2014

Developing effective hospital management information systems: A technology ecosystem perspective

Christopher Bain
Edith Cowan University

Developing effective hospital management information systems: A technology ecosystem perspective

Christopher Bain
Edith Cowan University, bainchri@optusnet.com.au

Edith Cowan University

Copyright Warning

USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.

PhD Research Thesis-

Developing Effective Hospital Management Information Systems: A Technology Ecosystem Perspective

DATE OF SUBMISSION:

5 October 2014

PREPARED BY:

Dr Christopher Bain

MBBS, Master Info. Tech

Student No: 10054499

Edith Cowan University

Course: Doctor of Philosophy (Business)

Supervisor: Prof Craig Standing

ABSTRACT

This thesis presents the results of the program of research performed in the completion of a Doctor of Philosophy (Business) entitled: *Developing Effective Hospital Management Information Systems: A Technology Ecosystem Perspective.*

The central contention of this thesis is that the current ecosystem models in the information technology (IT) and information systems (IS) literature can be extended and improved. In turn they can be better applied to the field of IS and the development and implementation of information systems. This research seeks to highlight an example of how these models can be extended, through an analysis of the specific context of the hospital management information system environment, using the technology ecosystems model (TEM) of Adomavicius et al (Adomavicius et al., 2005).

The environment in which hospital managers operate is characterised by high demand pressures, strong public service expectations, and an ever diminishing income stream (in relative terms) with which to provide services. Even in private hospital care, many of these pressures still apply, as well as a pressure to maintain profit margins. The agenda context here is a complex one, particularly when one considers the role of hospitals in this context. Hospitals have multiple competing priorities when viewed from a management perspective. This is despite the fact that the core mission of the hospital is to provide timely, safe care within available human and financial resources, to patients who present for care. This care can be across multiple care settings inside the hospital including the inpatient space, the operating theatres, the intensive care unit, and the emergency department; and in outreach settings. Hospitals however, have been described as a series of cottage industries each loosely coupled with a common objective of supplying care to patients. All of these factors combine to mean that managing a hospital with the above-mentioned aim in mind, is a very difficult task. Nakagawa et al (Nakagawa et al., 2011) talk specifically to this difficulty.

In this research I undertake this examination through 2 core exercises. Firstly I examine the literature – both the information related and health care literature, for insights into the questions at hand. Secondly I examine the lessons learned from five Case Studies (CSs). The first four of these are based in physical hospital facilities across three Australian states. The final one is a “virtual CS” in which the views of multiple parties,

not centred on any given physical institution, are sought and examined in relation to these questions.

Based on the data collected in both the literature review and the CS', and through a process of triangulation and research model validation, I conclude that a **ho**spital **m**anagement technology **e**cosystem (a HOME) can be described. Its existence thus validates the core TEM, and in fact the findings support some meaningful extensions to the TEM.

The HOME is predominantly characterised by the presence of strong drivers of change that arise from outside the immediate hospital environment. Examples include changes in the labour market, and the skill sets of workers; changes in the broader development and availability of technology (for example – think of the effects of the rise of smart phones), and changes in government policies and funding arrangements. In the majority of cases these broader influencing forces (Environment Shaping Forces – ESF's) can be seen to act on the local management environment and the role of technology in that environment, through describable intermediaries. A very obvious example of this is the effect of a global financial downturn - eventually this wide reaching force could be expected to affect hospitals (be they private or public) through struggling performance of a parent company, or state government funding cutbacks. In turn this could easily lead to reduced spending on IT in a given hospital. These findings, along with those around services provided by the ecosystem, and the measurement of ecosystem success or failure, add substantially to the IS knowledge base in this area.

This research thus acts as a sound basis for further research in this new direction, but also provides a usable conceptual and practical framework within which stakeholders – managers, clinicians, beauracrats and the software development community - can view the management of hospitals and the technologies in support of that management.

DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

i. incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education

ii. contain any material previously published or written by another person except where due reference is made in the text of this thesis; or

iii. contain any defamatory material

Signed:

Student Name: Christopher Ashley Bain

ECU Student Number: 10054499

Date: 1/10/2014

ACKNOWLEDGMENTS

I would like to acknowledge the support of my supervisor Prof Craig Standing whose helpful advice has enabled me to complete this long PhD journey – the conclusion of which is marked by the production of this thesis.

I would also like to thank all of the hospital staff and other professionals who supported me, by graciously allowing me into their organizations and to better understand their issues, and desires for the future.

Most importantly though, I would like to thank my wife Debra and my children Emily and Addison for their enduring support along this journey. Addison was naught but a twinkle in my eye when I commenced this journey. Without the love and support of my family I would not have been able to complete this work.

PUBLICATIONS AND PRESENTATIONS ARISING FROM THE THESIS

- Bain, C., & Standing, C. (2009) A technology ecosystem perspective on hospital management information systems: lessons from the health literature. *International Journal of Electronic Healthcare, 5* (2), 193-210.

- Bain, C. (2009) Poster – Australian College of Health Service Managers (ACHSM) Annual Congress August 4-7, 2009 – Building our Health System around People and their Needs. Gold Coast, Qld.

- Bain, C. (2010) Oral Presentation - Innovations in Healthcare Management and Informatics (IHMI) 2010 Conference - March, 2010. Singapore

- Bain C. (2010) Workshop - Innovations in Healthcare Management and Informatics (IHMI) 2010 Conference - March, 2010. Singapore

TABLE OF CONTENTS

ABSTRACT ..... **II**
DECLARATION ..... **IV**
ACKNOWLEDGMENTS ..... **V**
PUBLICATIONS AND PRESENTATIONS ARISING FROM THE THESIS ..... **V**
ABBREVIATIONS AND ACRONYMS ..... **VIII**
LIST OF TABLES ..... **XII**
LIST OF FIGURES ..... **XV**
CHAPTER 1 - INTRODUCTION **1**
AN OVERVIEW OF THE PROBLEM 1
THE RESEARCH QUESTIONS 4
OVERVIEW OF THE METHODOLOGY CHOSEN 5
THE MAIN CONTRIBUTION OF THE THESIS 6
STRUCTURE OF THE THESIS 7
CHAPTER 2 - LITERATURE REVIEW **9**
ANALYSIS OF LITERATURE 9
Biological, Information and Technological Ecosystems *10*
IS and IT Planning in Healthcare *18*
IS and IT Success and Failure in Healthcare *20*
Summary of the Literature *24*
CONCEPTUAL MODEL 25
CHAPTER 3 - RESEARCH DESIGN **31**
METHODOLOGY 31
Overview *31*
The Approach in this Research *34*
RESEARCH MODEL 35
What is a Research Model? *35*
What is the Research Model in this Thesis? *35*
RESEARCH QUESTIONS 37
Question Set 1 ..... *38*
Question Set 2 ..... *40*
DATA GATHERING 44
Literature Review The literature base under consideration is in the following domains and disciplines: *44*
Case Studies *46*
DATA ANALYSIS 47
Literature Review Analysis *47*
Case Study Analysis *48*
STUDY RELIABILITY AND VALIDITY 48
What is reliability in ISR? *48*
What is validity in ISR? *50*
How will this work meet these criteria? *50*
CHAPTER 4 - FINDINGS **51**
CASE STUDIES 51
Hospital Characteristics *51*

Key Descriptive Features of Informants *52*
Case Study 1 – Large Metropolitan Hospital *55*
Case Study 2 – Outer Metropolitan Hospital *74*
Case Study 3 – Conjoined Metropolitan Hospital *94*
Case Study 4 – Large Regional Hospital *112*
Case Study 5 – "Virtual" Hospital *129*
LITERATURE REVIEW 146
Question Set 1 ..... *147*
Question Set 2 ..... *164*

CHAPTER 5 - DISCUSSION 168

SUMMARY OF FINDINGS 168
Overview *168*
Question Set 1 ..... *169*
Question Set 2 ..... *214*
The Research Model *229*

CHAPTER 6 - CONCLUSIONS 232

SUMMARY OF THE THESIS 232
KEY FINDINGS OF THE RESEARCH 234
LIMITATIONS OF THE STUDY 235
Methodological Considerations *235*
Generalizability of the Research *236*
RESEARCH IMPLICATIONS 237
The Power of Analogy *237*
A New View of Technology Ecosystems? *237*
CONTRIBUTION OF THE THESIS TO THE IS DISCIPLINE 239
IMPLICATIONS FOR PRACTICE 241
Who can the model assist in a practical sense ? *241*
How will that new view assist in developing effective HMIS' *241*
FURTHER RESEARCH 242
Ecosystems Services *242*
The Biome Concept *243*
Further testing of the TEM Concept *243*
Synergies with other Key IS Theories *244*

REFERENCES 246

APPENDICES 258

APPENDIX 1- ARID ZONE ANALOGY 258
APPENDIX 2- KEY INFORMANT INTERVIEW QUESTIONS 259
APPENDIX 3- SITE 1 – IM AND T PLANNING ARTEFACT 268

ABBREVIATIONS AND ACRONYMS

Below are listed the relevant abbreviations and acronyms used throughout the document.

- 3D – Three dimensional
- ACHS – Australian Council on Healthcare Standards - http://www.achs.org.au/
- AIHW – Australian Institute of Health and Welfare
- AIMS – Anaesthesia Information Management System
- ATSI – Aboriginal and Torres Strait Islander
- BI – Business Intelligence
- CAH – Critical Access Hospital (a US specific designation)
- CAIS - Communications of the Association for Information Systems
- CDM – Chronic Disease Management
- CDS – Clinical Decision Support
- CEO – Chief Executive Officer
- CIO – Chief Information Officer
- CJD - Creutzfeldt–Jakob disease
- CMO – Chief Medical Officer
- CMS – Content Management System
- CN – Clinical Network
- CNM – Clinical Network Manager
- COTS – Commercial Off The Shelf (Software)
- CPOE – Computerized Physician Order Entry
- CS – Case Study
- CVC – Central Venous Catheter (also known as a Central Line)
- CW – Commonwealth (of Australia - as in Australian Federal Government)
- DBE – Digital Business Ecosystem
- DE – Digital Environment
- DES – Digital Ecosystem
- DH – Health Department / Department of Health
- DOS – Disk Operating System
- DS – Digital Species
- DW – Data Warehouse
- ED – Emergency Department
- EDIS – Emergency Department Information System
- EHR – Electronic Health Record

- EMAR – Electronic Medication Administration Record
- EMR – Electronic Medical Record
- ESF – Environment Shaping Force
- FMIS – Financial Management Information System
- FT – Focal Technology
- FTE – Full Time Equivalent (the same as EFT)
- GFC – Global Financial Crisis
- GIGO – Garbage In, Garbage Out
- GP – General Practitioner
- GUI – Graphical User Interface
- HCP – Healthcare Provider / Practitioner
- HIT – Health Information Technology
- HITH – Hospital in the Home
- HL7 – Health Level-7
- HMIS – Hospital Management Information System
- HMO – Hospital Medical Officer
- HOME – **Ho**spital **M**anagement Technology **E**cosystem
- HN – Hospital Network
- HPW - Health Professional Workstation
- HR – Human Resources
- HRO - High Reliability Organization
- ICT - Information and Communications Technologies
- ICU – Intensive Care Unit
- IM – Instant Messaging / Information Management
- IMS – Incident Management System
- IM and T – Information Management and Technology
- IS – Information System(s)
- ISR – Information Systems Research
- ISS – Information Systems Success (Model)
- IT – Information Technology
- KI – Key Informant
- KII – Key Informant Interview
- KPI – Key Performance Indicator
- LAN – Local Area Network
- LIS – Laboratory Information System
- LOS – Length of Stay

- MAPU – Medical Assessment and Planning Unit
- MDM – Master Data Management
- MIS - Management Information System
- MRSA – Methicillin Resistant Staphylococcus Aureus (= “Golden Staph”)
- NEHTA – National E-Health Transition Authority
- NHS – National Health Service (UK Agency)
- NSQHS - National Safety and Quality Health Service (Standards)
- NUM – Nurse Unit Manager
- OR – Operating Room (= OT - Operating Theatre)
- ORIS – Operating Room (=Theatre) Information System
- ORMIS – Operating Room (=Theatre) Management Information System
- OSA – Obstructive Sleep Apnoea
- OT – Operating Theatre (= OR - Operating Room)
- PACS – Picture Archiving and Communication System
- PAS – Patient Administration System
- PC – Personal Computer
- PCIS – Patient Care Information System
- PDA – Personal Digital Assistant
- PM – Project Manager/Management
- POC – Point Of Care
- PSC – Primary Stroke Centre
- RFID – Radiofrequency Identification
- RIS – Radiology Information System
- RM – Research Model
- ROI – Return On Investment
- SAP – Systems, Applications and Products
- SDB – Sleep Disordered Breathing
- SLA – Service Level Agreement
- SME – Subject Matter Expert
- SV – Site Visit
- TAM – Technology Acceptance Model
- TE – Technology Ecosystem
- TEM - Technology Ecosystem Model
- TL – Technology Layer
- TP – Transaction processing
- TR – Technology Role

- TSF – Technology Shaping Force
- UC – Ulcerative Colitis
- UG – User Group
- UR – Universal Record (number)
- UTAUT - Unified Theory of Acceptance and Use of Technology
- VMO – Visiting Medical Officer
- VR – Virtual Reality

List of Tables

- Table 1 - Hospital Characteristics for Case Studies 1-4
- Table 2 - Key informant Job Roles for Case Studies 1-5
- Table 3 - Key Descriptive Features of Informants – Gender- Q1
- Table 4- Key Descriptive Features of Informants – Age- Q2
- Table 5- Key Descriptive Features of Informants – Sector-Q3
- Table 6- Key Descriptive Features of Informants – Job Role -Q4
- Table 7- Key Descriptive Features of Informants – Years in Sector/Healthcare- Q5 and 6
- Table 8 - Case Study 1 – Systems Success. Q 11 and 12
- Table 9 – Case Study 1 – Systems Changed. Q 13 and 14
- Table 10 – Case Study 1 – Internal / External factors Past. Q 15, 16 and 17
- Table 11 – Case Study 1 – Unmet Needs and Why ? Q 19 and 20
- Table 12- Case Study 1- And in which topic areas ? and why do you say that ? Q21 and 22
- Table 13 – Case Study 1 – How may systems change and why do you say that ? Q 23.
- Table 14 – Case Study 1 – Will these needs be met ? Q24.
- Table 15 – Case Study 1 – What internal and external forces will drive this ? Q25 and 26.
- Table 16 – Case Study 1 – How would you characterize the environment? Q29.
- Table 17 - Case Study 2 – Systems Success. Q 11 and 12
- Table 18 – Case Study 2 – Systems Changed. Q 13 and 14
- Table 19 – Case Study 2 – Internal / External factors Past. Q 15, 16 and 17
- Table 20 – Case Study 2 – Unmet Needs and Why ? Q 19 and 20
- Table 21- Case Study 2- And in which topic areas ? and why do you say that ? Q21 and 22
- Table 22 – Case Study 2 – How may systems change and why do you say that ? Q 23.
- Table 23 – Case Study 2 – Will these needs be met ? Q24.
- Table 24 – Case Study 2 – What internal and external forces will drive this ? Q25 and 26.
- Table 25 – Case Study 2 – How would you characterize the environment? Q29.

- Table 26 - Case Study 3 – Systems Success. Q 11 and 12
- Table 27 – Case Study 3 – Systems Changed. Q 13 and 14
- Table 28 – Case Study 3 – Internal / External factors Past. Q 15, 16 and 17
- Table 29 – Case Study 3 – Unmet Needs and Why ? Q 19 and 20
- Table 30- Case Study 3- And in which topic areas ? and why do you say that ? Q21 and 22
- Table 31 – Case Study 3 – How may systems change and why do you say that ? Q 23.
- Table 32 – Case Study 3 – Will these needs be met ? Q24.
- Table 33 – Case Study 3 – What internal and external forces will drive this ? Q25 and 26.
- Table 34 – Case Study 3 – How would you characterize the environment? Q29.
- Table 35 - Case Study 4 – Systems Success. Q 11 and 12
- Table 36 – Case Study 4 – Systems Changed. Q 13 and 14
- Table 37 – Case Study 4 – Internal / External factors Past. Q 15, 16 and 17
- Table 38 – Case Study 4 – Unmet Needs and Why ? Q 19 and 20
- Table 39- Case Study 4- And in which topic areas ? and why do you say that ? Q21 and 22
- Table 40 – Case Study 4 – How may systems change and why do you say that ? Q 23.
- Table 41 – Case Study 4 – Will these needs be met ? Q24.
- Table 42 – Case Study 4 – What internal and external forces will drive this ? Q25 and 26.
- Table 43 – Case Study 4 – How would you characterize the environment? Q29.
- Table 44 - Case Study 5 – Systems Success. Q 11 and 12
- Table 45 – Case Study 5 – Systems Changed. Q 13 and 14
- Table 46 – Case Study 5 – Internal / External factors Past. Q 15 and 16
- Table 47 – Case Study 5 – Unmet Needs and Why ? Q 19 and 20
- Table 48- Case Study 5- And in which topic areas ? and why do you say that ? Q21 and 22
- Table 49 – Case Study 5 – How may systems change and why do you say that ? Q 23.
- Table 50 – Case Study 5 – Will these needs be met ? Q24.
- Table 51 – Case Study 5 – What internal and external forces will drive this ? Q25 and 26

- Table 52 – Case Study 5 – How would you characterize the environment? Q29.
- Table 53 – Literature regarding the Focal Technology Concept
- Table 54 – Literature regarding the Technology Layers and Technology Role Concepts
- Table 55 – Literature regarding the Technology Shaping Forces Concept
- Table 56 – Literature regarding the key characteristics of the TEM
- Table 57 – Literature regarding the strengths and weaknesses of the TEM
- Table 58 - Literature regarding the usefulness of the model for analysing an HMIS infrastructure
- Table 59 - Literature regarding now the TEM compares with other planning lenses
- Table 60 - Literature regarding the definition of ecosystems success and failure in this environment
- Table 61 - Literature regarding the factors affecting ecosystems success and failure in this environment
- Table 62- Literature regarding now stakeholders can benefit from the application of the TEM to the HMIS environment

LIST OF FIGURES

- Figure 1 – Overview of Major Research Themes in Health IT
- Figure 2 – The Hospital Context
- Figure 3 – HOME Conceptual Framework
- Figure 4 – Research model for the HOME
- Figure 5 – Relationship between ESFs and TSFs
- Figure 6 - ESFs, TSF, and Ecosystems Success / Failure Drivers
- Figure 7 – Final Research Model for the HOME in light of Findings
- Figure 8 – The content of the technology layers of the HOME model

CHAPTER 1 - INTRODUCTION

An Overview of the Problem

Hospital managers have a large range of information needs- from quality, finance and access information needs to educational, resourcing and decision support needs. Currently these needs are met by the manager interacting with numerous disparate systems, both electronic – from SAP and Oracle Financials to PAS (patient administration) systems like HOMER, and relevant web sites- and paper based systems. The managerial interaction in this setting represents a significant imposition on hospital managers in terms of time taken to train on and use systems, and the integration of the information provided to them.

In addition to the burden on managers in relation to training and system interactions in order to have their information needs met, there are several other pressures on them. Many hospital managers have responsibilities that extend to system purchasing and maintenance decisions. Think for example of the managers of a key hospital area (e.g. – the Intensive Care Unit (ICU)). Such a role demands complete or partial responsibility be taken for clinical and management system procurement decisions and the implications of such decisions. In the real world these are not decisions for the hospital information technology department alone.

These various existing systems, and future systems, can be thought of as existing in a **technology ecosystem** (TE) as described by several authors (Adomavicius et al., 2006). High amongst the needs of hospital managers are newer, more advanced technologies that provide predictive and analytic capability not yet seen in this domain- for instance technologies arising out of the field of "nosokinetics" (Millard, 2006). Such systems will become critical elements of a **hospital management technology ecosystem (HOME) i**n this model. Nosokinetics is effectively the science of how patients move through hospitals, and is an evolving field. It has arisen out of the desperate need of hospital managers to better document, understand and control the way these movements occur.

