinical** information systems. (The Brender *et al.* Delphi study (Brender *et al.,* 2006) formed one of the key references for the study by Paré *et al.* (2008).)

Details of the factors identified in these studies are given in Annexure Q.

In broad terms, mapping between the dimensions from these two studies, and the factors of the conceptual model of CHIS use, is possible, although not complete, as shown in Table 6.16. Of interest is that the outputs from neither of the Delphi studies referred to HIS use as a factor associated with success, or failure/risk. This could be explained by the fact that the current study was aimed at obtaining user perspectives, rather than expert perspectives, and user opinions about how the CHIS was used in their environments provided a mechanism for obtaining this information. Neither of the Delphi studies seems to have identified quality of data in the HIS as a factor associated with success or failure. Again, this could be a reflection of the fact that these studies reflected expert, rather than user, perspectives. In terms of resources, there was no specific mention of resources to provide HIS support after implementation (although this could be implied in the factor 'lack of local personnel knowledgeable in IT' from the Paré *et al.* (2008) study). This could be a reflection of an emphasis on HIS development, rather than HIS use, in these Delphi studies.

Some of the factors identified in the Delphi studies could not be easily mapped to factors of the conceptual model of CHIS use, partly because there was no distinction between hospital-level factors, and factors which applied beyond hospitals. This could reflect an assumption that decision making about HIS acquisition and/or development takes place at hospital level, rather than at a higher organisational level, as in the current study.

Success or failure dimensions (Brender et al., 2006)	**Risk dimensions (Paré *et al.*, 2008)**	**Factors of the conceptual model of CHIS use**
Functional		Appropriateness of CHIS design CHIS software fit with user requirements
Organisational	Organisational/environmental	Management commitment to CHIS success Resource availability and allocation Knowledge and understanding of CHIS
Behavioural	Human/user	Management commitment to CHIS success
Cultural		
Management		Management commitment to CHIS success
Technical	Technological	Appropriateness of CHIS design (Performance)
Political	Strategic/political	Management commitment to CHIS success
Legal		
Strategy		
Economy		Resource availability and allocation
Education		Knowledge and understanding of CHIS
User acceptance	Human/user Usability	Perception of usefulness of CHIS
	Project team	CHIS supplier knowledge and understanding of environment
	Project	Resource availability (at provincial level) Management commitment to CHIS success
		Effective use of CHIS and/or outputs
		Organisational and contractual mechanisms

Table 6.16 Comparison between Dimensions of success, failure and risk, and factors of the extended conceptual model of CHIS use

(b) CPOE success and risk

CPOE success and risk are relevant for this study, because CPOE systems are typically implemented as components of CHISs at hospital level. CPOE risk factors could therefore overlap with factors associated with CHIS success or failure.

As part of a multi-method, multi-centre, multi-year study of CPOE implementations in the US, Ash *et al.* (2005) identified twelve principles for CPOE implementation. Although this study concentrated on CPOEs, which are clinical information systems, and therefore has a different scope to the current study, their results are partly based on work at community (as distinct from teaching) hospitals, making them potentially relevant to the current study. The second essential source of data for this study of principles for CPOE implementation was provided by the outputs from expert consensus conferences. The twelve principles, also grouped into dimensions, are listed in Table 6.17.

Dimensions	**Principles**
computer technology	temporal concerns
	technology and meeting information needs
	multidimensional integration
	costs
personal	value to users and tradeoffs
	essential people
	training and support
organisational principles	foundational underpinnings
	collaborative project management
	terms, concepts and connotations
	improvement through evaluation and learning
environmental issues	motivation for implementation
	context of implementation

Table 6.17 Twelve principles for CPOE implementation (adapted from Ash *et al.*, 2005)

Westbrook *et al.* (2007) developed an evaluation model for a study of a CPOE system implementation in an Australian hospital, including interconnected dimensions of

- Work and communication patterns;
- Organisational culture; and
- Safety and quality.

The model was used to inform the selection of appropriate methods for studying the impact of implementation of the system, in a planned multi-method multi-year study. This approach was of relevance for the current study because the CPOE being implemented was a commercial system rather than being locally developed, as for the CHISs implemented in the hospitals included in the current study. The dimensions identified for the Westbrook *et al.* study could also be regarded as dimensions for grouping factors associated with the success or failure of the CPOE in their study hospital.

Despite the necessary limitations in the comparisons between other studies and the current study, the comparisons do reflect broad agreement with the factors associated with CHIS success identified in the current study, and do not provide motivation for changing the factors identified in the current study.

More detailed comparison between the factors associated with CHIS success identified in the current study; and success factors, risk factors, gaps in different dimensions (as in the ITPOSMO model of Heeks *et al.* (1999)), for example, is beyond the scope of the current study. However, the factors and sub-factors identified in the current study could provide inputs to future studies of factors associated with HIS success or failure, and should be taken into account in future local studies related to CHIS success.

6.5.4 Revised conceptual model of CHIS use

The **revised conceptual model of CHIS use** presented in this Section reflects the results of the third and final phase of data collection and model development in this study. The conceptual model is shown in Figure 6.4.

Results of the survey related to hospital-level factors of the extended conceptual model of CHIS use were discussed in Section 6.5.1. The strength of evidence from the survey supported the retention of the current hospital-level factors of the conceptual model of CHIS use, as discussed. The evidence from the survey supported most of the relationships between factors in the extended conceptual model of CHIS success, although the strength of the combined quantitative and qualitative evidence was variable. However, the relationships among the factors were also not contradicted by the available quantitative evidence.

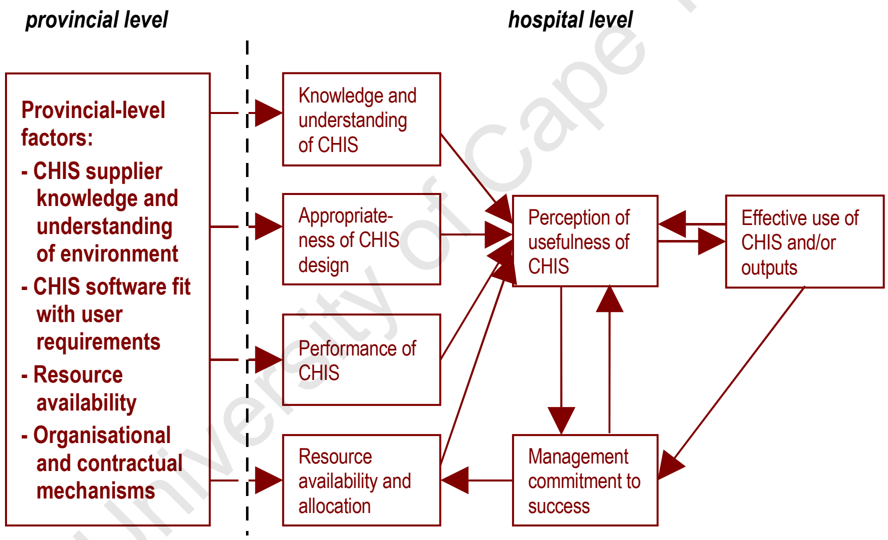

Figure 6.4 Revised conceptual model of CHIS use

Therefore, on the basis of the survey results, and taking account of the fact that the extended conceptual model of CHIS use had been developed on the basis of evidence from the case studies and expert interviews, the hospital-level component of the conceptual model of CHIS use has been retained in the revised conceptual model of CHIS use (see Figure 6.4). The decision not to change the hospital-level component of the conceptual model on the basis of the survey results implies justification for the assumption that the revised conceptual model **does** apply to the survey hospitals, even though it was not explicitly supported by the statistical evidence.

The provincial-level factors in the extended conceptual model of CHIS use were based on the results of the fourth case study, and inputs from experts. The survey of hospitals did not specifically address provincial-level factors. As discussed in Section 6.5.2, therefore, the provincial level in the conceptual model is represented in the revised conceptual model of CHIS use as a single factor 'provincial-level factors'; linked to the hospital-level factors 'knowledge and understanding of CHIS', 'appropriateness of CHIS design', 'performance of CHIS', and 'resource availability and allocation'; as shown in Figure 6.4. Links between the single provincial-level factor and the hospital-level factors are shown as dotted lines to indicate that there are relationships between the factors, but that the nature of the relationships is not well defined.

The initial comparison in Section 6.5.3 between the factors of the conceptual model of CHIS use, and those factors derived in some other studies which investigated success factors, failure criteria and risk factors associated with the implementation of health information systems, shows that there are some similarities across the groups of factors, but that more work would be required to investigate commonalities and differences between them. The factors of the revised conceptual model of CHIS use are different to those in the studies referenced, not only in terms of the methods used for deriving them; and their basis in a study of large-scale commercial CHIS implementations in a developing country; but also because they are included in a conceptual model, which reflects relationships between factors. The potential for further work on factors associated with CHIS success, based on multiple studies, is discussed in Chapter 7, Section 7.3.3.

The next section includes a review of the survey of hospitals, the results of the survey, and the output of the modelling component of this phase of the study: the revised conceptual model of CHIS use.

6.6 CONCLUSION

(a) Review of survey

The survey of CHIS use in level 1 and level 2 public sector hospitals in two South African provinces provided a unique opportunity to obtain information from CHIS users, and the managers of CHIS users, with the permission and support of the Provincial health authorities. Discussions and interviews with approximately one hundred people yielded quantitative and qualitative data on three CHISs in use in more than thirty hospitals across the two study provinces – resulting in an exploratory data set which proved to be highly challenging to analyse.

The results of the multi-faceted analyses which were carried out, as discussed in Section 6.4, made it possible to confirm factors associated with CHIS success in the study hospitals, and obtain support for most of the relationships between hospital-level factors in the conceptual model of CHIS use. The hospital-level factors in the model should be taken into account in future CHIS selection processes, since they have also been demonstrated to be associated with CHIS success in the study environments.

While the revised conceptual model of CHIS use constitutes a major output of the survey, an outstanding output is the reporting to the study provinces on the results obtained in hospitals for which they are responsible. The results, and the challenges experienced in analysing them, also provided important lessons which could be applied in future studies of CHIS acquisition, development, implementation and use, in South Africa and beyond, in order to ensure that the best use possible is made of the available resources for CHISs.

(b) Review of the conceptual model of CHIS use

The revised conceptual model of CHIS use, which includes factors associated with CHIS use at hospital and provincial levels, represents the culmination of the three phases of data collection and model building in this study. Westbrook *et al.* have described the process of model building as providing 'a strong theoretical basis from which to analyze and interpret findings' (Westbrook *et al.*, 2007, p746). The process of model building in this study has provided the opportunity to investigate and reflect on the complex interactions between CHISs and the hospitals in which they have been implemented, and identify aspects of these interactions which should assist in understanding (and improving the effectiveness of) future CHIS implementations. While there is always further work which can be done, the revised conceptual model of CHIS use could provide a framework on which future studies can build, in order to further extend the understanding of and decision making about CHISs, especially for use in LVR environments.

A review of all phases of this study, and an analysis of the potential for further work based on the results which have been obtained, are presented in Chapter 7.

CHAPTER 7 REVIEW AND SELF-EVALUATION

7.1 INTRODUCTION

This chapter returns to and reviews key aspects of this study to i) highlight the core findings and place them in the context of the key findings of this study, and ii) make proposals for extending the work initiated in this study of computerised hospital information system (CHIS) use in a developing country.

The pilot case studies described and discussed in Chapter 4 provided the basis for the development of the initial conceptual model of computerised hospital information system (CHIS) use. In the next phases of data collection for the project, an additional case study was conducted at a fourth hospital (H4) in Province 1 (see Chapter 5), and a survey of district and regional hospitals was carried out (as described in Chapter 6).

The initial conceptual model of CHIS use was developed to provide the lens through which the data from the case study were analysed (Chapter 5, Section 5.4), thereby providing the opportunity to test the initial conceptual model in a practical setting. The resulting extended conceptual model of CHIS (Chapter 5, Section 5.5) in turn provided the framework for the survey of level 1 and level 2 hospitals; the analysis of the data from the survey; and the revision of the conceptual model of CHIS use (Chapter 6).

7.2 REVIEW OF THESIS STUDY

7.2.1 Overview of chapters

The CHIS success study used a multi-method approach to make the best use possible of the unique opportunity provided by the study to examine the use of computerised hospital information systems in two South African provinces. Drawing on a wide range of relevant literature and three successive phases of data collection (the pilot case studies, a further case study, and a survey), a conceptual model of CHIS use has been developed and refined, as indicated in the diagram of the study process (Figure 7.1). The phases of the study are reflected in the chapters of the thesis.

(a) Background

Chapter 1 provided a background to and context for the study, describing health and health care in South Africa; the status of health information systems (HISs), especially in level 1 and level 2 public hospitals; and introducing the concept of environments of limited and vulnerable resources (LVR). The topic of the thesis was introduced by reviewing key references related to the evaluation of computerised hospital information systems (CHISs) and HISs in general, noting the lack of clear definitions for CHIS success, especially in level 1 and level 2 hospitals.

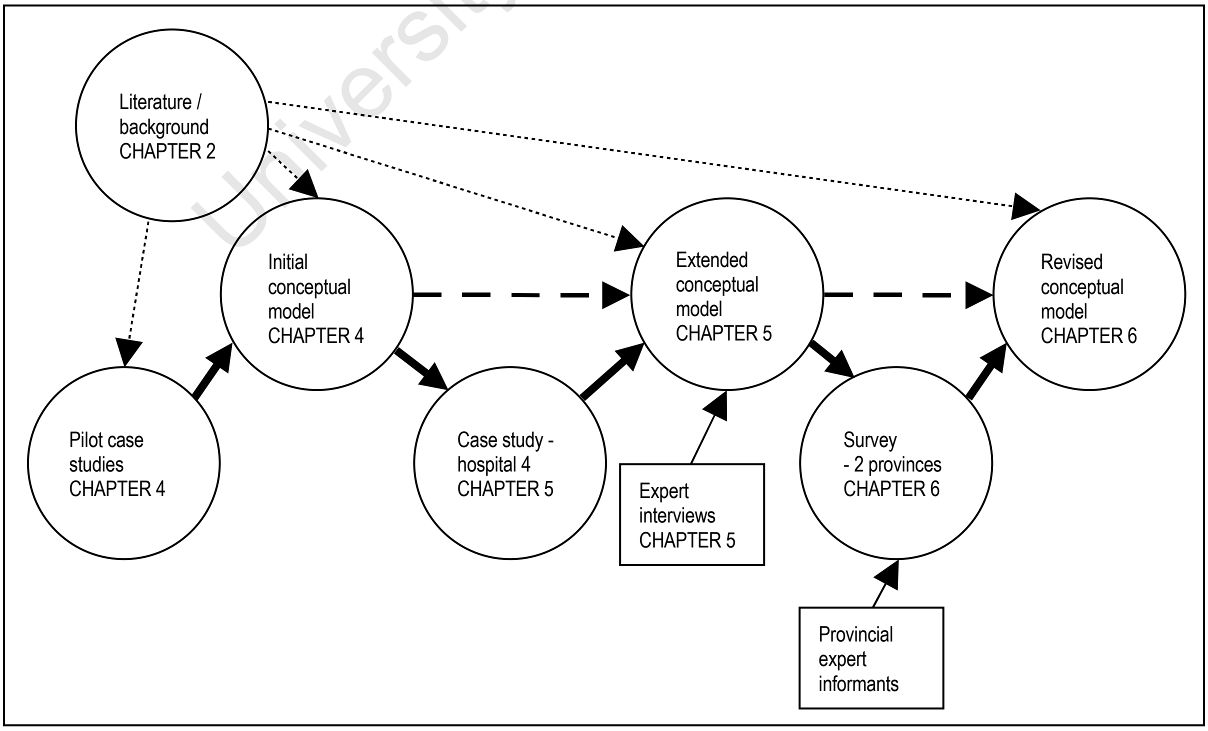

Figure 7.1 Diagram of the study process

(b) Literature review

Given the multiple strands of literature which had to be drawn on for this study, the literature review in Chapter 2 was wide-ranging, covering fields such as hospital information systems; the social and organisational issues related to the implementation of HISs; models and modelling of information systems; information system (IS) success; and evaluation of HISs.

(c) Research design, approach and theoretical underpinning

The research setting, consisting of multiple hospitals in two provinces, each hospital using one of three different CHISs, represented a highly complex environment. The study of CHIS implementation therefore required a multi method approach to take account of as many components of the study environment as possible. The combined qualitative and quantitative study design, and the motivation for the use of a combination of case studies, expert interviews and a survey of hospitals, were presented in Chapter 3.

(d) Pilot study and initial conceptual model

There were three cycles of data collection, followed by conceptual model development and/or review, in this study. The first cycle, consisting of three pilot case studies in Province 1, and the development of an initial conceptual model of CHIS use, was described and discussed in Chapter 4.

(e) Case study and model enhancement

The initial conceptual model of CHIS use provided the framework for the main case study for this project, conducted at hospital H4, which is also in Province 1. The case study was supplemented by interviews with CHIS experts, including two provincial CHIS managers, and a senior manager of a South African CHIS supplier company, as described in Chapter 5. The development of the extended conceptual model of CHIS use, based on the initial conceptual model, analysis of the data from the case study and the interviews, and further review of the literature, formed the rest of this chapter.

(f) Survey and review of model

The third cycle of data collection and model development was described in Chapter 6. This cycle of data collection consisted of a survey of level 1 and level 2 hospitals in the two provinces, described in the study as Province 1 and Province 2. While all four case study hospitals used the same CHIS, SystemA, the survey hospitals in Province 1 used either SystemA or SystemB, and all the study hospitals in Province 2 were using SystemC. The survey therefore covered a wider range of CHIS implementations than the case studies. As in the previous cycles of this study, the data from the survey, supplemented by insights from the literature, were used to review the conceptual model, resulting in the development of the revised conceptual model of CHIS use.

(g) Review and self-evaluation

The current, final, chapter of the thesis includes proposals for future work, based on the findings of the current study and identified gaps in the available information on related studies, as described in Section 7.3. The current study is reviewed in Section 7.2 in the context of proposals for related research, and final conclusions are presented in Section 7.4.

7.2.2 Review of study contribution

(a) Theory

(i) Factors associated with CHIS success or lack of success

The statistical analyses of user responses to questions about associations between hospital level factors of the conceptual model of CHIS use and CHIS success supported the hypotheses that these factors are associated with CHIS success (as described in Section 6.4.2). The converse hypotheses – that lack of the hospital level factors of the conceptual model of CHIS use are associated with lack of CHIS success – were also supported, although not as strongly as for the association between conceptual model factors and CHIS success. These results, supported by results from the rest of the study, contribute to the developing literature on factors associated with HIS success from the specific perspective of users of non-clinical systems implemented in level 1 and level 2 hospitals in a developing country, as discussed in Section 7.3.3.

(ii) Relationships among factors of the extended conceptual model of CHIS use

The statistical analyses of the relationships between pairs of factors in the extended conceptual model of CHIS success, described in Section 6.4.4 and summarised in Table 6.15, demonstrated support for some of the hypotheses about relationships between factors in the conceptual model, but yielded weak or inconclusive results for other hypotheses. Once statistical results had been combined with other data from the survey, the available evidence supported more of the hypotheses. For example, the cross correlation between measures of 'appropriateness of CHIS design' and 'perception of usefulness of CHIS' was inconclusive, but many of the comments from respondents about their perception of usefulness of the CHIS in use in their environments related to aspects of CHIS design, thus providing support for the hypothesis of a relationship between these factors. Similarly, the statistical analyses did not reflect a strong relationship between 'performance of CHIS' and 'perception of usefulness of CHIS', but comments from respondents about negative factors related to perception of usefulness included strong comments about problems with CHIS performance, supporting the hypothesis that poor CHIS performance is associated with poor perception of usefulness of the CHIS.

Overall, the statistical analyses of relationships among factors in the extended conceptual model of CHIS use did not yield clear, strong, support for the relationships in the conceptual model, reflecting a need for further work if statistical relationships between factors in the conceptual model are to be demonstrated. Since statistical confirmation of relationships in the conceptual model of CHIS use was not a primary aim of this study, this inconclusive result did not negate the usefulness and relevance of the study as a whole.

(iii) Models and modelling related to HIS success

The development of the conceptual model of CHIS use took place in three phases, starting with the initial conceptual model developed as an outcome of the pilot case study phase (Chapter 4, and Figure 7.2); progressing to the extended conceptual model developed on the basis of the case study and expert interviews, as described in Chapter 5 (and Figure 7.3); and culminating in the review of the conceptual model on the basis of the results of the survey phase resulting in the revised conceptual model of CHIS use (Chapter 6, and Figure 7.4).

The initial motivation for the development of the conceptual model was to clarify the results of the pilot case studies, especially in respect of the differing management responses to the requirements for the effective maintenance of the CHIS implementations at their hospitals. It was based on classic models of IS success, such as that of DeLone and McLean (2003), and tailored to take account of the local context, and factors which could be associated with CHIS success. In particular, the initial conceptual model reflected a relationship between the resources available for the maintenance and implementation of a CHIS and user or management perceptions of the usefulness of the CHIS, and between resource availability and hospital management commitment to CHIS success, as discussed in Chapter 4, Section 4.3.

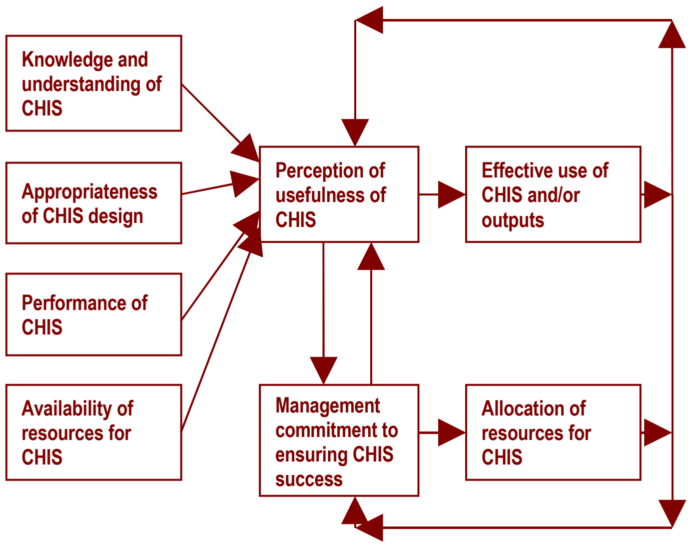

Figure 7.2 Initial conceptual model of CHIS use

The extended conceptual model of CHIS use developed in the second phase of the study, included factors associated with the provincial context, reflecting the fact that the major decision making about the acquisition of CHISs in the study environment took place at provincial level, rather than at hospital level (see Chapter 5, Section 5.5). The relationships between the factors 'perception of usefulness of CHIS', 'management commitment to CHIS success' and 'effective use of CHIS and/or outputs' and between 'management commitment to CHIS' and 'resource availability and allocation' were simplified and reflected as hypotheses to be explored in the survey phase of the study, as shown in Figure 7.3.

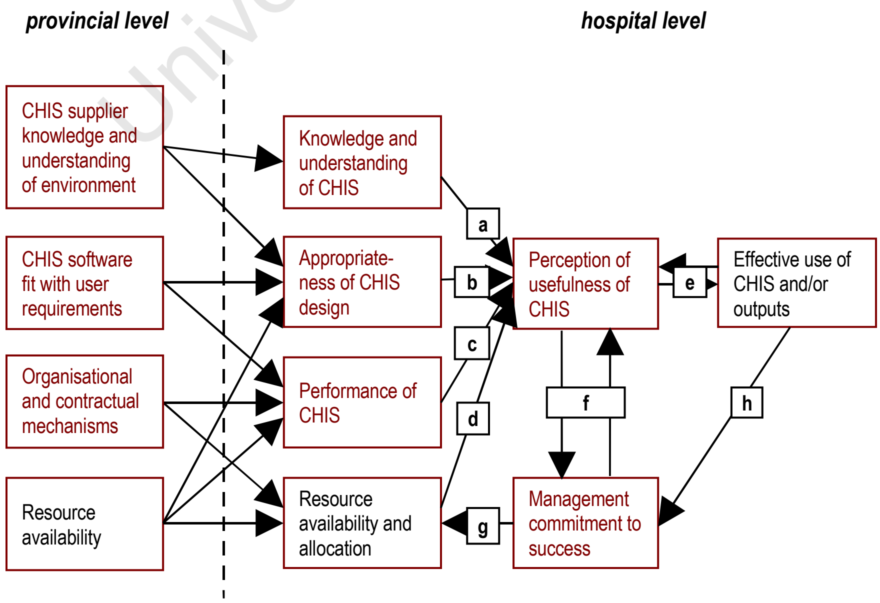

Figure 7.3 Extended conceptual model of CHIS use, identifying relationships (a) to (h) between model factors for analysis

In the final data collection and model review phase of the study, the revised conceptual model of CHIS use was developed, based on results from the survey. Since the provincial level factors had not specifically been addressed in this phase of the project, little data was available to support or refute the relationships postulated between provincial- and hospital-level factors, in the extended conceptual model of CHIS use. It was therefore decided to combine the provincial-level factors into a single factor, with simplified links between provincial- and hospital-level factors, as shown in Figure 7.4. The formulation of the revised conceptual model of CHIS use was described in Chapter 6, Section 6.5.