In order to more fully understand the scope of the knowledge base to be examined in this thesis, I will first establish a few key definitions. Firstly, for the purposes of this

research it is important to specify what I mean by the term “manager” and hence the term “management information system”. The fact that our area of study here is hospitals throws up a particularly important issue in relation to what a manager is.

In hospitals, many managers also provide “service line operations” for want of a better term (ie – they provide care to individuals). As a result, in some of their information needs, and in terms of some of the systems with which they interact – that distinction (managerial versus care provision) is only made by the kind of information they seek – focused on individual patients as providers of care (service line), or conversely, focused on groups of patients, wards, business units or non-patient related (e.g. -finance, human resources (HR) and throughput), with their managerial hats on. This is therefore, the definition I will use of a hospital manager (some of whom also provide care), and of management information systems.

In relation to this dimension of scale, Tringali and de Lusignan (Tringali and de Lusignan, 2005) note these 2 views are opposite but complementary sides of the same coin when examining hospitals through a knowledge management lens. In addition, Fichman et al (Fichman et al., 2011) make some interesting observations that further illustrate the point. They assert that information systems in healthcare allow the capture and dissemination of information to decision makers “for better coordination of healthcare at both the individual and population levels”. As an example they cite how "data mining and decision support capabilities can identify potential adverse events for an individual patient whilst also contributing to the population’s health by providing insights into the causes of disease complications". I strongly concur with these assertions. This world view is of great importance as I proceed to examine the literature base in the latter sections of the thesis.

Whilst I will explore the concept of a technology ecosystem later in the thesis, the definition that will be referred to in this work is that proposed by Adomavicius et al (Adomavicius G et al., 2005): **“A system of interrelated technologies that influence each other’s evolution and development.”** Furthermore, this definition includes the concept that **“A specific technology ecosystem view is defined around a focal technology in a given context.”** Although this definition was initially put forward in the context of a proposed new model of technology evolution, it is highly appropriate in the context of this research which seeks to aid in the development of effective hospital management information systems.

Importantly also, these authors define some other key concepts which are complementary to their definition of a technology ecosystem, and which are also directly relevant to the research being undertaken in this thesis. They are as follows:

- ***Technology Roles (TR's):*** "The influential roles that a technology can play with respect to other technologies in a given technology ecosystem."

- ***Technology Layers (TL's):*** "In a specific ecosystem view, technologies playing the same role with respect to the focal technology are grouped in a technology layer."

- ***Technology-Shaping Forces (TSF's):*** "External environmental forces that can influence the development and evolution of a technology or technology ecosystem. These include social and governmental forces, technical forces and economic forces."

The importance of such a model is that the information and decision support needs (in relation to the purchasing, development and maintenance of relevant management systems) of hospital managers that were referred to earlier, could be better understood and supported in the context of an environment that is described well by the model.

There has been no work published to date on the application of the technology ecosystem concept to the specific organizational context of hospital management information systems. In addition, although there have been some isolated further examples building on the original work (Adomavicius et al., 2007b, Adomavicius et al., 2007a, Adomavicius et al., 2008a, Adomavicius et al., 2008b) (Bhutto, 2008), the more general published work in this area does not have great breadth. For example, the work to this point in time has not examined the relevance of further biological ecosystem concepts to the field of information systems- for instance the existing work around "biomes" (Oracle ThinkQuest Education Foundation, 2006) which represent a group of related ecosystems – e.g.- all tropical rainforests are part of the tropical rainforest biome. It's possible for instance, that there may be commonalities among subsets of the various technology ecosystems.

Importantly, also, the existing work regarding technology ecosystems does not have great depth in relating the key lessons of ecological science to the information system

space. For instance there is little if any published work in relation to the factors affecting technology ecosystem success and failure, or in relation to the key types of technology ecosystems and what distinguishes them and their "inhabitants" from other ecosystems. There is also evolving work around the concept that biological ecosystems provide "services" for "users" such as humans (CSIRO Sustainable Ecosystems, 2004). In turn, there may be significant gains that can be made in our understanding of technology ecosystems by further investigation and application of these more detailed biological concepts.

It is the fundamental contention of this research that addressing issues such as the ones raised above will provide an extension to, and improvement on, the TEM for information systems, in a way that will increase its usefulness and its practical applicability. In summary:

- The field of hospital management information systems (HMIS) is evolving
- The current technology ecosystem model (TEM) lacks breadth and depth
- HMIS development and implementation could benefit from a broader and deeper TEM, and the HMIS environment may in fact may represents its own TE (the **Ho**spital **M**anagement Technology **E**cosystem (HOME))
- This research will, through case studies (CS') (in turn underpinned by site visits (SV's)), explore those ideas and demonstrate possible extensions to the concepts behind the TEM. At the core of the SVs are interviews with key informants (KII's)

The Research Questions

An initial consideration of the issues led to the formulation of some key questions that will address the problem at hand. They are as follows:

Question Set 1 *addresses the broad issue of if and how the HMIS environment relates to a TEM approach and viewpoint. Answering these questions will demonstrate ways in which the current TEM could be improved.*

- How does the TEM apply to a hospital environment? For instance – could it be conceptually related to the arid zone biome? (see Appendix 1). Implicit in this first question is the sub question – firstly does the TEM apply to the hospital environment ?
- What are the key characteristics of the TEM in this context?

- What are its strengths and weaknesses?
- How valid and useful is the model for analysing an HMIS infrastructure?
- How does it compare with other IT planning lenses?

Attempting to answer this set of questions will provide both some independent validation of the core concepts assumed in the original work, and validation of the conceptual framework being presented in this research.

Question Set 2 *addresses the issue of the practical utility of the TEM approach in the HMIS context, in light of the answers to Question Set 1(in fact this question set assumes the identification of a HOME from Question Set 1), such that potential stakeholders can gain the most benefit of the outcomes of this research.*

- What is the definition of ecosystems success and failure in this environment?
- What are the factors affecting ecosystems success and failure in this environment?
- How can stakeholders benefit from the application of the TEM to the HMIS environment (e.g. - via a HOME model)?

Attempting to answer this second set of questions will provide a view on the practical utility robustness of the TEM in the HMIS space, thus providing insights and guidance for relevant stakeholder seeking to apply the model.

Overview of the Methodology Chosen

The methodological philosophy underpinning this research is a mixed one – it draws on elements of both positivism and interpretivism. In addition it uses a mixture of techniques including a literature review and analysis, and case study approaches. The work has started from the observation that the original TEM did not appear to have any attempted external validation. That is to say, the original work of Adomavicius et al (Adomavicius et al., 2006) simply described a theory with a high level of logical coherence and potential utility, which used as its exemplar the case of digital music. The work did not seek to provide any attempt at empirical measurement regarding the actual plausibility of their model and it's extensibility to other contexts.

The positivist elements of this research seek to provide external and reproducible validation of the underlying theory. Whilst acknowledging the limitations of the positivist approach, the strength of this research is that it seeks to establish through quantitative and qualitative data collection and analysis, that the core theory is verifiable in some way, and hence that it can be applied to other settings beyond the original digital music context in which it was proposed.

The positivist viewpoint outlined above will be supplemented by the strong use of analogy in this setting. Clearly the underpinnings of the TEM are built on the power of analogy, and this research seeks to extend the breadth and depth of that biological analogy where possible.

These methodological considerations will be explored greater depth in Chapter 3 – Research Design.

The Main Contribution of the Thesis

In overview, the main contribution of this thesis and the research that underpins it is to provide independent external validation of the existing TEM, and to seek to apply it to the hospital management context, so as to allow stakeholders in that space (executives and managers, funders, technologists, vendors and researchers) to take advantage of the insights provided by the extended, validated TEM. In particular it should allow them to better understand how to plan for, purchase, develop and implement such technologies.

Let us examine the contribution of this thesis in a little more detail. In attempting to answer question set 1, this research seeks to validate the core assumptions of the TEM of Adomavicius et al (Adomavicius et al., 2005) ,and to extend it and apply it to the health context – specifically to health care management. These questions address the broad issue of how the HMIS environment relates to a TEM approach and viewpoint. Answering these questions will demonstrate ways in which the current TEM could be improved.

Specifically, if the work can more precisely define if and how the TEM applies to the HMIS environment, then that is a good theoretical basis for planning and investment decisions in this space. Furthermore, if this research can examine in more detail the real

world applicability of such concepts, then that is a good basis for actually assisting these same IT planning and investment decisions.

Structure of the Thesis

The research presented in this thesis follows a fairly traditional structure. Beyond this first Chapter (Introduction), the structure is as follows:

- Chapter 2 – Literature Review
- Chapter 3 – Research Design
- Chapter 4 – Findings
- Chapter 5 – Discussion
- Chapter 6 - Conclusions

In Chapter 2 (Literature Review) I will examine the existing literature regarding technology ecosystems, technology evolution and related concepts. As a result I will be able to describe a conceptual framework in which this work sits, so as to act as a foundation for the data gathering and analysis that follows. Work I have already published (Bain and Standing, 2009) has described much of the existing context around TE's and related concepts, but this Chapter will go into these issues in greater depth. Furthermore, the potential alignment of the core TEM to the HMIS context will be proposed in this chapter.

The Research Design chapter (Chapter 3) will provide more detail regarding the methodology being used in this work, and how that methodology will allow the data collected to validate and build upon the conceptual framework described above. Any research approach has its limitations and this section of the thesis will also address these. The 2 main components of the data gathering are a literature review and site visits involving KII's.

In Chapter 4 (Findings) I will relate the proposed conceptual model to the known existing literature and the CS'. In particular, the drivers for the research will be identified in relation to gaps in the existing literature around TE's and related IS constructs in the technology evolution space.

The literature base under consideration is in the following domains and disciplines:

- Information systems
- Information management
- Information technology
- Health and medical informatics
- Health service research
- Heath services management and
- Health service provision

The literature base being examined will go back in time 12 years to 2002 in relation to the TEM, its validation and related issues. This time frame was based on an initial 5 year backward view at the point time of commencement of the thesis, knowing that this time window would extend forward over the duration of the work. Research databases and portals searched include, but were not limited to:

- ACM Digital Library
- Journals of Information systems
- IEEE literature sources and
- Pub Med (the best known, and arguably most comprehensive central library of health research articles)

The KIIs were conducted across 4 health services in 3 states of Australia – these sites provide both public and private hospital services in the metropolitan and regional settings. These were supplemented by KIIs (CS 5) with other relevant actors in the environment, including a health bureaucrat, a clinical network manager and an IT services consultant.

In Chapter 5 (Discussion) I will examine the findings in more detail, summarizing the collected data and its relationship to the conceptual framework established in Chapter 2. I will then also explain the limitations of the work and identify potential avenues of future research in this area.

In the final chapter of the thesis (Chapter 6 – Conclusions), I will present the contribution of the thesis, including in relation to the broader body of work in understanding technology evolution and technology usage in information systems. In particular I will provide some explanatory context for those seeking to use the findings of the research in subsequent planning, purchasing and development decisions in the real world.

CHAPTER 2 - LITERATURE REVIEW

In this chapter I will examine the relevant issues around IS in the HMIS environment, their relationship to ecosystems type frameworks, and the evidence from the literature around the real world success and failure of IS in that environment.

The chapter will conclude with the presentation of a conceptual framework against which the subsequent evidence gathering and analysis will take place.

Analysis of Literature

An initial literature review was performed in support of this research and it searched the relevant information systems, business and information technology, and health literature, with no date restriction.

Firstly I will examine the available literature around biological ecosystems concepts in the business, information and technology spheres. Then I will examine available literature around IS and IT planning and will relate it to the HMIS context. Finally I will examine successes and failures of IS and IT systems in the healthcare setting, and some of the theoretical underpinnings of these. Throughout this section I will seek to relate the findings to the thesis and the opportunities it presents

It is important to consider up front how I will define HMIS systems, as there is a large body of literature around health IS' and health IT, and not all of it is relevant to this research. In order to scope the literature search here and for subsequent chapters (Chapter 4 – Findings), the following points are a guide:

- the management of patients (out of scope) and the management of hospital units, divisions or whole hospitals are at the ends of a spectrum. In the middle are hospital staff who do both – where search results may provide an insight into this middle ground they have been included
- equally, where results provide insights into the hospital environment – definitely in scope in this thesis- they have been included
- the definition of hospital managers that I will use is such that anyone who has management responsibility in a hospital (including clinician managers).This also

includes, for instance, Managers / Directors of Pharmacy and other support departments – so as not to limit the findings of the work to higher level hospital executives

- the relevant literature can extend to any system or context relevant to such managers (as defined above). So for example even to the work of Bay and Ergul (Bay and Ergul, 2004) or that of Muldur (Muldur, 2003), both of which extend into the hospital engineering space.

Biological, Information and Technological Ecosystems

In a special edition of the Information Systems Research (ISR) Journal in 2011, that was dedicated to healthcare and edited by Fichman et al (Fichman et al., 2011), the potential for information systems and information systems research to assist in improving the quality and efficiency if healthcare is highlighted. These authors assert that there are 6 "theoretically distinctive elements" of healthcare that ties together the articles published together in the special edition. These are that

- the stakes are life and death
- healthcare information is personal
- **healthcare is very influenced by regulation and competition**
- **healthcare is professionally driven and hierarchical**
- **healthcare is multidisciplinary in nature and**
- **healthcare IS implementations are complex**

I would argue that particularly in light of these last 4 points **(bolded**), analogies with biological ecosystems may be a useful means through which to better understand the complexities of the hospital management environment and the role of HMIS'.

Before proceeding it is worth briefly examining the issues surrounding the role of healthcare staff and in particular the role of medical staff, in the healthcare system, particularly in light of the bolded statement above about the "**professionally driven and hierarchical"** nature of healthcare. Whilst employment models for senior doctors (and they are my focus in this brief analysis, rather than junior doctors –"residents" or "house officers" - who tend to be the "medical worker bees" of the healthcare system), also known as "consultants" or "specialists", vary from hospital to hospital, there are some common principles and issues internationally.

Specialists can be employed as full time hospital employees, but are often "sessional staff" who spend periods of time working at and for a hospital, but who also often have private practices to run, and who in fact may have appointments at several hospitals at once. This model can apply in both the public and the private hospital setting. In conjunction with, and irrespective of this, specialists also often have positions of substantial influence in organizations that act in concert or partnership with healthcare providers like hospitals – for example, in non-government organizations with a health focus (eg – The Heart Foundation in Australia) or in universities.

In terms of what this means for this research – clearly many specialists do not "conform" to the mould of a typical employee of an organization in the same way other hospital staff (eg – administrative staff, or more junior healthcare staff) may. This is just a given amongst those of us who work in healthcare. In addition, many such specialists fulfil management functions in hospitals having risen to the tops of their fields. The particular relevance to this research is that as I further explore ecosystem concepts in the healthcare management environment, specialists could be viewed as a unique kind of "staff species", who may interact in unique ways with the environment.

In this same edition of the ISR Journal in 2011described above, there is a piece by Goh et al (Goh et al., 2011) that proposes a "dynamic, process model of adaptive routinization of healthcare IS ....." that identifies a cycle of "co-evolution" between routines and IS in the healthcare setting. The theme of evolution, with its implicit biological heritage, is a prevalent one throughout the literature when it comes to understanding information systems and the contexts in which they sit. Let us now consider a broader view of ecosystems as evident in the literature.

There are references to ecosystems analogies and concepts scattered right throughput the IS and IT literature (Jergensen et al., 2011, Karhu et al., 2009, Kim et al., 2010, Figay and Ghodous, 2009, Mitra et al., 2011, Kirkham et al., 2009, Tiwana et al., 2010, van Angeren et al., 2011). These are from a range of perspectives- from the technical (Hoile C et al., 2002), to the use of technology to study and monitor ecosystems (Baptista A, 2003) (Zhang and Shi, 2009). Information ecosystems have been analysed in relation to security issues (Carlsson B and Jacobsson A, 2005), and there is even published work on virtual ecosystems (Almada A et al., 1996), and modelling ecosystems on computing grids (Wang et al., 2005). There is not a lot of literature, however, that relates many concepts related to ecosystems such as different types of

ecosystems, or biomes, or the "services" provided by ecosystems, as outlined previously.

When one considers what a biological ecosystem is, there are a range of views in the literature. Some authors, however, have defined some key elements of all ecosystems. For example, five descriptors of an ecosystem as identified by Capra (Capra, 1996) are:

- *Recycling*- Successful ecosystems hold in the various nutrients, on which the ecosystem and its constituent species depend. For example, water, minerals and other nutrients. In turn, species within an ecosystem relate in a mutualistic fashion via a complex series of feedback mechanisms, which in turn are the processes by which this all important recycling occurs
- *Solar Power*- Virtually all ecosystems that succeed do so because of the availability of solar power. It is important in a number of processes, for example it is essential in photosynthesis.
- *Co-operation and competition* - There are important concepts from the knowledge in the domain of biodiversity in relation to biological ecosystems. For example, ideas that are important include the concept of mutualism – with its various manifestations (symbiosis, non-symbiotic mutualism, and others) (Rose P, 1997); and also the concept of mutualistic biodiversity networks. There are other references to these issues on the web (GreenFacts, 2005) – in particular in relation to the complex interdependencies between species. These concepts could be very useful in application to the HMIS domain.
- *Resilience* - A key feature of ecosystems is their resilience to the ravages of time and environmental stresses. The question that will be addressed in this context is: what are the implications of this concept for the development and sustainability of "species" (both IT artefacts and actors / stakeholders) in the HMIS context?
- *Diversity* -Most successful ecosystems are diverse. The reason being that in the event of ecological stress (e.g. – fire or flood) – there are enough varied species in the ecosystem to ensure that some at least will survive and the ecosystem as a whole will continue to exist, albeit in an altered state. This concept may have interesting corollaries in the world of technology ecosystems.

Further searching reveals that one of the key issues overlooked by the existing TEM is the concept of a range of uniquely identifiable types of ecosystems or biomes (Oracle ThinkQuest Education Foundation, 2006) – e.g.: temperate forest – this biome has an

annual rainfall > 75 cm up to 90+, conditions are temperate but may vary with the season. It includes the presence of certain tree varieties (e.g.- stringy bark, blue gum, karri, jarrah and mountain ash form a canopy blocking 30-70% of the sky)

In addition, some of the issues that need to be faced in the context of this research include the fact that many natural ecosystems are in a state of decline because of a range of factors, including human activity(Thompson, 2006). The question here is- do technology ecosystems really adopt this behaviour? That is to say what is the equivalent of degrading natural environments in the technology ecosystem model? Some of the above issues will be explored in the context of the proposed research approach. (Chapter 3 – Research Design)

There have also been a number of articles examining the concept of ecosystems in relation to specific technologies or business settings. For example, in relation to web technologies, Barros et al (Barros A et al., 2005), have proposed the concept of a web service ecosystem in which web services are "deployed, published, discovered, delivered to different business channels through specialist intermediaries." Quaadgras (Quaadgras A, 2005), in examining radiofrequency identification (RFID) technology, outlines her interpretation of the term business ecosystem as: "a set of complex products and services made by multiple firms in which no firm is dominant."

In relation to the concept of a technology ecosystem, there have been several definitions or descriptions put forward in the literature (Iansiti and Richards, 2006) (Berkman Center, 2006). In addition, the term "ecosystem" has been used in different ways even within the IS and IT literature. For example Benkler (Benkler Y, 2001) refers to the "economic and technological ecosystem within which information is produced" and Vuori (Vuori, 2006) uses the term in relation to a business ecosystem. As part of her examination of intellectual capital in the context of a business ecosystem, she refers to a business ecosystem as being "a dynamic structure which consists of an interconnected population of organizations". An important point proposed by Vuori is, however, that one of the characteristics of a business ecosystem (which she relates to a "business network") is that it "develops through self-organization, emergence and co-evolution, which help it to acquire adaptability." It is important to note that these usages of the term, with their implicit notions of relating the concept to business rather than IT specifically, are in contrast to what is being contemplated in this research, but provide important contextual information nonetheless.

Work by Hadzic and Chang (Hadzic and Chang, 2010) is relevant to this research as it seeks to apply a "digital ecosystem design methodology" to the health domain. In their work they describe a digital ecosystem (DES) as "the dynamic and synergetic complex of digital communities consisting of interconnected, interrelated and interdependent digital species situated in a digital environment that interact as a functional unit and are linked together through actions, information and transaction flows". Importantly however, embedded in their work is that belief that the analogy between information systems and biological systems can be extended into the systems design space, so in this paper they go on to outline a preliminary 5 step methodology for the design of a DES.

Irrespective of this, Hadzic and Chang also describe a high level of affinity with other ecosystems type approaches and frameworks in the literature. So for example, they make the following analogy: "Just as the biological ecosystems are composed of a variety of interrelated biological species that interact with each other and with their biological environment, so is a DES composed of a variety of interrelated digital species (DS) that interact with each other and with their digital environment (DE)". There is a good level of detail of thought expressed in this world view when it comes to the characteristics of the DS'being described in any given DES. These authors argue that most DS' consist of both hardware and software components, with the hardware being analogous to the physical structure or body of any given DS, and the software being akin to the "breath of life" of such species – arguing that without this "breath of life", a given species cannot survive.

It is interesting to compare and contrast this work (Hadzic and Chang) with that of Adomavicius et al (Adomavicius et al., 2005) as outlined in Chapter 1, as it (the work of Hadzic and Chang) is one of the more rich and complete models in an ecosystem sense, and because it has been explored specifically in the health domain.

One of the immediate differences one observes is that the work of Hadzic and Chang talks specifically about designing a digital ecosystem in healthcare, in addition to using the concept as a lens through which to view the health context. The work of Adomavicius and colleagues however, uses ecosystem concepts solely as a lens and analytical tool through which to examine and understand the context – and of course it is not specific to healthcare.

Another important difference however is that Hadzic and Chang express the view that a DES aligns with a given domain – so a health DES with the heath domain and a legal DES with the legal domain. In contrast, the TEM can – in theory – be applied to any environment or micro-environment. The implication here therefore, is that the TEM would allow healthcare to be seen as consisting of a very large number of ecosystems, each defined around the identification of a focal technology. The extent to which this is true of the TEM however, is being tested in this very research.

As described in the quote above, both models give heed to the idea that, as Hadzic and Chang say (Hadzic and Chang, 2010), digital species combine with their environment to create a DES - or substitute the term TE for DES in the case of the TEM. In addition both models acknowledge the concept of "species" in the ecosystem having roles, and that there are different kinds of roles, and different kinds of digital species to fulfil those roles. Specifically, in both models hardware and software are identified as having key roles. Finally, another key concept that both models have in common is that of interaction between species – as in the biological reality. Hadzic and Chang call it "inter-DS interaction".

In terms of yet another view of an ecosystem concept in the information system space, El Sawy et al (El Sawy et al., 2010) have published an interesting piece in the journal Information Systems Research in 2010. In that piece they described a phenomenon called "digital eco-dynamics". They define this as the confluence between environmental turbulence, dynamic capabilities, and IT systems – and the dynamic interactions between these entities, evolving as an ecosystem. Although El Sawy himself is quoted in this paper from previous work of 2003, it is again interesting to note that there is no reference to the work by Adomavicius et al (Adomavicius et al., 2005) first published in 2005. This is a notable pattern amongst the ecosystems literature as it pertains to IS and IS Research (ISR). I do not seek to address this particular issue, but note that it illustrates how there are a number of potentially related, but currently separate, views of how ecosystems concepts can be applied to the IS domain.

Hsi (Hsi, 2004) provides a similar definition to that of Adomavicius et al, in that author's 2004 work on the development of a computing ecosystem framework. Hsi defines a computing ecosystem as: "a set of use contexts that use computing to fulfil goals, contained within an environment of interest." In turn, they define a use context

as: “the external physical (or virtual) environment that contains the computing application and its users, the goals that the combined computing application/user system wishes to achieve, and the various nuances (business rules, customer demand, user and system capabilities) that govern the operation and performance of both environment and goal completion”.

Lin and Lin (Lin S and Lin F, 2006) also use the term in a in very similar way to the usage by Adomavicius et al (Adomavicius G et al., 2006) - namely to propose an ecosystem model as a means of explaining the functionality and development of online communities of practice. The other important and relevant assertion made by Lin and Lin is that the ecological perspective is useful if one is looking at the evolution of an entity since evolution also implies temporal change – just it was relevant to their work, it is also relevant to this research.

As stated in Chapter 1 , the definition that will be referred to in this work is that proposed by Adomavicius et al (Adomavicius G et al., 2005): **“A system of interrelated technologies that influence each other’s evolution and development.”** As I previously observed, this definition includes the concept that **“A specific technology ecosystem view is defined around a focal technology (FT) in a given context.”** The reader will also recall 3 key associated concepts that are critical to understanding the TEM , these being:

- Technology Roles (TRs)
- Technology Layers (TLs) and
- Technology-Shaping Forces (TSFs)

Adomavicius et al went on to publish further work on the TEM after their initial publication (Adomavicius et al., 2006, Adomavicius et al., 2007a, Adomavicius et al., 2008a, Adomavicius et al., 2008b, Adomavicius et al., 2007b) . This work began to explore in greater detail the ability of the core model to explain the actual changes in systems over time. It is in these latter pieces that the authors applied the TEM approach to different ecosystems (e.g. – intelligent storage) and gave further detailed examples of the 3 kinds of roles in the TEM, and the concept of “paths of influence”

The 3 roles they refer to are the component role, the product and application role and the infrastructure and support role. The paths of influence refer to the “impacts technology roles can have on one another over time”. Because there are 3 roles and each

can have a present and a future state – there are 9 (3x3) potential paths of influence that can act in a given TE (Adomavicius et al., 2008b).

Fichman et al (Fichman et al., 2011) make a key observation around healthcare that is relevant here. They firstly make a general observation which is that, in their opinion, it is the distinctiveness of a business or industry context that facilitates new theory or extensions of existing theory, to be instantiated through ISR. They then describe the most obvious feature of the healthcare industry as **diversity**, in patients, professional disciplines, treatment options, delivery processes and the range of stakeholder groups involved. I concur with this observation and I think, importantly, it is one key reason why a model, such as the TEM which would appear to allow for describing complex and diverse environments, is a good candidate lens through which to examine healthcare management and HMIS'.

In their work, Agarwal et al 2010 (Agarwal et al., 2010) produced a key diagram, looking at major research themes in health IT (see Figure 1 that follows). This diagram reinforces the notions of diversity and complexity that in many ways define healthcare and healthcare IT systems.

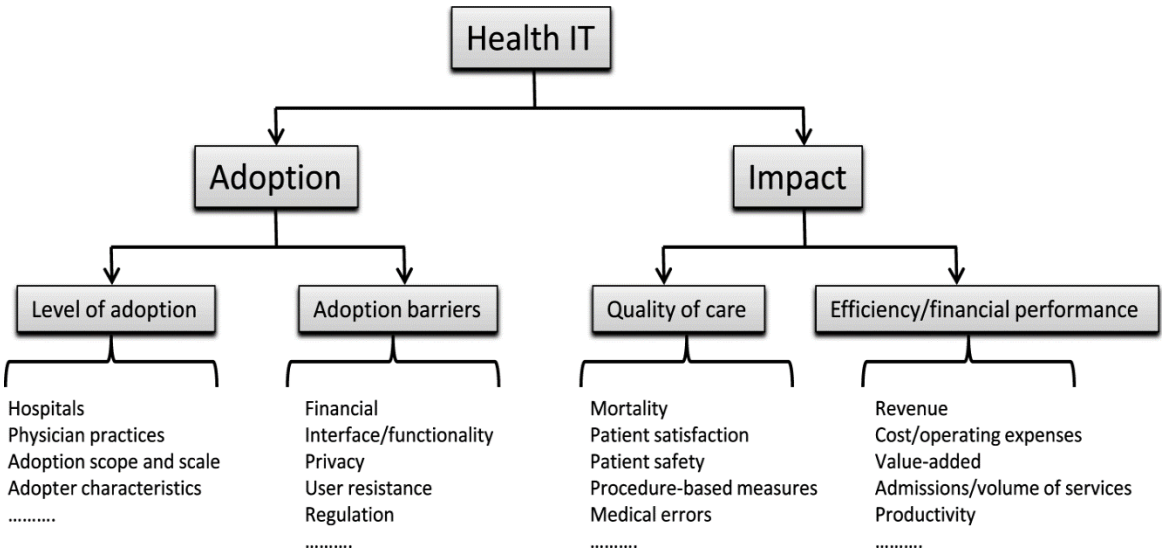

Figure 1 – Overview of Major Research Themes in Health IT

(reproduced with permission of Prof Ritu Agarwal, University of Maryland (Agarwal et al., 2010))

Their paper is very critical in the context of this research. They correctly note the huge expenditure on healthcare in nations - up to 16% of national spending in the US. They

proceed to then highlight the potential for ISR to assist in maximizing the potential benefits of health IS and IT. The key areas of further research they identify are

- " Health IT (HIT) design, implementation and meaningful use
- measurement and quantification of HIT payoff and impact and
- extending the traditional realm of HIT."

Their assessment forms a useful introduction to this next section of the thesis where I will examine the first 2 areas they identified in particular.

IS and IT Planning in Healthcare

One of the underlying motivations for examining the potential utility of ecosystems concepts in support of understanding the HMIS context is to allow better planning and investment decisions in the space. As Adomavicius et al (Adomavicius et al., 2008a) themselves suggested "(a) major problem for firms making information technology investment decisions is predicting and understanding the effects of future technological developments on the value of present technologies." To that end, this section of the thesis will examine some of the literature around IS and IT planning in organizations.

In considering why IS and IT planning is important, Besson and Rowe (Besson and Rowe, 2012) put it very eloquently. They state that "information systems are considered to be a major asset for leveraging organizational transformation owing to the disruptive nature of IT innovations, the deep digitalization of business and their cross-organization and systemic effects, notwithstanding the amounts of investments in enterprise systems."

Several authors do cast doubt however, on how well IS and IT planning activities are carried out currently. For example Pant and Hsu (Pant and Hsu, 1995) questioned: "has the paradigm of strategic planning changed sufficiently to support the new role of information systems and technology? " Furthermore, in a case study from the financial services industry, Teubner (Teubner, 2007) specifically studied the issue of information systems planning. Although his findings are from another industry and are limited to the German context, they nonetheless are thought provoking. In essence he found that although academic literature and findings were in part "inspiring" to practitioners on the ground, they were at the same time seen as not addressing real world findings and hence did not have credence in the practitioners' world.

Teubner and colleagues further report, albeit based on their anecdotal experiences, that practitioners in the filed would rather rely on advice and suggestions from peers in relation to IS planning (e.g. - gathered through conferences and trade magazines) than they would through academic findings in this field.

An interesting question then for this research is what the impact may be, if any, of the findings of this work on IS planning decisions in the hospital management environment?

There is a substantial body of background work to be considered in relation to IS and IT planning theory and how it may apply to healthcare. For example there is the work of Premkumar and King (Premkumar and King, 1994) which focuses on the characteristics of organizations in relation to IS planning and its success. Another example is the work by Segars and Grover (Segars and Grover, 1999) which examined different profiles of strategic IS planning in organizations – subsequently identifying a series of schools of thought in this regard, as defined by characteristics unique to organizations.

Professor Jean Hosseini, a US based Professor of Management Information Systems (MIS) (Hosseini, 2005) contends that it is important for organizations to establish a "strategic architecture plan" in relation to key information systems acquisitions. The basis of his contention is that "Despite advances in the development of new applications, many organizations are not able to embrace these new technologies mainly due to not having devised an appropriate plan to position themselves technologically and organizationally to incorporate these technologies".

Professor Hosseini goes on to describe the benefit of such a plan being that it will "provide organizations with specific technical requirements for the immediate needs as well as a migration path to "plug in" the component and the products the business is moving towards". This observation forms an interesting juxtaposition against the potential benefits of a usable ecosystems world view around the HMIS context. It is conceivable that a TEM that can be described for the HMIS context could form key background for such a plan. In addition, it could certainly assist in an organization not only understanding the "products the business is moving towards" and why, but also the likelihood of them reaching their destination in this regard, through a better understanding of the environment in which they and their desired technologies sit.

Another illustrative piece of research in the IT systems planning space in healthcare is the work by Iveroth et al (Iveroth et al., 2013). This study examined empirical data gathered over a six-year period across six healthcare organisations in Stockholm. The findings suggested a misalignment between organisational strategy and IT strategy and the authors concluded that a more complex picture of IT alignment in healthcare needs to be borne in mind. Another important implication of the study was that the authors identified that there are a range of different kinds of IT in healthcare that require diverse decisions, investments and prioritised actions as well as differing implementation approaches.

IS and IT Success and Failure in Healthcare

A key underpinning of this research is a desire to see more effective implementation and usage of information systems in the healthcare environment, and more particularly in the HMIS environment. This section of the thesis will provide an overview of some relevant literature in this regard.

There is certainly healthcare literature pointing to success and failure in relation to hospital information systems, and the reasons for it– for example the work by Freed (Freed, 2006). But there is also some background to be considered here – the IS and IT literature already contains theory and principles describing the drivers of success and failure in IS and IT projects. In fact there are a range of theories and models in the IS and IT literature that seek to explain the relative success or failure of system development and implementation projects. However, Enns et al (Enns et al., 2003) put forward some interesting ideas in this space. They proposed that "no idea is intrinsically strategic or important" but rather that the ability of key decision makers - namely CIOs - to influence peers is a key determinant of systems success. Their survey based research provided some evidence for this postulation.

In similar work, Sharma and Yetton (Sharma and Yetton, 2007) also cite the importance of management support to the success of IS implementations. They then expand on this core concept by examining the role of task interdependence as a moderating factor on the effect of management support. In 2007 the same authors (Sharma and Yetton, 2007) went on to study further the factors affecting IS success and

failure, examining the role of end user training in the context, as well as moderating factors on that effect.

Venkatesh et al (Venkatesh et al., 2003) wrote a telling piece in MIS Quarterly in 2003. They identified 8 separate models of user acceptance of technology (user acceptance being one measure of IS success) and then noted the divergent approaches, and sought to establish a "unified model" which they termed UTUAT - the Unified Theory of Acceptance and Use of Technology. This work is of course quite well known in IS circles.

In terms of the potential for information technology to assist in health care, the possible gains are great. An example of the potential gains are seen in the work by Gonzalez-Molero et al (González-Molero et al., 2012) in their study of the implementation of a telemedicine approach in subjects with type I diabetes equipped with an insulin pump and real-time blood sugar monitoring. In this prospective one-year study, the investigators followed 15 subjects and noted that the telemedicine approach to care improved multiple outcomes of care including the variability in blood sugar control, and a long-term measure of good sugar control (HbA1c). Such programs offer great potential to improve patient access to care, to reduce travel time and cost for patients, and to reduce the burden on an already stretched health system. These are all good outcomes from a healthcare management perspective.

The large pool of the potential benefits of information systems in healthcare is contained in the work of Li et al (Li et al., 2012) in the Journal of Medical Systems. In this study the authors undertook a cost benefit analysis in relation to the implementation of an electronic medical record (EMR) system for a six-year period. They found the net benefit to be in the range of a half a million dollars (US). Benefits followed from a reduction in the effort of creating new medical records, decreased full time equivalent (FTE) employees, savings in relation to the adverse drug events, and from improved billing processes. This is an example of the hospital management benefits of an EMR, in addition to the clinical benefits of such systems.

The work by Appari et al (Appari et al., 2012) is another very concrete example of the potential benefits for hospital managers of health IT systems. In their examination of 2600 hospitals in the US, they concluded that “Implementation and duration of use of health information technologies are associated with improved adherence to medication

guidelines at US hospitals. The benefits are evident for adoption of eMAR systems alone and in combination with CPOE" (EMAR – Electronic Medicines Administration Record and CPOE - Computerised Physician Order Entry).

Yet another example of the importance and potential of robust information systems in health care is the work by Gaskin et al (Gaskin et al., 2012) in BMC Geriatrics in 2012. In their paper entitled "Examining the role of information exchange in residential aged care work practices – a survey of residential aged care facilities" the authors surveyed 119 staff across 4 residential aged care facilities in the Australian context. They concluded that in this aged care setting there were a high volume of information exchange activities. In addition they identified inefficient procedures such as paper to computer transfer of information. They therefore concluded that there is a need for interoperable IT systems to allow more reliable and efficient exchange of information between these facilities and across the borders of each facility. This paper indicates the substantial potential for improving the efficiency of care, and the efficiency of management of that care, in this kind of setting.

Shekelle et al (Shekelle et al., 2006) undertook a large piece of research involving a systematic review of the evidence around the cost and benefits of health information technology (HIT) projects, many of which involved Electronic Health Records (EHRs). They examined 256 research studies in depth (from a screened pool of 855 individual studies) and concluded that "HIT has the potential to enable a dramatic transformation in the delivery of health care, making it safer, more effective, and more efficient. Some organizations have already realized major gains through the implementation of multifunctional, interoperable HIT systems built around an EHR".

Berg (Berg, 2001), writing in the International Journal of Medical Informatics, summarised much of the view from the literature when he wrote "Successfully implementing patient care information systems (PCIS) in health care organizations appears to be a difficult task". Although he is not speaking specifically about systems in the HMIS environment, this is the prevailing view across many healthcare IS and IT implementations.

Importantly Berg's paper goes on to describe the implementation of a PCIS as "a process of mutual transformation; the organization and the technology transform each other during the implementation process." Interestingly there are parallels between this

assertion and the nature of influencing factors (technology shaping forces) in the TEM described by Admoavicius et al. Furthermore, this parallel is also evident in Bergs description of a balancing act in IS implementation between "initiating organizational change, and drawing upon IS as a change agent" He goes on to say state that "Accepting, and even drawing upon, this inevitable uncertainty might be the hardest lesson to learn" in the IS implementation space. This kind of dynamic interplay is definitely able to be described by the TEM.

Lorenzi et al (Lorenzi et al., 2008) have written a key piece in relation to IT implementation failures in healthcare. They quote high levels of project failure (18% outright failure, 53 % partial in some areas) described in primary sources, and then go on to propose 4 types of implementation "chasms" underpinning these outcomes in healthcare. Their 4 types of chasms are:

- Design
- Management
- Organization and
- Assessment.

This piece of work often talks to the impact of these chasms in relation to clinical IT, but arguably some (e.g. – Design and Management) could be said to equally apply to the HMIS context. As has been noted previously also, for some hospital managers that distinction (clinical systems vs MIS) is somewhat arbitrary, and is more about the information being sought than the system being interacted with.

Let us examine this work a little more closely. One interesting observation to be made is that Lorenzi et al describe the potential for an interplay between these categories of chasms in determining the ultimate fate of a project. Given the concepts of interplay in the TEM of Adomavicius et al. (e.g. – technology roles and technology shaping forces), there are interesting concepts ripe for exploration regarding the TEM and the factors affecting success or failure in IS and IT implementations as described by Lorenzi et al.

Further insights into the theories in support of successful IT implementation in healthcare can be derived from the work by Ketikidis et al (Ketikidis et al., 2012). This work examined the acceptance of IT in health professionals using the underpinnings of the Technology Acceptance Model (TAM). In this work, the authors undertook a questionnaire with 133 participants. They found that perceived ease of use is a key

predictor of HIT usage intentions; but not usefulness, relevance or subjective norms. They claim that their findings suggest that a modification of the original TAM approach is required to better understand why health professionals do support IT in healthcare. Such findings suggest many further insights can be obtained about IT planning and implementation in health care, it is possible that an examination of technology ecosystems could have a beneficial impact in this regard as a new lens through which to examine these issues.

Summary of the Literature

It can be seen from the overview of the literature presented in this chapter to date, that there are a couple of key findings that act as a platform for the conceptual framework that follows.

These findings are:

- There is a large body of literature around the analogy between biological ecosystems and businesses, technology, and information capture, flows and use.
- There is also a large body of literature around the discipline, and issues of, IS and IT planning in various business settings, including in healthcare; and
- There is a significant amount of evidence in the literature of the actual or potential importance of IS and IT to healthcare, and of the over-representation of system and implementation failures in the healthcare context internationally. Whitten et al (Whitten et al., 2008) make an interesting assertion in relation to the importance of healthcare IT. They claim that "Overall, evidence is continually mounting that there is something special about health care organizations that invest in IT (hospitals that are "wired")".