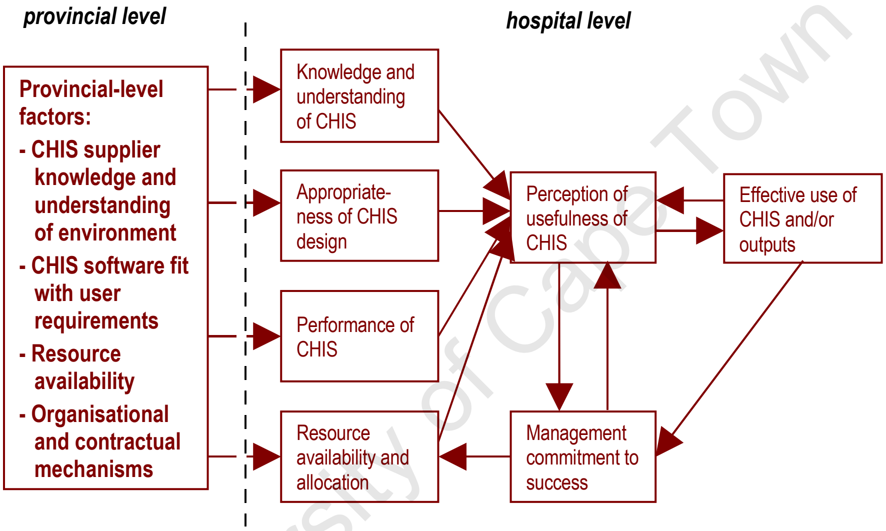

Figure 7.4 Revised conceptual model of CHIS use

The development of successive versions of a conceptual model of CHIS use is one of the key innovations of this study. The final version of the conceptual model, the revised conceptual model of CHIS use, represents the synthesis of data from the three stages of this project (as described in Chapters 4, 5 and 6) in a form which could facilitate comparison and consolidation with other existing and future work in this domain, thereby contributing to the body of knowledge about CHIS implementations in particular, and HIS implementations in general. Even more broadly, it contributes to the development of models of IS success, in the tradition of DeLone and McLean (2003) and others, as described in the background to this study, from the particular perspective of the health domain in a developing country, which is currently represented in this work only to a limited extent.

(b) ***Methodology***

(i) ***Multiple methods and approaches***

Starting in interpretivist mode, the case studies resulted in the first versions of a conceptual model of CHIS use, which reflected both factors associated with CHIS use and the relationships between them, as described in Chapters 4 and 5.

The mainly positivist component of the project – the survey of hospitals, described in Chapter 6 – was designed to obtain data to enable the testing and extension of the conceptual model of CHIS use developed in the previous phases of the study. Hypotheses about the associations between factors of the conceptual model and CHIS success, and among the factors of the extended conceptual model, were tested.

This approach is consistent with the multi-method approach followed by groups such as Ash *et al.* (2008) and Westbrook *et al.* (2007), in conducting long term comprehensive studies of HIS implementations, as being the most appropriate approach to investigating highly complex phenomena. The current study provides the basis for similar comprehensive, long term studies of CHIS and other HIS implementations in South Africa, which could provide valuable support to management decision making at multiple levels in the healthcare system.

(ii) ***Quantitative analyses***

Despite the wide scope of the survey, with data collected representing approximately 80% of the target hospitals in Province 1 and approximately 40% of the target hospitals in Province 2, the actual numbers of respondents were modest – 72 user responses from 30 hospitals, with varying amounts of data available from each respondent and for each hospital, especially in Province 2. This meant that statistical analyses of data were conducted and interpreted with caution. The survey, and supporting interviews with provincial informants, also yielded qualitative data, which were used to supplement some of the numeric data used in the statistical analyses.

The identification of appropriate numeric measures to represent the factors in the conceptual model of CHIS success, to enable statistical analysis, proved to be a significant challenge, due to the complexity of the concepts represented by the factors, as discussed in Chapter 6, Section 6.3.2. Numeric measures were identified and used for the statistical analyses, but future work on the development of unambiguous composite measures for factors of the conceptual model, suitable for application in large scale surveys, could greatly facilitate the ongoing evaluation of HIS implementations (see further discussion on HIS evaluation in Section 7.3.3).

Although the results of the statistical analyses (mainly in the form of cross tabulations of data on different variables and the calculation of cross correlation coefficients for data on appropriate pairs of variables, as described previously) were variable, they did support some of the hypotheses investigated in the survey, as will be discussed in subsequent sections.

Overall, despite the limitations experienced, the statistical analyses of the data from the survey of level 1 and level 2 hospitals represented a significant first attempt at quantitative analysis of the hypotheses associated with the conceptual model of CHIS use, and the relationships between factors of the conceptual model and CHIS success. As described before, the results of the statistical analyses were supplemented by insights derived from analysis of the qualitative data from the survey. This study thus combined qualitative and quantitative approaches in practice by testing the extended conceptual model of CHIS use, developed on the basis of qualitative studies, using quantitative approaches supported by qualitative data.

(c) Practice

(i) Scope and context

This study of CHIS implementations in level 1 and level 2 hospitals in South Africa provided the opportunity to investigate a cross sectional view of a widespread phenomenon in South Africa: the implementation of HISs designed to record and analyse the movements of patients through public sector hospitals. The study was unique in its scope and in its approach: an examination of the use of three different CHISs in level 1 and level 2 hospitals in two provinces, using multiple methods as a means of addressing the issues related to IS implementation in the highly complex environment of hospitals.

While not a focus of this study, the survey also provided coded and uncoded data on the status of CHIS implementations in the study hospitals which could in future usefully be combined with similar data on other CHIS implementations in South Africa, to provide an overview of this domain.

Given that the factors in the extended conceptual model of CHIS use had been shown to be associated with CHIS success, it was possible to compare the experiences of users of the three CHISs in this study in terms of the factors of the conceptual model. Thus, based on the data from the survey, it was possible to suggest that SystemA was the most successful of the three CHISs, and that SystemC was the least successful of the three, in terms of the hospital-level factors of the extended conceptual model of CHIS use. Further work will be required to investigate and understand these results in detail, but these data from the survey could provide useful indicators to the relevant hospital and provincial managers, and the CHIS suppliers, of issues to be addressed in order to improve the performance of the CHISs in the study hospitals. In fact, there was a strong expectation from some of the interviewees (at hospital C21, for example) that the results of the survey, if made available to management in the province, could be used to improve the performance of the CHIS in their environment (hospital C21, interviews I1 and I2).

(ii) Generalisation of results

One of the aims of the survey component of this study was to find out whether the extended conceptual model of CHIS use, developed on the basis of case studies in four level 2 hospitals, in the same province and using the same CHIS, could be more widely applied to level 1 and level 2 hospitals in more than one province in South Africa, using different CHISs. In reviewing this study as a whole, it is also necessary to consider the potential for generalisation of results, in the form of the revised conceptual model of CHIS use described in Section 6.5, beyond the study hospitals.

As argued in Section 6.5 --- the review of the conceptual model of CHIS use in the light of the survey results --- the hospital-level component of the revised conceptual model of CHIS use remained unchanged from the previous version of the model (the extended conceptual model of CHIS use). The province-level component was revised in the light of the available evidence. From the perspective of hospital-level factors of the conceptual model, the analysis of the relevant data from the survey demonstrated that there was agreement among respondents that the hospital-level factors of the conceptual model are associated with CHIS success. Furthermore, analysis of the survey data related to the factors of the conceptual model made it possible to demonstrate relative success between the three CHISs used by hospitals included in the survey (Section 6.4.3). These components of the analysis of the survey therefore provided strong evidence that the hospital-level factors of the conceptual model apply to all the study hospitals and, by extension, to other level 1 and level 2 hospitals in Province 1 and Province 2.

Based on these results, there is an argument to be made that the hospital-level factors associated with CHIS success in this study also apply to other CHIS implementations in level 1 and level 2 hospitals in South Africa, and possibly in level 3 hospitals as well, but further studies would be required to confirm this. Further work on provincial-level factors associated with CHIS success is also required. It could be expected that the likelihood of applicability of these factors would be stronger where CHIS selection and implementation are done on a provincial basis (as in Province 1 and Province 2), than in situations where there may be local development of a CHIS for a specific hospital, or where there is a strong emphasis on IS adaptation to meet local needs, as in the DHIS implementation at ward level reported by Venter (2007). Future studies to examine the generalisability of association of the factors in this model (at provincial and hospital levels) with CHIS success should therefore include multiple types of CHIS implementations to ensure that these diverse experiences are taken into account in any analyses.

In considering the potential for generalisability of the revised conceptual model of CHIS use beyond the study hospitals, it is necessary to examine the relationships between the model factors. The analysis of the survey results showed that most of the relationships in the model were supported, either on a statistical basis (although not always statistically significant) and/or taking into account both numeric and non-numeric data from the survey, as described in Section 6.4.5. Based on these results, the relationships between hospital-level factors in the conceptual model were retained, implying that the relationships between hospital-level factors of the conceptual model applied to all the study hospitals. A simpler relationship between provincial-level and hospital-level factors is postulated in the revised conceptual model of CHIS use, than the relationships in the extended conceptual model of CHIS use. Further studies will be required to test the applicability of the revised conceptual model of CHIS use beyond the hospitals included in the case studies and the survey for the current study.

The potential for further work arising from these results is discussed in more detail in Section 7.3.3.

(iii) Recommendations arising from the survey results

Recommendations arising from the survey results made in Chapter 6, Section 6.4.5(g), are reproduced here for completeness:

- The factors associated with CHIS success identified in this study should be taken into account in making decisions about the selection and development of CHISs for use in level 1 and level 2 hospitals in South Africa;
- The results of the comparisons between the CHISs in terms of the conceptual model of CHIS use indicate large differences in the experiences of CHIS users, and could indicate areas for improvement. These results will be provided directly to the study provinces.
- The responsible managers need to ensure that the CHIS performs according to specifications in all hospitals. Poor CHIS performance was a serious cause of frustration and concern among respondents. System availability of at least 99% is required for effective operation in environments which provide continuous service. Lack of system support outside office hours was widely identified as a problem.
- The responsible managers need to ensure that CHIS suppliers update systems so that they meet the agreed specifications in all hospitals, especially in terms of adaptation to local requirements.
- Ongoing training and education of hospital and provincial staff is essential, to enable them to use the available CHIS functionality as effectively as possible.

7.2.3 Research contribution

The research objectives identified for this project were:

- to contribute to the identification of factors associated with CHIS success in LVR environments;
- to identify relationships between factors associated with CHIS success, and the relative significance of the identified factors;
- to contribute to the identification of and explanations for risks associated with HIS implementation, especially in LVR environments;
- to contribute to theory building and modelling of HIS success, as reflected in the IS success literature, and to a lesser extent in the HIS success and HIS evaluation literature.

The research objectives were met to varying degrees:
Factors associated with CHIS success in LVR environments were identified in terms of factors of the conceptual model of CHIS use which was developed and refined in this project. Relationships between factors of the conceptual model of CHIS use were tested in the survey, as described in Chapter 6. The statistical analysis of the survey results supported some of the relationships between hospital-level factors in the conceptual model. Results were inconclusive for other relationships. However, none of the relationships between factors of the conceptual model of CHIS use was contradicted by the survey results. As explained in Section 6.4.2(a), it was not possible to obtain data from the survey to enable a weighting of the conceptual model factors relative to each other.

A primary research objective of this project was to contribute to theory-building as reflected in the IS success literature (as discussed in Section 2.4).
The multi-method approach followed in the project yielded results which were reflected in the development and refinement of the conceptual model of CHIS use in successive phases of the project, as described in Sections 3.4.4, 4.3.8, 5.5 and 6.5.4.
The testing in the survey of the conceptual model developed through the case studies resulted in a conceptual model of CHIS use which was at least generalisable across the survey sample: level 1 and level 2 hospitals in two South African provinces. There are few reported studies of HISs which match this study in scope, as described in Section 7.3.1. Further work on the extension of this conceptual model, as identified in Section 7.3.3, could further enhance the contribution of this work to theory-building in HIS and IS success. The extent to which the

results of this project are regarded as being useful in the IS success research community will only become apparent once they have been published.

The research contributions from this study are analysed in terms of aspects of the framework developed by Barrett and Walsham (2004) for use in interpretive case studies. The framework is applied in this instance to a multi-method study involving a strong interpretivist component (mainly from the case studies) and a positivist component (from the survey of hospitals). An outline of the Barrett and Walsham (2004) framework is given in Table 7.1.

Strategic concept	Tactical approach
Structuring intertextual coherence	• Synthesized coherence • Progressive coherence • Non-coherence
Problematizing context for contribution	• Incompleteness • Inadequacy • Incommensurability
Positioning as translating interests	• Framing for particular audiences • Staging to highlight what audiences should find interesting to discuss, and admitting what they may find disputable • Captation or subtle control of objector's moves with due consideration of allowed margin of negotiation of soft facts • Stacking of the extension of evidence to inductively support theories
Qualitative generalisations	• Development of concepts • Generation of theory • Drawing of specific implications in particular domains of action • Contribution of rich insights

Table 7.1 Key concepts for constructing contributions
(adapted from Barrett and Walsham, 2004, Table 1, p297)

Structuring intertextual coherence, the first concept identified by Barrett and Walsham (2004), refers to making justification for a study as an extension of related work. The approach in this study related more to 'synthesised coherence' than to 'progressive coherence', since the project background relates to multiple areas of work and literature, e.g. IS success and HIS evaluation. As described in the literature review (Chapter 2) few of the researchers on HIS evaluation are familiar with and/or report on the IS success literature, and even fewer HIS evaluation papers are referenced by IS success researchers. In this multi-method study, an attempt is made to identify as many relevant streams of literature as possible, and use them as the basis for the study.

Problematization of the context for contribution requires that gaps in existing work which are addressed by the study be identified. For this CHIS success study, the limited extent to which multiple relevant streams of literature have been taken into account in previous work provided the opportunity to address some resulting **inadequacy** in reported work. Thus, while modelling of HIS success has been conducted in a few studies (including Mohd.Yusof *et al*., 2008 for example); the setting has generally been that of one or a few organisations in developed environments, in contrast with the identification of limited or vulnerable resource (LVR) environments as the focus for the current study. Few HIS evaluation studies explicitly address the implementation of commercial systems, rather than HISs developed for specific study sites. The current study covers three different commercial CHISs. A further important distinction between the current study and other published work is that the informants for the study are mainly CHIS users, rather than CHIS or HIS experts. In related studies of factors associated with success and risk (Paré *et al*, 2008 and Brender *et al*, 2006, for example) the major inputs are derived from HIS experts.

Barrett and Walsham's third concept, '**Positioning as translating interests**', refers to the processes by which study results are incorporated into the body of knowledge about a particular area of work: HIS evaluation and IS success are the main areas of work expected to be influenced by the current study.

In relation to '**framing for particular audiences**' as a tactical approach, the results of this study are expected to be of interest to at least two audiences: the provincial and hospital managers in the study environment; and the HIS evaluation research community and other related research communities. Accordingly, the results of the study will be published as research papers, but also fed back to the management in the study environments in the form of reports; and presentations and discussions of the results.

A **stacking** approach to developing supporting evidence for the results of the study is embedded in the research design for this study(as shown in Figure 7.1): case studies were carried out in four level 2 hospitals in one province, all using the same CHIS. Following the further development of the conceptual model of CHIS use, this model was tested and extended through the survey which covered level 1 and level 2 hospitals in two provinces, each hospital using one of three CHISs. Thus, the conceptual model, initially based on case studies in similar hospitals using a single CHIS, was shown to be generalisable to the environments reflected in the survey through the use of a multi-method approach.

The use of **captation** as a tactical approach designed to influence future uses and/or development of the study outputs (Barrett and Walsham, 2004, p298) is reflected in the ideas for future research described in Section 7.3.3). Some of the potential extensions of the work in this study include:

- Investigation of the potential of the conceptual model to be applied in situations beyond those covered in the current study; and
- Following the broad approach of IS success researchers in the current study, in order to demonstrate links between CHIS success modelling and models of IS success.

The final component of the Barrett and Walsham framework is the construction of **qualitative generalisations** from interpretive research (Barrett and Walsham, 2004, pp298-299). This study included both qualitative and quantitative components, which are used together to construct generalisations from the available data. The strongest contributions of this study in this aspect of the framework

The **development of concepts**, in the form of factors associated with CHIS success, is a core component of this study. The combined results of the case studies and the survey provided confirmation that the hospital-level factors of the revised conceptual model of CHIS, which is the final output of the study, are associated with CHIS success in the study environments – level 1 and level 2 public sector hospitals in two provinces in South Africa. While evidence was provided, mainly from the case studies and the expert interviews, for the inclusion of provincial-level factors in the conceptual model, further work is required to enable a more detailed elaboration of these factors.

The **generation of theory** is also fundamental to the study, as reflected in the development and iterative revision of the conceptual model of CHIS use in successive phases of the study. The survey component in the study provided statistical support for some of the relationships in the conceptual model, thus strengthening the evidence for the accuracy of the model, as described in Section 6.4.4. Further work will be required to demonstrate statistical support for the remaining relationships.

7.3 SELF EVALUATION

7.3.1 Key challenges for research studies on information systems in developing countries

In their review of the literature relating to research on information systems in developing countries, Walsham and Sahay (2006) discuss the key challenges addressed in the literature, and identify gaps which could usefully be addressed in future research. Several of the examples quoted from the literature relate to health information systems (HISs), and the discussion is highly relevant to this CHIS success project.

The authors reviewed the articles identified for the study in terms of

- the key challenges identified;
- the role of technology; and
- the theories and methodologies used.

'Looking ahead' to potential future work in this domain, the authors suggest a

> conceptual framework of four questions which all research studies on ICTs [Information and Communication Technologies] in developing countries should address:
>
> - What is the "development" to which ICTs aim to contribute?
> - What are the key issues being studied related to ICTs?
> - What is the theoretical and methodological stance?
> - What level and focus of analysis is being adopted? (Walsham and Sahay, 2006, p15)

This project does not directly address development issues, except that the general aim is to improve decision-making in relation to the acquisition of expensive technologies, i.e. computerised hospital information systems (CHISs). Data on actual costs of systems were not gathered as part of this project, but press reports related to the acquisition of CHISs for provinces in South Africa refer to amounts of hundreds of millions of rands for the value of the tenders - reportedly R261million for the tender for upgrading and maintenance of CHISs for five years for Limpopo province (Glazier, ITWeb, 2006).

In terms of key issues, Walsham and Sahay (2006) recommend that scalability and sustainability should be addressed. The CHIS implementations being analysed in this project address very large-scale implementations of systems across more than 25 hospitals in Province 1, and more than 30 hospitals in Province 2 (excluding a total of four level 3 hospitals and approximately ten specialist hospitals such as maternity and psychiatric hospitals in the two provinces studied). The issue of sustainability of these large-scale implementations is directly addressed in the analysis of resource availability and resource commitment to ensure the effective use of the CHIS, in the face of multiple competing requirements in the provincial public healthcare systems. The basis of the analysis is that the level 1 and level 2 hospitals studied are environments of limited and vulnerable resources (LVR) for the implementation, maintenance and effective use of CHISs.

Further key issues identified in Walsham and Sahay's proposal (Walsham and Sahay, 2006) are in-depth studies of technologies and of large-scale technological infrastructure. In this project, the technology being examined is the CHISs in use in the study hospitals in two provinces in South Africa. No studies of CHISs of similar scope have been identified to date (December 2008) in the literature.

Although not a specific focus of the CHIS success study, two of the three CHIS implementations in the two provinces studied (SystemB and SystemC) depend on the availability of wide area networks (WANs) linking the hospitals with the central servers housing the master patient index (MPI) for each province – definitely 'large-scale technological infrastructures'. (The hospitals using SystemA operate in stand-alone mode, with the terminals inside each hospital linked to the hospital server via a LAN.) The WANs were identified as points of vulnerability in several of the hospitals in both provinces, with many references to 'slow networks' or 'system unavailability' in interviews (for example, hospitals C2, C6, S6, S8). According to the provincial manager of the rollout (interview P3, May 2008), the rollout of SystemB in Province 1 was in large measure being determined by the availability of the required network infrastructure to ensure effective WAN operation, and the manager responsible for the health IT infrastructure in Province 1 referred to problems with the networks which had caused difficulties for the hospitals (interview P4, May 2008). The dependence on the effective operation of the technological infrastructures, which cannot be taken for granted in LVR environments, is reflected in the explicit 'resources' factors in the conceptual model developed in this study, and in the results of both case studies and surveys, in which infrastructure and infrastructure support were widely identified as points of vulnerability.

The resources addressed in the CHIS success study also very explicitly include human resources after it was realised following the pilot case studies that allocation of human resources at hospital level to support information management in general, and the CHIS in particular, was a significant point of difference across the case study hospitals. Human resource availability and skills were identified as having significant effects throughout the project, albeit in some unexpected ways. For example, during the initial site visits and interviews in Province 2 (during February 2008) it was noted that specific provision had been made in hospital organograms for personnel with responsibility for CHIS support. In addition, the CHIS supplier had assigned personnel to provide support during the implementation phase. However, it was also reported that difficulties were being experienced with filling and/or retaining staff in network controller positions (which require specific technical background and skills) at hospital level (hospital C2, interview I1; hospital C3, interview I1)).

Walsham and Sahay (2006) noted that the literature on IS in developing countries had been found to be stronger methodologically than had been the case a decade earlier. This CHIS success study has attempted to use a combination of qualitative and quantitative, and interpretive and positivist methods, using case studies to obtain a rich picture of CHIS implementations, combined with a wide survey of implementations across two provinces. An interpretivist approach was used in the case studies to gain an understanding of CHIS success. The survey of CHIS use in level 1 and level 2 hospitals in two provinces (including the province in which the case studies were conducted) provided opportunities for combining positivist and interpretive approaches: the extended conceptual model of CHIS use was used as the lens for the survey, and the questionnaires were constructed in such a way as to provide the opportunity for testing the relationships defined by the model. Again, the interpretivist mode continued by making provision for recording additional comments, to enable respondents to provide inputs beyond the confines of the formal questions. Both quantitative and qualitative data were collected through the questionnaires, requiring both quantitative and qualitative methods of analysis.

This project does not address the comment made by Walsham and Sahay (2006) that more action research is required, in which the intention is to provide results and insights which influence the technologies (CHISs in use, in this case) as they are developed. In this study, no attempt has been made to influence the design of the CHISs. The aim was to provide insights to guide future selection and implementation of CHISs in similar environments. Due to the decision making process for the selection of CHISs in the public healthcare sector in South Africa, it would be difficult to carry out action research on the CHISs themselves. This is a reflection of the situation in many environments, in which decisions about the acquisition of HISs are made externally to the environment in which they are being implemented, and there is limited, if any, opportunity to influence the ongoing modification of the HIS to meet local needs. In this CHIS success study attempts have been made to understand the extent of hospital-level interaction with the system suppliers, and the extent to which users were requesting changes and/or additions to available reports from the CHIS, as reflections of CHIS support, and of the level of understanding and use of the CHIS, respectively.

Walsham and Sahay (2006) refer to the value of having ‘cross-cultural’ research teams, in the sense of people from within and outside the country of focus in the research. While not ‘cross-cultural’ in this sense, the author is South African, with wide experience of HISs in the country. Others involved in the research (the research assistant, and the second interviewer) were also South African. However, this project team was not representative of all the environments being studied (i.e., all from Province 1, with no ability to communicate in the local languages in some of the study environments), and this limitation was felt in some of the interviews, especially in Province 2**.** The project team could thus be viewed as being both from within the country of focus and as ‘outsiders’ in some of the study environments.

In terms of the ‘level and focus of analysis’ for this study, in concentrating on level 1 and level 2 public hospitals, an attempt has been made to obtain a wide view of the use of CHISs in hospitals throughout the study provinces, in a wide range of settings in a developing country. The conceptual model of CHIS use developed on the basis of case studies in four level 2 hospitals in Province 1 has been demonstrated to be applicable also in the level 1 and level 2 hospitals in the two provinces included in the survey. The model includes both hospital- and provincial-level factors to reflect the decision-making and management processes for CHISs in public sector hospitals in South Africa: selection of CHISs is carried out at provincial level, and management of resources for CHISs is determined by a combination of provincial-level and hospital-level decisions and processes.

An important opportunity for future work would be to link with researchers in other developed and developing countries, to obtain a cross-country understanding of CHIS success in environments of limited and vulnerable resources.

In terms of Walsham and Sahay’s analysis (2006), the CHIS success project addresses many of the issues related to research on information systems in developing countries which they identified as requiring attention. A challenge for those involved in this kind of research is to publish results in journals widely available to and respected by the IS and HIS communities, to ensure that the work being done is known and recognised.

7.3.2 Study limitations

The major limitation experienced in this study was the sample size achieved for the survey of level 1 and level 2 hospitals in the two provinces. As described, it was not possible to obtain survey responses from approximately 70% of the target hospitals in Province 2, due to the difficulty of arranging interviews with very busy CHIS users. A total of 24 responses was received from nine hospitals, with 12 of these from one hospital, meaning that only one user questionnaire was obtained for most of the hospitals in this sample. For Province 1, a highly satisfactory response rate was achieved in terms of number of hospitals (approximately 80% of the target hospitals). However, the total number of respondents was relatively small: 48 users from 21 hospitals. An average of three users per hospital (between 60 and 70 respondents) would have provided a stronger sample, representative of the different CHIS user groups in the hospitals. The limited sample sizes meant that extensive statistical analysis of the available data was not possible. As an exploratory data set, however, the survey data yielded useful results, and provided important pointers for further studies of CHIS implementations in South Africa and other developing environments.

The fact that only two of the nine provinces in South Africa were included in the survey could also be regarded as a limitation. The decision was taken, in consultation with the study supervisors, to aim for large samples in two provinces, rather than attempting to obtain a representative sample of respondents from hospitals in each province. The concentration on two provinces made it possible to compare situations across provinces and CHISs, without having to contend with an even more complex study environment than that provided by a sample covering three CHISs and two provinces. The extensive resources which would have been required to conduct surveys across nine provinces and multiple CHISs, in multiple languages, were also not available for this study. Further studies which do cover all provinces could provide valuable insights into the status of CHIS implementations in particular, and HIS implementations more generally, in South Africa.

A further limitation to be taken into account in future related studies is the wide number of languages in use across the country (11 official languages, with four of them being widely used in the study provinces). The interviewers for this study were able to communicate in only two of the four languages in use in the study provinces, which resulted in communication difficulties in a few interviews, as has been discussed. Special attention would have to be given to consistency of data collection and recording across the larger research teams which would be required to ensure the availability of people able to communicate in all languages used by the target respondents. As a compromise, the translation of the survey questionnaires into all languages used by potential respondents could facilitate communication.

Due to resource constraints, this study spanned six years, although individual components of the study (each of the four case studies, and the survey) each spanned a few weeks or months. Since this was a cross-sectional study, it would have been preferable for all studies to be completed in a shorter time. Fortunately, however, the CHIS in use in the case study hospitals (SystemA, in hospitals H1 to H4 in Province 1) was still in use in many of the survey hospitals in Province 1, and there had not been significant changes in the SystemA implementations between the time when the case studies had been conducted and the time when the survey had been conducted, so the time span of the study did not negate the results obtained.