Despite the contributions of the literature to his area of study as described above, there are seemingly some notable gaps in this space. In relation to the specific relationship of ecosystem concepts to business or technology settings in healthcare, there is really only the work of Hadzic and Chang (Hadzic and Chang, 2010) and that of Goh et al (Goh et al., 2011)

In the IS and IT planning space, and with specific reference to healthcare, only the work of Iveroth et al (Iveroth et al., 2013) stands out. This is of concern given the troubles observed in acquiring and implementing many major systems in the healthcare setting.

There is definitely a more rich coverage of the issues of healthcare IS and IT success and failure in the literature than of the 2 dimensions described above. Importantly for this research however, these gaps mean that these areas of knowledge are even more able to be enhanced by the research I have undertaken.

In the next section of this chapter I will seek to relate the proposed conceptual framework for this research to the literature base described above, and specifically how the proposed framework could explain and expand on these findings from the literature.

Conceptual Model

In this section of the thesis I will outline a conceptual framework (model) based on the investigation of the literature and thinking to this point, in relation to technology ecosystems, and how they may apply to the HMIS context.

Figure 2 "The Hospital Context" (as follows) is intended to describe a generic context in which any hospital, anywhere in the world could sit. It is intended to represent this context in a way that is agnostic of the funding mechanisms for the hospital and the remuneration approaches to its employees (doctors, nurses, allied health professionals, back office staff, clinical support staff etc.). So in Australia, for instance, this context applies to publically or privately funded hospitals.

What this diagram outlines, in deliberately high level terms, is that if one takes a hospital centric view - which is the intent if this research - then there a handful of key entities (external to the hospital) that exert either a passive or an active influence on what services are provided by that hospital, and how those services are provided.

These key entities include, but are not limited to:

- The public at large
- Law and policy makers
- Funders
- Medical suppliers the biggest of which are pharmaceutical companies
- The scientific community
- The software development community

Internal influencers can obviously also be at play in terms of what services are provided by the hospital and how they are provided. These can include for instance

- The skills and experience of staff
- Internal business strategies such as competition and subsidization
- Soft factors such as morale and culture
- Equipment availability.

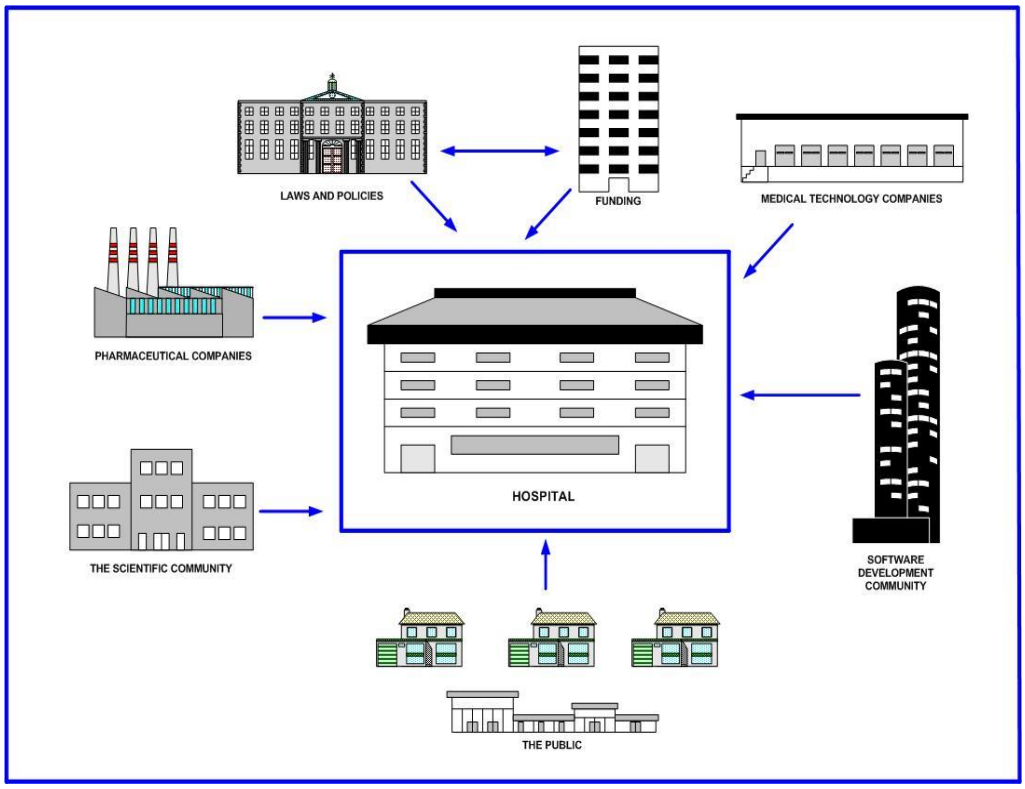

Figure 2 – The Hospital Context

It can be seen from Figure 2 (above) that I have made a link between the entities "Laws and Policies" and "Funding". This is intended to signify the fact that in some cases laws and policies governing healthcare and hospitals are imposed by the same entities that also provided funding to hospitals. This is not always the case however.

Whilst some of the inter-relationships between these entities are obviously more complex than this diagram suggests, the reason for outlining these entities and influencers is simply to set the scene for the conceptual model to be presented later in this chapter. As Fichman et al (Fichman et al., 2011) argued, one of the defining characteristics of healthcare is diversity, and they also asserted that implementing IS in

healthcare is therefore complex. The diagram above is intended to act as a base point from which to explore this diversity and complexity.

Let's examine an example of these entities and influencing factors at work. So let's consider a hospital manager - let's say somebody managing the operating theatres. This manager may only be allowed to have certain surgeries performed in their operating theatres, and this could be for many reasons to do with any of the entities mentioned above. If the hospital is privately funded, it may be because the board or senior hospital management have made a strategic decision to not be in the business of, for example, paediatric surgery. If it’s publically funded, it may be because the state health department has a co-ordinated strategy around providing paediatric surgery in a limited range of specialist locations, and this hospital is not one of those locations. It may be that they are not permitted to undertake paediatric surgery in their operating theatres because there are no anaesthetists available to work at the hospital who have suitable qualifications to provide anaesthetics to children, or there are no ward areas in the hospital suitable equipped to care for children and their parents after the surgery. Just with this isolated example, it fairly quickly becomes clear how multiple internal or external (to the hospital) entities can exert an influence on what services a provided by a hospital, and how they are provided. This example will become more significant as I explore the relevant literature later in the thesis.

Now let us consider therefore the overlay of information and information systems on this base, from the view point of the hospital manager, as defined previously. In order for the manager to comply with the requirement above, given that they are not (and cannot be expected to be) present on site 24/7, they have information needs, and whilst these needs could be met in multiple ways, they must be met. The primary information need this manager has is to be sure that there are no operations occurring on children (let's say anyone 15 years or younger) in the operating theatres of the hospital. This need could be met by a range of solutions with varying levels of sophistication and effectiveness. At the simple end of the spectrum, the manager could receive a report every morning when they arrive at work that details all the ages of patients operated on in the preceding 24 hours. At the more complex end of the spectrum, the hospital patient administration system (PAS) could have a business rule in it the alerts the manager by SMS whenever a patient under 15 is admitted to the hospital. Influencing factors as to which of these 2, or a myriad of other, solutions comes to be implemented include

existing technical infra and info-structures, available funding, and mandatory reporting requirements - amongst many others.

It is clear from the literature just examined in Chapter 2 that there is widely held belief in the information systems community internationally, with varying levels of evidence behind it, that the construct of a biological ecosystem is a valid lens through which to examine information systems, their interrelationships with each other, and the interrelationships with the business context in which they sit.

In essence the core drivers of the conceptual framework are as outlined below:

- Information systems, development, acquisition and investment decisions can be critically influenced by factors external to an organization
- Any ways in which such decisions can be made on a more informed basis has the potential to improve organizational outcomes in this space
- The TEM model of Adomavicius et al (Adomavicius et al., 2005) is at the core of this work and represents many of the concepts evident in other theoretical ecosystems frameworks, whilst including the added dimension of a way to track system evolution
- However the model is yet to be validated in a range of contexts.
- In addition there are ways in which the model can be expanded both in depth and breadth

In summary, the conceptual framework I am proposing is as follows: (see Figure 3)

- The Hospital Management Technology Ecosystem (HOME) model is an identifiable entity with
    - At least one focal technology able to be identified
    - Several TR's able to be identified
    - Several TL's able to be identified
    - A range of TSF's able to be identified
- The existence of this HOME then acts a validation of the core TEM
- The HOME also demonstrates characteristics that allow the expansion of the core TEM

This framework ought to be able to act as lens through which to examine the various forces (both internal and external to a hospital) acting on the hospital, and hence on the management function of a hospital, and in turn on the MIS' used in the context of that

management function. (again recall Figure 2 – The Hospital Context) . In addition it should go a long way to explaining the diversity, and the interaction of diverse elements of the system, as proposed by Fichman et al (Fichman et al., 2011)

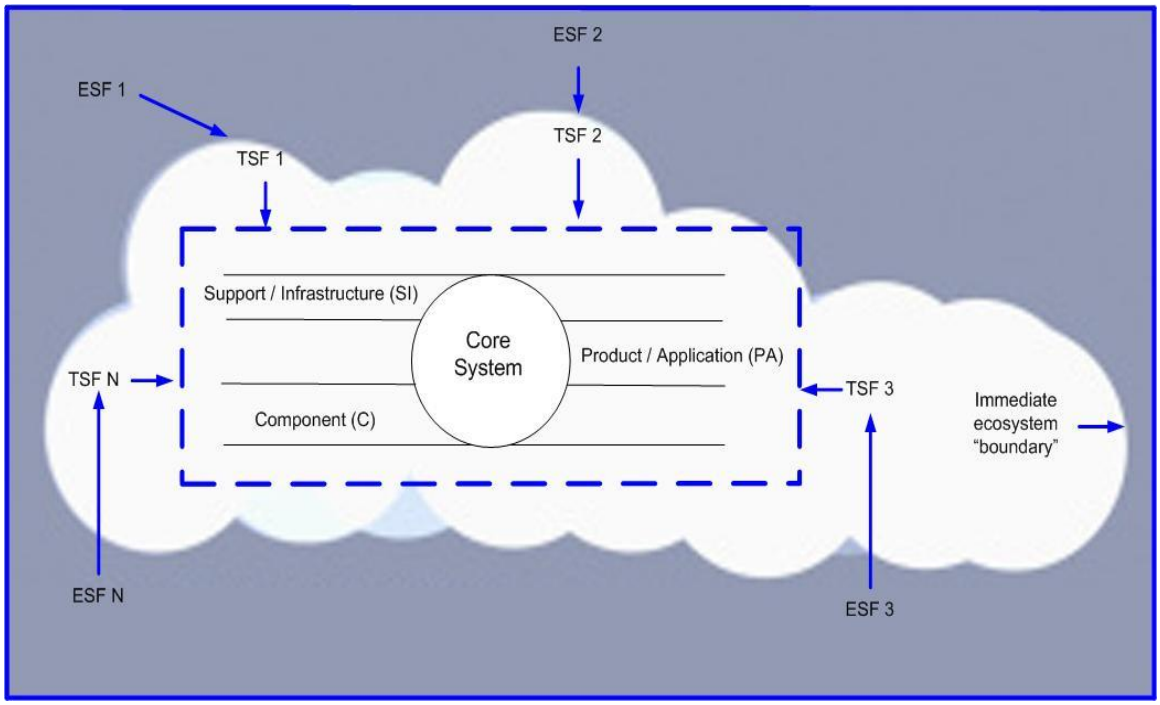

Figure 3 – HOME Conceptual Framework

The 2 previously outlined question sets are designed to allow validation of the conceptual framework, and hence to validate (or otherwise) the HOME construct in both a theoretical and a practical sense. More specifically the HOME model, if validated by this research, could then act as a lens through which planners, developers and purchasers of systems can make more informed strategic and operational decisions in relation to HMIS'.

In addition, researchers would also then have a position from which to expand and deepen the research base around HMIS', and technology ecosystems more broadly. More specifically, the model would allow the more generic assertions and theories in relation to IS planning, IS success and IS evolution to be examined in the healthcare management setting, in light of the detailed HOME model.

In order to more precisely define the scope of this conceptual framework, let us examine some further details around the ecosystems concept. The work by De Tommasi et al (De Tommasi et al., 2005) around a business modelling language for digital business ecosystems (DBEs) has some synergies with the previous work by Hadzic and Chang

(Hadzic and Chang, 2010). These authors note the potential to relate business contexts, the use of technology in those contexts, and the kinds of models evident in biological ecosystems. Another similarity is the concept that our understanding of digital business ecosystems (DBEs) or DES' in light of these biological analogies, can allow better planning of investment and development decisions around technology. To quote the authors, "the DBE project aims at overcoming the aforementioned difficulties by creating a new way of conceiving co-evolution among organisation and technology that shifts from:

- a mechanistic way of organising business based on static view of the market to a new organicistic approach based on mathematics, physics and biological science models,
- an approach to technology development unrelated to inter organisational issues to new paradigms in which technology and organisation are related variables enabling innovative ways of collaborating and competing".

In addition, and as previously noted, Adomavicius et al produced a number of papers beyond their initial work of 2005, (Adomavicius et al., 2006, Adomavicius et al., 2007b, Adomavicius et al., 2007a, Adomavicius et al., 2008a, Adomavicius et al., 2008b) in which they gave further examples of the more complex aspects of their core TEM, like paths of influence; and how they could be used as a real world analytic tool. In this conceptual framework however, I am taking a more conservative approach. I am seeking primarily to validate the core TEM in the HMIS context (thus identifying a HOME). I would argue that having done so in some detail, this research can then act as a sound basis for subsequent work to explore the finer detail afforded by the TEM, in the HMIS context. Furthermore, unlike in the work of this groups of author, in my conceptual framework I will not seek to go as far as to describe in detail how technologies can be purchased and/or developed with the specific knowledge of biological ecosystems in mind. Rather I will seek to more accurately, and more specifically, describe in the HOME context that such concepts are primarily valid and could provide a platform for the next level investigation. Such investigation would then lead us to the sorts of conclusions these authors have already appeared to have arrived at – somewhat prematurely I would argue.

CHAPTER 3 - RESEARCH DESIGN

In this chapter I will explain the research methodology and the underlying research model. This will be followed by a detailed examination of the research questions, and then of the approach to data gathering and analysis. I will conclude the chapter by also examining the issue of the reliability and validity of the research.

Methodology

Overview

The IS literature is populated with many papers on the research methodologies that can be used in ISR (Walsham, 1995, Cavaye, 1996, Palvia et al., 2003, Pare, 2004, Palvia et al., 2006, Parikh, 2002) and it could be argued that there are several warring camps in relation to what is the "best" methodological philosophy (Weber, 2004).

In establishing the proposal for this thesis I was challenged to identify whether the research was to be positivist or interpretivist in nature. It could be argued that the use of the arid zone ecosystem analogy is interpretivist in nature, but also that the use of the analogy in the way proposed here is more aligned with critical research (Ngwenyama and Lee, 1997) as advocated by Jurgen Habermas. This could particularly be argued in light of the nature and intent of Question Set 2.

There has been an awareness of the power of analogy in many fields, for example in political science (Houghton, 1996, Whaley and Holloway, 1997, Santibanez, 2010), for many years. In fact Whaley and Holloway (Whaley and Holloway, 1997) contend that "Analogy in its various forms has been central to political philosophy, political reasoning, and political language for centuries." Analogy has also been used to apply economic concepts to the field of marine biology (Bloom et al., 1985) and in other biological and ecological settings (Wiman, 1995). There has also been the successful use of a parenthood metaphor in gaining insight into entrepreneurship in the business domain (Cardon et al., 2005).

Analogy (and metaphor) has been used in the IS and IT space, for example by Chua and Wareham in 2008 (Chua and Wareham, 2008) in relation to internet auction fraud. In

this work the authors use a parasite metaphor, and 3 theories from the parasitism literature, to highlight the insights that can be provided in relation to "con artist" and victim. This is done by examining both roles in an ecological context.

There are other examples of the use of analogy and metaphor in the information sciences. Neuman and Nave (Neuman and Nave, 2009) used the metaphorical context in which terms were embedded to attempt to elicit their meaning, in the context of electronic searching. Whilst Hsu (Hsu, 2006) has undertaken some relevant work in examining the effects of metaphors on learning, specifically in the context of mental model development in interacting with computer systems.

As far back as 1994 and in a healthcare specific IT setting Esterhay (Esterhay, 1994) examined the use of metaphors in the development of better prototypes of Healthcare Professional Workstations (HPW's), specifically advocating the use of "transporting" metaphors like three dimensional (3D) rooms.

The biggest advantage of analogy as a tool to aid theory building in IS, is the potential explanatory power of the analogy. In this case, for example, there is a rich history and detailed knowledge base in the environmental sciences that can be drawn on through the lens of an ecosystems world view. This potential explanatory power is not only in the sense of explaining the details of the complex interactions that exist in the hospital management technology environment however. It also extends to the accessibility of an ecosystem analogy to a broad audience. Let me explain further. This concept can also extend to the ease of explanation - particularly relevant in the context of this research as I seek to eventually translate the research into some practical guidelines for non-academics, and even non-IS personnel, including purchasers of systems and hospital executives. Due to an increasing awareness of environmental issues in the general community, ecosystem type concepts stand a good chance of being understood by lay people.

In terms of disadvantages, the key risk is in not knowing where to draw the line relation to the utility of the analogy. In addition, the limitations of an analogy can also be related to taking just one feature of an analogy in an arbitrary way and building an entire logic upon it. I do not believe that this is the case in the underlying TEM work, whilst at the same time acknowledging opportunities to enrich that work, that in turn drive this

research. Equally I do not believe I have focused on a single aspect of the ecological analogy either, rather I have sought to first establish that the core analogy is plausible beyond the initial context of use, then to look for ways to extend it if supported by objective evidence. That exploration will continue in the subsequent phases of this research.

As I have explored the methodological literature in relation to IS however, I have found a number of experts in the field who are shunning the traditional methodological divide between positivism and interpretivism, and are focusing more on the approaches used to carry out the research and the robustness of those approaches. One of the original examples of this change in philosophy was an article by Kaplan and Duchon (Kaplan and Duchon, 1988) in the MIS Quarterly in 1988: "Combining qualitative and quantitative methods information systems research: a case study".

A more recent one was an Editorial in MIS Quarterly by Weber (Weber, 2004). Whilst Weber was careful to couch his piece as a "personal view", no doubt his view carries weight as an expert in the field and as the Editor of such a well-known journal. Weber makes several points with which I strongly agree, and in part the basis for my agreement is my own background of publication in the medical and health services related literature (Loekito et al., 2013, Bain et al., 2010, Brand et al., 2010, Fleming et al., 2009). In that space, researchers have traditionally worked in in the equivalent of the positivist paradigm – relying on hypotheses (or tightly framed research questions) to be proven or disproven by objectively measured facts. But even in that context, there has been an acceptance of an increasing role for interpretivist type research, often seeking to maximise the utility of qualitative information. These 2 different types of approaches are frequently used in concert and are certainly accepted as both having strengths and weaknesses and thus complementary roles when used in the appropriate context. This has been acknowledged by Weber as applying to the IS community. To emphasise the force of his assertion he states "It is time for us to move beyond labels and to see the underlying unity in what we are trying to achieve via our research methods".

It is the contention of this research that, as in other fields, the research philosophy adopted does not need to be seen in such black and white terms. Furthermore, it is my contention that rather than the research philosophy necessarily defining the approach, the problems or questions being addressed, and the context of those problems or questions, can equally define the approach used.

The Approach in this Research

As if to underline the point about old paradigms no longer being as relevant, several researchers note that case studies can in fact be used in both a positivist and an interpretivist paradigm (Cavaye, 1996) including Weber himself (Weber, 2004). Cavaye goes on to state that "case study research can be used in the positivist and interpretivist traditions, for testing or building theory, with a single or multiple case study design, using qualitative or mixed methods. The range of case study research alternatives makes it a highly versatile research strategy for IS."