7.3.3 Further work

A primary aim of this study was to identify factors associated with CHIS success in level 1 and level 2 hospitals in South Africa. Given the highly complex environment in which CHIS implementations take place, as has been described, it was not possible in a single study to address all the aspects of the contexts, the users, and the information systems (the CHISs) themselves, which could affect CHIS success. Several issues related to CHIS implementation and management were identified in the course of the study as being relevant to the study, but were outside its scope. These issues are addressed in this section, in the context of proposals for further work which could arise from this study.

(a) Integration between information systems in hospitals

The focus of this CHIS success study was on the use of hospital-wide CHISs in the study hospitals. In most cases, as has been described, the CHIS in use was largely or entirely administrative in focus, covering admission/discharge/transfer and billing functions. In practice, there are multiple HIS in use in hospitals, both computerised and manual. In all the study hospitals for which data on this issue were available, daily management decisions appeared to be based on daily manual nursing reports, rather than on the midnight state report from the CHIS. The CHIS daily figures were reconciled against the nursing daily figures to varying degrees within the study hospitals. In many of the hospitals included in this study, there were also multiple computerised information systems in use, including a few patient information systems, apart from manual patient record and other systems. A summary of the available data on multiple HISs in use in the study hospitals (from case studies and the survey of hospitals) is given in Table 7.2.

While the focus of the current study was not on the relationship between the multiple information systems in use in the study hospitals, this could be a worthwhile area of study for the future. Multiple reporting requirements at hospital and provincial and national level normally require integration of data from multiple information sources within hospitals to enable all aspects of the reports to be completed. Thus, the responsibility for ensuring that the required data are integrated, especially for reporting purposes, but also to support patient care, rests ultimately with the hospital management. Since the results of the study confirmed that there is little clinical data available in the CHISs in use in the study hospitals, it would be important to understand how and whether clinical data, especially in electronic form, could be made available from other sources. One obvious example that could be further investigated is the availability of laboratory results in electronic form from the National Health Laboratory

Service (NHLS) in parallel with, rather than being integrated into, the CHIS (as noted specifically at hospital H4 during the case study). From the author's experience in South African level 3 hospitals in the 1980s and 1990s, the availability of laboratory results as part of the CHIS patient record signalled a major shift in clinician attitude to the CHIS because these data were of direct relevance for their patient care activities. The examples from the survey of hospitals using parallel clinical information systems (hospitals H3, D5 and S7) could also provide important insights into the potential for electronic clinical information system use in level 1 and level 2 hospitals in South Africa, and similar environments.

Description of computerised information system	**Hospital/s**	**Notes**
SystemA pharmacy module	D24; H4; multiple district hospitals	SystemA pharmacy module was in use at hospital D24 at the time of the survey; plans to implement module at hospitals H4 and D9, D11, D16 and D14 were reported during the survey.
SystemB pharmacy module	D23, S8	Implementation of pharmacy module planned at S8; D24 transition to SystemB partially dependent on availability of integrated pharmacy module.
Pharmacy stock control system	H4	There is a standalone pharmacy stock control system in use at H4, which only covers bulk pharmacy stock. There are plans to implement the SystemA pharmacy module at H4, but this will not be integrated with the existing stock control system (interview I6)
Clinical obstetric information system	H3; S7	Clinical obstetric IS developed inProvince 1 for local use had been implemented at hospital H7 (interview I1). The version of this IS in use in S7 replaced an older system in use at H3 at the time of the H3 case study; the new system was due to be implemented at the study hospital in that year (2004).
Clinical information system (discharge summary and pharmacy)	D5	Clinical IS, including pharmacy module, had been developed in house for hospital D5, using open source software. The IS had been in use for approximately five years at the time of the survey (2008). (D5, interview I1)
Nursing statistics database	H4	A separate spreadsheet-based reporting system had been developed by the nursing management at hospital H4, based on nursing reports, especially related to patient movements within the hospital, and who had treated the patient during their hospital encounter. This database was used to support clinical and management reporting. (H4, I8)
Laboratory results reporting	H4	Laboratory results available via terminals in hospital H4; not integrated with CHIS; Consolidated laboratory results, including clinical data from the laboratory request forms, provided on CD on a monthly basis. Data related to laboratory reporting were only specifically collected at the case study hospital H4. However, since laboratory results are provided to all public hospitals by the National Health Laboratory Service (NHLS), it can be assumed that electronic data are also available at other hospitals.
DHIS (District Health Information System)	C3 and other Province 2 hospitals	The DHIS, or its equivalent, is used for reporting in all public healthcare facilities in South Africa. A standard monthly report for hospitals is recorded and reported via the DHIS.
Transversal systems		Transversal computerised systems used for stock control, financial management and personnel management (for example, LOGIS, BAS and PERSAL) are in use at all public hospitals in South Africa, but are not integrated with the CHISs.

Table 7.2 Computerised information systems in use in study hospitals (in addition to CHISs)

References from the literature provide some useful insights into local (to South Africa) and other activities related to integration of data at hospital level. Hedberg (2003), reporting on HIS progress in the South African Health Review, examined the extent to which data collection processes were integrated, and noted that much work remained to be done to ensure the development of effective Health Management Information Systems, which should include 'efforts to enhance the integration' between multiple systems. Ellingsen and Monteiro examined the integration of HISs in the context of the implementation of an electronic patient record system in Norway (Ellingsen and Monteiro, 2003). They developed a useful framework for the analysis of non-integration between systems. These authors highlighted the danger of having inconsistent values for the same variable in different HISs, but also came to the conclusion that some redundancy between systems (which would be evidence of non-integration) could provide necessary backup in the event of failure or non-availability of a particular HIS. Jaana *et al.* (2005) conducted a survey of clinical information technology in hospitals in the US and Canada, building on an earlier study of what the authors describe as 'information technology sophistication' in Canadian hospitals (Paré and Sicotte, 2001). These studies provide a validated survey instrument and classification of computerised information system applications in hospitals which could be considered for application in the local South African environment, to provide a rich picture of the status of computerisation in study hospitals, as well as the extent of integration between different applications. The authors of both papers highlight the importance of promoting integration between information systems, to gain the most benefit possible from the implementations. Ward *et al.* (including three of the co-authors of the 2005 study by Jaana *et al.*) conducted a further study in Iowa, to examine variations in clinical information system availability and use between urban and rural hospitals in the state, indicating that the study also provided information about 'electronic medical record "readiness"' in the study environment (Ward *et al.*, 2006) In view of current (2008) plans in South Africa to launch a national electronic health record (eHR.za), this kind of study could prove useful in guiding planning for future implementation.

(b) Communication within hospitals

Intra-hospital communication in Province 1 hospitals using SystemA was limited by the fact that, in most of the study hospitals, CHIS access was not available in wards and other clinical areas of the hospitals. Clinical staff therefore did not have easy access to the patient information which was available on the CHIS. For the users of SystemB in Province 1, the possibilities for using the CHIS were much improved due to the widespread deployment of terminals in administrative and clinical areas, including wards. In Province 2, terminals for the SystemC CHIS were available in administrative areas and wards, although several respondents commented on the lack of ward clerks to operate the CHIS in wards.

In reporting on a review of the status of health information systems internationally (focussed on developed environments), Giuse and Kuhn (2003, p109) noted that one of the key problems seemed to be the fact that 'the need to support person-to-person communication' in supporting the clinical care processes in hospitals had not been given due attention. They refer to a number of authors to support this assertion, noting that what is required is an approach based on the need to support communication between personnel in a flexible manner (which could involve developing a front-end to existing systems, to provide a single user interface) (Guise and Kuhn, 2003, p111). Jacucci *et al.* reported on an important example of local innovation and redesign of simple computerised information systems to support decision making in a small rural hospital in the Eastern Cape province in South Africa (not one of the study provinces for the CHIS success project) (Jacucci *et al.*, 2005), in which communication between the hospital personnel was key in enabling an appropriate and effective local solution to be found. While not a specific focus of the current study, there was little evidence of focus on facilitation of communication between hospital personnel through the CHISs in use.

Investigation of communication requirements could usefully form one of the foci of studies of integration between information systems in hospitals, as discussed in the previous section, since communication requirements should have a significant influence on any attempts to streamline information management.

(c) Adaptation of CHISs to meet user needs

One of the recurring themes in the literature related to the implementation of health information systems (HISs) is the need to ensure that the HIS is able to adapt or be adapted to meet local needs. Related to this need for adaptation is the wider concept of sustainability of HISs, which refers to the ability of local personnel and their institutions to maintain a system after the implementers have handed it over to the institution. This is a serious problem especially in environments of limited and vulnerable resources (LVR environments), where the required resources (including finance, people and infrastructure) and knowledge and understanding of the HIS may not be available at institutional (hospital) level. Braa *et al.* (2004) examine this issue in the light of experiences of implementing the Health Information Systems Project (HISP) district health information system in LVR environments in several developing countries, including South Africa.

The need for effective and ongoing adaptation of CHISs has clearly been demonstrated in the results of the current study, with multiple references by interviewees to problems such as incorrect drop-down lists months after implementation; incorrect calculations related to patient billing; and the need for reports which cannot be generated at hospital level; as has been described in previous sections.

The processes of adaptation of CHISs for use in the study hospitals were not specifically examined in this study, since this was a cross-sectional study of existing CHIS implementations, rather than an investigation of the processes associated with these implementations.
Two different approaches were evident in the implementation of SystemB in Province 1 and SystemC in Province 2:

- In Province 1, the requirements for the SystemB CHIS for level 1 and level 2 hospitals had been determined by a working group including provincial- and hospital-level representatives (hospital S7, interview I1; provincial interview P3). Implementation was being undertaken on a case by case basis, taking into account hospital requirements for a CHIS, and the availability of the required WAN infrastructure, trained personnel, and other resources (provincial interviews P3 and P4).
- In Province 2, the SystemC CHIS had been implemented in all hospitals across the province, as a replacement for the CHIS which had previously been in use in these hospitals (provincial interview P1, and discussions with users at hospitals).
- The acquisition processes for SystemA were not specifically discussed with any of the provincial-level informants, since none of these interviewees had had direct experience of this process, the CHIS having been selected for use in Province 1 more than five years previously. (SystemA had been in use at survey hospital D5 from the time the hospital was established in 2002 until SystemB had been implemented at that hospital (interview I1).)

A different approach to the implementation of CHISs in level 1 and level 2 hospitals in South Africa has been reported by Venter (2007), and should also be taken into account in future studies. Venter reported at a conference on projects to facilitate implementation of an existing HIS, the District Health Information System (DHIS) at ward level in the Eastern Cape and Mpumalanga provinces in South Africa, noting the specific processes followed to ensure that the implemented version of the DHIS had been tailored to meet local needs. The project team worked from the bottom up with specific hospitals, and a limited number of wards within the study hospitals, to identify information needs (especially for reporting purposes).

In environments such as public sector hospitals in South Africa, where decisions about acquisition and adaptation of CHISs are typically made at provincial level, it would be a challenge to follow, on a large scale, the intensive processes for effective adaptation reported by authors such as Venter (2007); Heeks (2006); and Thompson (2002).

A combination of the top-down approach followed in Provinces 1 and 2 (and in other provinces in South Africa, as indicated by the tender specifications for the Free State Province, for example (Free State Department of Health, 2008)), and the bottom-up approach reported by Venter (2007) could provide an effective future approach. One approach could be to work towards common requirements for similar wards and hospitals, while still making provision for local modifications where required. **More detailed studies of, and comparisons between, the implementation experiences to date in South Africa, and similar environments elsewhere, would provide important insights to inform future approaches.**

In practice, there seems to have been little opportunity and/or inclination and/or incentive in the study hospitals to examine ways in which modifications to the CHIS and/or the work processes in the hospitals could facilitate patient care. In Province 2, for example, extensive mechanisms and resources had been put in place to support the CHIS implementation, but the overall impression gained from discussions with users is that they have little effect in practice: the scope of the implemented CHIS did not meet many of their expectations; the support systems and services from the CHIS providers and supporting service providers (for example, networking) were often not available after office hours (when the hospitals were still functioning and internal support personnel were not on site); and requests for support and modifications or corrections to the CHIS (for example, updating of contents of drop-down menus) were not responded to within the expected and agreed timeframes (in terms of service level agreements (SLAs)). In the hospital H3 pilot case study, the case manager noted that she seemed to be the only person in the hospital who was interested in finding out how the CHIS could better meet her requirements (hospital H3, interview I13).

Another aspect of CHIS adaptation which seems to have received little attention in the study hospitals is ensuring that the available capabilities of the CHISs are effectively used. One notable exception was the claim by a member of the management team at hospital D24 that ‘we are using all the capabilities (of the CHIS) to the utmost’ (hospital D24, interview I1). Even at this hospital, though, it could not be established whether the (limited but potentially useful) CHIS capability for the collection of patient clinical data was being used effectively.

Of relevance for this discussion is the proposal by Aarts *et al.* (1998) of a model for framing discussions and activities related to the effective implementation of HISs in organisations. Within the context of the health care system, these authors identified three levels of clinical activity that should be the focus of HISs, and which should therefore be taken into account in attempting to ensure 'an effective fit' of an HIS in an organisation: diagnosing and treating a patient; learning from sets of patients; and organising and managing clinical practice. Although the CHISs in this study do not directly support clinical work, they do contribute to the organisation of the environment in which the clinical services are provided, and this framework proposed by Aarts *et al.* must be taken into account in considering requirements for CHISs. For example, all the CHISs represented in the current study make provision for the collection of some clinical data on each patient. Taking account of the argument that the focus of all HIS implementations should be on improving the clinical care of patients, it could be argued that, if more resources were allocated to the collection of clinical data via the CHIS (even after discharge), the availability of the data on future patient visits could contribute directly to the potential for 'learning from sets of patients' and 'diagnosing and treating' individual patients, thereby contributing directly to improved patient care.

The implications for future selection and implementations of CHISs could be to ensure that the CHIS has been designed to enable adaptation to meet local needs without the need for reprogramming as far as possible. Related to the process of CHIS adaptation is the need for people with the necessary skills to facilitate the detailed definition of requirements for adaptation at hospital level, and the possible implementation of such adaptations. Additional to the need for flexible software and skilled personnel, either internal to the hospital or external, is the need for at least a core of CHIS users with the confidence and the necessary mindset to assess the possibilities for and implications of ongoing adaptation to meet evolving needs at hospital level. In fact, Venter (2007) makes the argument for adaptation at individual ward level. All these components of an approach to effective CHIS adaptation would be dependent on the creation in provincial departments of health of environments which encourage and facilitate this process, both in terms of resource allocation, but, even more significantly, in terms of organisational arrangements and attitudes which ensure that concerns and requirements are addressed effectively. **One contribution to this process could be the establishment (where these do not already exist) of forums at hospital level which encourage and support the ongoing review of information systems and information flows, to ensure that information is optimally used as a resource to support patient care.**

(d) The need for ongoing HIS evaluation studies

Since the current study aimed to identify and analyse factors associated with successful CHIS implementation, it falls squarely within the domain of HIS evaluation studies. Discussion of results, and the limitations of the current study, have highlighted the need for further evaluation studies in the South African health information system domain. On an international level, numerous authors have motivated for increased emphasis on health information system evaluation studies. For example, the participants in the Giuse and Kuhn review of the status of health information systems also highlighted the need for 'continuing and increased rigorous evaluation of HIS interventions, in order to increase the scientific usefulness of the findings' (Giuse and Kuhn, 2003, p111). Other authors such as Rigby (2006), Talmon (2006), Kaplan and Shaw (2004); Littlejohns *et al.* (2003) and Southon *et al.* (1999); have also made recommendations for future work. The report of Ash *et al.* (2008) on the results and outputs from a multi-year, multi-centre, multi-method study of Computerised Physician Order Entry (CPOE) Systems, and the multiple reports on the work of the HISP project (including Braa *et al.* (2007) and Shaw (2007), for example), have highlighted the need for extensive, ongoing evaluation of HIS development and implementation efforts, to ensure that lessons learned are applied in later implementations, and that potential risks associated with HIS implementations are avoided as far as possible.

In the light of these recommendations, the results of the current study must be viewed as potentially the first phase of ongoing further investigation of HIS implementations in South Africa. There is a need for long-term, national studies of the multiple HIS activities in both public and private sectors, to understand better the strengths and weaknesses of existing implementations, in order to do better the next time round. For example, the survey component of the current study could be extended to cover all CHIS implementations in South Africa, to establish a set of baseline data which could be used for comparison with the results of future studies. The surveys conducted by Jaana *et al.* (2005) and Ward *et al.* (2006) in hospitals in the US and Canada provide a clear picture of the usefulness of relatively simple studies, conducted over large samples of healthcare facilities, to explain current situations, and provide pointers for management action and requirements for further studies to support ongoing decision-making about HIS acquisition and implementation. The need for investigations of how multiple information systems are used at hospital (or other facility) level has been argued in a previous section, as has the need to understand the processes of adaptation of HISs to meet local needs. The current South African environment provides a rich tapestry of experiences and approaches, from which many lessons must surely be available to be learned.

Apart from studies within South Africa, Walsham and Sahay (2006), and others, have highlighted the need for comparative studies between organisations, and between countries. Especially for developing countries, with rich and diverse experiences, but also many needs to be met from limited resources, the results of comparative evaluation studies of HIS acquisition, development and implementation should be seen as essential components of the decision making and ongoing management processes in departments and ministries of health at all levels of government. Thus, an important opportunity for future related research work would be to link with researchers in other developed and developing countries, to obtain a cross-country understanding of CHIS success in environments of limited and vulnerable resources.

(e) Factors associated with CHIS success

Delphi studies (as reported by Brender *et al.* (2006) and Paré *et al.* (2008)) and consensus conferences (as reported by Ash *et al.* (2005)) are among the approaches being used to develop an understanding of factors associated with HIS success, and risk factors associated with HIS implementation, from groups of expert informants. The current study obtained opinions from CHIS users on factors associated with CHIS success, but it was not possible to obtain information on the relative weighting of factors, possibly due to the fact that the respondents were likely to have had only limited experience of HISs. Future studies of factors associated with HIS success and /or HIS risk factors, based on data gathered both from local HIS experts and from HIS users, could provide important complementary perspectives to those reported in the literature to date, which have reflected the opinions of HIS experts in developed countries.

In addition to identifying factors associated with HIS success or risk, the development of measures of CHIS success could result in useful tools for CHIS implementers and managers, to facilitate monitoring and evaluation of CHIS implementations. The availability of such measures could also facilitate comparison between CHIS implementations through the development of benchmarks for CHIS implementations. One approach could be the development of a composite index of CHIS success, based on the measurement of multiple factors associated with CHIS success. This approach was followed by Otieno *et al.* (2008) in developing an index for measuring the effectiveness of electronic medical records. The POET (physician order entry team) project, and the Heeks group in the application of the ITPOSMO model for assessing perception-reality gaps, have used the approach of assigning weights for identified factors associated with HIS success, in order to then calculate an overall measure of the risk of lack of success or adverse outcome in a specific environment (Ash *et al.*, 2008; Heeks, 2006).

(f) Further work to develop the conceptual model of CHIS use

The final stage of review of the conceptual model of CHIS use in this study has highlighted potential areas of further work to develop the model further.

The focus in the case studies and in the hospital survey was on the hospital-level factors of the conceptual model. Since decision making about CHIS selection and implementation for public sector hospitals in South Africa is made at provincial level, further development of the provincial level factors of the conceptual model of CHIS use is essential. This work could include an analysis of the relationships between provincial- and hospital-level factors of the conceptual model.

The analysis of survey results highlighted challenges in the identification of appropriate/effective/accurate measures for some of the conceptual model factors. Further work on these measures would facilitate future statistical analysis of data related to the conceptual model.
The identification and/or validation of measures used in other studies and then applied in the conceptual model could facilitate comparisons between and pooling of data from multiple settings, to enhance understanding of factors associated with HIS success within and beyond the study environment.

Apart from further investigation of relationships between factors in the conceptual model of CHIS use developed in this study, further work is required to clarify the relative weighting between factors. This is especially important if the conceptual model is to be used in future to inform decision making about the selection and acquisition of CHISs for public sector hospitals in South Africa, and in other environments where such decisions not made at the level of individual institutions.

7.4 CONCLUSIONS

The aim of this study was to contribute to the effective use of information for management in South African public sector level 1 and level 2 hospitals, by providing support for the decision-making process in the selection of computerised hospital information systems at provincial level. The study design provided the opportunity to discuss information and information systems with a wide range of users, user managers, and hospital and provincial managers, and explore a wide range of literature reflecting studies of information systems, both within and beyond the healthcare domain.

The practical data gathering, the literature review and the process of model development have confirmed again the fact that the implementation and ongoing maintenance and use of computerised information systems in hospitals is a highly complex process, requiring inputs from a wide range of sources, with people and infrastructure chief among them. This process is especially challenging in environments of limited or vulnerable resources, as has been illustrated in this study. The lack of resources provides both challenges and opportunities: challenges, especially at hospital level, to ensure that the essential processes of patient care continue even in the face of information systems which are not always reliable, have limited scope, and do not meet all user requirements; and opportunities for managers and users to develop creative and practical approaches to coping with the challenges posed by using important but imperfect tools, such as computerised hospital information systems which are not tailored to the detailed requirements of individual hospitals.

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ANNEXURE A

LETTER OF APPROVAL FROM THE MEDICAL RESEARCH COUNCIL ETHICS COMMITTEE

See next page.

SOUTH
AFRICAN
MEDICAL
RESEARCH
COUNCIL

ETHICS COMMITTEE

PO Box 19070, Tygerberg 7505, South Africa,
Francie van Zijl Drive, Parow Valley 7500, Cape Town
Tel: +27 (0)21 938 0341, Fax: +27 (0)21 938 0201
Email: adri.labuschagne@mrc.ac.za
http://www.sahealthinfo.org/ethics/ethics.htm

14 June 2007

Ms L Hanmer
Health Informatics R&D Co-ordination
MRC Cape Town

Dear Ms Hanmer

Protocol ID: EC06-013
Protocol title: Factors associated with the successful implementation of computerised hospital information systems in South Africa
Meeting date: 28 May 2007

Thank you for the revised information sheet submitted on 7 May 2007. I am pleased to inform you that ethics approval is now granted for the study.

Wishing you well with your research.

Yours sincerely

PROF. D DU TOIT
CHAIRPERSON: MRC ETHICS COMMITTEE

ANNEXURE B

The Hospital Manager/Senior Medical Superintendent

____________________ Hospital

Dear Colleague

RESEARCH PROJECT: FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS IN SOUTH AFRICA

Permission is hereby requested to interview between two and four members of your staff as part of a survey on the use of computerised hospital information systems (CHISs) in district and regional hospitals in South Africa. This survey forms part of a project which aims to identify factors which are associated with the success of CHISs in district and regional hospitals in South Africa.

Permission to conduct the study has been obtained from the Provincial Administration: Limpopo: Department of Health. Please note that the study does not aim to evaluate the CHIS in use in your hospital.

A list of the questions to be covered in the interviews is attached. Each interview is expected to last no longer than one hour, and will be conducted at the convenience of the interviewee and the hospital. The identities of neither the interviewees nor the hospital will be indicated in any reports on the study.

It would be appreciated if a representative of each of the following categories of hospital staff could be identified to participate in this survey:

- Hospital senior management
- End user manager/other representative of end users
- A personnel member with primary responsibility for information management at the hospital (if there are designated personnel for this function)
- A case manager for private patients (if there are designated personnel for this function).

This project has been approved by the Ethics Committee of the Medical Research Council. Project participants are welcome to contact the Chairperson of the Committee if they have any queries or problems related to the ethical conduct of the project:

Professor Danie du Toit
Tel: 021 938 0341
Email: adri.labuschagne@mrc.ac.za.

Should you require further information about this project please contact me as follows:

Tel: 021-938 0343
Fax: 021-938 0315
Cell: 082 496 6546
Email: lyn.hanmer@mrc.ac.za

I hope that it will be possible for this survey to be conducted in your hospital.

Sincerely

Lyn Hanmer
Division Manager: Health Informatics R&D Co-ordination

ANNEXURE C

____

____________________ Hospital

Dear Colleague

RESEARCH PROJECT: FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS IN SOUTH AFRICA: SURVEY OF CHIS USE IN DISTRICT AND REGIONAL HOSPITALS

Your participation in a survey of CHIS use which I am conducting at district and regional hospitals is hereby requested.

The aim of the survey is to gain an understanding of how users define the success or failure of computerised hospital information systems (CHISs) used in district and regional hospitals in the province. Permission to conduct the study has been obtained from the Provincial Administration: Western Cape: Department of Health.

This survey forms part of a project which aims to identify factors which are associated with the success of CHISs in district and regional hospitals in South Africa. Please note that the project does not aim to evaluate the CHIS in use in your hospital.

Between two and four key users of the CHIS at your hospital will be interviewed. A list of the questions to be covered in the interviews is attached. Each interview is expected to last no longer than one hour, and will be conducted at your convenience. The identities of interviewees will not be indicated in any reports on the study. Participation in this study is completely voluntary, and you are free to withdraw at any time without having to provide a reason.

This project has been approved by the Ethics Committee of the Medical Research Council. Project participants are welcome to contact the Chairperson of the Committee if they have any queries or problems related to the ethical conduct of the project:
Professor Danie du Toit
Tel: 021 938 0341
Email: adri.labuschagne@mrc.ac.za.

Should you require further information about this project please contact me as follows:
Tel: 021 9380343
Cell: 082 496 6546
Fax: 021 9380315
Email: lyn.hanmer@mrc.ac.za

If you are willing to participate in this project, please read and sign the attached consent form.

Sincerely

Lyn Hanmer
Division Manager: Health Informatics R&D Co-ordination

ANNEXURE D

FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS IN SOUTH AFRICA

PROTOCOL FOR CASE STUDY

AIM

The aim of this study is
- to describe and analyse the effects on the study hospital of CHIS implementation,
- to identify those factors which are associated with perceptions of the success or lack of success of the implementation, and
- To inform the refinement of a conceptual model of CHIS use.