This is relevant as case studies are at the core of the approach I will use in this research. The unit of analysis in this research is the hospital management environment. Both forms of data collection being employed in this work - the literature review and the case studies, are focused on this unit of analysis. By examining this unit of analysis, against the backdrop of the TEM, it is expected that the identification and characterisation (if possible at all) of the TEM in this context, can be carried out by answering the research questions at hand. Furthermore, the fact that multiple health services are being visited and multiple perspectives are being sought, will allow the characterisation, or not, of multiple variants of a HOME. If there are commonalities to the various HOMEs identified, this may in turn allow the description of a HOME biome.

This last point is a critical one. The original work by Adomavicius et al (Adomavicius et al., 2005) was based around a specific technology in a specific context. It could be argued that this represents a major limitation of the underlying work, and hence of its widespread applicability. So, if the model is designed to be used by an individual analyst in an individual hospital, starting with a specific focal technology, I would argue that it becomes far less useful, and more prone the interpretation of individuals, than if the same basic model can be reasonably applied by analysts at all hospitals, or at least at all public hospitals, or all US hospitals, or all children's hospitals... or whatever the case may be. The identification of one, or a small number of, hospital management technology biomes (HOME biome) is what would allow the latter outcome.

Research Model

In this section of the paper I will examine the issue of research models (RM) and attempt to identify a relevant research model for this work.

What is a Research Model?

By way of context, Palvia et al (Palvia et al., 2006) covered the topic of RMs in IS very well in their 2006 paper in the Communications of the Association for Information Systems (CAIS). In this paper they define an RM as "the theoretical image of the object of study", and the authors sought to establish taxonomy of RMs as a guide for researchers who followed. This work is very interesting and comes off the back of an exhaustive search of the literature. The authors examined a pool of 1226 articles across 7 key IS journals over a period of 6 years. Interestingly they noted that after multi-tier influence diagram (34.9%), the most frequent scenario was the absence of a model ("no model" in their analysis) (21.5%). Other model types identified varied from the simple (listing of variables) to the complex (temporal influence diagram, mathematical model, combination model).

What is the Research Model in this Thesis?

Despite the surprise finding by Palvia et al of "no model" being the status quo in nearly 22% of examined articles, there are substantial benefits, particularly in the area of reader understanding, in defining a visual research model. I will now proceed to identify the model to be used in this work.

It is important consider the base on which this research is building in arriving at an appropriate research model. If I examine the original works by Adomavicius et al (Adomavicius et al., 2006) (Adomavicius et al., 2005) (Adomavicius et al., 2007a, Adomavicius et al., 2007b, Adomavicius et al., 2008a, Adomavicius et al., 2008b) I note the use of several different kinds of research models by the authors as per the taxonomy of Pavlia et al, these include

- Listing of variables and level
- Simple and complex grids and
- Various kinds of influence diagrams (including temporal influence) and
- Some mathematical models

Notably, the authors have not provided a higher level RM or visual representation of the core concepts and functions of the TEM. They did however; use the more complicated forms of influence diagrams particularly in explaining the appropriately named "paths of influence" between different layers in their core TEM. As previously mentioned, it is not the intention of this work to explore paths of influence in any great detail in the HMIS context, but rather to focus more on validation of the core model constructs. It should also be noted that in one of their later pieces of work (Adomavicius et al., 2008b) the original authors actually provided a step by step guide as to how to identify an ecosystem view in a given business or technology context (Figure 1, p 118). This approach – which could have been used in this research – post-dated the commencement of this research, but I would also argue that again this approach assumes an underlying validity of the core TEM beyond its initial contexts; an assumption that is being challenged by this research.

Let us recall the conceptual framework put forward in Chapter 2 – Literature Review – of the HOME model. I stated then that the aim of the thesis was to test the hypotheses that:

- **The Hospital Management Technology Ecosystem (HOME) is an identifiable entity with**
  - **At least one focal technology able to be identified**
  - **Several TR's able to be identified**
  - **Several TL's able to be identified**
  - **A range of TSF's able to be identified**
- **The existence of this HOME model then acts a validation of the core TEM**
- **The HOME model also demonstrates characteristics that allow the expansion of the core TEM**

With that stated aim in mind I propose the following research model to guide the work in this thesis:

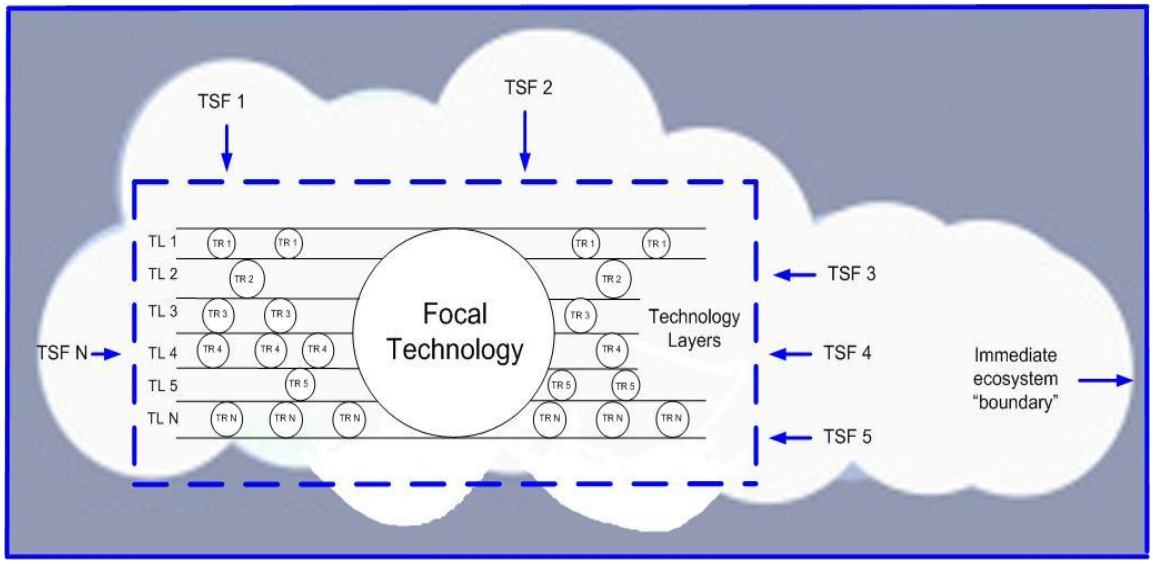

Figure 4 – Research model for the HOME

Let us reflect back on the taxonomy created by Palvia et al (Palvia et al., 2006), this model is a combined model – part influence diagram, and part listing of variables and implicit relationships.

The model represented in Figure 4 describes both the structure and function of the proposed HOME, drawing on the original work of Adomavicius et al, including the concepts of a FT, TRs, TLs and TSFs, and the relationships between theses core model constructs. Importantly this visual representation allows the reader to see how:

- The FT is the centre of an / the HOME model
- Technologies that take on TRs align in layers (TLs) with respect to how they relate (in groups) to the FT under consideration
- TSFs can operate in a broad fashion on any technology in the environment, and
- This core model ought to easily allow visualisation of extensions to the core TEM, as identified through the validation of the HOME model in a way that readers can understand – for instance the identification of intermediaries through which TSFs act.

Research Questions

In the earlier chapters of the thesis I introduced the 2 question sets under consideration in this research, each having a different but complementary focus. In this section of the thesis I will examine each of the constituent questions in greater depth. These question

sets are designed to allow testing of the core hypotheses of the work, as outlined in the previous section of the thesis.

Attempting to answer question set one will provide both some independent validation of the core concepts assumed in the original work, and validation of the conceptual framework being presented in this research.

Question Set 1

Question Set 1 *addresses the broad issue of how the HMIS environment relates to a TEM approach and viewpoint. Answering these questions will demonstrate ways in which the current TEM could be improved.*

- **How does the TEM apply to a hospital environment? For instance – could it be conceptually related to the arid zone biome? (see Appendix 1)**

Before I can attempt to answer this and subsequent questions, I first need to establish that the TEM is a valid lens through which to examine the hospital management IS environment. But of course this is a chicken and egg scenario - by seeking to apply the TEM to the HMIS environment, I will be establishing whether or not it is a valid lens. Further than this, successful application of the TEM to the HMIS context (by validating the proposed HOME model) may allow further insights to be generated that in turn aid the utility of the HOME model going forwards. The example cited above is the potential relationship of the HOME to an arid zone biome.

Let us examine this idea further. Recalling from Chapter 1, a biome is defined as a group of related ecosystems. Then if I discovered that the HOME – or more particularly many instances of the HOME – exhibited a core set of characteristics through the biological lens, then an argument can be made that all HOMEs are part of a given biome. In this particular case, the case of the arid zone biome, this would imply an analogy between the dry, low rainfall environment of the biome (see Appendix 1) and the HOME is general. This would then allow insights (informed by other parts of this research) to be gleaned about the behaviours of the "species" in the HOME (vendors, purchasers, technologies, users etc).

- **What are the key characteristics of the TEM in this context?**

Assuming the evidence points to the TEM as a valid lens, this question gets to the issue of what are the unique characteristics of the HOME? If I continue the thread of discussion from the question above, the reasoning is as follows. Let us make a simpler assumption than that made above, namely that an instance of the HOME is analogous to the arid zone ecosystem (rather than all HOMEs are analogous to arid zone ecosystem, and hence the HOME as a generalization is analogous to the arid zone biome).

Following on from this assumption, I am therefore saying that the "species" in the HOME and the "climate" in the HOME are analogous to the arid zone ecosystem. Let us remind ourselves of some of the characteristics of the arid zone ecosystem. These include:

- highly specialised plants and animals (highly adapted)
- little water - it is diverted into forests
- sporadic rain – life forms as above, are adapted for opportunistic use/storage of water
- high temperature
- competition for scarce resources.

So, in the this analogy, it may be that the HOME exhibits behaviours like "competition for scarce resources" and that it has "sporadic rain" such that only appropriately adapted life forms can survive. It is well known internationally, particularly in some public hospital settings, that funding is either already tight or increasingly threatened to be so (Unknown, 2012) (Barasa et al., 2012) (James et al., 2006, Ricciardi et al., 2009, Carlson, 2012, Bachmann, 2010), so the "rain" in this case may be funding for software development (e.g. – from government stimulus), or for the ability of hospitals to purchase relevant systems. So using this analogy, perhaps only cheap software solutions, or firms with flexible pricing models or a willingness to enter collaborative partnerships with cash strapped hospitals, can survive in this environment.

- **What are its strengths and weaknesses?**

This question talks to the extent to which various elements of the analogy can be seen as more valid and convincing than others. So if for example, the evidence from the data gathering phase of the research is as strongly supportive of the "rain is equivalent to funding" analogy in the HMIS context, then this part of the model could be seen as particularly strong and able to be relied upon. But for arguments sake, if the HMIS

contexts examined appear to be quite diverse and cannot be reasonably be described as being a single kind of ecosystem, then the generalizability of any analogy that is drawn will, by default, be low.

- **How valid and useful is the model for analysing an HMIS infrastructure?**

In this setting I am using the term infrastructure to include not only physical hardware and devices but also software. Remembering the original constructs of the base TEM - including the "technology role" (e.g. – component) concept - then this makes sense.

This question is an extension of previous ones, and talks to the extent to which such an analogy is or isn't both valid and useful. So if for example, the evidence from the data gathering phase of the research is as strongly supportive of the "rain is equivalent to funding" analogy in the HMIS context, then users of the model could rely on that fact in understanding how to use other parts of the HOME, and indeed how best to plan and invest in this environment in the real world.

- **How does it compare with other IT planning lenses?**

Assuming the successful establishment of the HOME, this question will seek to address the potential strengths and weaknesses of the HOME as a planning lens when compared to other IT and IS planning lenses. Such comparator lenses will be established by the literature search in Chapter 4 – Findings, but will also include known and accepted planning lenses such the work by Segars and Grover (Segars and Grover, 1999), or some of the work covered by Porter et al. (Porter et al., 1991) and Millet and Honton (Millet and Honton, 1991) as quoted in Adomavicius et al (Adomavicius et al., 2007a).

Question Set 2

Attempting to answer the second set of questions (below) will provide a view on the practical utility and robustness of the TEM in the HMIS space, thus providing insights and guidance for relevant stakeholders seeking to apply the model.

Question Set 2 *addresses the issue of the practical utility of the TEM approach in the HMIS context, in light of the answers to Question Set 1, such that potential stakeholders can gain the most benefit of the outcomes of this research.*

- **What is the definition of ecosystems success and failure in this environment?**

In the biological world, people would generally understand the concept of a given ecosystem coming under stress (failing) or even "dying". Just think of a river and its fish and bird life killed by pollution, or the effects of salinity on a lake and its associated wildlife. There are certainly examples in the literature describing how entire ecosystems are degrading or failing, and of what the contributing factors to those failures are (Reid and Mooney, 2005). Some specialist bodies – such as the Biodiversity Indicators Partnership (Unknown, 2013a) - have also described examples of ecosystem failure – in this case, human induced:

- "From the collapse of some marine fisheries stocks due to overfishing, with no subsequent recovery once fishing was halted or reduced. A well-known example is the collapse of the Newfoundland cod stock.
- When soil erosion and land degradation reach levels beyond which plant growth and soil formation are not possible
- Bleaching or die-off of coral reefs due to high temperatures or pollution
- Aquatic and marine dead zones, caused by chemical nutrients from fertilisers and erosion, resulting in eutrophication and harmful algal blooms. When the algal blooms die off oxygen is used to decompose the algae and oxygen levels in the water are too low to permit life."

In addition, there are examples of individual species or entities within an ecosystem "failing" – such as the aforementioned problems with cod in Newfoundland, or the example of species of Eucalypts in some Australian work (Fensham and Holman, 1999). No doubt ecologists or biologists may disagree with the concept of isolated "species failure" within an ecosystem – possible arguing that all species or entities within an ecosystem are by definition interdependent. Such arguments are getting beyond the scope of this research however.

Even in the biological literature, the concept of what constitutes success and failure of ecosystems is a challenging one to pin down. As previously mentioned, there is an evolving area of research regarding "ecosystem services" (Nicholson et al., 2009) . It is in this area of research that arguably the best pointer to a definition of success and failure lies.

In their research, Nicholson et al (Nicholson et al., 2009) defined ecosystems services as "the benefits we (humans) obtain from ecosystems and upon which our existence

depends". They go on to cite examples of different services types - for example provisioning services like fresh water.

Although this particular paper is now 7 years old, the authors go on to raise a telling concern, bemoaning science's "fundamental lack of understanding of many processes that underpin the dynamics of ecosystem services, even at a basic level". Despite that, they acknowledge concepts of "failure" of ecosystems - using the term "rapid collapse or change of state of an ecosystem service" and give the example of fish stock collapse due to over harvesting. There seems to be a plausible basis therefore, extending our biological analogy, upon which to define ecosystems failure in the TEM context as the "temporary or permanent failure of provision of one or more services of a given ecosystem".

Having established this definition, it is not difficult to see how it may apply to hospitals and the HMIS environment. So for example, if adequate provision of information to support decision making of operational managers is a key service of the described ecosystem, this may become temporarily or permanently unavailable if a given application or applications in the ecosystem are upgraded, or one vendor's solution is replaced with another's.

In the context of the TEM, this question seeks to explore the extent to which such biological phenomena can be applied to the TE world view, specifically using the HOME if possible. So for example, evidence will be sought from the gathered data (see Chapter 4 – Findings) that a HOME can in fact be (in part or whole) successful or, conversely, a failure. It may be for example, that during the site visits, key informants believe that their own HOME is a failure, perhaps because their information needs have not been met on an ongoing basis, or because a key system that they wanted to use could not be successfully implemented in their hospital.

- **What are the factors affecting ecosystems success and failure in this environment?**

Obviously this question flows from the previous one. If I can establish, in the previous question, a definition for success and failure in the HOME, it would then allow us to establish what the factors underpinning that success or failure are. So, continuing our example above, if failure is the fact that key stakeholders (e.g. – key hospital managers) have not had their information needs met by the ecosystem, then I can proceed to

examine why that is. It may be that in this example of failure, it is the absence of a key information system (e.g. – an intranet based hospital reporting portal) that would meet 80% of their total needs on its own. In turn, when traced back it may be that there has been no funding available to be allocated for such a system, be it built in house or purchased (ie – continuing the previous example analogy, not enough "rain has fallen", and hence the ecosystem is out of balance, or has "failed")

- **How can stakeholders benefit from the application of the TEM to the HMIS environment (e.g. - via a HOME model)?**

This question gets to the heart of the entire thesis, and subsequent research that may flow from it. Assuming the HOME can be reasonably postulated to exist, and that the answers to some of the previously outlined questions demonstrate that it has utility in at least some dimensions, then what next? This question will explore the overall validity of the HOME and the ways in which it may be used. Arguably one of the greatest areas of potential for such a model is in assisting with IS and IT planning decisions in the hospital management environment. This could be from several related, but separate, viewpoints:

- For hospital managers and hospital system implementers – if they knew the nature of the HOME or HOME's, it could potentially assist them in procurement and implementation decisions. So using a previous example, an understanding of the HOME using an arid ecosystem analogy could lead them to better understand which products (system species) were best suited to achieving longevity in the environment. This could be through a better understanding of how vendors could implement sustainable business models, knowing about the environment; and / or through a better understanding of which vendors had products capable of adapting to the environment (for example which were best placed to deal with future reporting requirements mandated by government)

- For software developers and vendors – again knowing the nature of the HOME, or the range of HOME's that may exist, would enable those building or establishing development paths for relevant software, to make better decisions. So, again using the original arid zone example, knowing that the environment is characterised by little, sporadic rain (or funding) may drive developers and vendors towards modular software development with module based licensing.

This would enable them to maintain market share whist allowing for the fact that organizations may only to be able to afford piecemeal or incremental investment in products as bursts of funding become available.

- For funding agencies (both those with an affiliated regulatory function and those without such a function), an understanding of strategically well placed vendors (as described above) could also inform better investment decisions. So for example, a state government, responsible for funding mandatory reporting across say 25 hospitals, may well value insights as to which vendor or vendors are best placed to meet the mandatory reporting requirements (especially as they evolve into the future) based on their system architectures, development paths and product extensibility, as informed by the HOME model.

In summary, exploring this final question will provide insights into the areas outlined above, some of the most crucial in relation to this research.

Data Gathering

The aim of this part of the research will be to understand the issues posed by question sets 1 and 2, in the real world

Literature Review

The literature base under consideration is in the following domains and disciplines:

- Information systems
- Information management
- Information technology
- Health informatics and medical informatics
- Health service research
- Heath services management and
- Health service provision

The literature base being examined will go back in time 12 years to 2002 in relation to:

- the TEM, its validation and related issues

- the hospital management environment (in its broadest sense).

Research databases and portals searched include, but are not limited to:

- ACM Digital Library
- Journals of Information systems (including but not limited to ISR, MIS Quarterly)
- IEEE literature sources and
- Pub Med.

Search Strategy

- in the IS, IM and IT sources
    - [“hospital” or “ecosystem”] in all text

This strategy has been chosen on the basis that the term “ecosystem” is very specific and will clearly return a superset of articles from these sources, from which the key relevant articles can be gleaned. The use of the term hospital is again fairly specific in this context, and will draw out all relevant articles about systems and processes in hospitals, and will assist in then gleaning those articles about the use of IT, and study of IS and IM in the hospital context.

- in Pub Med
    - [“hospital” and (“information system” or “system”)] in all text

This strategy has been chosen on the basis that the combination terms “hospital” and “information system”, or “hospital” and “system”, are fairly specific and will go a long way to isolating the articles needed from the many hundreds of thousands of articles about hospitals in the health literature. These terms will assist on focusing on those articles about the functioning of hospitals as systems, and information systems more relevant to hospitals than patient specific applications, of which there are thousands, that will not be relevant to this research. In the health literature, more often than not, the term “management” is focused on clinical management interventions (e.g. – drug therapies, surgeries) for patients and not on managerial and administrative issues in the health system, and hence I have deliberately chosen to omit this term.