BACKGROUND

Permission to conduct this study will be obtained from the Department of Health of the Provincial Administration: Western Cape. Ethical approval for the study will be obtained from the Ethics Committee of the South African Medical Research Council (MRC). Permission to conduct the study in a specific hospital will be obtained from the hospital manager.

ACTIVITIES AT THE HOSPITAL

A OBSERVATION OF THE USE OF THE CHIS IN THE HOSPITAL
For the observation component of the study, it will be necessary to observe the use of the different components of the CHIS under normal working conditions, especially at busy times. Permission will be sought from the hospital staff involved to observe their activities. The researcher will arrange with hospital personnel to spend time observing the use of the CHIS in each section of the hospital in which the CHIS is used, e.g. hospital admissions, patient care areas, the finance section, and at different times of the day or night, and of the week.

It is expected that approximately one week will be required for this component of the study.

The aim of this component of the study is to understand the scope and operation of the CHIS in use in the hospital, to identify any major difficulties being experienced by the system users, and to identify any limitations of the CHIS in its implemented form at the hospital.

B REVIEW OF DOCUMENTS RELATED TO THE USE OF THE CHIS IN THE HOSPITAL
Attempts will be made to obtain access to the following documents related to the implementation of the CHIS in each of the hospitals in this study:
- User requirements specification for the CHIS at the hospital
- CHIS implementation plan/s for the hospital
- Previous reports, if available, on the performance of the CHIS in relation to the user requirement specifications
- Forms used in conjunction with the CHIS
- Standard reports produced from the CHIS
- Ad hoc reports produced from the CHIS.

The aims of this component of the study are:
- to understand the scope of the CHIS, according to the user requirements specification;
- to obtain a description of the implemented CHIS, and the outputs provided to users
- to obtain information on documented user experiences with the CHIS, including problems encountered and solutions implemented.

C INTERVIEWS WITH HOSPITAL PERSONNEL

Interviews with hospital personnel are expected to provide the most detailed information on how users assess the CHIS. Between 10 and 15 interviews will be conducted at the hospital. A few interviews will also be conducted with non-hospital personnel.

In order to minimise time requirements, and to enable consolidation of data collected from different interviewees, a questionnaire will be used to guide each interview. Open-ended answers are expected for most of the questions, and additional interviewee comments will be recorded, thus allowing the opportunity to capture a potentially wide range of responses. The interviewer (the researcher) will complete the questionnaire. The permission of interviewees will be sought to tape record interviews, to facilitate later analysis.

The first aim of the user interviews is to record user experiences of the CHIS, both in terms of the ability of the system to operate according to specifications and in terms of the ability of the system to meet user needs. The second, and most important, aim for this project is to compare user experiences with user assessments of the CHIS as a tool, as described in the interviews.

By comparing actual user experiences with users' overall assessments of the CHIS in terms of its effect on the ability of users to do their jobs, it is hoped to derive patterns which indicate the factors which users take into account when assessing CHISs.

Interviewees will be selected on the basis of their ability to act as key informants on the CHIS for the hospital. Potential interviewees include:
- Members of the top management team of the hospital.
- Provincial personnel involved in the selection of CHISs for use in district and regional hospitals in the province.
- End users of the CHIS, who are responsible for data entry and for generating standard reports from the system.
- Hospital personnel responsible for user support for the CHIS at the hospital.
- Non-hospital personnel responsible for user support for the CHIS at the hospital.
- Hospital information officers, whether formally appointed or carrying out the function in an acting capacity or informally.
- Hospital personnel recognised as 'superusers' of the CHIS, and who provide support for other hospital users of the CHIS, although CHIS support is not their primary function.
- Hospital personnel who are senior enough to be able to comment on the CHIS from the perspective of a department or section of the hospital, e.g. admissions, ward administration, nursing management, clinical management.
- Case managers: hospital personnel (typically professional nurses) with responsibility for case management for private patients being treated in the (public) hospital, including coding of clinical data to enable complete and efficient patient billing.
- Hospital clinical personnel will be interviewed in order to gain an understanding of how clinical data is analysed in the hospital, both using data from the CHIS and externally to the CHIS.
- A representative of the CHIS supplier will be interviewed to obtain a supplier perspective of the CHIS implementation at the hospital.

ANNEXURE E

OUTLINE OF QUESTIONNAIRE TO ASSESS HOW USERS DEFINE THE SUCCESS OR FAILURE OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS (CHISs)

Indicate whether you are responding to this questionnaire in your personal capacity or on behalf of the department or section of the hospital in which you work (or which you manage).

Identify the CHIS which is most important for your work.

Describe how you use the CHIS in your work.

Please rate the CHIS in terms of the following criteria:

- System operation (as defined in the system specifications and in terms of end user expectations)
  - Are system response times acceptable?
  - What is your estimate of the system availability? 50%? 75%? 90%? 100%?
  - Is the system availability acceptable?
  - Does the system functionality meet your requirements?
  - Are there outstanding system modifications which would facilitate your work?
  - When components of the CHIS become unavailable, is the time taken to rectify the problem acceptable?
  - What are the major problems experienced in ensuring that all components of the CHIS are available all of the time?
- Timeliness of information (as defined in the system specifications)
  - Does the timeliness of information meet system specifications?
- Timeliness of information in terms of own needs
  - Do you require any information from this system more often or less often than you are able to receive it at present (according to the system specifications)?
  - How often do you require the information?
- Accuracy of output from the system
  - What is your assessment of the accuracy of the information which you can obtain from the system?
  - Please explain your answer.
- Accuracy of input to the system
  - What is your assessment of the accuracy of the data which is input to the system?
  - Please explain your answer.

To what extent does the CHIS meet your needs?

- Do you obtain all the information relevant to your operational activities which is available from the system (as defined in the system specifications)? This could include clinical data for which provision is made in the CHIS.
- Do you obtain the information in a format which is appropriate for your needs?
- Describe reports from the system which you would like to receive, but cannot receive at present.
- Have you requested the developers of the information system / the providers of the information to provide any of these reports? Please give details.

What do you like about the CHIS?

What do you dislike about the CHIS?

How does the CHIS facilitate your job?

How does the CHIS complicate your job?

Overall, in terms of your job, do you regard the CHIS as a success or a failure?
Can you give reasons for this assessment?

ANNEXURE F

FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS IN SOUTH AFRICA: SURVEY OF CHIS USE IN DISTRICT AND REGIONAL HOSPITALS

SURVEY PROTOCOL

Overview

A survey will be conducted of CHIS implementations in district and regional hospitals in SA, in order to supplement the data from the case studies with data from a cross section of district and regional hospitals
The aim of the survey is to test and refine the conceptual model developed in the first phase of the project, and to determine the relative significance of the factors identified as being associated with success or lack of success in CHIS implementation in the hospitals surveyed.
The focus of the survey will be on obtaining input on factors which could be associated with CHIS success or lack of success from a larger sample of hospitals than in the case studies. The conceptual model will be further developed and extended on the basis of the survey results.

An outline of the survey questionnaire is attached as Annexure B
The survey questionnaire will be pilot tested before being finalised.

Objectives of survey

- Identify those factors which are associated with CHIS success;
- Identify those factors which could predict CHIS success or lack of success;
- Identify differences between hospitals/groups of hospitals (district and regional; urban and rural, etc) in respect of factors associated with CHIS success or lack of success;
- Provide further data for identifying factors which could predict CHIS success or lack of success.

Sampling

All district and regional hospitals in two provinces will be included in the sample, except those regional hospitals at which case studies have already been conducted. This sample has been chosen to provide a balance between the requirement to obtain data from as wide a range of SA public sector district and regional hospitals as possible, and the practicality of conducting surveys on a wide scale.

Approval will be sought from the provincial authorities to conduct the survey in the Western Cape (where the case studies will have been conducted), and a second province which has more rural areas than the Western Cape, and is known to be relatively under-resourced, e.g. the Northern Cape Province, the North West Province or Limpopo Province. The second province will be chosen to ensure that the sample used is broadly representative of the range of district and regional hospitals in SA. Permission will be required from provincial and hospital management to administer questionnaires to hospital personnel.

One questionnaire will be completed for each of the following categories of users/hospital personnel at each hospital:

- hospital management
- end users
- information officers and other staff with full-time responsibility for information management, e.g. statistics clerks (whether appointed or seconded to this role)
- case managers for private patients in hospital (if there are designated personnel for this function).

A description of the hospital CHIS implementation will be obtained from the hospital manager or another key informant designated by hospital management.

Piloting of questionnaires

The questionnaire will be piloted by administering a draft version to health researchers or other health personnel familiar with the public hospital environment, who are resident in the Cape Town area. Since the outline of the questionnaire is similar to the interview guide used in the case study interviews with hospital personnel, the case study interviews also functioned as a pilot for the survey questionnaires.

Survey administration

Prior to conducting the survey at any hospital, a letter will be sent to the hospital manager to request permission. **The text of the letter is attached as Annexure C.**

The questionnaires will be administered by a researcher visiting the hospital, or telephonically. All interviews will be conducted by appointment, and at the convenience of the interviewee.
The questionnaire will be forwarded to each hospital in advance, to enable the respondents to obtain the required information from colleagues, if necessary.
The researcher will complete the questionnaires on the basis of inputs received from the interviewees at each hospital.

Data analysis

Data from the survey will be analysed using appropriate statistical tests, in consultation with an experienced biostatistician (Dr Sedick Isaacs, one of the project supervisors). It is expected that non-parametric methods will generally have to be used, in view of the fact that the opinions of respondents will be sought about the performance of the CHIS in use in their environment.

Potential extensions or alternative approaches for the hospital survey

All district and regional hospitals (except the case study hospitals) will be surveyed, but no questionnaires will be completed if there is no CHIS in use in the hospital. Therefore, the actual sample size will be determined by the number of district and regional hospitals in the survey provinces in which a computerised hospital information system (CHIS) is in use. Once the size of the actual sample has been determined, it may be necessary to extend the survey to a third province to obtain a sufficiently large sample of district and regional hospitals which use CHISs. This decision will be taken in consultation with the biostatistician.

An attempt will be made in the data analysis to weight the factors which could contribute to CHIS success or lack of success, in order to identify the most significant factors which affect CHIS success. This would be a precursor to identifying key factors which could predict CHIS success or failure.

ANNEXURE G

OUTLINE OF SURVEY QUESTIONS – LINK TO FACTORS IN CONCEPTUAL MODEL

	Survey question	Factor 1	Factor 2			
2	Is the CHIS easy to use?	design				
11	Available reports do not meet needs	design				
14	Describe reports from the system which you would like to receive, but cannot receive at present.	design			use	??use of available functions
15	Have you requested the developers of the information system / the providers of the information to provide any of these reports? Please give details.	design			use	??use of available functions
16	Is the CHIS midnight state report routinely used by hospital management If not, please indicate why this function is not used	design			use	
17	Is there another (non-CHIS) daily patient report which is used by hospital management?	design		useful		
H	o Describe any proposed or planned changes in the CHIS implementation at this hospital. Please indicate the reasons for the change, and the expected benefits of the changes.	design				
19	[Have superusers of the CHIS been identified and what role do they play in the implementation and use of the CHIS?] If you need assistance with or advice on the CHIS, which member of the hospital staff do you contact?	hresource	know			
H	Information Management (IM) personnel; other personnel within the hospital with information management responsibilities	hresource	know	commit		
H	CHIS support and maintenance resources available to hospital within the hospital	hresource		commit		
21	If you need assistance with or advice on the CHIS AFTER HOURS OR DURING WEEKENDS OR HOLIDAYS, who do you contact?	hre-source	Pre-source			
H	Personnel who provide CHIS input – from list, plus 'other'	hre-source				IMPLEM
H	Location of workstations used for data input	hre-source				IMPLEM
6	Users at this hospital adequately trained	know				
7	Respondent adequately trained	know				
10	Do not know available reports	know				
22	Does ICD-10 coding take place at the hospital?	know	hresource			implem

	Survey question	Factor 1	Factor 2			
23	Whose data is coded? Private/paying/non-paying patients	know	QUAL hresource			
24	Who does the ICD-10 coding?	Hresource	know QUAL			
3	Are system response times acceptable?	perform				
4	What is your estimate of the system availability? 50%? 75%? 90%? 100%?	perform				
5	Is the system availability acceptable?	perform				
20	If you need assistance with or advice on the CHIS, who do you contact OUTSIDE the hospital?	Pre-source				
12	Assessment of accuracy of data available from the CHIS	QUAL				
13	Assessment of completeness of data available from the CHIS	QUAL				
H	CHIS support and maintenance resources available to hospital external to the hospital	resources				
18	Are there other functions of the CHIS which are not being used in this hospital? Please indicate the functions, and the reasons for their not being used.	design				
25	What do you like about the CHIS?			useful		MODEL
26	What do you dislike about the CHIS?			useful		MODEL
27	How does the CHIS facilitate your job?			useful		MODEL
28	How does the CHIS complicate your job?			useful		MODEL
29	Overall, in terms of your job, do you regard the CHIS as a success or a failure?			**??useful**	use/ success	MODEL
29a	Can you give reasons for this assessment?			**??useful**	use/ success	MODEL
30	Perception of usefulness of CHIS (by management)			useful		MODEL
31	Perception of effectiveness of CHIS use by management				use	MODEL
32	Perception of management commitment to CHIS success			commit		MODEL
33 - 39	**Factors associated with CHIS success – from list**					**MODEL**
40 - 46	**Factors associated with lack of CHIS success – from list**					**MODEL**
H	Scope of CHIS implementation (could be zero if no CHIS in use) – from list		***FUNC***			IMPLEM
H	Personnel who use CHIS outputs/reports		***RE-SOURCES***			IMPLEM

ANNEXURE H

MRC SOUTH AFRICA

Health Informatics
R&D Co-Ordination
Division

FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS (CHISs)

Survey of District and Regional hospitals - hospital overview

Interview date: ________________

Respondent role in hospital	
Name of the computerised hospital information system (CHIS) which supports patient activities in the hospital.	

1 What is the scope of the CHIS implementation at the hospital?				
a. Patient identification/master patient index (MPI)	**YES**	**NO**	**Not known**	
b. Admission/discharge/transfer (ADT)	**YES**	**NO**	**Not known**	
c. Billing	**YES**	**NO**	**Not known**	
d. Other functions. Please specify.	**YES**	**NO**	**Not known**	

2 What is the location in the hospital of the workstations for CHIS?				
a. Inpatient reception	**YES**	**NO**	**Not known**	
b. Outpatient reception	**YES**	**NO**	**Not known**	
c. Emergency unit reception	**YES**	**NO**	**Not known**	
d. Wards	**YES**	**NO**	**Not known**	
e. Finance/fees department	**YES**	**NO**	**Not known**	
f. Other locations. Please specify	**YES**	**NO**	**Not known**	
3 Describe any proposed or planned changes in the CHIS implementation at the hospital.				
a. Please indicate the reasons for the planned change(s), and the expected benefits of the change(s).				

4	**Which groups of personnel in the hospital provide input to the CHIS?**				
	a. Admissions staff	**YES**	**NO**	**Not known**	
	b. Ward staff	**YES**	**NO**	**Not known**	
	c. Finance/fees officers	**YES**	**NO**	**Not known**	
	d. Case manager	**YES**	**NO**	**Not known**	
	e. Other groups. Please specify.	**YES**	**NO**	**Not known**	

5	**Are there members of the hospital staff who have specific responsibility for information management (IM); i.e. IM is their primary function?**	**YES**	**NO**	**Not known**	
	a. Information officer	**YES**	**NO**	**Not known**	
	b. Information manager	**YES**	**NO**	**Not known**	
	c. Information clerk	**YES**	**NO**	**Not known**	
	d. Other staff member. Please specify.	**YES**	**NO**	**Not known**	
6	**Are the identified IM personnel in temporary posts or on secondment to the IM positions?**	**YES**	**NO**	**Not known**	

7	Is there a **case manager** on the staff of this hospital?	**YES**	**NO**	**Not known**	

8	**Which other members of the hospital staff have defined responsibility for information management (IM); i.e. IM is part of their job descriptions?**	**YES**	**NO**	**Not known**	
	a. Hospital managers	**YES**	**NO**	**Not known**	
	b. Case manager	**YES**	**NO**	**Not known**	
	c. Admissions supervisor	**YES**	**NO**	**Not known**	
	d. Clinical managers	**YES**	**NO**	**Not known**	
	e. Other staff member. Please specify.	**YES**	**NO**	**Not known**	

9 Which groups of personnel in the hospital use CHIS outputs/reports?				
a. Hospital management	**YES**	**NO**	**Not known**	
b. Admissions supervision	**YES**	**NO**	**Not known**	
c. Finance/fees officers	**YES**	**NO**	**Not known**	
d. Nursing management	**YES**	**NO**	**Not known**	
e. Clinical management	**YES**	**NO**	**Not known**	
f. Other groups. Please specify.	**YES**	**NO**	**Not known**	

10 Which are the CHIS support and maintenance resources available to the hospital – from hospital resources?	
11 Which are the CHIS support and maintenance resources available to the hospital – from resources external to the hospital?	

12 Are there hospital meetings at which the CHIS functioning and use is discussed? Please specify.	**YES**	**NO**	**Not known**			
13 here is sufficient knowledge of the CHIS among hospital personnel to enable the hospital to use the CHIS effectively. Please comment.	Strong-ly agree	Agree	No opinion (neu-tral)	Dis-agree	Strong-ly dis-agree	No com ment

14 Overall comments	

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ANNEXURE I

Health Informatics R&D Co-Ordination Division

FACTORS ASSOCIATED WITH THE SUCCESSFUL IMPLEMENTATION OF COMPUTERISED HOSPITAL INFORMATION SYSTEMS (CHISs)

Survey of District and Regional hospitals

Interview date: ___________________

Respondent role in hospital	Hospital manager / member of hospital management team	
	Supervisor of CHIS users / CHIS user e.g. Head: Fees Office / Head: Admissions	
	Case manager	
	Information officer / statistics clerk / other information management role	

Name of the CHIS which supports patient activities in the hospital.	

COMMENTS/NOTES

System performance					
1. Do you use the CHIS directly?	**YES**	**NO**	no comment		
2. Is the CHIS easy to use?	**YES**	**NO**	no comment		
3. Are CHIS response times acceptable?	**YES**	**NO**	no comment		
4. What is your estimate of CHIS availability?	**50%**	**75%**	**90%**	**100%**	**No comment**
5. Is CHIS availability acceptable?	**YES**	**NO**	No comment		

User training						
6 Users at this hospital are adequately trained to use the CHIS.	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
7 I have been adequately trained to use the CHIS.	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
8 Describe the training on the use of the CHIS which						

you have received.	

COMMENTS/NOTES

System outputs						
9 Do you use reports from the CHIS?	**YES**	**NO**	No comment			
10 I do not know which reports are available from the CHIS	Strongly agree	Agree	No opinion (neu-tral)	Dis-agree	Strongly dis-agree	No com-ment
11 Available CHIS reports do not meet needs	Strongly agree	Agree	No opinion (neu-tral)	Dis-agree	Strongly dis-agree	No com-ment
12 Data in CHIS reports are inaccurate	Strongly agree	Agree	No opinion (neu-tral)	Dis-agree	Strongly dis-agree	No com-ment
13 Data in CHIS reports are incomplete	Strongly agree	Agree	No opinion (neu-tral)	Dis-agree	Strongly dis-agree	No com-ment
14 Describe reports which you would like to receive, from the CHIS but do not receive at present.						
15 Have you requested the developers of the information system / the providers of the information to provide any of these reports?	**YES**	**NO**	No comment			
a. If you have requested additional reports, please give details.						
16 Is the CHIS midnight state report (daily patient report) used by hospital management?	**YES**	**NO**	No comment			
a. Describe how the CHIS midnight state report is used by hospital management.						
b. If the CHIS midnight state report is NOT used by hospital management, please indicate the reason/s.						
17 Is there another (non-CHIS) daily patient report (e.g. a nursing management report) which is used by hospital management?	**YES**	**NO**	No comment			
a. Describe how the non-CHIS daily patient report is used by hospital management.						
18 Are there other functions of the CHIS which are not being used in this hospital?	**YES**	**NO**	No comment			
a. Please indicate the functions, and the reasons for their not being used.						

CHIS support	
19 If you need assistance with or advice on the CHIS, which member of the hospital staff do you contact? Indicate the professional role of the person in the hospital, e.g. nurse manager, information officer, etc.	
20 If you need assistance with or advice on the CHIS, who do you contact OUTSIDE the hospital?	
21 If you need assistance with or advice on the CHIS AFTER HOURS OR DURING WEEKENDS OR HOLIDAYS, who do you contact?	

COMMENTS/NOTES

ICD-10 coding				
22 Does ICD-10 coding take place at the hospital?	**YES**	**NO**	No comment	
23 For which patients is ICD-10 coding completed?				
a. Medical aid patients and other private patients	**YES**	**NO**	No comment	
b. All patients for whom an account is raised, i.e. all patients who pay for treatment	**YES**	**NO**	No comment	
c. All inpatients for whom an account is raised, i.e. all inpatients who pay for treatment	**YES**	**NO**	No comment	
d. All patients.	**YES**	**NO**	No comment	
24 Who does the ICD-10 coding at this hospital?				

User opinion of the CHIS						
25 What do you like about the CHIS?						
26 What do you dislike about the CHIS?						
27 How does the CHIS facilitate your job?						
28 How does the CHIS complicate your job?						
29 Overall, in terms of my job, the CHIS is a success	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
a. Can you give reasons for this assessment?						

Your opinion of hospital management attitude to CHIS						
30. The hospital management regards the CHIS as a useful management tool	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
31. The hospital management uses the CHIS effectively	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
32. The hospital management is committed to the success of the CHIS	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment

Factors associated with CHIS success						
The following factors contribute to CHIS success in my hospital						
33. Knowledge and understanding of CHIS	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
34. Appropriateness of CHIS design for the environment in which it is being implemented.	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
35. CHIS performance	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
36. Availability of the resources required to run the CHIS (people, equipment, consumables, etc)	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
37. User perception that the CHIS is useful	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
38. Hospital management commitment to ensuring CHIS success	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
39. Effective use of CHIS and/or CHIS outputs.	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment

Factors associated with lack of CHIS success						
The following factors are associated with lack of CHIS success in my hospital.						
40. Lack of Knowledge and understanding of CHIS	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
41. Inappropriate CHIS design for the environment in which it is being implemented.	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
42. Poor CHIS performance	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
43. Lack of the resources required to run the CHIS (people, equipment, consumables, etc)	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
44. User perception that the CHIS is not useful	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
45. Lack of Hospital management commitment to ensuring CHIS success	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment
46. Ineffective use of CHIS and/or CHIS outputs.	Strongly agree	Agree	No opinion (neutral)	Dis-agree	Strongly dis-agree	No com-ment

Overall comments	
47.	
48.	
49.	
50.	

Thank you for your contribution to this study

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ANNEXURE J

DATA COLLECTION FOR PROVINCE 1 AND PROVINCE 2

A summary of the data collection process is given in Section 6.2.6. An overview of the timeframes for the data collection process is given in Table J.1.

(a) Data collection: Province 1

The case study hospitals (H1 to H4) included three level 2 hospitals, and one level 2 specialist hospital (H3). All the case study hospitals were using SystemA at the time of the studies. One of the case study hospitals (H1) has since been reclassified as a level 1 hospital and has implemented SystemB. For the purpose of this study, hospital H1 will continue to be considered as a level 2 hospital using the SystemA, since this was its status at the time of the case study.

In consultation with the project biostatistician, it was decided that the case study hospitals would not be included in the survey, since the data from the survey questionnaires would reflect a subset of the data gathered during the case studies. Inclusion of the case study hospitals in the survey would therefore have resulted in a duplication of data for the case study hospitals.

All the level 2 hospitals in province 1 were either surveyed or included in the case studies, so the sample of level 2 hospitals for Province 1 was complete. No member of the senior management team at hospital S8 was interviewed. The medical superintendent at hospital S7 was among the interviewees, and a member of the senior management team (the head of administration) at hospital S6 was interviewed. Since the medical superintendents were among the interviewees at all the case study hospitals, input from members of the senior management team were obtained from most of the level 2 study hospitals in province 1.

Three hospitals previously classified as level 2 hospitals have been reclassified as level 1 hospitals: case study hospital H1, and hospitals D23 and D24 in the survey. At both the surveyed hospitals in this category (D23 and D24), hospitals were visited and group interviews were held with representatives of various categories of staff as identified in the survey protocol. Members of the senior management team were not included in the group of interviewees at either hospital. As indicated above, the case study hospital H1 was regarded as a level 2 hospital for the purpose of this study.

According to the provincial officer responsible for the rollout of SystemB in province 1, there were a total of six level 1 (district) hospitals using this CHIS (interview P3). All the other level 1 (district) hospitals in province 1 were still using SystemA at the time of the survey. One of the six level 1 hospitals using

SystemA was the case study hospital (H1) as described above. Four of the remaining five level 1 (district) hospitals using SystemB were included in the survey (hospitals D5, D6, D17 and D23). Despite numerous follow-ups, it was not possible to arrange interviews or obtain completed questionnaires for hospital D22. Thus, survey data was obtained for four of the six level 1 hospitals using SystemB at the time of the survey.

There were three level 2 and 23 level 1 hospitals in the target group for the survey in Province 1. Attempts were made to survey as many of the level 1 hospitals in Province 1 as possible, including hospitals in each of the health districts in the Province. Where it was not possible to arrange interviews, hospital contacts were requested to arrange for self-completed questionnaires to be returned to the researcher. The pool of data obtained through the survey was representative enough of the hospitals in Province 1 using either SystemA or System B, since it included all the hospitals in some of the subsets across the province, as described, and 78% of the largest subset: level 1 hospitals using SystemA. A summary of the data collected from the study hospitals in Province 1 is given in Tables J.1 and J.4.

Hospital category	**Number of hospitals with CHIS**	**Number of hospitals for which data are available**	**% hospitals with data**	**Notes**
Level 1 hospitals in survey using SystemA	18	14	78%	
Level 1 hospitals in survey using SystemB	5	4		No data from survey for hospital D22. Hospital D25 (hospital H1 in case studies) was not included in the survey.
Total level 1 hospitals in survey	23	18	78%	
Level 2 hospitals in survey using SystemA	1	1		Hospital S6
Level 2 hospitals in survey using SystemB	2	2		Hospitals S7 and S8
Total level 2 hospitals in province	5	5		Two level 2 hospitals were included in the case studies: hospital S1 (H2 in case studies) and hospital S2 (H4 in case studies)). Case study hospital H1 was a level 2 hospital at the time of the case study, but had since been reclassified as a level 1 hospital (hospital D25). The fourth case study hospital (H3) is a specialist level 2 hospital.
Total level 2 hospitals in survey	3	3	100%	
Total hospitals in survey	26	21	81%	

Table J.1 Data collection for Province 1 - summary

(b) Data collection: Province 2

Permission to conduct the survey in province 2 was received from the province (HOD: Health and Social Development) in January 2008, based on a letter dated December 2007. Initial site visits and limited data collection took place between 25 and 28 February 2008. Follow up of contacts at the initial 7 hospitals visited commenced in July 2008, and contacts with the remaining level 1 and level 2 hospitals were established during August and September 2008. Although the aim had been to complete all data collection before the end of August 2008, this was not possible, and most data collection for province 2 only took place during September and early October 2008.

The preferred method of data collection for this survey was through in-person or telephone interview, with a researcher recording interviewee responses on the standard questionnaires. However, due to the difficulty experienced with scheduling interviews, it was decided to request respondents to self-complete questionnaires and return them to the researcher. This decision was taken in consultation with the thesis supervisors, in view of severe time constraints, and based on the availability of a strong sample of responses for province 1 (as described in the previous section).

(i) Province 2 site visits, February 2008

The author conducted visits to hospitals in four of the five regions in the Province. In two of the regions, visits to one provincial (level 2) and one district hospital were arranged. In total, visits of varying length were paid to 2 level 2 and 5 level 1 hospitals (see Table J.5). A visit to an eighth hospital (a second hospital in district A) had been planned, but could not be undertaken due to lack of time.

A formal letter requesting permission to conduct interviews for the survey, with an outline of the survey questions and a copy of the letter of permission from the HOD, was provided to the head of six of the hospitals at the commencement of the visit. (This documentation was forwarded to the seventh hospital following the visit.)

Short informal discussions were held with available personnel, including the CEO or acting CEO of three of the hospitals visited, and with one member of the provincial head office staff responsible for district hospitals who accompanied the author on some hospital visits. Discussions and written communications with a senior manager responsible for district hospitals in preparation for and during this visit provided essential background information from a provincial perspective (interview P1). Information management personnel at four of the hospitals (three level 1 and one level 2) were interviewed to obtain an overview of the CHIS implementations in their institutions. These interviews, and additional discussions at the hospitals, provided a valuable overview of the CHIS implementations in the province. Notes were taken by the author on the formal and informal discussions, and were incorporated in the standard questionnaire formats (hospital questionnaire and user questionnaire) as far as possible.

At all hospitals visited, contact details were obtained for potential interviewees, to facilitate arrangements for future interviews by telephone. In general, hospital telephone and private cellphone numbers were obtained. Where available, email addresses and fax numbers for potential interviewees were also obtained.

The data collection during the initial site visits in February 2008 yielded 3 completed questionnaires (2 hospital questionnaires (hospitals C2 and C3) and 1 user questionnaire (hospital C7)), and notes on meetings and discussions from three hospitals (C2, C6 and C7). Visits to the other three hospitals (C1, C4 and C5) were short, and therefore provided only limited information.

(ii) Province 2 data collection July – October 2008

The data collection during the second phase of data collection was very varied, including a telephone interview with a group of senior managers from hospital C3 (including the information managers interviewed during the initial site visit to this hospital); telephone interviews with two staff members from hospital C21; a set of 12 self-completed questionnaires from one hospital (hospital C27); and 12 self-completed questionnaires from eight other hospitals (see Table J.5). Great difficulty was experienced in scheduling telephone discussions with staff members, and interviews with the staff members from hospital C21 were scheduled after hours because no time could be found during their working days.

During this second phase of data collection, further data could be collected from only four of the seven hospitals visited during February 2008. The pool of data available for hospital C3, one of the two level 2 hospitals in this group, was strengthened during the second phase of data collection by a comprehensive group interview with senior hospital managers.
Thus, following the two phases of data collection in Province 2, varying amounts of data were available for 13 of the 33 level 1 and level 2 hospitals in the province using the SystemC CHIS, including only two of the five level 2 hospitals in the province. The data included a combination of completed questionnaires and notes on interviews and discussions, as described in Table J.5.

(iii) Province 2 data set

As summarised in Table J.2, completed user questionnaires were obtained from 24 respondents at 9 hospitals in Province 2. 12 of the questionnaires were received from one level 1 hospital (C27). All but three of the user questionnaires were self-completed. Hospital questionnaires for two hospitals were completed on the basis of interviews during site visits to hospitals C3 (level 2) and C2 (level 1) in February 2008. Both hospital C3 and hospital C2 are in region B of Province 2. These data were incorporated in the qualitative descriptions of the CHIS in use at these hospitals.

For consistency with the description of results and data analysis for Province 1, the available questionnaire data from Province 2 are analysed similarly to the Province 1 data as far as possible. In addition to this approach, data from two of the hospitals C21 and C27) are combined in 'mini cases' in order to make the best possible use of the data collected.

Hospital category	**Number of hospitals**	**Number of hospitals for which data are available**	**Number of hospitals for which user question-naires are available**	**Number of hospitals for which interview data are available**	**Number of hospitals used as mini cases**
Level 2 hospitals using SystemC	5	2	1	1	1
Level 1 hospitals using SystemC	28	11	8	4	5
Total level 1 and level 2 hospitals using SystemC	33	13 (40%)	9 (27%)	5 (15%)	6 (18%)

Table J.2 Data collection for Province 2 - summary

January 2008	permission received for survey from Province 2		
February 2008	Preparation for initial site visits with provincial colleagues	Initial visits and data collection in 7 hospitals in Province 2	
March 2008			Initial analysis of data from initial data collection in Province 2
April 2008			
May 2008	Permission received for survey from Province 1		
	Letters to hospital- and region-level contacts in Province 2		
	Following up contacts, obtaining hospital-level contacts (where these were not provided) – in Province 1	Interviews with two provincial-level experts involved in the implementation of the CHISs in Province 1	
June 2008	Further establishment of contacts in Province 1	Telephone interviews by two interviewers (author and one other) in hospitals in Province 1	
	Setting up of interviews in Province 1	In person interviews by author in hospitals in Province 1 (individual interviews; group interviews in two hospitals)	
		Self completion of questionnaires by respondents from hospitals in Province 1	
July 2008	Setting up of interviews continues in Province 1	Telephone interviews by two interviewers (author and one other) in hospitals in Province 1	
		Self completion of questionnaires by respondents from hospitals in Province 1	Initial analysis of available data from Province 1
	Followup of contacts at 7 hospitals in Province 2 previously visited: letters to hospitals, and contacts with interviewees previously identified		
	Setting up of interviews in initial group of 7 hospitals in Province 2		
	Establishment of hospital-level contacts for remaining level 1 and level 2 hospitals in Province 2		
August 2008	Setting up of final interviews in level 1 and level 2 hospitals in Province 1	Telephone interviews in hospitals in Province 1	**Initial data entry and data analysis for available data from Province 1 survey**
	Setting up of interviews in initial 7 hospitals in Province 2 continues	Telephone interview in initial 1 hospital in Povince 2	**Initial analysis of available data from Province 2**
	Setting up of interviews in remaining hospitals in Province 2		
September and October 2008	Setting up of interviews in remaining hospitals in Province 2	Telephone interviews in remaining hospitals in Province 2	**Data entry and data analysis for data from Province 1 and Province 2 surveys**

Table J.3 Overview of data collection process for survey of hospitals

HOSPITAL	HOSP CODE	HOSP TYPE	CHIS	Hosp QQ	Ma n	IO	Fees	Admit	Admin	Case man.	Group	Inter-view	Total user QQ	NOTES
1	D24	1	A	1							1		1	
2	S6	2	A	1	1	1	1	1		1			5	CEO interview
3	S7	2	B	1	1	1							2	
4	S8	2	B	1		1	1	1					3	
5	D5	1	B	1	1	1			1	1			4	CEO interview
6	D6	1	B	1		1			1	1			3	
7	D22	1	A										--	No response
8	D23	1	B	1							1	*	1	
9	D7	1	A	1		1			1				2	
10	D2	1	A										--	Nil return
11	D3	1	A				1						1	
12	D16	1	A	1	1	1							2	Joint CEO and IO with D11
13	D11	1	A	1	2	1							3	CEO and nurse manager
14	D19	1	A	1	1	1							2	Joint IO with D13
15	D13	1	A	1	1	1		1		1			4	
16	D17	1	A	1		1	1						2	
17	D10	1	A			1							1	
18	D20	1	A										--	No response
19	D4	1	A					1					1	
20	D21	1	A					1					1	
21	D1	1	A		1								1	
22	D8	1	A	1	1		1						2	CEO interview
23	D12	1	A										--	No response
24	D9	1	A	1	1	1			1	1			4	
25	D14	1	A	1		1			1	1			3	
26	D15	1	A										--	No response
TOTALS	**26**			**16**	**11**	**14**	**5**	**5**	**5**	**6**	**2**		**48**	**TOTALS**

Table J.4 Data collection for Province 1 by hospital

	Hosp code	Hosp type	Re-gion code	Hos-pital QQ	Man	IM	IO	Fi-nance	Ad mit	**Not known**	Inter-view	Total user QQ	NOTES February 2008	NOTES June – October 2008
1	C3	2	B	**1**							**		Joint interview with Manager: IRM and DM: IRM.	Senior management group interview 2IM 4Man; notes and recording
2	C4	2	C			1						1	Short discussion with Manager: IRM.	1 self-completed qq
3	C1	1	A								*		Short discussions with acting CEO, Deputy Manager: Information and Records Management (IRM), information officer, and Head: Patient admin.	***No further data***
4	C2	1	B	**1**		1					*	1	Short discussion with CEO. Group discussion with Acting DM:IRM, system administrator and representatives of CHIS supplier. Interview with Acting DM:IRM.	1 self-completed qq
5	C5	1	C										No interviews, since personnel were not available. Short visit to OPD reception with head: admissions.	***No further data***
6	C6	1	D								*		Joint discussion with Manager: Corporate, Head: Patient Admin, Information officer, ?deputy manager: IRM, head: OPD reception, ?? Visit to OPD and emergency reception areas with head of OPD reception and Head: Patient admin.	***No further data***
7	C7	1	D				1				*	1	Joint discussion with OPD supervisor and IO; Interview with system administrator (experience of all three CHIS implementations). No DM:IRM at present.	***No further data***
8	C8	1	A			1				1		2	--	2 self-completed qq
9	C14	1	B			1						1	--	1 self-completed qq
10	C18	1	E			1	1					2	--	2 self-completed qq
11	C21	1	E					1	1			2	--	2 interviews
12	C24	1	D		1			1				2	--	2 self-completed qq
13	C27	1	D			1		2		9*		12	***Included clinical personnel at this hospital.**	12 self-completed qq
To-tals	***13***			***2***	***1***	***6***	***2***	***4***	***1***	***10***		***12 +12***		

Table J.5 Data collection for Province 2 by hospital

ANNEXURE K

STATISTICAL ANALYSIS: MEASURABILITY AND MEASURES

Identification of selected variables related to factors in the extended conceptual model of CHIS use

(a) Knowledge and understanding of CHIS

Two sub-factors of this conceptual model factor were defined in order to highlight different aspects of this factor reflected in the survey data: user training ('training') and data quality ('quality of data in the CHIS').

User responses to three statements were considered:
- 'training' - Users at this hospital are adequately trained to use the CHIS (question 6)
- 'inaccurate?' – Data in CHIS reports are inaccurate (question 12)
- 'incomplete?' – Data in CHIS reports are incomplete (question 13).

The results of the cross correlation are shown in Table K.1.

There was a strong correlation between the variables 'inaccurate?' and 'incomplete? indicating that one or the other could be used to represent the conceptual model sub-factor 'quality of data in the CHIS'. The correlation between 'training' and 'incomplete?' was not statistically significant. The correlation between 'training' and 'inaccurate' was statistically significant at the 0.05 level.

It was decided to use the variable 'training' to represent the conceptual model sub-factor 'training'. Question 7 in the user questionnaire related to the adequacy of training of the respondent. Since the issue of interest in this analysis was to obtain a hospital-level understanding, the more general variable was used.
The variable 'incomplete?' was used to represent the sub-factor 'quality of data in the CHIS'. The two variables could be used in this way, due to the weak correlation between them.

		training	inaccurate?	incomplete?
training	Pearson Correlation	1	-.298(*)	-.178
	Sig. (2-tailed)		.035	.210
	N	57	50	51
inaccurate?	Pearson Correlation	-.298(*)	1	.579(**)
	Sig. (2-tailed)	.035		.000
	N	50	54	53
incomplete?	Pearson Correlation	-.178	.579(**)	1
	Sig. (2-tailed)	.210	.000	
	N	51	53	58

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table K.1 Variables related to 'knowledge and understanding' (Provinces 1 and 2 users)

(b) Appropriateness of CHIS design

User responses to three questions/statements in the user questionnaire were considered:

- 'ease of use' - Is the CHIS easy to use? (question 2)
- 'rep not appr' - Available reports do not meet needs (question 11)
- 'midnight stt' - Is the CHIS midnight state report routinely used by hospital management? (question 16).

The results of the cross correlation are shown in table K.2.

All these questions relate to the sub-factor 'fit' for this conceptual model factor, relating to the fit between user requirements and CHIS functions. The other sub-factor for this factor is 'functionality', relating to the scope of the CHIS and the functions available to users. Numerical data related to this sub-factor were not collected at user level.

The bivariate cross correlations among the three variables reflected a significant correlation at the 0.05 level between 'ease of use' and 'report not appr'. Since the emphasis in the questionnaire was on obtaining data related to the conceptual model factor 'effective use of CHIS and/or outputs', it was decided to use the factor 'report not appr' as a reflection of the extent of match between user expectations in terms of CHIS outputs and the outputs available to them from the CHIS. The (non-significant) correlation between 'ease of use' and 'midnight stt' was not taken into account, since in practice ease of use of the CHIS and routine use of the midnight state report by hospital management are not related issues.

The midnight state report is a standard hospital management report reflecting the number of people in hospital at midnight, and the movements of patients into and out of the hospital during the previous 24 hours. The responses to the question about management use of the CHIS midnight state report on a daily basis should reflect the extent to which these data in the CHIS are trusted by hospital management as input to daily hospital planning. The responses to this question, and related questions in the questionnaire, were discussed separately.

		ease of use	rep not appr	midnight stt
ease of use	Pearson Correlation	1	-.331(*)	.293
	Sig. (2-tailed)		.019	.054
	N	56	50	44
rep not appr	Pearson Correlation	-.331(*)	1	-.144
	Sig. (2-tailed)	.019		.330
	N	50	56	48
midnight stt	Pearson Correlation	.293	-.144	1
	Sig. (2-tailed)	.054	.330	
	N	44	48	54

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

Table K.2 Variables related to 'appropriateness of CHIS design' (Provinces 1 and 2 users)

(c) Performance of CHIS

Data collected about system availability (questions 4 and 4a, and question 5) were converted to the variable 'availability factor', as described in Section 6.3.2. The other variable related to CHIS performance is 'response?', the answer to question 3 'Are system response times acceptable?' The correlation between these variables was significant at the 0.05 level, as shown in table K.3.

The variable 'availability factor' was chosen as a proxy for 'performance of CHIS' because it was based on user estimates of actual CHIS availability, rather than on opinions of acceptability of performance, and was therefore deemed to be the stronger indicator of CHIS performance.

		response?	availability factor
response?	Pearson Correlation	1	.353(*)
	Sig. (2-tailed)		.015
	N	54	47
availability factor	Pearson Correlation	.353(*)	1
	Sig. (2-tailed)	.015	
	N	47	49

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

Table K.3 Variables related to 'Performance of CHIS' (Provinces 1 and 2 users)

(d) Resource availability and allocation

Questions in the user questionnaire related to resource availability addressed two issues: ICD-10 coding of patient diagnoses (questions 22, 23a to 23d, and 24), and resources available for end user support, both within and beyond the hospitals (questions 19, 20 and 21 in the user questionnaire; questions 10 and 11 in the hospital questionnaire).

The data related to end user support described the categories of staff or other resources (such as call centres) available to users, and were therefore not amenable to statistical analysis.
For ICD-10 coding, the variable 23d ('all patients') is the variable which reflects whether or not ICD-10 coding was done for all hospital patients. This variable was therefore used to reflect the resource availability for ICD-10 coding at the hospitals. Data were also obtained on which staff members were responsible for ICD-10 coding, but these data were not analysed statistically.

Therefore, the variable in the statistical analyses related to 'resource availability and allocation' is
- 'all patients' for the question 'Is ICD-10 coding carried out for all patients?'

ANNEXURE L

OVERVIEW OF CHIS IMPLEMENTATIONS

(a) Comparison between provinces in relation to extended conceptual model

factor	Province 1 SystemA	Province 1 SystemB	Province 2 SystemC
Supplier knowledge and understanding (P)	*local supplier with extensive local knowledge	*external supplier, with local partner * implementation driven by provincial personnel; with supplier personnel	*external supplier; previously supplied this Province and a second Province *same supplier as in Province 1 supplied previous CHIS. *supplier personnel providing hospital support - there are provincial and supplier personnel involved in the implementation process. *overall, users in Province 2 report that current system does not meet requirements as well as previous system did.
Hospital knowledge and understanding of CHIS	**concerns about management understanding of CHIS functionality **reception/admission supervisors have good knowledge of CHIS **end users adequately trained	*management interviewed understand functionality *end users adequately trained; training limited	**limited end user training; some users had experience of previous CHIS * C3 management involvement with CHIS varied (from interview).
Software fit with user requirements (P)	**limited scope **good fit	*same scope currently as SystemA; more widely implemented in hospitals – terminals in wards and in OPD treatment areas; therefore accessible to clinical staff, including PAMs *reported good fit *billing module from a separate supplier integrated with ADT module **one respondent (hospital S7, I1) was involved in scoping of CHIS for implementation in level 1 and level 2 hospitals	**overall, users in Province 2 report that current system does not meet requirements as well as previous system did. **limited scope; implementation of further modules planned.
Appropriateness of design (H)	**system reportedly easy to use **provides good support to administrative functions at admission, including billing **??	*design reportedly appropriate *separate billing module; due for replacement by another separate billing module **pharmacy module still being linked **concern expressed by some users about menu updating/ customisation for local environment	**concern expressed by some users that system has not been adequately tailored to local needs (e.g. explanation for billing category; menu of services does not reflect situation at hospital; no label printing at one hospital – also other hospitals in another region of the Province **concern re. poor fit/errors in billing module, especially C21

factor	Province 1 SystemA	Province 1 SystemB	Province 2 SystemC
Resource availability (P)	**Limited HR: - no IM personnel on organogram in case study hospitals; - IO on organogram in survey hospitals - Case managers or case manager function in most hospitals - software and hardware support only during office hours; limited personnel; some hospital staff make direct contact with supplier personnel.	*IO on organogram; IO in 'system controller' role *Admin, fees and nursing reps seconded to implementation team. -*software and hardware support only during office hours; limited personnel - case managers or case manager function at most hospitals	**Extensive HR: IM and IS personnel on organogram at each hospital; Supplier personnel in transition period: hospital- and district-based Expressed need for ward clerks in each ward; shared between wards at present **?? all required equipment. **Call centre: ??24/7 operation/availability **no case managers at survey hospitals
Hospital resource availability and allocation - people - support structures - infrastructure	**information manager at one hospital **information clerk at two hospitals **hospital manager also had responsibility for IM at one hospital **case manager at three hospitals **IN SURVEY - some IOs effectively on call out of hours - additional hospital resource allocation not clear	- some IOs effectively on call out of hours - additional hospital resource allocation not clear	**additional hospital resource allocation not clear; **acting system administrators at two hospitals; **IS positions unfilled at some (?all) hospitals * problem with reporting lines for system administrator at one of the hospitals
Organisational and contractual mechanisms (P)	- no detail on service level agreement obtained **Some hospital staff contact call centre people/consultants directly	- no detail on service level agreement obtained - Should take maximum 48 hours for response to call from call centre - Some hospital staff contact call centre people/consultants directly	**SLA reported to be in place - one report that turnaround times on call centre reports and requests for changes are not being met; general concern about call centre availability out of office hours.
Performance (H)	**Generally good performance with high reliability and availability **electricity supply problems do have an effect – not all servers and other equipment on emergency power. **85% availability estimate at D23	**reported good CHIS performance; there are network problems which do affect performance at times; sometimes reported as being linked to electricity supply problems (rather than other causes)	**concerns about performance expressed in several interviews (incl estimates of 85% and 65% availability) - hospital C3 management reported improved performance in interview.
Perception of usefulness (H)	**variable opinions, depending on respondent and hospital	**variable opinions	**perception of usefulness negatively influenced by performance limitations -- generally poor (February 2008)
Management commitment to CHIS success (H)	**variable, according to survey data	**variable, according to survey data	**variable, according to survey data 'perception of management commitment to CHIS success'

factor	Province 1 SystemA	Province 1 SystemB	Province 2 SystemC
Effective use of CHIS and/or outputs (H)	**Standard reports used in conjunction with other reports; midnight state not used; **CHIS reports not generally used directly by hospital management	**there is use of reports by management **management generally do not check CHIS themselves * midnight state not used for daily management decision making.	**indications that reports do not currently meet needs in terms of format (fields), and content (data completeness and reliability) *Provincial manager in Province 2 indicates that current reports are of limited value (February 2008)

(b) Case A (Hospital C21) Billing module concerns

The author conducted survey interviews with two respondents at hospital C21 during September 2008: a senior state accountant, who was in charge of revenue collection for the hospital (interview I2) and the supervisor of CHIS users in the outpatients department (OPD) (interview I1). Both interviewees expressed concerns about inaccuracies and difficulties being experienced with the SystemC billing module, which had been implemented at the hospital during the second half of 2007 ('after July 2007' interview I2) - approximately one year prior to the interview.

Although overall the OPD supervisor rated the CHIS a success in terms of his job ('agree' – question 29 of the user questionnaire), he highlighted several problems which he had experienced related to billing (interview I1):

- The billing component of the CHIS was 'a bit difficult sometimes' (ease of use - question 2 of the user questionnaire);
- He was not able to gain access to revenue reports (system outputs - question 14 of the user questionnaire);
- Patient classifications for non-paying patients were not specific enough: he needed to be able to identify maternity patients separately;
- He was not able to view the whole account for patients who had both inpatient and outpatient components of their accounts: the inpatient component of the account had to be accessed via the record of the inpatient hospital stay, and the outpatient component of the account had to be accessed via the outpatient record.

While other interviewees had also noted some concerns about the billing component of the CHIS, the second interview at this hospital was focussed on this issue (hospital I21, interview I2).
Among the problems highlighted by this interviewee were the following:

- Problems with reconciling patient accounts, and hence reconciling accounts at hospital level, because of incorrect rounding: medical aid accounts were being rounded to the nearest rand, while accounts for public patients sometimes included additional cents (e.g. a patient being billed R85,01, when the rate should have been R85,00). The requirement is for medical aid accounts to be accurate to the last cent to enable reconciliation.
- Categories of patients (e.g. medical aid, private) reflected incorrectly on a report.
- Inability to reprint a bill without authorisation.
- Inability to modify patient classification with supervisor authorisation.

The interviewee reported that problems had been reported; some had been fixed after ‘a long time’; but problems had come back after a time.

Despite these reported difficulties, this interviewee indicated that the CHIS did simplify his work. Overall, he remained ‘neutral’ on the success of the CHIS for his work (question 29).

(c) Case B – Hospital C27 Multiple user responses

A range of users provided self-completed user questionnaires for this level 1 hospital in region D of Province 2. Respondents included in hospital Information Manager and two users from the finance department, a user from the outpatients department (OPD), but also users from clinical departments such as occupational therapy, dentistry and surgery.

Two of the twelve respondents effectively provided nil returns, with neutral or no responses to all the questions in their questionnaires. A further two respondents provided specific responses to only a few questions.

For the questions related to perceptions of success of the CHIS in use; and perceptions of management commitment to and use of the CHIS (questions 29 to 32 in the user questionnaire), only between two and four of the twelve respondents provided non-neutral responses. These respondents included the information manager, who is not a direct user of the CHIS.

Six of the twelve respondents provided input on the questions related to the factors in the conceptual model but two of the six (from the finance department) only provided neutral or no comments.

The limited number of non-zero or non-neutral responses to questions related to user perceptions, and user understanding of factors associated with CHIS success could be a reflection of difficulties with interpreting the questions, as also experienced in some of the user interviews.

Overall, for the SystemC users in Province 2, there was a high number of non-responses for the questions related to the association of the conceptual model factors with CHIS success (between nine and twelve of the 24 user questionnaires for Province 2), which could reflect similar problems.

Notably, only one of the hospital C27 respondents, the information manager, regarded the CHIS as being successful (rating value = 1). Two other respondents rated the CHIS as being unsuccessful (rating values = -1 and -2), and the other respondents either provided no response (4 respondents) or a neutral response (5 respondents). Overall, for SystemC, only 6 of the 24 respondents regarded the CHIS as being successful for their work (rating value = 1). These results for hospital C27 are consistent with the results from other hospitals in Province 2.

The twelve survey responses from hospital C27 reflected a wide range of opinions, where these were given. They therefore underline the fact that user opinions could vary, depending on the actual application being used, or the user position in the hospital. The emphasis in this study has been on obtaining an overall hospital view, rather than emphasising variations within hospitals, as described previously. However, future studies which concentrate on specific groups within hospitals, such as information management personnel, hospital management, or specific group of users, could be useful, in order to better understand their specific attitudes and requirements.

From the perspective of CHIS performance at hospital C27, the respondents from finance and OPD, who would be expected to use the CHIS to support the major components of their work, reported 50% system availability, which is very low (classified as 'unacceptable' for this study). Such low CHIS availability could be expected to have a direct negative effect on these users' ability to undertake their required work functions. Two of these users indicated that system availability was unacceptable (rating value = 0), while the third did not comment. Unfortunately, none of these respondents provided any opinion about the success of the CHIS for their work.