Literature Review Data Collation

The retrieved literature will undergo an initial screen for broad relevance, then a full copy will be retrieved (soft copy if possible, hard copy if not) for further assessment of relevance (see Section below – Data Analysis)

Case Studies

Avison et al (Various, 2005) note in their reference text "Research in Information Systems: A Handbook for Research Supervisors and their Students" that "case studies and site visits can be one "of the most difficult aspects" of IS research because the student "not only needs access to the organization or organizations where data can be collected" but also the "willingness of its employees to help and that requires trust and credibility".

Pilot Implementation

The interview structure was piloted on a small group of relevant stakeholders in order to gauge its potential effectiveness or possible problems in its use. The resultant finalized KII question list can be seen in Appendix 2.

Case Study Interviewee Selection

In light of the difficulties alluded to by Avison et al (Various, 2005) above, the selection of sites and key informants to be visited was a compromise between availability, the level of organizational support, and a diversity of roles.

The KIIs were conducted across 3 health services in 3 states of Australia – these sites provide both public and private hospital services in the metropolitan and regional settings. Interviews were undertaken in 4 different hospitals (3 urban and 1 regional) in the 3 different health services, with 19 different healthcare managers. Interviews went for a minimum of 30 minutes, but preferably for 60 minutes, depending on availability of the staff. These were supplemented by interviews with 4 other relevant stakeholders in the environment (in CS 5), including a health bureaucrat, a clinical network manager and an IT services consultant.

In the case of the hospital based KII's, staff were identified via an initial communication, usually facilitated by an initial mail or email contact to the organizations' Chief Executive Officer (CEO) or equivalent. The interview format was structured - using a 29 question schedule. The question format was predominantly open ended, with only a handful of closed questions pertaining to the experience and demographic features of interviewees.

At the commencement of the interview, participants were asked if they had read the "Information Letter for Participants" and were provided with a copy to read if they had forgotten the content of the letter.

Case Study Data Collation

The data from each interview was transcribed from the hand written interview notes into an MS Excel spread sheet, to facilitate both quantitative and qualitative analysis depending on the question at hand.

Data Analysis

In overview, both the findings of the case studies and the articles and papers from the literature review will be used as evidence to attempt to answer the line item questions in the 2 question sets.

Literature Review Analysis

In the case of the literature review, retrieved articles and papers will first be filtered to exclude those sources that:

- are purely about the clinical management of individual patients or groups of patients or
- that do not shed light on the hospital management environment

and to include those sources that:

- do shed light on the hospital management environment and / or the information needs and systems relevant to that environment.

Case Study Analysis

The data from the case studies and component KIIs will be analyzed for thematic patterns, and then cross referenced with the findings of the literature review, against the context of each of the line item questions in the 2 questions sets.

An inherent limitation of this research will be that any relevant conclusions that are drawn will be heavily influenced by the findings of the specific case studies in this approach. This will be offset to some extent by the use of an international literature base against which to triangulate findings and draw conclusions. The conclusions to be drawn from the research will be tempered against this backdrop however.

Study Reliability and Validity

In this section of the thesis I will examine the concepts of reliability and validity in information systems research (ISR), and their meaning in the context of this particular research.

What is reliability in ISR?

There is much literature in the IS, IT and IM domains about the concepts of reliability and validity. In relation to reliability however, in many cases the literature is referring to the reliability of systems (Zahedi, 1987), of the data within systems, or even organisations. An example is the work by Denyer et al (Denyer et al., 2011) examining high reliability organizations (HROs).

Other research examines issues such as the trade-off between system reliability and speed of use. An example of this is the work of Wyatt et al (Wyatt et al., 2010) in examining general practitioner (GP) preferences in relation to the use of GP systems

In ISR, reliability can be thought of as the extent to which a "measurement instrument" delivers trustworthy results. This can include further sub-concepts like test – retest reliability. This sub-concept is the expectation that the same "test" or "measure"

undertaken twice on the same "subject" will deliver comparable (if not identical) results if it has this property of high test-retest reliability. This sub-concept is also one deeply embedded in the perceived strengths of research in the biological and medical sciences, which as I have previously argued, align strongly with the positivist traditions of ISR.

In a key text on Qualitative Research in Information Systems edited by Lee et al (Various, 1997) an assertion is regarding the concept of reliability with ISR with which I concur. It is asserted that (Part 3, p 242) the "subjective nature of qualitative methods …..calls for a totally different perspective on reliability" when compared to the positivist tradition. The author then goes on to describe strategies for addressing the criterion of reliability of such research and suggests three they have used – consistency, triangulation and member checking. Looking for consistency amongst the collected evidence, and the use of triangulation, will be key in this research.

Let us briefly consider the concept of triangulation in more depth. Michael Myers, an internationally known IS researcher (Myers, 1997) notes "Although most researchers do either quantitative or qualitative research work, some researchers have suggested combining one or more research methods in the one study (called triangulation)". Similarly Oates, in her text in IS and computing research (Oates, 2006) states that (p 37) "The use of more than one data generation method to corroborate findings and enhance their validity is called method triangulation". She goes on to note however other types of triangulation that are not mutually exclusive, including time, strategy, space, and investigator triangulation. Finally, Ammenwerth et al (Ammenwerth et al., 2003) also support the idea of various types of triangulation (data, investigator, theory and methods) – and importantly assert that **"triangulation is not limited to combination of methods, but also describes the combination of data sources, investigators, or theories".**

Specifically in this research I will use the triangulation approach in respect to data and methods, within the framework of answering each of the proposed question sets.

What is validity in ISR?

In relation to validity in ISR, and specifically case studies, Bhutto argues that the "the case study must demonstrate that its means of measuring are valid" and whilst acknowledging different kinds of validity, she posits that "The primary concerns for case studies are construct validity. It proves whether or not the measurements reflect the phenomena they are expected to reflect." (Bhutto, 2008). Importantly however, this research is using 2 forms of "measurement" – a literature review and case studies.

Construct validity refers to the extent to which our chosen measurement instruments truly measure the phenomenon under consideration.

How will this work meet these criteria?

In relation to reliability, this will be achieved in this research through triangulation of the results of the literature review with the results and insights from the case studies.

Put simply construct validity, in this research, will have been achieved if the literature review results and the case studies measure the existence, or otherwise, of a HOME(s) and / or a HOME biome in the way that was intended. Of course, as has been stated throughout, this will have been through the intermediary of the 2 question sets and their component line item questions.

Given the novel nature of the research in this topic area - particularly given the fact that the research is not purely grounded in positivism - there is an inevitable sense in which the findings of the work will be increased in reliability (in particular) through further research undertaken by others over time. In the same way this research –pending its outcome- may increase the reliability of the work of Adomavicius et al (Adomavicius et al., 2005). Equally – given that there are no existing formal "instruments" that can be used in the case studies, the construct validity of the questions used in the KII's can only truly be borne out over time.

CHAPTER 4 - FINDINGS

Case Studies

In this section of the thesis I will outline the results of the 5 case studies undertaken as part of the research. Four of the case studies involved looking at the hospital management environment in the context of an individual physical health service. The fifth involved the examination of a virtual (non-physical) health service by speaking to staff relevant to the environment but not affiliated with a single, particular health service. Another way to view the difference between the first four case studies and the fifth, is that the first four were from the perspective of individuals within the health services, and the fifth was from the perspective of individuals external to a range of health services.

The common thread in each CS is an examination of the relevant hospital management environment through the KIIs with stakeholders and other relevant obtainable information (e.g. – web site data, annual reports).

The results of the case studies will be presented in toto, with their applicability to the 2 core question sets to be addressed at a later stage in the thesis.

Hospital Characteristics

Table 1 below outlines some of the key characteristics of each of the hospitals visited.

Table 1- Hospital Characteristics for Case Studies 1-4 (sourced from Hospital and Health Department web sites 26/6/2010 unless otherwise stated)

Characteristic	Hospital 1 (linked to Hospital 2)	Hospital 2 (linked to Hospital 1)	Hospital 3	Hospital 4
Metro/ Regional/ Rural	Metro	Metro (Outer)	Metro	Regional
Num Beds	600	Estimated 150+	334	678
Public/Private	Public	Public	2 conjoined facilities	Public

Characteristic	Hospital 1 (linked to Hospital 2)	Hospital 2 (linked to Hospital 1)	Hospital 3	Hospital 4
			(one of each)	
Range of Services	Full range of tertiary services	Smaller facility including a Community Health Service	Large range including subacute and hospice care	Large range including Rehabilitation Services
Inpatient Services Per Annum (inc Same Day)	50,000	NA	NA	34,000
Outpatient Services Per Annum	770,000	NA	NA	239,000 (FY 2008-9)
Staff	2500 EFT	NA	>1000	> 3000
State of Australia	1	1	2	3

With the exception of hospital 2 (for which little data was publically available) it is clear that each of the hospitals are large organizations, with huge numbers of staff, delivering a high volume and complex range of services.

Key Descriptive Features of Informants

Let us examine the key descriptive features of the informants interviewed across the above 4 sites and the "virtual" site

Table 2 - Key informant Job Roles for Case Studies 1-5

Characteristic	Hospital 1 (linked to Hospital 2)	Hospital 2 (linked to Hospital 1)	Hospital 3	Hospital 4	Hospital 5
Metro/ Regional/ Rural	Metro (Inner)	Metro (Outer)	Metro	Regional	N/A
Physical /	Physical	Physical	Physical	Physical	Virtual

Characteristic	Hospital 1 (linked to Hospital 2)	Hospital 2 (linked to Hospital 1)	Hospital 3	Hospital 4	Hospital 5
Virtual					
Job Role 1	Human Resources Manager	As left	Director Quality and Safety	Community and Continuing Care Executive	Professional Services Consultant
Job Role 2	Manager Patient Safety and Quality	As left	Operations Manager	Surgery and Nursing Executive	Manager Clinical Network
Job Role 3	Manager of Performance and Activity	As left	Director of Corporate Services	Director of Governance and Risk	Manager of a Programs Area
Job Role 4	General Manager	As left	CIO	CIO	CEO of a Software Company
Job Role 5	Clinical Service Manager	As left	ED Manager	Clinical Service Manager	N/A
Job Role 6	Nursing Executive	N/A	Director Ambulatory Care and Allied Health	N/A	N/A
Job Role 7	IT Executive	As left	N/A	N/A	N/A
Job Role 8	N/A	Hospital Executive	N/A	N/A	N/A

Table 3 – Key Descriptive Features of Informants – Gender- Question 1 of Interview Schedule (Q1)

Gender	M	F
Number	10	13

So amongst the informants, there was a fairly even mix of males and females.

Table 4 - Key Descriptive Features of Informants – Age- Q2

Age Group	19-34	35-44	45-54	55-64	65+	Total
Number	3	6	10	4	0	23

So of all the informants, 20 (87%) were at least 35 years of age, representing a relatively senior group of people.

Table 5 - Key Descriptive Features of Informants – Sector - Q3

Sector	Hospital	Government	IT Industry	Clinical Network
Number	19	1	2	1

Table 6 - Key Descriptive Features of Informants – Job Role- Q4

Job Role	Hospital Manager/Executive	IT and Information Ops	IT and Information Management	Clinical Network Manager	Clinician Manager	Program Leader	Total
Number	14	1	4	1	2	1	23

Table 7- Key Descriptive Features of Informants – Years in Sector/Healthcare- Q5 and 6

Num Years	0-5	6-9	10-14	15-19	20-24	25+	Total
Years in sector	5	2	2	1	3	10	23
Years in healthcare	3	2	2	2	2	12	23

It can be seen from the preceding tables that informants brought a high level of experience both in the healthcare industry and in the hospital sector specifically – 61 %

and 70% respectively had at least 15 years' experience. (Table 7). In relation to job role, most were hospital executives or managers (61%).

In part because of the large amount of data gathered, this chapter is focused on describing the data collected, and not demonstrating and interpreting its patterns. So in this section that follows, the findings of the case studies are presented as discovered, with some minimal summarisation, identification of themes, and analysis. Further triangulation and analysis occurs in detail in Chapter 5 – Discussion.

Case Study 1 – Large Metropolitan Hospital

The first CS was undertaken at a large inner urban hospital which provides a large range of tertiary clinical services. The hospital is located in state 1 and is also a designated major trauma service. Areas of expertise of the hospital include critical care, surgery, cancer care, medicine, women's and children's health, mental health, community health and medical imaging. Based on information from the hospital's web site its part of a hospital network (HN), which includes community health facilities. The broader HN provides some key governance functions for this hospital. The hospital seeks to provide services to some 250,000 residents of local region, and about 35% of the hospital area's residents are from a non-English speaking background. In addition, with its broader trauma role, it accepts patients from around the state.

In relation to **Question 7** in the interview schedule, informants at this site identified a large range of systems as being **"a key part of the hospital IT environment"** Several informants at this site identified all of the listed systems as being important, whilst the Human Resources (HR) manager focused on HR and Finance systems, and Executive dashboards, as being more important.

In terms then of which systems were seen as essential to managing hospitals **(Question 8)** – Finance and HR systems, Executive dashboards and the PAS system were all seen as important across this group of informants. Patient flow systems (ie – that track and monitor patient flow) also rated a mention with this group.

In relation to **Question 9 – "Do you think that there is one critical technology that is a must in terms of managing hospitals, or that acts as a cornerstone of that management – which do you think it would be? And why? "**, informants at this site

differed to many others as will be seen when I examine the latter case studies. In this CS the informants identified HR systems as being the most likely candidate for such a critical technology, as well as Finance systems. As one informant put it a HR system is "the people system". They expanded by explaining that knowing how many people are in the workforce, and how many hours they are working; allows relevant staff to have a good handle on ongoing costs. Another informant identified the HR system as critical because of the key role of staff in running the organization.

Notably however, even the HR manager also acknowledged that health is a "people business" and that the PAS is a vital system given its role in tracking patients through the hospital; another informant also mentioned the PAS as being critical. It is also important to note that at the time of the site visit, that organization was in the middle of developing a position management system (a key system in the HR space). Notably also, in response to a later question one senior manager stated that the "current HR system (is) not very good."

In relation to **Question 10: "Do you believe that there are any key relationships between that technology and other you have described ?"** one informant noted that the "PAS populates the others with key information". In most cases however, respondents at this site described relationships between HR and Finance / Payroll systems, and between both of those systems, and Data warehouses and Executive dashboards.

Table 8 - Q 11. Do you think these systems you described in Question 10 (the preceding question) have been successful in that role of assisting the management of hospitals ? (1 – totally unsuccessful thru to 10 = totally successful) ? and Q 12. In your mind, how have you established that level of success ?

Respondent	Q 11 Answer	Q 12 Answer
Human Resources Manager	About a 6 currently	"The programs rule us". Not 10 as we don't get the full functionality that we need or could get - because insufficient funding. Hence we don't see end game achieved.

Respondent	Q 11 Answer	Q 12 Answer
Manager Patient Safety and Quality	Difficult to comment and depends on what level you are working at	Every system has its faults and as humans we adapt to these and get used to/ accept less than ideal. People looking at systems (using them) need experience and knowledge (ie - systems and/or training not ideal)
Manager of Performance and Activity	5 - would be better if a better match of skills being used to available systems.	Skills mismatch as left. Also issue of difficulty of time poor staff having to interact with sluggish systems. Sense of IT systems replacing (not in a good way) skilled staff in some situations. Skill mix/experience in decision makers not ideal.
General Manager	Depends on the systems	PAS and EHR core to patient treatment. Patient flow and Bed board provide strategic assistance
Clinical Service Manager	Varies on system. PAS OK - some things need to be better.	Some systems don't talk to each other. Current HR system not very good. "Don't tell us what we want to know" - end result is arguing over correctness vs the problems. Inaccuracy/inconsistency over data entry. Small data entry errors can extrapolate to thousands of dollar's worth of errors in terms of revenue/expenditure
Nursing Executive	Varies on business side. There is "no consistency in how people present information in health". Prior HR system - 9/10. Finance system - 8/10. Dashboards good - 7-8/10.	Speed of responsiveness of systems. Level of functionality – e.g. - some allowed user generated quality control. Use of systems in routine decision making.

Respondent	Q 11 Answer	Q 12 Answer
IT Executive	Depends on systems. Bed boards - 8; Management decision support - 8; Financial management information system (FMIS) - 5; HR - 5; Exec dashboards - should have but don't - 0	Reliability of system and information - accurate, effective information. Sometimes a lack of understanding and training re how to use. In case of HR - strong sense of inaccurate information

As can be seen from the responses above, there were are a wide range of views at Site 1 regarding how well management information systems have assisted in the management of the hospital. Often the responses of individuals were qualified depending on the perceived success or failure of individual sub systems. Although overall a picture of dramatic success was not evident. Reasons quoted for this relative lack of success included:

- poor user skills – this was referenced several times
- systems not telling staff "what they need to know"
- poor speed of response of systems
- insufficient funding for systems and hence incomplete functionality
- inaccurate data and information in (and hence obtained from) systems.

Table 9 - Q 13. Do you think these systems you described in Question 10 have changed in recent years in relation to their role in assisting the management of hospitals ? (1= very adverse change, 3 = no change, 5 = very positive change) and Q 14. In what ways, good or bad, do you think these systems have changed in recent years ?

Respondent	Answer Q13	Answer Q 14
Human Resources Manager	4 - ie positive change	Technologies are being embraced - driven by demographics of staff e.g. - younger; broader societal uptake of technology flowing on to work. But not a 5 as more room for increased uptake,

Respondent	Answer Q13	Answer Q 14
		plus need better access to hardware (Personal Computers (PC's)) and services (e.g. -email)
Manager Patient Safety and Quality	5 - very positive	Moving from paper has been a good thing. More user friendly systems- access, workflow support, navigability, individual adaptability (? Meaning personalisation)
Manager of Performance and Activity	4 - positive change	Improved governance structure around the systems - to incorporate feedback about the relevance and uptake of information. e.g. - exception reporting around length of stay (LOS) information provided in a personalised way for managers then allowing audit and action.
General Manager	3 - no key change	Technologies are only providing an enhancing function - making information more immediate and electronic
Clinical Service Manager	Varies - certainly in relation to PAS systems. Perhaps not in HR. Perhaps in Payroll	PAS - more functionality. Finance - better provision of information. Payroll - still some arguments re accuracy of FTE figures versus acting on the information on
Nursing Executive	4.5	Not clear from responses - systems generically better
IT Executive	4-5	Better tools.

Despite the observations just made, the responses to Question 13 indicate a strong sense that these systems have changed dramatically for the better in recent years in relation to supporting the management of hospitals. This sentiment was driven by several observations from these respondents, namely of:

- improved functionality and "better tools"

- improved information provision
- systems supporting the transition from paper-based approaches and
- improved user "friendliness"

Table 10 - Q 15. What forces and factors from <u>inside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? and Q 16. What forces and factors from <u>outside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? And Q 17 – What is the relative contribution of these forces (internal and external) ?

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
Human Resources Manager	More relevant locally developed functionality - e.g. - the system they mentioned earlier	Increased ease of use (e.g. - Windows versus DOS). Better external system – e.g. - a new State-wide Payroll and Finance solution	More weighted towards the external forces
Manager Patient Safety and Quality	Consistency of user names and passwords	Feedback to DH re issues with systems locally has generated improvements. But there is good and bad re the centralised model. Sometimes an advantage is the funding that comes with standardisation/central imposition – e.g. – the state-wide IMS (Incident management system)	More external
Manager of Performance and Activity	Local management change the clearest factor.	Plausible ones but they did not feel they were at play here – eg - ACHS (Australian Council on Healthcare Standards); Department of Health (DH), the media and public pressure	Definitely internal things - local management change the clearest factor.

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
General Manager	No great change	No great change	See left
Clinical Service Manager	Bad history of choices in health – e.g. - arguments over specs. Impact of poor/wrong decisions	Choice decisions from DH - even if delegated to the local HN	Heavily externally driven.
Nursing Executive	Need to understand budget - an accountability issue	Different in different settings - hospitals must respond to upstream requests	Varies in different settings
IT Executive	Better ability of managers with technology. Better communication with developers. Nature of the business - working across multiple physical sites has driven better intra and extranets, and more supportive tools	More ubiquitous usage of systems at home for travel, buying and selling, banking etc. Global change in systems and technologies available and in use – e.g. – Microsoft technologies and Google	Majority of forces are external.