ANNEXURE M

QUANTITATIVE ANALYSES:

DATA RELATED TO FACTORS ASSOCIATED WITH CHIS SUCCESS AND LACK OF CHIS SUCCESS

CHIS ID	-2	-1	0	1	2	9	TOTAL
knowledge							
SystemA			2	11	13	7	33
SystemB		1		7	7		15
SystemC			6	5	5	8	24
Total		1	8	23	25	15	72
design							
SystemA		1	2	14	10	6	33
SystemB		2		9	4		15
SystemC			4	7	2	11	24
Total		3	6	30	16	17	72
performance							
SystemA			1	15	11	6	33
SystemB			2	11	2		15
SystemC			5	8	2	9	24
Total			8	34	15	15	72
resources							
SystemA			2	18	7	6	33
SystemB	1	2		8	4		15
SystemC		2	5	5	3	9	24
Total	1	4	7	31	14	15	72
usefulness							
SystemA			4	10	13	6	33
SystemB			1	9	5		15
SystemC			3	10	2	9	24
Total			8	29	20	15	72
commitment							
SystemA		1	2	9	15	6	33
SystemB		2	3	6	4		15
SystemC			3	6	5	10	24
Total		3	8	21	24	16	72
use effectively							
SystemA			2	12	13	6	33
SystemB			1	9	5		15
SystemC			3	7	3	11	24
Total			6	28	21	17	72

Table M.1 weighting of factors associated with CHIS success – all users all hospitals – per CHIS

		Know-ledge	design	Perfor-mance	Re-sources	Useful-ness	Commit-ment	use effect-tively
knowledge	Pearson Correlation	1	.393(**)	.472(**)	.416(**)	.438(**)	.321(*)	.495(**)
	Sig. (2-tailed)		.003	.000	.001	.001	.016	.000
	N	58	55	57	57	57	56	55
design	Pearson Correlation	.393(**)	1	.754(**)	.627(**)	.671(**)	.638(**)	.645(**)
	Sig. (2-tailed)	.003		.000	.000	.000	.000	.000
	N	55	55	55	55	55	54	54
Perfor-mance	Pearson Correlation	.472(**)	.754(**)	1	.635(**)	.722(**)	.645(**)	.687(**)
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
	N	57	55	57	56	56	55	54
resources	Pearson Correlation	.416(**)	.627(**)	.635(**)	1	.493(**)	.640(**)	.712(**)
	Sig. (2-tailed)	.001	.000	.000		.000	.000	.000
	N	57	55	56	57	56	55	55
usefulness	Pearson Correlation	.438(**)	.671(**)	.722(**)	.493(**)	1	.681(**)	.694(**)
	Sig. (2-tailed)	.001	.000	.000	.000		.000	.000
	N	57	55	56	56	57	56	55
Commit-ment	Pearson Correlation	.321(*)	.638(**)	.645(**)	.640(**)	.681(**)	1	.685(**)
	Sig. (2-tailed)	.016	.000	.000	.000	.000		.000
	N	56	54	55	55	56	56	54
use effectively	Pearson Correlation	.495(**)	.645(**)	.687(**)	.712(**)	.694(**)	.685(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	55	54	54	55	55	54	55

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table M.2 Correlations: CHIS use model factors (Provinces 1 and 2)

		Know-ledge	design	Perfor-mance	Re-sources	Useful-ness	Commit-ment	use effec-tively
knowledge	Pearson Correlation	1	.596(*)	.296	.662(**)	.659(**)	.504(*)	.847(**)
	Sig. (2-tailed)		.015	.265	.005	.005	.046	.000
	N	16	16	16	16	16	16	16
design	Pearson Correlation	.596(*)	1	.573(*)	.627(**)	.857(**)	.547(*)	.743(**)
	Sig. (2-tailed)	.015		.016	.007	.000	.023	.001
	N	16	17	17	17	17	17	17
performance	Pearson Correlation	.296	.573(*)	1	.281	.685(**)	.685(**)	.491(*)
	Sig. (2-tailed)	.265	.016		.274	.002	.002	.046
	N	16	17	17	17	17	17	17
resources	Pearson Correlation	.662(**)	.627(**)	.281	1	.710(**)	.537(*)	.769(**)
	Sig. (2-tailed)	.005	.007	.274		.001	.026	.000
	N	16	17	17	17	17	17	17
usefulness	Pearson Correlation	.659(**)	.857(**)	.685(**)	.710(**)	1	.734(**)	.787(**)
	Sig. (2-tailed)	.005	.000	.002	.001		.001	.000
	N	16	17	17	17	17	17	17
commitment	Pearson Correlation	.504(*)	.547(*)	.685(**)	.537(*)	.734(**)	1	.787(**)
	Sig. (2-tailed)	.046	.023	.002	.026	.001		.000
	N	16	17	17	17	17	18	17
use effectively	Pearson Correlation	.847(**)	.743(**)	.491(*)	.769(**)	.787(**)	.787(**)	1
	Sig. (2-tailed)	.000	.001	.046	.000	.000	.000	
	N	16	17	17	17	17	17	17

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table M.3 Correlations: CHIS use model factors PER HOSPITAL (Provinces 1 and 2)

CHIS ID	-2	-1	0	1	2	9	TOTAL
lack knowledge							
SystemA	2	3	4	4	6	14	33
SystemB	1	3		6	5		15
SystemC	1	1	4	3	4	11	24
TOTAL	4	7	8	13	15	25	72
lack design							
SystemA	2	5	3	2	6	15	33
SystemB	1	3	2	8	1		15
SystemC	1		3	4	4	12	24
TOTAL	4	8	8	14	11	27	72
lack performance							
SystemA	2	5	2	4	6	14	33
SystemB	1	3	1	6	4		15
SystemC	1	2	2	6	3	10	24
TOTAL	4	10	5	16	13	24	72
lack resources							
SystemA	1	6	2	4	6	14	33
SystemB	2	3	1	5	4		15
SystemC			2	8	5	9	24
TOTAL	3	9	5	17	15	23	72
lack usefulness							
SystemA	2	6	2	3	6	14	33
SystemB	1	3	1	6	4		15
SystemC	1	4	2	2	3	12	24
TOTAL	4	13	5	11	13	26	72
lack commitment							
SystemA	2	5	2	4	6	14	33
SystemB		5	1	4	5		15
SystemC	5	3	1	2	3	10	24
TOTAL	7	13	4	10	14	24	72
lack use effectively							
SystemA	1	7	2	3	6	14	33
SystemB	2	3	1	5	4		15
SystemC	1	2	2	7	2	10	24
TOTAL	4	12	5	15	12	24	72

Table M.4 - weighting of factors associated with LACK OF CHIS success – all users all hospitals – per CHIS

		lack knowledge	lack design	lack performance	lack resources	lack usefulness	lack commitment	lack use effectively
lack knowledge	Pearson Correlation	1	.820(**)	.799(**)	.605(**)	.721(**)	.619(**)	.602(**)
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
	N	47	44	47	47	45	46	46
lack design	Pearson Correlation	.820(**)	1	.821(**)	.716(**)	.705(**)	.593(**)	.638(**)
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000
	N	44	45	44	45	45	44	44
lack performance	Pearson Correlation	.799(**)	.821(**)	1	.687(**)	.751(**)	.554(**)	.568(**)
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
	N	47	44	48	48	45	46	47
lack resources	Pearson Correlation	.605(**)	.716(**)	.687(**)	1	.625(**)	.444(**)	.567(**)
	Sig. (2-tailed)	.000	.000	.000		.000	.002	.000
	N	47	45	48	49	46	47	48
lack usefulness	Pearson Correlation	.721(**)	.705(**)	.751(**)	.625(**)	1	.778(**)	.845(**)
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
	N	45	45	45	46	46	45	45
lack commitment	Pearson Correlation	.619(**)	.593(**)	.554(**)	.444(**)	.778(**)	1	.584(**)
	Sig. (2-tailed)	.000	.000	.000	.002	.000		.000
	N	46	44	46	47	45	48	47
lack use effectively	Pearson Correlation	.602(**)	.638(**)	.568(**)	.567(**)	.845(**)	.584(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	46	44	47	48	45	47	48

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

Table M.5 Correlations CHIS use model factors reversed (Provinces 1 and 2)

		lack know-ledge	lack design	lack perfor-mance	lack re-sources	lack useful-ness	lack commit-ment	lack use effec-tively
lack knowledge	Pearson Correlation	1	.425	.526	.593(*)	.569(*)	.423	.748(**)
	Sig. (2-tailed)		.168	.065	.033	.043	.150	.003
	N	13	12	13	13	13	13	13
lack design	Pearson Correlation	.425	1	.552	.801(**)	.922(**)	.911(**)	.815(**)
	Sig. (2-tailed)	.168		.063	.002	.000	.000	.001
	N	12	12	12	12	12	12	12
lack performance	Pearson Correlation	.526	.552	1	.799(**)	.582(*)	.613(*)	.417
	Sig. (2-tailed)	.065	.063		.001	.037	.026	.157
	N	13	12	13	13	13	13	13
lack resources	Pearson Correlation	.593(*)	.801(**)	.799(**)	1	.879(**)	.903(**)	.699(**)
	Sig. (2-tailed)	.033	.002	.001		.000	.000	.008
	N	13	12	13	13	13	13	13
lack usefulness	Pearson Correlation	.569(*)	.922(**)	.582(*)	.879(**)	1	.977(**)	.892(**)
	Sig. (2-tailed)	.043	.000	.037	.000		.000	.000
	N	13	12	13	13	13	13	13
lack commitment	Pearson Correlation	.423	.911(**)	.613(*)	.903(**)	.977(**)	1	.785(**)
	Sig. (2-tailed)	.150	.000	.026	.000	.000		.001
	N	13	12	13	13	13	13	13
lack use effectively	Pearson Correlation	.748(**)	.815(**)	.417	.699(**)	.892(**)	.785(**)	1
	Sig. (2-tailed)	.003	.001	.157	.008	.000	.001	
	N	13	12	13	13	13	13	15

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table M.6 Correlations: CHIS use model factors reversed (PER HOSPITAL Provinces 1 and 2)

ANNEXURE N

QUANTITATIVE ANALYSES:

PERCEPTION OF SUCCESS AND CONCEPTUAL MODEL FACTORS

(a) Cross correlations – 'successful?' and conceptual model factors - hospitals

		training	incomplete	rep_not_appr	availability_factor	all_patients	man_useful_tool	man_commit	man_use	successful
Province 1 & Province 2	Pearson Correlation	.228	-.252	-.239	.503(**)	-.399	.379(*)	-.143	.581(**)	1
	Sig. (2-tailed)	.243	.196	.221	.007	.053	.046	.468	.001	
	N	28	28	28	27	24	28	28	27	29
Province 1	Pearson Correlation	.397	.016	-.303	.030	-.081	.000	.143	.000	1
	Sig. (2-tailed)	.083	.944	.181	.901	.751	1.000	.548	1.000	
	N	20	21	21	19	18	20	20	20	21
SystemA	Pearson Correlation	.452	-.203	-.141	.051	.025	.153	.258	.270	1
	Sig. (2-tailed)	.091	.467	.617	.867	.935	.602	.373	.350	
	N	15	15	15	13	13	14	14	14	15
SystemB	Pearson Correlation	.408	.739	-.600	-.250	-.408	-.707	-.250	-.525	1
	Sig. (2-tailed)	.495	.094	.208	.633	.495	.116	.633	.285	
	N	5	6	6	6	5	6	6	6	6
SystemC	Pearson Correlation	-.277	-.841(*)	.249	.480	-.387	.587	-.404	.797(*)	1
	Sig. (2-tailed)	.506	.018	.590	.229	.448	.126	.321	.032	
	N	8	7	7	8	6	8	8	7	8

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table N.1 Correlations of 'success' and factors in the extended conceptual model of CHIS use – hospital level

(b) Cross correlations – 'successful?' and conceptual model factors - users

		trai-ning	incom-plete?	rep not appr	availa-bility factor	all pa-tients	man useful tool	man commit	man use	suc-cess-ful?
Province 1	Pearson Correlation	.509(**)	-.240	-.471(**)	.338(*)	-.330(*)	.207	.557(**)	-.274	1
&	Sig. (2-tailed)	.000	.083	.000	.023	.046	.153	.000	.052	
Province 2	N	53	53	51	45	37	49	49	51	60
Province 1	Pearson Correlation	.455(**)	.032	-.348(*)	.039	-.296	.105	.374(*)	-.014	1
	Sig. (2-tailed)	.005	.846	.038	.834	.159	.531	.019	.933	
	N	36	39	36	31	24	38	39	38	41
SystemA	Pearson Correlation	.458(*)	-.080	-.264	-.161	-.305	.495(*)	.570(**)	.248	1
	Sig. (2-tailed)	.028	.699	.224	.523	.204	.014	.003	.233	
	N	23	26	23	18	19	24	25	25	27
SystemB	Pearson Correlation	.550	.311	-.516	.103	.250	-.292	.000	-.325	1
	Sig. (2-tailed)	.052	.302	.071	.738	.685	.312	1.000	.279	
	N	13	13	13	13	5	14	14	13	14
SystemC	Pearson Correlation	.428	-.621(*)	-.294	.239	-.219	.224	.393	-.615(*)	1
	Sig. (2-tailed)	.086	.018	.288	.411	.473	.508	.261	.025	
	N	17	14	15	14	13	11	10	13	19

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table N.2 Correlations of 'successful?'and factors in the extended conceptual model of CHIS use – user level

(c) Cross tabulations 'successful?' and measures for model factors - users

Case Processing Summary – HOSPITALS PROVINCE 1 PROVINCE 2

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
training * successful?	28	93.3%	2	6.7%	30	100.0%
incomplete? * successful?	28	93.3%	2	6.7%	30	100.0%
rep not appr * successful?	28	93.3%	2	6.7%	30	100.0%
availability factor * successful?	27	90.0%	3	10.0%	30	100.0%
all patients * successful?	24	80.0%	6	20.0%	30	100.0%
man use * successful?	27	90.0%	3	10.0%	30	100.0%
man commit * successful?	28	93.3%	2	6.7%	30	100.0%
man USEFUL tool * successful?	28	93.3%	2	6.7%	30	100.0%

training * successful? Crosstabulation

		successful?					Total
		-2	-1	0	1	2	
training	-1	0	0	0	2	0	2
	0	0	0	1	1	0	2
	1	1	1	1	12	5	20
	2	0	0	0	1	3	4
Total		1	1	2	16	8	28

incomplete? * successful? Crosstabulation

		successful?				Total
		-1	0	1	2	
incomplete?	-2	0	0	2	2	4
	-1	0	0	9	3	12
	0	0	1	3	1	5
	1	1	1	3	1	6
	2	0	0	0	1	1
Total		1	2	17	8	28

rep not appr * successful? Crosstabulation

		successful?				Total
		-1	0	1	2	
rep not appr	-2	0	0	3	4	7
	-1	1	0	7	3	11
	0	0	2	3	0	5
	1	0	0	2	1	3
	2	0	0	2	0	2
Total		1	2	17	8	28

availability factor * successful? Crosstabulation

		successful?					Total
		-2	-1	0	1	2	
availability factor	0	1	1	2	3	1	8
	1	0	0	0	10	5	15
	2	0	0	0	2	2	4
Total		1	1	2	15	8	27

all patients * successful? Crosstabulation

		successful?					Total
		-2	-1	0	1	2	
all patients	0	0	0	0	8	5	13
	1	1	1	1	6	2	11
Total		1	1	1	14	7	24

man use * successful? Crosstabulation

		successful?					Total
		-2	-1	0	1	2	
man use	-2	1	0	0	0	0	1
	-1	0	1	1	2	1	5
	0	0	0	0	1	2	3
	1	0	0	0	13	3	16
	2	0	0	0	0	2	2
Total		1	1	1	16	8	27

man commit * successful? Crosstabulation

		successful?					Total
		-2	-1	0	1	2	
man commit	0	0	0	1	1	1	3
	1	0	0	1	12	4	17
	2	1	1	0	3	3	8
Total		1	1	2	16	8	28

man USEFUL tool * successful? Crosstabulation

		successful?					Total
		-2	-1	0	1	2	
man USEFUL tool	-1	1	0	0	0	0	1
	0	0	0	1	3	3	7
	1	0	1	1	11	2	15
	2	0	0	0	2	3	5
Total		1	1	2	16	8	28

--- END CROSSTABS – HOSPITALS PROVINCE 1 PROVINCE 2

(d) Cross tabulations 'successful?' and measures for model factors - users

successful? * training Crosstabulation– PROV 1 PROV 2

		training					Total
		-2	-1	0	1	2	
successful?	-2	1	0	0	1	0	2
	-1	0	1	0	1	0	2
	0	0	1	1	5	0	7
	1	0	4	1	17	2	24
	2	0	0	0	10	8	18
Total		1	6	2	34	10	53

successful? * incomplete? Crosstabulation– PROV 1 PROV 2

		incomplete?					Total
		-2	-1	0	1	2	
successful?	-2	0	0	0	1	0	1
	-1	0	0	0	1	0	1
	0	0	2	1	4	0	7
	1	6	10	3	6	1	26
	2	4	7	1	5	1	18
Total		10	19	5	17	2	53

successful? * rep not appr Crosstabulation– PROV 1 PROV 2

		rep not appr					Total
		-2.00	-1.00	.00	1.00	2.00	
successful?	-2	0	0	0	0	1	1
	-1	0	1	0	0	0	1
	0	0	1	4	1	1	7
	1	6	9	1	6	3	25
	2	10	5	1	1	0	17
Total		16	16	6	8	5	51

successful? * availability factor Crosstabulation– PROV 1 PROV 2

		availability factor			Total
		0	1	2	
successful?	-2	1	0	0	1
	-1	1	0	1	2
	0	4	0	0	4
	1	4	13	4	21
	2	2	11	4	17
Total		12	24	9	45

successful? * all patients Crosstabulation– PROV 1 PROV 2

		all patients		Total
		0	1	
successful?	-2	0	2	2
	-1	0	1	1
	0	3	4	7
	1	6	9	15
	2	8	4	12
Total		17	20	37

successful? * man USEFUL tool Crosstabulation– PROV 1 PROV 2

		man USEFUL tool					Total
		-2.00	-1.00	.00	1.00	2.00	
successful?	-2	0	1	0	0	0	1
	-1	0	0	0	1	0	1
	0	0	0	1	2	1	4
	1	0	1	4	17	3	25
	2	1	1	3	4	9	18
Total		1	3	8	24	13	49

successful? * man commit Crosstabulation– PROV 1 PROV 2

		man commit					Total
		-2	-1	0	1	2	
successful?	-2	1	0	0	0	0	1
	-1	0	1	0	0	0	1
	0	0	0	1	1	1	3
	1	0	4	1	16	4	25
	2	0	0	2	6	11	19
Total		1	5	4	23	16	49

successful? * man use Crosstabulation– PROV 1 PROV 2

		man use					Total
		-2	-1	0	1	2	
successful?	-2	0	0	0	0	1	1
	-1	0	0	0	0	1	1
	0	0	0	1	2	2	5
	1	0	2	2	18	3	25
	2	2	2	3	6	6	19
Total		2	4	6	26	13	51

Case Processing Summary – PROV 1 PROV 2

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
successful? * training	53	29.6%	126	70.4%	179	100.0%
successful? * incomplete?	53	29.6%	126	70.4%	179	100.0%
successful? * rep not appr	51	28.5%	128	71.5%	179	100.0%
successful? * availability factor	45	25.1%	134	74.9%	179	100.0%
successful? * all patients	37	20.7%	142	79.3%	179	100.0%
successful? * man USEFUL tool	49	27.4%	130	72.6%	179	100.0%
successful? * man commit	49	27.4%	130	72.6%	179	100.0%
successful? * man use	51	28.5%	128	71.5%	179	100.0%

ANNEXURE O

PROVINCE 1 AND PROVINCE 2: VARIABLES ASSOCIATED WITH FACTORS OF THE EXTENDED CONCEPTUAL MODEL OF CHIS USE

A summary of the hypotheses investigated in this section of the analysis is given in Table O.1. Details of the analyses are given in the following sections.

Hypotheses related to CHIS success and factors of the conceptual model of CHIS use	**Hypothesis number**
Knowledge and understanding of the CHIS (among users and hospital management) is associated with CHIS success	(1)
Lack of knowledge and understanding of CHIS is associated with lack of CHIS success	(1a)
Appropriate CHIS design is associated with CHIS success	(2)
Lack of appropriate CHIS design is associated with lack of CHIS success	(2a)
Good CHIS performance is associated with CHIS success	(3)
Poor CHIS performance is associated with lack of CHIS success	(3a)
Availability of resources is associated with CHIS success	(4)
Lack of resources is associated with lack of CHIS success	(4a)
Hospital management commitment to CHIS success is associated with CHIS success	(5)
Lack of hospital management commitment to CHIS success is associated with lack of CHIS success	(5a)
Perception of usefulness of CHIS success is associated with CHIS success	(6)
Lack of perception of usefulness of CHIS is associated with lack of CHIS success	(6a)
Effective use of the CHIS and/or CHIS outputs is associated with CHIS success	(7)
Lack of effective use of the CHIS and/or CHIS outputs is associated with lack of CHIS success	(7a)

Table O.1 Hypotheses to be tested in survey of hospital respondents

(a) Variables associated with 'knowledge and understanding of CHIS'

Questions in the user questionnaire related to knowledge and understanding of the CHIS in use include:

- Question 6: Users at this hospital are adequately trained to use the CHIS.
- Question 7: I have been adequately trained to use the CHIS.
- Question 10: Do not know which reports are available from the CHIS.
- Question 12: Data in reports is inaccurate.
- Question 13: Data in reports is incomplete.

The conceptual model factor 'knowledge and understanding of CHIS' is associated with CHIS success, in terms of the hypothesis (1) in table O.1. In terms of this hypothesis, the survey results described in tables O.2 to O.4 indicate that SystemA and SystemB are more successful than SystemC in terms of user training; and SystemA is more successful that SystemB and SystemC in terms of quality of data in the CHIS; as described below.

As described previously, two aspects of the factor ‘knowledge and understanding of CHIS’ were addressed in the user questionnaire: user training and knowledge of available reports from the CHIS; and accuracy and completeness of the data in the CHIS. The rating values for variables related to user training and knowledge of available reports (questions 6, 7 and 10) are given in table O.2. The assessments of accuracy and completeness of data in the CHIS were used as proxies for obtaining information about the quality of data in the CHIS (questions 12 and 13 in the user questionnaire). Results are summarised in table O.3.

In general, the SystemC users were of the opinion that they were less well trained than their counterparts using SystemA and SystemB. 65% of SystemC respondents agreed or strongly agreed that users had been adequately trained to use the CHIS, compared with 92% for SystemA and 85% for SystemB. In a similar pattern, only 41% of SystemC respondents believed that they themselves had been adequately training to use the CHIS, compared with 80% and 64% for SystemA and SystemB respectively. A similar pattern was also reflected in terms of knowledge of available CHIS reports, with 78% of SystemA respondents, 62% of SystemB respondents and 50% of SystemC respondents indicating that they **did** know which reports were available from the CHIS (rating values -2 or -1 for the variable ‘rep not known’).

The assessments of accuracy and completeness of data in the CHIS were used as proxies for obtaining information about the quality of data in the CHIS. Results are summarised in table O.3. For the variables related to data quality, respondents rated SystemA better than SystemB and SystemC. 77% of SystemA users were of the opinion that the data in the CHIS were accurate (rating values -2 or -1 for the variable ‘inaccurate?’), compared with 57% of SystemB respondents and 64% of SystemC respondents. For the variable ‘incomplete?’, a similar pattern of responses was obtained: 68% of SystemA users, 46% of SystemB users and 47% of SystemC users were of the opinion that data in the CHIS were incomplete (rating value -2 or -1 for the variable ‘incomplete?’).

Rating value	training SystemA	training SystemB	training SystemC	own training SystemA	own training SystemB	own training SystemC	rep not known SystemA	rep not known SystemB	rep not known SystemC
2	8	2	1	11	7	3		2	1
1	14	9	12	9	2	6	5	3	4
0	1		2	1	2	4			4
-1	1	2	4	2		7	11	2	8
-2			1	2	2	2	7	6	1
9	9	2	4	8	2	2	10	2	6
TO-TALS	33	15	24	33	15	24	33	15	24
% +ve	*92%*	*85%*	*65%*	*80%*	*64%*	*41%*	*78%*	*62%*	*50%*
% most +ve	*33%*	*14%*	*5%*	*44%*	*50%*	*14%*	*30%*	*46%*	*6%*

Table O.2 Rating values for factors related to 'knowledge and understanding of CHIS' – training and knowledge of reports

Rating value	inaccurate? SystemA	inaccurate? SystemB	inaccurate? SystemC	incomplete? SystemA	incomplete? SystemB	incomplete? SystemC
2	2			2		
1	4	4	4	6	4	8
0		2	1	1	3	1
-1	15	4	7	13	3	7
-2	5	4	2	6	3	1
9	7	1	10	5	2	7
TO-TALS	33	15	24	33	15	24
% +ve	77%	57%	64%	68%	46%	47%
% most +ve	19%	29%	14%	21%	23%	6%

Table O.3 Rating values for factors related to 'knowledge and understanding of CHIS' – data quality

Rating value	CHIS ID		
CHIS knowledge	SystemA	SystemB	TOTAL
2	6	3	9
1	2	2	4
0			
-1	1		1
-2			
9	1	1	2
Grand Total	10	6	16

Table O.4 Rating values for 'CHIS knowledge' – Province 1

(b) Variables associated with 'appropriateness of CHIS design'

Questions in the user questionnaire related to CHIS design include:

- Question 2: Is the CHIS easy to use?
- Question 11: Available reports do not meet needs.
- Question 14: Describe reports from the system which you would like to receive but cannot receive at present (free text responses).
- Question 15: Have you requested the developers of the information system / the providers of the information to provide any of these reports?
- Question 18: Are there other functions of the CHIS (apart from the CHIS midnight state report) which are not being used in this hospital?

Questions 1 and 3 in the hospital questionnaire relate to the scope of the CHIS implementation in each hospital (question 1), and any proposed or planned changes in the CHIS implementation at the hospital (question 3). These responses were recorded in free text.

Numeric results from the user questionnaires are summarised in tables O.5 and O.6.

While the overwhelming majority of respondents indicated that SystemA and SystemB were easy to use (95% and 100% respectively), just fewer than 50% of the SystemC users indicated that this CHIS was easy to use. A similar pattern emerged in terms of appropriateness of reports: while 33% of respondents indicated that reports from the SystemC were appropriate, these percentages were much higher for the other two CHISs: 84% for SystemA and 69% for SystemB.

Thus, in terms of the hypothesis that appropriateness of CHIS design (as represented by these variables from the user questionnaire) is associated with CHIS success (hypothesis (2) in table O.1), SystemA was most successful, followed by SystemB and SystemC, based on the survey results.

Rating value	ease of use SystemA	ease of use SystemB	ease of use SystemC	rep not appr SystemA	rep not appr SystemB	rep not appr SystemC
2				1	1	4
1	21	13	10	3	2	3
0	1		11		1	5
-1				12	4	4
-2				9	5	2
9	11	2	3	7	2	6
TOTALS	33	15	24	33	15	24
%positive	*95%*	*100%*	*48%*	*84%*	*69%*	*33%*
% most positive	*0%*	*0%*	*0*	*36%*	*38%*	*11%*

Table O.5 Rating values for factors related to 'appropriateness of CHIS design'

Rating value	reports requestd SystemA	reports requestd SystemB	reports requestd SystemC	functions not used SystemA	functions not used SystemB	functions not used SystemC
2						
1	8	5	7	5	3	6
0	7	9	7	13	6	3
-1						
-2						
9	18	1	10	15	6	15
TOTALS	33	15	24	33	15	24
%positive	*53%*	*36%*	*50%*	*28%*	*33%*	*66%*
% most positive						

Table O.6 Rating values for factors related to 'appropriateness of CHIS design'

(c) Variables associated with 'performance of CHIS'

The data presented in this section relate to the hypothesis that CHIS performance is associated with CHIS success (hypothesis (3), table O.1). Three variables from the user questionnaire relate to CHIS success: acceptability of response times, CHIS availability, and acceptability of CHIS availability, as described in tables O.7 and O.8. In terms of these variables from the survey of hospitals, SystemA is more successful than SystemB, and both are more successful than SystemC.

All respondents who answered this question for SystemA indicated that the CHIS availability ('coded % availability') was good or acceptable, in terms of the classification defined in table O.9, and all reported that the system availability was acceptable ('availability OK'). Most respondents for SystemA (20 of 23, or 87%) also indicated that response times were acceptable, reflecting a generally high level of performance of this CHIS.

There were marked differences between SystemA, and SystemB and SystemC, in terms of reported availability of the CHIS. Very few of the respondents for SystemB or SystemC indicated 'good' CHIS availability in terms of the definition used in this discussion (one respondent for SystemB and two respondents for SystemC). Overall, 69% of SystemB respondents and only 41% of SystemC respondents indicated that CHIS availability was 'good' or 'acceptable'.

A similar pattern was reflected for the other variables, with fewer than 50% of respondents reporting that response times and system availability were acceptable.

These responses were influenced in a number of cases by the fact that power supply problems were being experienced at the time of the survey interviews in both study provinces. Several SystemB and SystemC users also alluded to network problems. Performance was thus being affected by resource availability problems.

Rating value	Response times? SystemA (question 3)	Response times? SystemB (question 3)	Response times? SystemC (question 3)
2			
1	20	8	8
0	3	5	10
-1			
-2			
9	10	2	6
TOTALS	33	15	24
% positive	*87%*	*62%*	*44%*
% most positive	-	-	-

Table O.7 Rating values of factors related to 'performance of CHIS' – response times

Rating value	Coded % availability SystemA (question 4*)	Coded % availability SystemB (question 4*)	Coded % availability SystemC (question 4*)	Availability OK SystemA (question 5)	Availability OK SystemB (question 5)	Availability OK SystemC (question 5)
2	7	1	2			
1	12	8	5	19	8	9
0	0	4	10	0	5	10
-1						
-2						
9	14	2	7	14	2	5
TOTALS	33	15	24	33	15	24
% positive	*100%*	*69%*	*41%*	*100%*	*62%*	*47%*
% most positive	*37%*	*8%*	*12%*	-	-	-

Table O.8 Rating values of factors related to 'performance of CHIS' – CHIS availability

% availability	Code	Description	Notes
99% - 100%	2	good	Minimum required availability for an IS which supports continuous operation, as in a hospital, is more than 99%. 1% down time is equivalent to an average of more than 90 minutes per week.
90% - 98%	1	acceptable	Ongoing operation could be possible in an environment where clinical services are not directly dependent on the availability of the CHIS. 10% down time is equivalent to an average of nearly 17 hours per week.
below 90%	0	not acceptable	

Table O.9 Coding of CHIS availability

(d) Factors associated with 'availability and allocation of resources for CHIS' (hospital level) and availability of resources at provincial level

Questions in the user questionnaire related to resources include:

- questions 19 to 21 related to CHIS user support;
- questions 22 to 24 related to ICD-10 (diagnosis) coding of patient information;
  The factor 'all patients' (response to question 24d in the user questionnaire) indicates whether ICD-10 coding is done for all patients in a hospital. This variable was used in statistical analyses as the measure for 'availability and allocation of resources for CHIS'.

Questions in the hospital questionnaire related to resources include:

- question H2 workstations
- question H4 personnel who input data to the CHIS
- questions H5 and H6 information management (IM) personnel

(i) CHIS user support (questions 19 to 21)

Responses to the questions related to internal support for the CHIS (question 19); external support for the CHIS (question 20); and after hours, weekend and public holiday support for the CHIS (question 21) reflect a range of resources used, with some important differences between hospitals using SystemA and those using SystemB

Respondents at hospitals using SystemB supported the information obtained from the head of the provincial rollout team for this system: one representative each from finance, administration and nursing had been seconded to the implementation team, and returned to their normal positions approximately 3 months after CHIS implementation at their hospitals. These members of staff continued to function as resource people at their hospitals – they were specifically referred to as 'superusers' by the senior medical superintendent at hospital S7. In at least one case (hospital S8), one of these superusers had subsequently been appointed as the information officer for the hospital, and functioned as the CHIS system controller for the hospital.

At the surveyed hospitals using SystemA, there was either a dedicated information officer, or the appointment of an information officer was planned. However, it was noted at several survey hospitals that the effective system controller, i.e. the key person in the hospital responsible for the operation of the CHIS, was not the IO. Where the IO had been recently appointed (within fewer than 8 months of the survey), the person providing support was the person who had fulfilled this function prior to the appointment of the IO.

Thus, in the hospitals using SystemB, there was a group of between 2 and 4 people who could provide at least first-line support to hospital users (some of the people who had participated in the CHIS implementation had since left the hospitals, according to survey responses), while at hospitals using SystemA, there was typically a single person able to provide first-line support to CHIS users – a clear situation of vulnerable resources.

As was found in the case study hospitals, the limited support available at hospital level, as well as the limited support available from the system suppliers (telephone support, supplemented by regular support visits to hospitals (between 2 and 6 times a year, according to survey respondents), was not highlighted by users as being problematic.

(ii) Coding of patient information

Discussed in main text in Chapter 6, Section 6.4.2.

(e) Variables associated with 'perception of usefulness of CHIS' and perception of success of the CHIS

Two types of data were analysed: coded responses to questions from users (using a 5-point scale from strong agreement to strong disagreement with statements; or coded yes/no responses), or coded text data as described previously. The data are summarised in tables O.10 to O.13.

(i) Questions related to perceptions of usefulness of CHIS

Five questions related to perceptions of usefulness of the CHIS were included in the user questionnaire:

- Question 25: What do you like about the CHIS?
- Question 26: What do you dislike about the CHIS?
- Question 27: How does the CHIS facilitate your work?
- Question 28: How does the CHIS complicate your work?
- Question 30: The hospital management regards the CHIS as a useful management tool

Question 30 refers to respondents' perceptions of whether management regard the CHIS as a useful tool, thus referring to management perception of the usefulness of the CHIS in use in a hospital. Rating values for question 30, for Provinces 1 and 2, and shown in table O.10.

Rating value	Useful man tool perception Province 1 30	man useful tool A	B	Useful man tool perception SystemC 30
2	14	14	1	1
1	19	10	8	8
0	7	3	4	1
-1	1		1	3
-2	1		1	
9	6	6		11
TOTALS	48	33	15	24
	79%	*89%*	*60%*	*64%*
	26%	*52%*	*7%*	*7%*

Table O.10 Rating values for 'man useful tool' – all users; Province 1 and Province 2

Rating values for this variable were markedly better for SystemA than for SystmB and SystemC, in terms of these data. While 89% of SystemA user respondents (i.e., excluding those respondents for whom data were not available) thought that management regarded the CHIS as a useful tool, this was true for 64% of SystemC user respondents, and 60% of SystemB user respondents. In terms of the factors of the conceptual model, these data indicate that, in terms of perception of usefulness, SystemA is more successful than either SystemB or SystemC.

(ii) Coded comments related to perception of usefulness, success and lack of success

Coded comments from all respondents in Province 1 and Province 2 related to perception of usefulness, and success and lack of success ,are summarised in tables O.11 and O.12. Most of the comments relate to 'input' factors at hospital level in the conceptual model (knowledge and understanding; appropriateness of design; performance; and resource availability and allocation) and to outputs from the CHIS (included under 'effective use' in the conceptual model).

Factor	Factor code	Like1 25	Like2 25	Fac1 27	Fac2 27	Sccs1 29	Sccs2 29	TOT
Knowledge and understanding of CHIS	know	1		1 +1		1	1	4
Quality of data in the CHIS	qual		2			3	1	6
Training	train	1		2 +1	1			4
Appropriateness of CHIS design	design	20 +7		11 +1		5		36
Functionality	func	4 +1	3	6 +9	4	9	1	27
Fit	fit	2				2		4
Performance of CHIS	perf	3	1					4
Resource availability and allocation	resources		1					1
Human resource availability and allocation	Hresource							
Resources for CHIS support	Support							
Perception of usefulness of CHIS	useful					1		1
Attitude to CHIS	at/att							
Management commitment to CHIS success	Commit							
Effective use of CHIS and/or outputs	use							
Outputs	op	5 +1	4 +1	14	2	2	2	29
CHIS supplier knowledge & understanding (P)	*Suppknow*							
CHIS software fit with user requirements (P)	*Designfit*							
Resource availability (P)	*Presource*							
Organisational & contractual mechanisms (P)	*Contract*							
(status of CHIS implementation)	IMPLEM							
(relationships in the conceptual model)	MODEL							
No factor		1 +2		3				1
Other						**ORG**		
TOTALS		**37 +12**	**11 +1**	**34 +15**	**7**	**23**	**5**	***117 +28***

Table O.11 Factors related to perceptions of USEFULNESS and SUCCESS in the extended conceptual model of CHIS use – Province 1 and Province 2

For factors ‘like’ and ‘facilitate’: total 89 + 28 + 117

For factors ‘like’ and ‘facilitate’ and ‘successful?’: total 117 + 28 = 145

Factor	Factor code	DIS-Like1 26	DIS-Like2 26	NOT Fac1 28	NOT Fac2 28			TOT
Knowledge and understanding of CHIS	know							
Quality of data in the CHIS	qual	1		1				2
Training	train	1	2	2				5
Appropriateness of CHIS design	design	7		2	1			10
Functionality	func	2	1	1				4
Fit	fit		1					1
Performance of CHIS	perf	12		5				17
Resource availability and allocation	resources	1	1	1				3
Human resource availability and allocation	Hresource							
Resources for CHIS support	Support							
Perception of usefulness of CHIS	useful							
Attitude to CHIS	at/att							
Management commitment to CHIS success	Commit							
Effective use of CHIS and/or outputs	use							
Outputs	op			1				1
CHIS supplier knowledge & understanding (P)	*Suppknow*							
CHIS software fit with user requirements (P)	*Designfit*							
Resource availability (P)	*Presource*							
Organisational & contractual mechanisms (P)	*Contract*							
(status of CHIS implementation)	IMPLEM							
(relationships in the conceptual model)	MODEL							
No factor		9		17				26
Other								
TOTALS		**33**	**5**	**30**	**1**			***69***

Table O.12 Factors related to perceptions of LACK OF USEFULNESS and LACK OF SUCCESS in the extended conceptual model – Province 1

(f) Variables associated with 'management commitment to CHIS success'

Rating value	Management commitment perception Province 1	management commitment perception SystemA	management commitment perception SystemB	Management commitment perception SystemC
2	17	14	3	1
1	20	11	9	4
0	4	1	3	
-1	1	1		6
-2	0			1
9	6	6		12
TOTALS	48	33	15	24
	88%	*93%*	*80%*	42%
	40%	*52%*	*20%*	8%

Table O.13 rating values for 'man commit' – variable related to 'management commitment to CHIS success

The variable 'man commit' – the response to the statement at question 32 in the user questionnaire: The hospital management is committed to the success of the CHIS – was the major measure used for the conceptual model factor 'management commitment to CHIS success'. In the hospital questionnaire, question 12 refers to hospital meetings at which the CHIS is discussed. The responses to this question, and information about meetings obtained from interviews and discussions, were also considered in relation to management commitment of CHIS success, as described below.

Rating values for the variable 'management commitment to CHIS success' were markedly different for the Province 1 and Province 2 respondents: 93% of the SystemA users and 80% of the SystemB users who responded to this question were of the opinion that their hospital management were committed to the success of the CHIS. Only 42% of the SystemC user respondents shared this opinion.

Most of the respondents from Province 1 (37 of 48, or 77% overall; corresponds to 88% of the 42 respondents for this question) were of the opinion that the management in their hospitals were committed or very committed to the success of the CHIS in the hospitals (question 32 'man commit' = 1 or 2). One respondent felt that the hospital management were not committed to the success of the CHIS, and the remaining respondents were either neutral on this issue, or no response was available.

HOSPITAL MEETINGS

In the hospital questionnaire, respondents were asked whether there were hospital meetings at which the CHIS was discussed. This question was related to the conceptual model factor 'management commitment to CHIS success', since it was assumed that management commitment to CHIS success could be reflected in a requirement and an opportunity for hospital management and CHIS users to discuss problems related to the CHIS, and address potential responses to the problems being experienced.

Responses to this question were varied: In Province 1, discussions about the CHIS in hospital meetings occurred in 10 of the 16 hospitals for which answers to this question were available. In five of the remaining six hospitals, there were no discussions of the CHIS in hospital meetings, and there was no response to this question for the remaining hospital in this sample. The nature of the discussion also varied across the 10 Province 1 hospitals in which meetings were held: in some cases, issues related to the CHIS were raised in management meetings if there were problems; other respondents reported that the CHIS was discussed in weekly or monthly management meetings; at two hospitals, the CHIS was discussed in the context of finance meetings; and only one of the respondent hospitals reported on a monthly ‘issue list meeting' for the CHIS, in the context of the SystemB CHIS implementation process at that hospital (S7). Hospital D17 reported that implementation meetings for SystemB CHIS implementation had previously been held. Thus, in Province 1, there were no dedicated meetings at which the functioning of the CHIS in the hospitals was discussed, except in the context of the SystemB implementation process (as reported at two of the hospitals).

The details of how the meetings operated in the survey hospitals were not discussed, but the fact that there were no dedicated meetings except during implementation (meetings at hospital D17 had been discontinued after the implementation phase) seems to indicate that the issue of how to use the CHIS effectively in the context of the work of the study hospitals in Province 1 was unlikely to be discussed in these environments. This was also the situation in case study hospital H4, where there were no specific opportunities for hospital personnel to discuss the CHIS and its use in that hospital.

Overall, therefore, for the Province 1 hospitals in the survey, the perceived hospital management commitment to CHIS success was not matched in terms of a formal structure for discussion and management of the CHIS in use in the form of discussion time in meetings. In contrast, in Province 2, hospitals were required to set up CHIS meetings, in terms of a directive from the provincial head of hospital services. Discussions with management staff of hospital C3 indicated that this meeting was held at the hospital, chaired by the most senior clinician at the hospital, who commented that these meeting were expected to become more important once the components of the CHIS which included functionality designed to support the clinical staff had been implemented. These meetings, at least in hospital C3, therefore had the potential to provide essential forums for discussion among stakeholders to facilitate the effective use of the CHIS in that environment.

The differing roles of project meetings in the implementation of electronic patient record (EPR) systems in cases in Canada and Norway was found by Boulus and Bjorn (2007) to have affected the extent of effective adaptation of EPR systems in the two settings: In one hospital, the project meetings provided the opportunity for detailed discussion of the changing work patterns of users related to current and potential uses of the EPR in that setting, resulting in increasingly sophisticated use of the EPR in the study hospital. In contrast, meetings in the second hospital were reported to have discussed the system functioning in isolation from general work practices (especially of physicians and secretaries in the areas using the EPR), and thus the extent to which the EPR was used to improve the effectiveness of work practices was found to be much more limited.

The large difference in respondents' perceptions of management commitment to the success of the CHIS across the two study provinces still justifies the conclusion that, in terms of the conceptual model factor 'management commitment to CHIS success', the Province 1 CHIS implementations (SystemA and SystemB implementations) are more successful than the Province 2 CHIS implementation (SystemC implementation).

(g) Effective use of CHIS and/or outputs

- Question 16: Is the CHIS midnight state report routinely used by hospital management?
- Question 17: Is there another (non-CHIS) daily patient report which is used by hospital management?
- Question 31: The hospital management uses the CHIS effectively

In the development of the conceptual model, effective CHIS use was identified as a reflection of successful CHIS implementation. Therefore, responses to survey questions related to CHIS use are included in this discussion, and summarised in Tables O.14 and O.15.

The midnight state report is a standard daily hospital in patient report, which reflects the patients in hospital at midnight, and identifies those patients who have been admitted to and discharged from the hospital during the previous 24 hours. The CHISs in use in the study hospitals all have the functionality to generate midnight state reports. The CHIS midnight state report was used in the survey as a marker for the effective use of CHIS reports for and by hospital management (question 16). From experience in the case study hospitals, and other hospitals with which the author has been associated, the daily nursing report prepared by the ward staff and submitted to nursing management each morning, which incorporates the data included in the midnight state report, is often used in preference to the CHIS midnight state report. The use of daily patient reports other than the CHIS midnight state report was therefore used as a further indicator of the extent to which CHIS midnight state reports were (or were not) used to support hospital management decision-making on a daily basis.

More generally, respondents were asked whether they used reports generated by the CHIS (question 9) and whether the reports available to them met their needs. Responses to these questions were not included in the analysis of numeric data.

Respondents were also asked about their perceptions of whether management used the outputs of the CHIS effectively (question 31), in order to obtain an overall opinion of the perception of the use of CHIS outputs to support hospital management decision-making. As discussed in Section 6.4.3, this variable was used as a measure of the conceptual model factor ‘effective use of CHIS and/or outputs’ in the statistical analyses of relationships between factors in the extended conceptual model of CHIS use.

Rating value	Midnight state SystemA	Midnight state SystemB	Midnight state SystemC	Other man rpt SystemA	Other man rpt SystemB	Other man rpt SystemC
2						
1	23	4	6	12	7	8
0	6	6	9	9	7	2
-1						
-2			9			
9	4	5	24	12	7	14
TOTALS	33	15		33	15	24

Table O.14 Rating values for factors related to 'Effective use of CHIS and/or outputs'

Responses to questions related to the use of the midnight patient report (question 16 were less conclusive: 27 of the 48 respondents from Province 1 (56%) indicated that the midnight state report from the CHIS was used by the hospital management. However, comments related to this question reflected that, in most cases, the report was not used by hospital management on a daily basis. The daily patient report prepared by nursing staff for the nursing management was used more widely by management (question 17 and comments). Comments by Province 1 respondents on questions 16 and 17 reflected a lack of reliance on the midnight state generated by the CHIS, since it was not regarded as being up to date, as reflected in comments such as 'no ward clerks' (to update the CHIS during the night). These results were consistent with findings from the case studies, and reflect a lack of reliance on the CHIS as a core management tool, at least on a daily basis, in many of the study hospitals.

Rating value	man use Province 1	man use SystemA	man use SystemB	man use SystemC
2	8	7	1	
1	19	14	5	5
0	8	5	3	8
-1	4	2	2	
-2	3		3	2
9	6	5	1	9
TOTALS	48	33	15	
%positive	*64%*	*75%*	*43%*	*33%*
% most positive	*19%*	*25%*	*7%*	*0%*

Table O.15 Effective management use of CHIS

27 of the 48 respondents from Province 1 (56%) agreed or strongly agreed with the statement that hospital management used CHIS outputs effectively (question 31), 7 of the 48 respondents (15%) disagreed or strongly disagreed with this statement, and 14 of the respondents (29%) either were neutral or made no comment. Thus, of the Province 1 respondents, 64% were of the opinion that hospital management used CHIS outputs effectively.

There were clear differences between the responses for the different CHISs: 75% of SystemA users who responded to this question thought that hospital management used the CHIS effectively, whereas 43% of respondents for SystemB and 33% of respondents for SystemC gave positive responses.

ANNEXURE P

ANALYSIS OF RELATIONSHIPS IN THE CONCEPTUAL MODEL

Eight relationships between factors in the extended conceptual model of CHIS use have been analysed. In some cases, more than one variable was used as a proxy for the conceptual model factor, as described in the summary table (Table P.1).

The results of the statistical analyses of data reflecting the relationships between conceptual model factors are described in Tables P.2 and P.3

Hypotheses related to relationships between factors of the conceptual model of CHIS use	**Relationships in the conceptual model**
Knowledge and understanding of CHIS are associated with perception of usefulness of CHIS	(a)
Accuracy and completeness of CHIS data are associated with perception of usefulness of CHIS	(a)
Appropriateness of design is associated with perception of usefulness of CHIS	(b)
CHIS performance is associated with perception of usefulness of CHIS	(c)
Availability of resources for CHIS is associated with perception of usefulness of CHIS	(d)
Perception of usefulness of CHIS is associated with effective use of the CHIS and/or CHIS outputs	(e)
Hospital management commitment to CHIS success is associated with perception of usefulness of CHIS	(f)
Hospital management commitment to CHIS success is associated with resource allocation for CHIS	(g)
Effective use of CHIS and/or outputs is associated with hospital management commitment to CHIS success	(h)

Table P.1 Hypotheses to be tested in survey of hospital respondents

(i) Relationships between 'input' factors and 'perception of usefulness' (relationships (a), (b), and (c)

There were some statistically significant correlations between the variables 'man useful tool' (reflecting respondents' perceptions of management's view of the CHIS as a tool) and 'incomplete?' (reflecting respondents' assessment of the quality of data in the CHIS). However, the relationships between the characteristics of users and the CHIS; and perception of usefulness of the CHIS (relationships (a) to (c)); were generally not strongly supported by the results of the cross correlations.

Evidence from respondents' comments to questions related to their perceptions of the usefulness (or not) of the CHIS in use in their environments did support relationships between 'appropriateness of CHIS design' and 'perception of usefulness'; and 'performance of CHIS' and 'perception of usefulness'.

In general, the data from cross tabulations between the rating values of these variables did support these relationships.

(ii) Relationships involving 'resource availability and allocation' (relationships (d) and (g))

Overall positive, but not statistically significant, relationships were shown for the relationship between 'management commitment to CHIS success' and 'resource availability and allocation' (relationship (g)), especially taking the relationship between 'man commit' and 'availability factor' into account.

Only a weak relationship between 'all patients' (reflecting resource availability for ICD-10 coding) and 'perception of usefulness of CHIS' (relationship (d)) could be demonstrated. Further analysis of non-numeric data will be required to demonstrate support for this key relationship in the conceptual model.

(iii) Relationships involving 'management commitment to CHIS success', 'use of CHIS outputs' and 'perception of usefulness' (relationships (e), (f) and (h))

Strong, but not necessarily statistically significant, relationships were demonstrated for these three relationships for most groups of respondents. Where cross correlations were counterintuitive, cross tabulations did reflect positive relationships between these variables, as expected in terms of the conceptual model.