Let us consider the responses to Q 15 -17 as a whole. In the majority of cases, (with only one clear exception - "definitely internal things"), the relevant forces driving change (and only 1 respondent felt change had not occurred) were felt to be predominantly external. These forces included:

- increased frequency of use and availability of IT systems generally
- increased ease of use of IT systems generally
- access to better IT systems (e.g. – through external purchasing programs at State or HN level) and
- funding attached to externally imposed "standard" or common systems

In terms of interplay between these forces (Q 18) identified in Q 15 and 16, informants at this site identified a number of interesting possibilities. Most powerfully, one respondent noted that a lot of drivers are internal instantiations of external (e.g. – Health Department (DH) and HN) imperatives – e.g. - patient access imperatives. Another example quoted was that case mix (a funding system paradigm in public health) drivers from externally lead to a greater need to understand budget. This in turn acts as a driver to improve those systems (e.g. - HR and Finance systems) that primarily assist with budgetary management. A different kind of interplay was described by one respondent where new externally available technologies influence internal implementation and upgrade decisions – thus driving internal improvements in relevant systems.

Table 11 - Q 19. What are the currently unmet needs of hospital managers (of all types) in relation to IT in your opinion? (a base assumption of the PhD is that there are some) and Q 20 – and why do you say that ?

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Human Resources Manager	Unmet functionality needs – e.g. – in current HR and Payroll systems – there is insufficient reporting functionality. This may require going in and out of the FMIS - if the user is an operational manager - (e.g. Nurse Unit Manager - NUM) a problem exists with the lack of support and training – they may require also multiple log ins to multiple systems (up to 18 (?) if the user is a NUM). You then get task dilution of operational managers. Data accuracy problems from data entry errors	Still not enough buy in in system use/benefits - need to win over biggest naysayers. There is inadequate training and support for system use. There is prioritisation of functionality provided because of cost and other trade-offs. Too much reliance still on human entry and hence subsequent errors.
Manager Patient Safety and Quality	Especially for clinical managers - too	

Respondent	Unmet Needs (Q 19)	Why (Q 20)
	much information across too many different systems which is not integrated enough. Plus may require different log ins – e.g. – Patient flow, PAS, IMS, stock and ordering. Also a range of reports that could be better integrated and provide better analytic support	Lack of system and information integration
Manager of Performance and Activity	Inadequate education for managers around systems and information Some reports are not used as much as they could be	Only sufficient resources for this to be done on an ad hoc basis Due to turnover in middle management, training and awareness issues.
General Manager	Low accessibility to information, "clunkiness" of systems – versus web based, easily navigated systems - if the work environment mirrored the home environment there would be better buy in by users (vs DOS based systems/ Excel spreadsheets).	The work environment does not mirror the home environment e.g. – "clunkiness" of systems Lack of support for work processes.
Clinical Service Manager	Ability for less trained/skilled users – e.g. NUMs - to drill down without needing analysts; need systems to better support decision analysis and action – ensuring all the information they need is available. Need to free up time of key staff and not add to the burden.	Insufficient skills, training in key user groups (e.g. – NUMs) "Too many gauges and not enough levers"

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Nursing Executive	They need personalised views of information directly relevant to an individual's specific role. Speed of accessing information and ability to drill down - not having to wait 2 weeks. Respondent put forward need for an experienced person to do this - possibly on their behalf.	Need more personalised information provision / presentation and faster responsiveness in meeting their information needs
IT Executive	Too much data, not enough information. Need improved support for mobility – e.g. – for managing across geographic sites. Need easy ad hoc reporting tools for managers, or those working on their behalf.	Need more consolidation / transformation of data to information and easy to use reporting tools

In relation to Q 19 and 20, a number of useful insights were obtained. The themes were:

- too much data for managers and not enough information which is not personalised enough for consumption by them
- this is compounded by too many systems with which managers need to interact to obtain this information
- in turn there is a mismatch between the current skills of users (e.g. – NUMs) and the demands placed upon them in relation to systems use
- there is also inadequate training on, and support for, key systems and finally,
- workflows are not always well supported by these systems eg – mobile workflows.

Table 12 - Q 21. - and in which topic areas ? and Q 22.– and why do you say that ?

Respondent	Topic areas (Q 21)	Why (Q 22)
Human Resources	HR, Finance, Reporting	Not answered

Respondent	Topic areas (Q 21)	Why (Q 22)
Manager		
Manager Patient Safety and Quality	In all the listed areas. Also reports time consuming to extract. Plus they have a wide variance in meaning and action. Also - issues of memory and training - if a manager doesn't use a system or a report very often ….. "how do I do this again ?"...."what was the password again ? "	Reports time consuming to extract. Plus they have a wide variance in meaning and action. Task dilution
Manager of Performance and Activity	FMIS, HR, Data warehousing and Reporting - perception of poor quality - so an issue of quality control one way or another; sluggish system responsiveness from reporting system.	Poor quality and sluggish reporting system response
General Manager	Including HR and Finance - state finance solution is accessible to accountants but not to people from a clinical background when needed	Poor usability of system for non-subject matter experts (SME)
Clinical Service Manager	Especially - Finance ; HR; even things like CPOE - from a management perspective could save $$ and lives	Lost savings and quality improvement opportunities
Nursing Executive	Tends to be generic …..or brought out thru ad hoc tasks (e.g. – obtaining information on a specific topic e.g. - a "search" for information on team nursing performance)	Information too generic and not tailored enough to context of need
IT Executive	Reporting, mobility, analytic tools. Clinical information still lagging behind compared with - Financial/HR	Inadequate clinical information vs Finance and HR information

Respondent	Topic areas (Q 21)	Why (Q 22)
	information	

The unmet needs were seem to be in many areas, but HR, Finance and Reporting systems (including the Data warehouse) were mentioned on several occasions by various respondents. Poor system responsiveness, poor accessibility of information from systems, task dilution for managers, and lost savings and quality improvement opportunities (pertaining to unmet clinical information needs) were the reasons for the answers in this case.

Table 13 - Q 23 . In light of these unmet needs, in what ways do you think these systems may change in the next 5-10 years? and why do you say that ?

Respondent	Possible changes	Why
Human Resources Manager	They will be more integrated - e.g. FMIS and HR - as long as funding follows. There will be more one-stop shops for managers – e.g. the (perceived by interviewee) better systems available to manage a general practice. Systems will be increasingly easier to use as Windows predominates (e.g. over Disk operating system (DOS)) and improves.	If funding/investment follows. And technology will naturally drive us this way.
Manager Patient Safety and Quality	Better integration, fewer systems (by consolidation) – especially at 10-12 years from now	Integration already happening – e.g. - Operating Room Management Information System (ORMIS) into EMR. Health is a bit behind (e.g. - older, slower systems) other industries so it is implied that we will catch up
Manager of	Unsure	No point putting together an IS plan as

Respondent	Possible changes	Why
Performance and Activity		systems and strategy are often imposed - most of the state wide systems projects have been implemented at this site
General Manager	Likely that more centrally imposed solutions will come in; and local applications will not be maintained and hence knowledge loss to staff and organization. Also likely to be more centralization of IT staff	Because of trends to date and knowledge of state programs
Clinical Service Manager	More and more immediate information. It may be made available to the public.	More info is the perceived versus the real need. May be expectations about national benchmarking - but is a problem with this as the industry itself has less than an ideal understanding of indicators and performance - let alone the public.
Nursing Executive	Systems should be better integrated within next 5 - 10 years - more likely 10 – but informant does not believe that they will be	Unclear from response
IT Executive	Is very positive provided funds flow. More wireless, more Executive dashboards implemented. More tightly integrated systems.	Some steps already taken – eg - DH staff are in place to support a broad Executive dashboard roll out

In summary, the informants at Site 1 believe that, in light of these unmet needs, hospital management systems will change as follows in the next 5-10 years:

- greater integration between systems (e.g. – between HR and Finance systems)
- more centralisation of systems (fewer systems to have to interact with)
- more centralization of IT staff (which could mean at a HN level in this case – ie – not in the hospital itself)

- greater ease of use of systems
- more immediate information provision

Their reasoning for postulating these changes includes

- assumed improvements in the amount of funding
- projected ongoing trends in how the state funds hospital ITS
- broader societal technology drivers ("technology will naturally drive us that way")
- new National imperatives – e.g. – National benchmarking

Table 14 - Q 24 . Ultimately do you think these unmet needs will be met in the next 5-10 years in light of the changes you think may occur ? (1= very confident <u>they will not</u>, 3 = unsure, 5= very confident <u>they will</u>)

Respondent	**Score**
Human Resources Manager	Unsure- 3
Manager Patient Safety and Quality	3-4 - not overly confident that these needs will be met
Manager of Performance and Activity	2-3 - not very confident – unsure
General Manager	1 - they will not be met at all
Clinical Service Manager	Not clearly stated. Possible
Nursing Executive	Some unmet needs will be met but many unlikely to – e.g. - better integrated, better functioning or better looking systems
IT Executive	80% confident of getting there

Despite the rich picture painted by the informants around developments in this space, in light of current unmet needs, they have a collective low confidence that these positive changes will occur (ie – few 4 or 5 responses)

Table 15 - Q 25 . What <u>intra hospital forces</u> and factors do you think will drive towards your predicted outcome in the next 5-10 years ? and Q 26 . What <u>forces external to hospitals</u> do you think will drive towards your predicted outcome in the next 5-10 years ?

Respondent	Answer Q 25	Answer Q 26
Human Resources Manager	Funding. Plus see right - plus given a patient care focus - can be difficult to stick to strategic direction (e.g. – versus say Westfield) because there is always the next internal or external crisis or burning issue.	Patient perception is important - how to justify $ expenditure on MIS', when patient care can always be improved and funded more. Knee jerk responses to external forces and influences –eg- political pressure. And the next immediate need – e.g. - gastro outbreak, Creutzfeld-Jacob transmission, methicillin resistant staph aureus (MRSA; "golden staph") outbreak. The complexity of managing hospitals including the balance of services versus community demands – e.g. - this hospital is a trauma centre but does many other things - so for example an issue is local vs specialised services
Manager Patient Safety and Quality	User feedback, investment. Collaboration and information sharing	Approaches by external companies - but can come at a cost. Strong sense of imposition by HN and in turn DH re the strategic direction in this area and $ funding attached… "we can put forward the case but who pays the bills" ?
Manager of Performance and Activity	Unsure - possibly better education of users - but will not be a targeted program	There is uncertainty as a change in (state) government seen as highly likely and may throw much into disarray. Also a sense of likely cutbacks on the admin side of th

Respondent	Answer Q 25	Answer Q 26
		business- and hence a reduced user pool +++. Other factors at play may be younger and more IT savvy users coming into the system.
General Manager	Feels the HN have little say	Have little confidence in the imposed state-wide solutions
Clinical Service Manager	More access to computers and information at desks but most staff aren't interested as came to management from clinical care and hence may not have an affinity with management systems. There is an issue of infrequent use and hence the need for better support for the infrequent users – e.g. - experts on tap ad hoc; and better support for analysis/interpretation and decision making	Nil stated
Nursing Executive	Nil response recorded	Nil response recorded
IT Executive	See right	Funding and people – but there is a risk of centralised staff losing touch with the coalface - so these need to be the right people and deployed in the right way.

In summary, these informants identified the following forces as driving them towards the outcome they alluded to – remembering of course that they have a low collective confidence that this outcome will eventuate. In terms of intra-hospital forces they identified:

- funding
- user feedback
- improved user education

- improved user support – e.g. – through "super-users" ; and in the analysis and interpretation space

In terms of forces external to the hospital forces they identified:

- community pressure and demands (which may in turn affect funding)
- political agendas and crises (which may in turn affect funding)
- political uncertainty – e.g. – governments voted out
- approaches by external companies
- HN strategic plans and approaches
- A younger and more technology savvy workforce in healthcare

Q 27. In thinking about the sorts of technologies important to the management of hospitals – can you identify things that take any of the following roles (component, product /application or support / infrastructure) ?

In having informants answer this question I always set the scene for them by explaining the original analogy used by Adomavicius et al (Adomavicius et al., 2005) in the digital music setting.

Informants in this CS, as became the case at most sites visited, struggled to give insightful responses to this question, In short it left many informants stumped. One informant had no useful comments relating to the environment as discussed but did acknowledge a possible component role in terms of technology infrastructure - cabling, servers, hard drives etc. Another informant referred to the new HR system ("establishment system") to be implemented at this site They felt that system would fill a support and infrastructure role as it "plugs into expenditure - to compare what was due to be spent versus what was done – then (we) can look at leave / overtime / activity. So (we) can look at staffing as it was intended to achieve an outcome versus the actual outcome." Finally, another informant saw the PAS as a critical component - "the better the PAS, the better it takes account of all our business …… the better it (the business) will be". They expanded by saying that an example of the application role (but they had not mentioned this system earlier) may be the commercial off-the-shelf (COTS) clinical system (product name withheld) they use.

Q 28. In thinking about planning in this environment, from the perspective of your role (as a manager or clinician manager, product developer, hospital

executive, funder etc) how do you go about it ? What frameworks do you use? What drivers do you take account of ? What constraints do you have to bear in mind?

The IT executive at this site provided an artefact (see Appendix 3) entitled "Priority ranking for new IM and T Project Requests" pertaining to how this hospital prioritises IM and T projects. In addition, a 2 tiered committee structure exists to provide governance of these processes. Both the proposer of any project, and the organizational IT committee, use this ranking form to assess the relative priority of such projects.

Another informant suggested the organization had no approach to IT planning decisions, but that they would go about such an endeavour by researching existing systems in similar organizations, even if in different industries. They suggested that they would then examine the cost benefit of any IT investment decision as the hospital is in the public health setting; before then exploring the probity issues, and examining approved procurement processes.

Another informant answered the question with a more strategic interpretation in mind. A key driver for them is "what is our core business and how might that change in next 5-10 years?" They did acknowledge that in many ways this is imposed on the organization from the DH and the HN.

Yet another informant outlined a series of principles they would use in making these planning decisions:

- need to invest against core business
- need to be smarter
- need to identify, regarding IT, why we should put it in and what would we get out of it ?
- would use/need clear and current business strategies - including - finance/HR; clinical - these would be prioritised
- would need to include a horizon gaze, identifying gaps in clinical services
- would need to include corporate governance of systems - their growth, implementation and prioritization
- would need to aim for a seamless environment that supports decision making

Yet another informant felt that the state and HN plans in this space made IT planning decisions at a hospital level somewhat redundant, noting that the "biggest framework is

that imposed by state plan." And noting that they (the hospital) "cannot start from a greenfield world view" with the constraints being "dollars, system capacity (the business system), (and) government priorities". To round out a quite disparate range of views on this topic, another informant felt that all IT dollars should be spent on clinical IT (e.g. – CPOE, care plans, PDAs for clinical staff etc), even when viewed through a management lens, as such innovations will drive down LOS and costs.

Finally, I asked informants **Q. 29 "in thinking about this interview and the questions you have answered – how would you characterise the hospital IT environment as it pertains to the management of hospitals (as opposed to the management of individual patients)?"**

Informants were given the option of the following responses, including "other" if they felt that another kind of environmental analogy better captured their overall view of the environment:

- as a lush forest full of trees, wildlife, birds and plentiful rainfall
- as a barren desert with not much water, harsh sun and where not many species of plants and animals can survive
- as a coastal environment with seaside plants and creatures, and exposed to the elements and tides
- as a woodland with trees, much wild life, and beautiful flowers
- as a snowscape with much moisture, cold temperatures and specially adapted wildlife and plant life
- Or another physical environment you can think of

Table 16 - Q 29 . How would you characterize the environment ?

Respondent	Answer Q 29
Human Resources Manager	A coastal environment - because there is lots going on, lots of systems, and we are always a bit exposed to organizational and external needs and forces.
Manager Patient Safety and Quality	A coastal environment - we are exposed to elements and tides and we adapt

Respondent	Answer Q 29
Manager of Performance and Activity	A snow scape is the closest. - "we adapt to our environment and what we have, and the way we know (how) to use it". Is not lush, bountiful or easy but there is a lot of useful information out there.
General Manager	Barren desert or Coastal environment - harsh but not as harsh as a desert. Ebbs and flows of $ governs what can be done. We adapt as best we can with available funds to do as much as we can / health is more adaptable than most (other industries). $$ are key.
Clinical Service Manager	No obvious alignment – they see adequate natural resources (? = information). People are in the way - they seek more of A when they need more of B.
Nursing Executive	A coastal environment - in a public system – we are exposed to elements and tides. Tides change - political scene, clinical work, juggling $ versus outcomes. "We manage today for what we need to" - need to adapt but is therefore hard to capture all that information.
IT Executive	A coastal environment - because attractive environment, many great aspects. But always exposed to external forces - even whilst running projects - and hence to changing needs and requirements.

Quite clearly in this case study, the analogy of the proposed HOME with the "coastal environment" is the one that rang most true for most informants.

Case Study 2 – Outer Metropolitan Hospital

The second CS was undertaken at a more community focused hospital in an outer suburb of the same city as the hospital in CS 1. Like site 1, site 2 is a public facility but with the ability to treat private patients and it is related to site 1 in a network sense –

both are part of the same HN in state 1. Based on information from the hospital's website, the local area has a population of over 200,000 people and the vast majority of the hospital's patients come from that local area (almost 100%). The hospital provides a comprehensive range of surgical, medical, child, youth and family, aged care, rehabilitation, mental health and community services.

It is important to note therefore, the strong overlap with CS 1 as both sites are part of the one HN, and so have some shared services and structures. Despite that, each facility is radically different in its size and service profile, and each site in a very different socio–geographic setting (site 1 – inner urban. site 2 – outer urban)

Whilst a purist may believe that these 2 case studies overlap too much to be of use, the main commonality is some (but not all) of the management staff. The systems under consideration, and even more so, the business and care models they support, are different. At any rate, such governance arrangements are not uncommon in healthcare, certainly in Australia, and to exclude such a site from analysis runs the risk of the resultant research not actually sitting in the context of real world healthcare.

In relation to **Question 7** in the interview schedule, informants at this site identified a large range of systems as being **"a key part of the hospital IT environment"** Several informants at this site identified all of the listed systems as being important, but systems with an emphasis on patient tracking – e.g. – the PAS, Emergency Department Information System (EDIS), Operating Room Management Information System (ORMIS), and Patient flow systems – and information display (e.g. - Executive dashboards) were mentioned on several occasions.

In terms then of which systems were seen as essential to managing hospitals **(Question 8)** – unlike Site 1 Finance and HR systems were less prominent in the thinking of informants, rather Patient flow systems (including the PAS) as mentioned above, and Executive dashboards, were seen as more important.

In relation to **Question 9 – "Do you think that there is one critical technology that is a must in terms of managing hospitals, or that acts as a cornerstone of that management – which do you think it would be? And why? "**, informants at this site offered responses more in line with those from other sites – HR and Finance Systems rated a mention, but the PAS and Executive dashboards also featured prominently in

response to the question. As previously noted in CS 1, even the HR manager also acknowledged that health is a "people business" and that the PAS is a vital system given its role in tracking patients through the hospital.

In relation to **Question 10: "Do you believe that there are any key relationships between that technology and other you have described ?"** one informant noted that the "PAS populates the others with key information". Some informants at this site described relationships between HR and Finance / Payroll systems. There was also a view amongst several informants of a key relationship between Executive dashboards and many underlying systems including Patient flow type systems, and even then HR and Finance systems – one informant commenting that you cannot manage patient flow if you cannot manage the staffing to deliver good patient flow.

Table 17 - Q 11. Do you think these systems you described in Question 10 (the preceding question) have been successful in that role of assisting the management of hospitals ? (1 – totally unsuccessful thru to 10 = totally successful) ? and Q 12. In your mind, how have you established that level of success ?