Pearson correlation coefficient / Data category	'training' & 'man useful tool'	'incom-plete' & 'man useful tool'	'know-ledge' & 'man useful tool'	'rep not appr' & 'man useful tool'	'availa-bility factor' & 'man useful tool'	'all patients' and 'man useful tool'
hospital data: Provinces 1 and 2	.064	-.398*	---	-.106)	.332	.116
hospital data: Province 1	-.013	-.365	.117	-.182	.263	.359
hospital data: Province 1, SystemA	-.201	-.385	.245	-.106	.018	.213
hospital data: Province 1, SystemB	-.408	-.522	-.167	.000	.000	.612
hospital data: Province 2 (all users of SystemC).	-.127	-.488	---	.482	.000	-.200
user data: Provinces 1 and 2	*.091*	*-.193*			*.236*	
user data: Province 1	*.070*	*-.316*			*.222*	
user data: Province 1, SystemA	*.056*	*-.643***			*-.196*	
user data: Province 1, SystemB	*-.183*	*.129*			*.020*	
user data: Province 2 (all users of SystemC)	*.010*	*.396*			*-.129*	

Table P.2 Results of cross correlations between measures of factors of the extended conceptual model of CHIS use

Pearson correlation coefficient / Data category	'availa-bility factor' & 'success-ful?'	'all patients' & 'success-ful?'	'man use' & 'man useful tool'	'man commit' & 'man useful tool'	'man commit' & 'all patients'	'man commit' & 'man use'	'man commit' & 'availa-bility factor'
hospital data: Provinces 1 & 2	.503**	-.399	.538**	.300	.168	.227	.349
hospital data: Province 1	.030	-.081	.461*	.619**	.062	.548*	.599**
hospital data: SystemA	-.051	.025	.000	.419	-.239	.285	.501
hospital data: SystemB	-.250	-.408	.928**	.707	.408	.525	.250
hospital data: Province 2 (all users of SystemC).	.480	-.387	.483	-.267	.316	-.075	.218
user data: Provinces 1 and 2			*.450***		*-.200*		*.384**
user data: Province 1			*.629***		*-.049*		*.445**
user data: SystemA			*.283*		*-.258*		*.000*
user data: SystemB			*.708***		*.535*		*.590**
user data: Province 2 (all users of SystemC)			*.121*		*-.111*		*-.147*

Table P.2 Results of cross correlations between measures of factors of the extended conceptual model of CHIS use (part 2)

	Relationships between factors in the extended conceptual model of CHIS use	Relationships between related variable(s) analysed statistically	Summary of results of statistical analyses
(a)	**Knowledge and understanding of CHIS** & **Perception of usefulness of CHIS**	incomplete? & man useful tool	- *some statistically significant corrrelations*
		training & man useful tool	- *weak, sometimes negative correlations; crosstabs more consistent with model*
		CHIS knowledge & man useful tool	- *similar to above*
(b)	**Appropriateness of CHIS design** **& Perception of usefulness of CHIS**	rep not appr & man useful tool	- *not supported by statistical analysis* - *??require a different variable for 'appropriateness'* - *But note user comments re. CHIS (+ve and –ve)*
(c)	**Performance of CHIS** **& Perception of usefulness of CHIS**	availability factor & man useful tool	- *Strong relationship not reflected in statistical analyses* - *But note user comments re. CHIS (-ve)* - *Stronger correlation with 'success' in some groups*
(d)	**Resource availability and allocation** **& Perception of usefulness of CHIS**	all patients (factor for ICD-10 coding) & man useful tool	- *Non-significant/weak relationship reflected;* - *Require combination with other data*
(e)	**Perception of usefulness of CHIS** **& Effective use of CHIS and/or outputs**	man useful tool & man use	- *Relatively strong correlation;* - *Values are based on respondents' perceptions*
(f)	**Management commitment to CHIS success** **& Perception of usefulness of CHIS**	man commit & man useful tool	- *Relatively strong correlation, except for SystemA* - *Crosstabs for SystemA 'positive'*
(g)	**Management commitment to CHIS success** **& Resource availability and allocation**	man commit & all patients (factor for ICD-10 coding)	- *Positive but not strong relationships, except for SystemA (negative)* - *Positive for SystemA in crosstabs*
		man commit & availability factor	- *Relatively strong correlations, including statistically significant correlation for Province 1 hospitals, and some groups at user level*
(h)	**Effective use of CHIS and/or outputs** **& Management commitment to CHIS success**	man use & man commit	- *Positive; strong for Province 1 users* - *Close to zero for Province 2*
		man use & CHIS meetings	- *Inconclusive; results for Province 1 only*

Table P.3 Summary of results of statistical analyses: variables related to conceptual model factors

(a) 'Knowledge and understanding of CHIS' (user training; data quality; CHIS knowledge) and 'Perception of usefulness of CHIS'

The extended conceptual model of CHIS use postulates a relationship between 'knowledge and understanding of CHIS' and 'perception of usefulness of CHIS'. For the statistical analysis, the relationships between the factors 'training' and 'incomplete?', and 'man useful tool' were analysed. From the hospital questionnaire, the variable 'CHIS knowledge' could also be used as a proxy for user training. Therefore, the relationships between 'man useful tool' and the variable 'CHIS knowledge' from the hospital questionnaire were also analysed.

(i) 'training' and 'man useful tool'

A simple correlation between these variables, at both hospital and user level, yielded varying results (see Table P.4).

None of the results at hospital level was statistically significant, and weak negative relationships between 'training' and 'perception of usefulness' were reflected for Province 1 hospitals; Province 1 hospitals using SystemA; and Province 2 hospitals (using SystemC). A rather strong negative correlation (r = -.408) was calculated for the five hospitals using the SystemB CHIS which were included in this group, although this result was not statistically significant. The cross correlations at user level were generally weak, but also included a weakly negative cross correlation for SystemB users. These results are hard to explain intuitively, since poor training should not be associated with a good perception of usefulness for a CHIS.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.064 (27)
hospital data: Province 1	-.013 (19)
hospital data: Province 1, SystemA	-.201 (14)
hospital data: Province 1, SystemB	-.408 (5)
hospital data: Province 2 (all users of SystemC).	-.127 (8)
user data: Provinces 1 and 2	*.091*
user data: Province 1	*.070*
user data: Province 1, SystemA	*.056*
user data: Province 1, SystemB	*-.183*
user data: Province 2 (all users of SystemC)	*.010*

Table P.4 Results of cross correlations between 'training' and 'man useful tool'

The cross tabulation of these variables for the hospitals using SystemB showed that, for one hospital, the perception that users were not adequately trained to use the CHIS ('training' = -1) was linked to the perception that management viewed the CHIS as a useful management tool ('man useful tool' = 1). For the other four hospitals in this group, user training was viewed as adequate ('training' = 1). For two of these hospitals, the perception was that management viewed the CHIS as a useful management tool ('man useful tool' = 1), and for the remaining two hospitals, the perception was that management did not view the CHIS as a useful management tool ('man useful tool' = -1). Thus, the actual values of the variables were counter-intuitive for only one of the five hospitals in this group

The cross tabulation for hospitals using the SystemA CHIS shows that respondents at all 14 hospitals regarded end user training as adequate or good ('training' = 1 or 2). For two hospitals, the overall response on whether management viewed the CHIS as a useful management tool was neutral ('man useful tool' = 0). For the remaining 12 hospitals, there was agreement or strong agreement ('man useful tool' = 1 or 2, respectively) that management viewed the CHIS as a useful management tool.

Thus, the cross tabulations were not consistent with negative relationships between 'training' and 'man useful tool'. In fact, they seemed to strongly support a positive relationship between the two variables, except for one instance among the SystemB user hospitals.

(ii) 'incomplete?' and 'man useful tool'

The results of simple correlations between these variables are given in Table P.4

Although only the result for all hospitals (r = -.398) was statistically significant at the 0.05 level, all the other results did indicate a reasonably high level of correlation between the variables. Overall, these correlations were stronger than the correlations between 'training' and 'man useful tool', as described in the previous section.

These results can be interpreted as meaning that there is some correlation between completeness of data (i.e. the **opposite** of data being incomplete) and the respondents' perception that management regard the CHIS is a useful management tool. Conversely, respondents who regarded data in the CHIS as being incomplete linked this to management perception that the CHIS is **not** a useful management tool.

In commenting on positive or negative aspects of the CHIS, several users noted that quality of data in the CHIS was a problem. In Province 2, especially during the site visits in February 2008, many interviewees commented that incomplete data made it impossible to rely on the CHIS for management information, reflecting a link between quality of data in the CHIS, and users' perceptions of the usefulness of the CHIS.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	-.398 (27)*
hospital data: Province 1	-.365 (20)
hospital data: Province 1, SystemA	-.385 (14)
hospital data: Province 1, SystemB	-.522 (6)
hospital data: Province 2 (all users of SystemC).	-.488 (7)
user data: Provinces 1 and 2	*-.193*
user data: Province 1	*-.316*
user data: Province 1, SystemA	*-.643***
user data: Province 1, SystemB	*.129*
user data: Province 2 (all users of SystemC)	*.396*

Table P.4 Results of cross correlations between 'incomplete' and 'man useful tool'

Considering the user-level data, the cross correlations between 'incomplete?' and 'man useful tool' for all users; for users in Province 1; and for users of SystemA in Province 1; were consistent with the results at hospital level. The result for the users of the SystemA CHIS was significant at the 0.01 level (r = -.643), while the result (r = -.316) for all users in Province 1 was not statistically significant. The simple cross tabulation between these variables for the users of SystemA indicated that 6 of the 26 respondents in this group linked the strongest scores for the two factors ('-2' for 'incomplete?' - meaning that the data were **not** incomplete - and '2' for 'man useful tool'). A further 11 respondents linked a score of -1 for 'incomplete?' with scores of 2 or 1 for 'man useful tool'. Thus, 17 of the 26 respondents linked completeness of data with the perception that management viewed the CHIS as a useful management tool.

The data for users of SystemB were based on 13 responses. Seven of the respondents were of the opinion that the data in the CHIS in use in their hospital were incomplete (4) or they were neutral (3) on this issue. Only two of the 13 respondents reported both that data in the CHIS were complete ('incomplete?' = -1 or -2), and that they thought that management viewed the CHIS as a useful management tool ('man useful tool' = 1), as shown in Table P.5.

		man USEFUL tool					Total
		-2.00	-1.00	.00	1.00	2.00	
incomplete?	-2	0	0	2	1	0	3
	-1	0	1	1	1	0	3
	0	0	0	1	2	0	3
	1	1	0	0	2	1	4
Total		1	1	4	6	1	13

Table P.5 incomplete? * man USEFUL tool Crosstabulation– PROVINCE 1 SYSTEM B

(iii) 'CHIS knowledge' and 'man useful tool'

The cross correlation between the variable 'CHIS knowledge' (from the hospital questionnaire) and 'man useful tool' reflects weakly positive correlations for the whole Province 1 data set, and for SystemA hospital users. The correlations between these variables were weakly negative for the hospitals using SystemB. These patterns were similar to those for the cross correlations between the variables 'training' and 'man useful tool', as described in a previous section.

Data from the hospital questionnaire were only available for Province 1, and for two hospitals in Province 2. The Province 2 hospital data were not included in the sample for statistical analysis.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	---
hospital data: Province 1	.117
hospital data: Province 1, SystemA	.245
hospital data: Province 1, SystemB	-.167
hospital data: Province 2 (all users of SystemC).	---

Table P.6 Results of cross correlations between 'CHIS knowledge' and 'man useful tool'

(b) 'Appropriateness of CHIS design' (fit) and 'Perception of usefulness of CHIS' ('rep not appr' and 'man useful tool')

The results of simple correlations between these variables are given in Table P.7.
For all groups except the hospitals using SystemC, there was a negative correlation between these two variables reflected in the data, as expected, but it was very weak.
The results for the small sample of SystemC users (therefore Province 2 hospitals) are counterintuitive, in that they reflect a weak positive correlation between these variables.

The cross tabulation between these variables for Province 2 hospitals (i.e., hospitals using SystemC) showed that four of seven hospital-level responses were neutral, and the remaining responses in this small sample reflected very divided opinions on the appropriateness of reports.

The sample for hospitals using SystemB was also very small (6 for SystemB and 7 for SystemC). Results of cross tablulations for four of the SystemB hospitals reflected the opinion that reports were appropriate, but did not reflect a related perception of usefulness of the CHIS by hospital management.

These results reflect the fact that the variable 'rep not appr', which reflects the respondents' perceptions of whether or not the reports available from the CHIS reflect their needs, does not adequately reflect the model factor 'appropriateness of CHIS design'. The variable reflects one of the sub-factors of this model factor. The functionality of the CHIS, which is the other sub-factor, is not reflected in this variable.

The coded comments related to users' opinions of the CHIS which they were using reflected an overwhelming majority of comments related to the appropriateness of CHIS design – in terms of design as a whole, and the subfactors 'functionality' and 'fit': 67 of the 117 comments related to CHIS success were coded as 'design', 'functionality' or 'fit'. 15 of the 43 coded comments related to **lack** of CHIS success were related to design, and the sub-factors of design, as described for this conceptual model.
Thus, these data reflect stronger relationships between these factors than that reflected in the (limited) statistical analysis.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	-.106 (27)
hospital data: Province 1	-.182 (20)
hospital data: Province 1, SystemA	-.106 (14)
hospital data: Province 1, SystemB	.000 (6)
hospital data: Province 2 (all users of SystemC).	.482 (7)

Table P.7 Results of cross correlations between 'rep not appr' and 'man useful tool'

(c) 'Performance of CHIS' and 'Perception of usefulness of CHIS' ('availability factor' and 'man useful tool')

The results of the correlations between these factors, as reflected in Table P.8, do not include any statistically significant results. The combined data sets for Provinces 1 and 2, and the data set for Province 1 hospitals, do reflect non-significant positive correlations between the variables. However, the smaller groupings of hospitals according to the CHIS in use reflect correlations of zero or very close to zero. Similar results were obtained from cross correlations of the related user-level data for these variables, as indicated in the table below.

A strong relationship between CHIS performance and user perception of usefulness of the CHIS would have been expected, since it is a hypothesis of the extended conceptual model of CHIS use that poor performance would be strongly correlated with a poor perception of usefulness of the CHIS. The coded comments related to users' opinions of the CHIS in their hospitals do reflect this relationship: 17 of the 43 comments recorded for Province 1 related to lack of success of the CHIS referred to poor performance (see table O.12 and discussion in Annexure O).

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.332 (27)
hospital data: Province 1	.263 (19)
hospital data: Province 1, SystemA	.018 (13)
hospital data: Province 1, SystemB	.000 (6)
hospital data: Province 2 (all users of SystemC).	.000 (8)
user data: Provinces 1 and 2	*.236*
user data: Province 1	*.222*
user data: Province 1, SystemA	*-.196*
user data: Province 1, SystemB	*.020*
user data: Province 2 (all users of SystemC)	*-.129*

Table P.8 Results of cross correlations between 'availability factor' and 'man useful tool

An alternative relationship to be considered is that between 'availability factor' and the variable 'successful', since this is the variable related to perception of success, which could be regarded as a proxy for perception of usefulness. As summarised in Table P.9 below, these two variables correlate significantly (r = .503; significant at the 0.01 level) using the combined data from all hospitals. The correlation is good but not significant (r = .480) for the Province 2 hospitals, but weak or negative for the Province 1 hospitals.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.503**
hospital data: Province 1	.030
hospital data: Province 1, SystemA	-051
hospital data: Province 1, SystemB	-,250
hospital data: Province 2 (all users of SystemC).	.480

Table P.9 Results of cross correlations between 'availability factor' and 'successful?'

(d) 'Resource availability and allocation'
and 'Perception of usefulness of CHIS' ('all patients' and 'man useful tool')

The variable 'all patients' reflects the resources allocated to the coding of patient diagnoses using ICD-10. Other aspects of resource allocation are reflected in the human resources available to operate the CHIS, and the physical resources associated with the CHIS, as described by the data collected at hospital level.

Although none of the cross correlations of 'all patients' and 'man useful tool' was statistically significant, there was a positive correlation between the variables for all groups except SystemC user hospitals (Province 2). The relationship was counter-intuitive for SystemC hospitals, as indicated by a weak negative correlation between the variables. Cross tabulations at hospital level for these variables indicate that, overall, coding is/should be done for all patients at 11 of the 23 hospitals for which data were available. At five of the six SystemC user hospitals in the available sample, coding was done for all patients, and at most of these hospitals (four of six) coding for all patients was linked to a perception than management do regard the CHIS as a useful tool. Therefore, the negative statistical correlation between the variables for this group is not consistent with the pattern of the cross tabulations.

The strongest correlation between these variables (r = .612) was for the small sample of SystemB user hospitals. For three of the five hospitals in this group, coding is not done for all patients and there is a perception that management do not regard the CHIS as a useful tool. These data therefore largely reflect an opposite situation to that in the SystemC user hospitals. However, these small data sets mean that it is not appropriate to draw any conclusions based only on the statistical analyses.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.116 (23)
hospital data: Province 1	.359 (17)
hospital data: Province 1, SystemA	.213 (12)
hospital data: Province 1, SystemB	.612 (5)
hospital data: Province 2 (all users of SystemC).	-.200 (6)

Table P.10 Results of cross correlations between 'all patients' and 'man useful tool'

One of the main hypotheses of this study is that poor access to the required resources is an important factor which influences the potential for success of computerised hospital information systems (CHISs) in level 1 and level 2 hospitals in South Africa. Access to resources is discussed in more detail in relation to other results from the survey in the main text, for example, in Sections 6.4.4 and 6.4.5.

(e) 'Perception of usefulness of CHIS' and 'Effective use of CHIS and/or outputs' ('man useful tool' and 'man use')

These two variables correlate more strongly than any of the others in this analysis. For all study hospitals, and for hospitals using SystemB, the correlation was strongly significant (r values of .538 and .986 respectively; significant at the 0.01 level). For all Province 1 hospitals, the correlation was statistically significant at the 0.05 level (r = .461), while the r value of .483 for SystemC user hospitals reflects a strong relationship, although it is not statistically significant at 0.05 level or above.

The zero correlation for SystemA user hospitals seems to be an anomaly in this set of data. However, the cross tabulations for these variables for the hospitals using SystemA did reflect a positive relationship between them (see Table P.11): There were 14 hospitals in this group. There were no negative responses for either 'man useful tool' or 'man use'. For 10 of the 14 hospitals in this group, the responses were positive for both 'man useful tool' (rating 1 or 2) and 'man use' (rating 1 or 2).

The cross correlations for these variables based on user-level data reflect similar trends: strong correlations for Province 1 and 2 hospitals combined; Province 1 hospitals; and Province 1 SystemB users; and weaker relationships for Province 1 SystemA users and Province 2 (SystemC users).

Apart from the SystemA group of hospitals, therefore, the strong relationship between the model factors 'perception of usefulness of CHIS' and 'effective use of CHIS and/or outputs' in the extended conceptual model of the CHIS is reflected in the data for the survey hospitals.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.538 (27) **
hospital data: Province 1	.461 (20) *
hospital data: Province 1, SystemA	.000 (14)
hospital data: Province 1, SystemB	.928 (6) **
hospital data: Province 2 (all users of SystemC).	.483 (7)
user data: Provinces 1 and 2	*.450***
user data: Province 1	*.629***
user data: Province 1, SystemA	*.283*
user data: Province 1, SystemB	*.708***
user data: Province 2 (all users of SystemC)	*.121*

Table P.11 Results of cross correlations between 'man use' and 'man useful tool'

(f) 'Management commitment to CHIS success' and 'Perception of usefulness of CHIS' ('man commit' and 'man useful tool')

Apart from SystemC user hospitals, there is a positive correlation between the variables 'management commit' and 'man useful tool', including an r value of 0.619 for all Province 1 hospitals, which is significant at the 0.01 level. The correlation coefficients for each group of hospitals from the data are shown in Table P.12.

Anomalous results are again obtained for SystemC user hospitals (r = -.267), which seem to reflect a negative correlation between these variables. The crosstabulation of these variables for SystemC user hospitals reflected that, for 5 of the 8 responses, positive management commitment was linked to positive perception of usefulness of the CHIS to management (see table P.13). For only 1 of the 8 hospitals was there the perception of strong management commitment (rating = 2) linked to a negative view of the CHIS usefulness for management (rating = -1). Overall, therefore, the crosstabulation for Province 2 SystemC users reflects a positive relationship between perception of management commitment to CHIS success and perception of usefulness of the CHIS by management.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.300 (27)
hospital data: Province 1	.619 (19)**
hospital data: Province 1, SystemA	.419 (13)
hospital data: Province 1, SystemB	.707 (6)
hospital data: Province 2 (all users of SystemC).	-.267 (8)

Table P.12 Results of cross correlations between 'man commit' and 'man useful tool' – hospitals

man useful tool / man commit	-1 or 0	1	total
0	1	0	1
1 or 2	2	5	7
total	3	5	8

Table P.13 man commit * man USEFUL tool Crosstabulation –Province 2 (SystemC user hospitals)

(g) 'Management commitment to CHIS success' and 'Resource availability and allocation' ('man commit' and 'all patients')

This combination of variables reflects the relationship in the conceptual model between management commitment, and the allocation of hospital resources for the CHIS. The hypothesis reflected in the conceptual model is that management commitment to CHIS success would be reflected in the allocation of hospital resources to ensure the effective implementation and use of the CHIS.

Although not statistically significant, a positive relationship between 'man commit' and 'all patients' was reflected in the cross correlations between these variables for Province 1 and 2 hospitals combined; and for SystemB and SystemC user hospitals, as shown in Table P.14. The correlation was close to zero for all Province 1 hospitals combined.

For SystemA user hospitals, the correlation between the variables was counterintuitive (r = -.239). The crosstabulation of data for the SystemA hospital users indicates that, for all 12 hospitals in the group, the rating of the variable 'man commit' is positive. However, in seven of the 12 hospitals, ICD-10 coding is not done for all patients (implying that sufficient resources are not available for coding to be done for all patients), while coding is done for all patients in the remaining five of the 12 hospitals in this group.
[Weak negative cross correlations are also reflected in the user-level data for all groups, except for SystemB users where the data reflect a positive correlation (r = .535).]

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.168 (23)
hospital data: Province 1	.062 (17)
hospital data: Province 1, SystemA	-.239 (12)
hospital data: Province 1, SystemB	.408 (5)
hospital data: Province 2 (all users of SystemC).	.316 (6)
user data: Provinces 1 and 2	*-.200*
user data: Province 1	*-.049*
user data: Province 1, SystemA	*-.258*
user data: Province 1, SystemB	*.535*
user data: Province 2 (all users of SystemC)	*-.111*

Table P14 Results of cross correlations between 'man commit' and 'all patients'

(h) 'Effective use of CHIS and/or outputs' and 'Management commitment to CHIS success' ('man use' and 'man commit')

The hypothesis reflected in this relationship between model factors is that effective use of CHIS outputs contributes to increased management commitment to CHIS success. The data reflect some support for this hypothesis. A positive correlation between these variables was reflected in most groups of respondents, with the correlation for Province 1 hospitals being significant at the 0.05 level (r = .548), and the result for SystemB user hospitals also being fairly strong, but not statistically significant (r = .525). The result for Province 2 hospitals (SystemC user hospitals) was close to zero (r = -.075). These results are summarised in Table P.15.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	.227 (26)
hospital data: Province 1	.548 (19)*
hospital data: Province 1, SystemA	.285 (13)
hospital data: Province 1, SystemB	.525 (6)
hospital data: Province 2 (all users of SystemC).	-.075 (7)

Table P.15 Results of cross correlations between 'man use' and 'man commit'

An additional reflection of this hypothesis is provided by the relationship between 'man use' and the variable 'CHIS meetings' from the hospital questionnaire (results available only for Province 1, as reflected in the table below (table P.16). The variable 'CHIS meetings' is a reflection of whether or not there are hospital meetings at which the CHIS is specifically discussed, and could therefore be interpreted as a proxy measure for 'management commitment to CHIS success'.
However, these data were very variable: near zero correlation for all Province 1 hospitals; positive for SystemA user hospitals, and negative for SystemB user hospitals; and therefore did not support the hypothesis, except for SystemA user hospitals.

	Pearson correlation coefficient
hospital data: Provinces 1 and 2	--
hospital data: Province 1	-.015
hospital data: Province 1, SystemA	.567
hospital data: Province 1, SystemB	-.559
hospital data: Province 2 (all users of SystemC).	--

Table P.16 Results of cross correlations between 'man use' and 'CHIS meetings'

ANNEXURE Q

FACTORS ASSOCIATED WITH CHIS SUCCESS, FAILURE AND RISK

Success dimensions	Success factors
Functional	Careful preparation of the User Requirements Specification to appropriate and balanced take into account and express users' requirements, needs as well as demands
	Alignment of the role and design of the IT-system
Organisational	Collaboration and cooperation
	make implementation a transparent process within the organisation
	Work from the workflow
	high competencies
	support from higher level organisations (regional/ national institutes)
Behavioural	The personal attitude, engagement and commitment
	the users are key
	motivational activities
Cultural	Preparedness and willingness towards cultural change
	in general
	understand medicine and healthcare in general as a separate culture
	understand the local culture
Political	high-level commitment
	monitoring political implications
	considering IT-systems a service rather than a product from a vendor
	collaboration and concertation in providing new solutions
	transparency
Management	Management support
	Flexible planning
	Prospective and proactive control
	consider IT implementation as a change process
	coping with the impact of change
	User involvement
	Strategy
	communication
	Handling the diversity within stakeholder goals
Technical	Standard based
	Data validity procedures are part of system qualities
	use proven technology
	Usability
	Integrated functionality
	Communication standards
	Flexibility and adaptability, enabling future functional and technical changes
Legal aspects	Know what the legal constraints/opportunities are
Strategy	Organisational
	Accepted also at lower levels
	National
	Regional
Economy	There has to be a return of investment (whether material or immaterial)
	justification of increase of costs
	sufficient funding
Education	(in general)
	sufficient training
User acceptance	

Table Q.1 HIS success factors (adapted from Brender *et al.*, 2006; supporting documentation)

Failure dimensions	**Failure Criteria**
Functional	The system does not meet expectations
	Limitations in the way the user can express his/herself
	moving target
Organisational	Not understanding the organisational context
Behavioral	Overloading the user
	Underestimating user acceptance
	Resistance because of fear or loss of control of own job situation
Cultural	Assuming that what works at one place also works somewhere else
	Users have too high expectations
Management	overambitious implementation plans
	judgement based on wrong premises
	improper tendering
	business reorganisation of the vendor
Technical	Limitations in the way the user can express his/herself
	Response rate and other performance measures
	Vendor did not support the functionality quoted
	Insufficient verification of conformity with requirements specification
	the technology is so restricted that it impacts design and implementation choices
Legal	Low concern on regulations and standards
	Compliance with laws and existing ethical rules of conduct
Economy	lacking financial power of a vendor
Education	Visible discrepancy between successive versions of the IT-system

Table Q.2 HIS failure criteria (adapted from Brender *et al.*, 2006; supporting documentation)

Risk dimensions	Risk factors
Technological	introduction of a new technology
	complex/unreliable technical infrastructure or network
	complex software solution
	complex/incompatible hardware
	poor software performance
Human/user	unrealistic expectations
	overall resistance to change
	lack of cooperation/commitment from users
	poor computer skills
	prior negative experiences with CIS projects
Usability	poor perceived system ease of use
	poor perceived system usefulness
	misalignment of system with local practices and processes
Project team	changes to membership on the project team
	poor project leadership
	lack of required knowledge or skills
	lack of clear role definitions
	negative attitude of project team members
Project	large and complex project
	project ambiguity
	changes to requirements
	insufficient resources
	lack of a project champion
	lack of a formal project management methodology
Organisational/environmental	lack of commitment from upper management
	organizational instability
	lack of local personnel knowledgeable in IT
	legal and ethical constraints
Strategic/political	misalignment of actors' and partners' objectives and skills
	political games/conflicts
	unreliable external partners

Table Q.3 Revised taxonomy of CIS project risks (adapted from Paré *et al.*, 2008, p256)