Respondent	Q 11 Answer	Q 12 Answer
Human Resources Manager	About a 6 currently	"The programs rule us". Not 10 as we don't get the full functionality that we need or could get – because of insufficient funding. Hence we don't see the end game achieved.
Manager Patient Safety and Quality	Difficult to comment and depends on what level you are working at	Every system has its faults and as humans we adapt to these and get used to/ accept less than ideal. People looking at systems (using them) need experience and knowledge (ie - systems and/or training not ideal ?)
Manager of Performance and	5 - would be better if a better match of skills being used to available systems.	Skills mismatch as left. Also issue of

Respondent	Q 11 Answer	Q 12 Answer
Activity		difficulty of time poor staff having to interact with sluggish systems. There is a sense of IT systems replacing (not in a good way) skilled staff in some situations. Skill mix/experience in decision makers not ideal.
General Manager	Depends on the systems	PAS and EHR are core to patient treatment. Patient flow and Bed board systems provide strategic assistance
Clinical Service Manager	Varies on system. PAS OK - some things need to be better. Current HR system not very good. Inaccuracy/inconsistency over data entry.	Some systems don't talk to each other. Current HR system not very good. "(systems) Don't tell us what we want to know" - end result is arguing over correctness vs the problems. Inaccuracy/inconsistency over data entry. Small data entry errors can extrapolate to thousands of dollars' worth of errors in terms of revenue/expenditure
IT Executive	Depends on systems. Bed boards - 8; management decision support - 8; FMIS - 5; HR - 5; Executive dashboards - should have these but don't - 0	Reliability of system and information are factors –we need accurate, effective information. Sometimes a lack of understanding and training re how to use systems. In the case of HR system- there is a strong sense of inaccurate information
Hospital Executive	Varies with the system - some fantastic, some not.	When is yes - is because of precision and reliability of information to fit with management. When is no - is because of lack of integration between systems or inability to deal with variations from standard situations e.g. – measuring

Respondent	Q 11 Answer	Q 12 Answer
		agency and locum staff.

There were a range of responses at this site regarding this question, at best creating an unclear picture regarding the overall success of these systems. Factors driving the responses included:

- incomplete access to full system functionality
- mismatches between system functionality and in house skills
- mismatches between system functionality and in house processes
- lack of system flexibility to deal with "non-standard" scenarios
- lack of integration between systems
- poor data and information provision from the systems

Table 18- Q 13. Do you think these systems you described in Question 10 have changed in recent years in relation to their role in assisting the management of hospitals ? (1= very adverse change, 3 = no change, 5 = very positive change) and Q 14. In what ways, good or bad, do you think these systems have changed in recent years ?

Respondent	Answer Q13	Answer Q 14
Human Resources Manager	4 - ie - positive change	Technologies are being embraced - driven by the demographics of staff e.g. - younger; broader societal uptake of technology flowing on to the work setting. But not a 5 as there is more room for increased uptake, plus (we) need better access to hardware (PC's) and services (e.g. -email)
Manager Patient Safety and Quality	5 - very positive	Moving from paper has been a good thing. More user friendly systems - access, workflow support, navigability, individual adaptability (? Meaning personalisation)

Respondent	Answer Q13	Answer Q 14
Manager of Performance and Activity	4 - positive change	Improved governance structure around the systems - to incorporate feedback about the relevance and uptake of information. E.g.- exception reporting around LOS information provided in a personalised way for managers then allowing audit and action.
General Manager	3 - no key change	Technologies are only providing an enhancing function - making information more immediate and electronic
Clinical Service Manager	Varies - certainly in relation to PAS systems. Perhaps not in HR. Perhaps in payroll	PAS - more functionality. Finance - better provision of information. Payroll - still some arguments re FTE vs action
IT Executive	4-5	Better tools
Hospital Executive	Some positive change (?? about 4). But is a mixed picture.	Getting a lot more out of the IT systems eg - some reports online versus paper based/handouts. But many systems and multiple passwords - hence dashboard concept good. But a negative example – e.g. death audit - needs info sourced from PAS, EDIS and ORMIS.

Based on the responses above, these systems have changed for the better in recent years by way of:

- improved workflow support (automation)
- improved reporting
- greater levels of functionality
- greater system usability and
- improved levels of system tailorability.

Table 19 - Q 15. What forces and factors from <u>inside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? and Q 16. What forces and factors from <u>outside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? And Q 17 – What is the relative contribution of these forces (internal and external) ?

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
Human Resources Manager	More relevant locally developed functionality - e.g. - the system they mentioned earlier	Increased ease of use (e.g. - Windows vs DOS). Better external system – e.g. - a new State-wide Payroll and Finance solution	More weighted towards the external forces
Manager Patient Safety and Quality	Consistency of user names and passwords	Feedback to DH re issues with systems locally has generated improvements. But there is good and bad re the centralised model. Sometimes an advantage is the funding that comes with standardisation/central imposition – e.g. - IMS	More external
Manager of Performance and Activity	Local management change the clearest factor.	Plausible ones - but they did not feel they were at play here – are ACHS; DH, the media and public pressure	Definitely internal things - local management change the clearest factor.
General Manager	No great change	No great change	See left
Clinical Service Manager	Bad history of choices in health – e.g. - arguments over specs. Impact of poor/wrong decisions	Choice decisions from DH - even if delegated to HN	Heavily externally driven.

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
IT Executive	Better ability of managers with technology. Better communication with developers. Nature of the business – eg - working across multiple physical sites has driven better intra and extranets, and more supportive tools	More ubiquitous usage of systems at home for travel, buying and selling, banking etc. Global change in systems and technologies available and in use – e.g. – Microsoft technologies and Google	Majority of forces are external.
Hospital Executive	Increased sense of organizational accountability and need for measurement.	DH and HN reporting requirements. Public perception can be a driver of those – e.g. stories in the media	More external – especially HN in this framework as there is no hospital board and the HN provides the budget stream

In relation to the responses to Q 15-17 – again in the majority of cases, (with only one clear exception - "definitely internal things"), the relevant forces driving change (and only 1 respondent felt change had not occurred) were felt to be predominantly external. These forces included:

- increased frequency of use and availability of IT systems generally
- increased ease of use of IT systems generally
- access to better IT systems (e.g. – through external purchasing programs at State or HN level) and
- funding attached to externally imposed "standard" or common systems
- DH and HN reporting requirements (and it was noted that public perception can be a driver of those)

In terms of interplay between these forces (Q 18) identified in Q 15 and 16, informants at this site identified offered no different a picture to that offered at site 1.

Table 20 - Q 19. What are the currently unmet needs of hospital managers (of all types) in relation to IT in your opinion? (a base assumption of the PhD is that there are some) and Q 20 – and why do you say that ?

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Human Resources Manager	Unmet functionality needs – e.g. - current HR and Payroll systems - insufficient reporting functionality. This may require going in and out of the FMIS - if this is an operational manager - (e.g. Nurse Unit Manager - NUM) . An extra difficult situation with the lack of support and training is multiple log ins to multiple systems (up to 18 if a NUM?) - get task dilution of operational managers. Data accuracy problems from data entry errors	Still not enough buy in in system use/benefits - need to win over biggest naysayers. Inadequate training and support for system use. There is prioritisation of functionality provided because of cost and other trade-offs. Too much reliance still on human entry and hence subsequent errors.
Manager Patient Safety and Quality	Especially for clinical managers - too much information across too many different systems which is not integrated enough. Plus may require different log ins – e.g. – Patient flow, PAS, IMS, Stock and ordering systems may all need different logins Also a range of reports that could be better integrated and provide better analytic support	Lack of system and information integration
Manager of Performance and Activity	Inadequate education for managers around systems and information Some reports are not used as much as they could be	Only sufficient resources for this to be done on an adhoc basis Due to turnover in middle

Respondent	Unmet Needs (Q 19)	Why (Q 20)
		management, training and awareness issues.
General Manager	Low accessibility to information, "clunkiness" of systems – versus web based, easily navigated systems - if the work environment mirrored the home environment there would be better buy in by users (vs DOS based systems/ Excel spreadsheets).	The work environment does not mirror the home environment e.g. – "clunkiness" of systems Lack of support for work processes.
Clinical Service Manager	Ability for less trained/skilled users – e.g. NUMs - to drill down without needing analysts; need systems to better support decision analysis and action - all the information we need is available. Need to free up time of key staff and not add to the burden.	Insufficient skills, training in key user groups (e.g. – NUMs) "Too many gauges and not enough levers"
IT Executive	Too much data, not enough information. Need improved support for mobility – e.g. managing across sites. Need easy ad hoc reporting tools for managers, or those working on their behalf.	Need more consolidation / transformation of data to information and easy to use reporting tools
Hospital Executive	Inadequate training and education as they use a super user model from central source but those users themselves too busy and have their own FT jobs. Inadequate support as is mainly provided centrally - log a call and wait for process to transpire - can be problematic delays.	Insufficient training. Need more super-users. Inadequate support including help desk

Again in relation to Q 19 and 20, a number of useful insights were obtained. The themes were:

- too much data for managers and not enough information
- this is compounded by too many systems with which managers need to interact to obtain this information
- in turn there is a mismatch between the current skills of users (e.g. – NUMs) and the demands placed upon them in relation to systems use
- inadequate help desk type support for systems
- there is also inadequate training on, and support for, key systems and finally,
- workflows are not always well supported by these systems (eg – mobile workflows).

Table 21 - Q 21 - and in which topic areas ? and Q 22– and why do you say that ?

Respondent	**Topic areas (Q 21)**	**Why (Q 22)**
Human Resources Manager	HR, Finance, Reporting	Nil answer
Manager Patient Safety and Quality	In all the listed areas, and reports are time consuming to extract. Plus they have a wide variance in meaning and action. Also - issues of memory and training - if a manager doesn't use a system or a report very often ….. "how do I do this again ?"...."what was the password again ? "	Reports time consuming to extract. Plus they have a wide variance in meaning and action. Task dilution
Manager of Performance and Activity	FMIS, HR, Data warehousing and Reporting - perception of poor quality - so an issue of quality control one way or another; sluggish system responsiveness from reporting system.	Poor quality and sluggish reporting system response
General Manager	Including HR and Finance - State Finance solution is accessible to	Poor usability of system for non-subject matter experts (SME)

	accountants but not to people from a clinical background when needed	
Clinical Service Manager	Especially - Finance ; HR; even things like CPOE – from a management perspective could save $$ and lives	Lost savings and quality improvement opportunities
IT Executive	Reporting, mobility, analytic tools. Clinical information still lagging behind – compared with - Financial/HR info	Inadequate clinical information versus Finance and HR information
Hospital Executive	Some not specific to topics - generic issues. Except HR - system – is a specific issue	HR - system does not support process/workflow well- can impose undue delays

The unmet needs were seem to be in many areas, but HR, Finance and Reporting systems (including the Data warehouse) were again mentioned on several occasions by various respondents. Poor system responsiveness, poor accessibility of information from systems, task dilution for managers, and lost savings and quality improvement opportunities (pertaining to unmet clinical information needs) were the reasons for the answers in this case. In addition, poor support for workflows and processes in the case of the HR system, was seen as a particular issue.

Table 22 - Q 23 . In light of these unmet needs, in what ways do you think these systems may change in the next 5-10 years? and why do you say that ?

Respondent	Possible changes	Why
Human Resources Manager	They will be more integrated – e.g. FMIS and HR - as long as funding follows. There will be more one-stop shops for managers – e.g. the (perceived by interviewee) better systems available	If funding/investment follows. And technology will naturally drive us this way.

Respondent	Possible changes	Why
	to manage a general practice. Systems will be increasingly easier to use as Windows predominates (e.g. over DOS) and improves.	
Manager Patient Safety and Quality	Better integration, fewer systems (by consolidation) – especially at 10-12 yrs from now	Integration already happening – e.g. - ORMIS into EMR. Health is a bit behind (e.g. - older, slower systems) other industries so is implied we will catch up
Manager of Performance and Activity	Unsure	No point putting together a local IS plan as systems and strategies are often imposed - most of the state wide systems projects have been implemented at this site
General Manager	Likely that there will be more centrally imposed solutions. And local applications will not be maintained and hence there will be a knowledge loss to staff and organization. Also likely to be more centralization of IT staff	Because of trends to date and their knowledge of state programs
Clinical Service Manager	More and more immediate info. May be available to the public.	More information is the perceived versus the real need. May be expectations about national benchmarking - but is a problem with this as industry itself has less than an ideal understanding of indicators and performance - let alone the public.
IT Executive	They will be more integrated - e.g. FMIS and HR - as long as funding follows. There will be more one-stop shops for managers – e.g. the (perceived by interviewee) better systems available	If funding/investment follows. And technology will naturally drive us this way.

Respondent	Possible changes	Why
	to manage a general practice. Systems will be increasingly easier to use as Windows predominates (e.g. over DOS) and improves.	
Hospital Executive	More summation ability, ability to search for what you need. Or even the concept of directories/ metadata. More interlinking of systems – e.g. no need to piece together or manually integrate information from 2 disparate systems.	More system and /or data integration

In summary, the informants at site 2 believe that, in light of these unmet needs, hospital management systems will change as follows in the next 5-10 years in ways outlined as follows:

- greater integration and interlinking between systems (eg – between HR and Finance systems)
- more centralisation of systems (fewer systems to have to interact with)
- more centralization of IT staff (which could mean at a HN level in this case – ie – not in the hospital itself)
- greater ease of use of systems
- more immediate information provision
- more summation ability of systems (e.g. – summary views of data)

Their reasoning for postulating these changes includes

- assumed improvements in the amount of funding
- projected ongoing trends in how the state funds hospital ITS
- broader societal technology drivers ("technology will naturally drive us that way")
- new National imperatives – e.g. – National benchmarking
- greater technical integration of systems

Table 23 - Q 24 . Ultimately do you think these unmet needs will be met in the next 5-10 years in light of the changes you think may occur ? (1= very confident <u>they will not</u>, 3 = unsure, 5= very confident <u>they will</u>)

Respondent	Score
Human Resources Manager	Unsure- 3
Manager Patient Safety and Quality	3-4 - not overly confident that these needs will be met
Manager of Performance and Activity	2-3 - not very confident – unsure
General Manager	1 - they will not be met at all
Clinical Service Manager	Not clearly stated. Possible
IT Executive	80% confident of getting there
Hospital Executive	If necessary changes made then are confident

At site 2 there was a mixed picture in relation to confidence that these unmet needs will be met through these postulated changes.

Table 24 - Q 25 . What <u>intra hospital forces</u> and factors do you think will drive towards your predicted outcome in the next 5-10 years ? and Q 26 . What <u>forces external to hospitals</u> do you think will drive towards your predicted outcome in the next 5-10 years ?

Respondent	Answer Q 25	Answer Q 26
Human Resources Manager	Funding. Plus see right - plus given the patient care focus - can be difficult to stick to strategic direction (eg – versus say Westfield) because there is always the next internal or external crisis or burning issue.	Patient perception is important - how to justify expenditure on MIS' when patient care can always be improved and funded more. Knee jerk responses to external forces and influences - political pressure. And the next immediate need - eg -gastro outbreak, CJD, MRSA. The complexity of managing hospitals including the

Respondent	Answer Q 25	Answer Q 26
		balance of services vs community demands - eg - this hospital is a trauma centre but does many other things - so for example an issue is local vs specialised services
Manager Patient Safety and Quality	User feedback, investment. Collaboration and information sharing	Approaches by external companies - but can come at a cost. Strong sense of imposition by HN and in turn DH re strategic direction in this area and $ attached. "we can put forward the case but who pays the bills" ?
Manager of Performance and Activity	Unsure - possibly better education of users - but will not be a targeted program	There is uncertainty as a change in (state) government seen as highly likely and may throw much into disarray. Also a sense of likely cutbacks on admin side of business- and hence a reduced user pool +++. Other factors at play may be younger and more IT savvy users coming into the system.
General Manager	Feels the HN has little say	Have little confidence in the imposed state-wide solutions
Clinical Service Manager	More access to computers and information at desks but most staff aren't interested as came to management from clinical care and hence may not have an affinity with management systems. There is an issue of infrequent use and hence the need for better support for the infrequent users - eg - experts on tap ad hoc; and better support for analysis/interpretation and decision making	Nil stated

Respondent	Answer Q 25	Answer Q 26
IT Executive	See right	Funding and people - but risk of centralised staff losing touch with the coalface - so need to be the right people and deployed in the right way.
Hospital Executive	Pressure of user needs; inability to staff properly with medical and nursing staff- need to reduce reporting and admin burden on these staff.	Public expectation (and they deserve it) of reporting will drive this - eg - league table type idea. Especially given ubiquity of internet and information available on it to the general public.

In summary, these informants identified the following forces as driving them towards the outcome they alluded to – remembering of course that they have a low collective confidence that this outcome will eventuate. In terms of intra-hospital forces they identified:

- funding
- user feedback
- improved user education
- improved user support – e.g. – through "super-users" ; and in the analysis and interpretation space

In terms of forces external to the hospital forces they identified:

- centralised funding and staffing (but not without risks)
- community pressure and demands (may in turn affect funding – above)
- political agendas and crises (may in turn affect funding – above)
- political uncertainty – e.g. – governments voted out
- approaches by external companies
- HN strategic plans and approaches
- younger and more tech savvy workforce in healthcare

Q 27. In thinking about the sorts of technologies important to the management of hospitals – can you identify things that take any of the following roles (component, product /application or support / infrastructure)?

Informants in this case study also struggled to give insightful responses to this question. One informant had no useful comments relating to the environment as discussed but did acknowledge a possible component role in terms of technology infrastructure - cabling, servers, hard drives etc. As in CS 1 another informant referred to the new HR system ("establishment system") to be implemented at this site They felt that system would fill a support and infrastructure role as it "plugs into expenditure - to compare what was due to be spent versus what was done - then (they) can look at leave / overtime / activity. So (they) can look at staffing as it was intended to achieve an outcome versus the actual outcome." Finally, another informant saw the PAS as a critical component - "the better the PAS, the better it takes account of all our business …… the better it (the business) will be". They expanded by saying that an example of the application role (but they had not mentioned this system earlier) may be the commercial off-the-shelf (COTS) clinical system (product name withheld) they use. In short – there was no different picture created here than in CS 1.

Q 28. In thinking about planning in this environment, from the perspective of your role (as a manager or clinician manager, product developer, hospital executive, funder etc.) how do you go about it ? What frameworks do you use? What drivers do you take account of? What constraints do you have to bear in mind?

As described in CS 1, the IT executive at this site provided an artefact (see Appendix 2) entitled "Priority ranking for new IM and T Project Requests" pertaining to how this hospital prioritises IM and T projects. In addition, a 2 tiered committee structure exists to provide governance of these processes. Both the proposer of any project, and the organizational IT committee use this ranking form to assess the relative priority of such projects.

Another informant answered the question with a more strategic interpretation in mind. A key driver for them is "what is our core business and how might that change in next 5-10 years"? They did acknowledge that in many ways this is imposed on the organization from the DH and the HN.

As in CS 1 - another informant outlined a series of principles they would use in making these planning decisions:

- need to invest against core business
- need to be smarter
- need to identify - re IT - why we should put it in, what would we get out of it.
- would use/need clear and current business strategies - including - Finance/HR; Clinical - these would be prioritised.
- would need to include a horizon gaze, identfying gaps in clinical services
- would need to include corporate governance of systems - their growth, implementation and prioritization.
- would need to aim for a seamless environment that supports decision making

Yet another informant felt that the state and HN plans in this space made IT planning decisions at a hospital level somewhat redundant, noting that the "biggest framework is that imposed by state plan." And noting that they "cannot start from a greenfields world view" with the constraints being "dollars, system capacity (the business system), (and) government priorities".

Another informant, as in CS 1, felt that all IT dollars should be spent on clinical IT (e.g. – CPOE, care plans, PDAs for clinical staff etc.), even when viewed through a management lens, as such innovations will drive down LOS and costs. A second informant supported that view, stating that funding was a "big inhibitor". However, they believe that free flowing clinical information is a good management outcome also - so point of care (POC) devices like personal l digital assistants (PDA's) and wireless connectivity were critical in support of that stated aim. In addition, they thought that strategically, most funding should be spent on clinical information systems including - CPOE, patient-held record functionality, the EMR and Picture Archiving and Communication Systems (PACS). But they also stated that in a supporting sense, the RIS and LIS are important strategic considerations when it comes to planning and investment in this environment.

Finally, I asked informants **Q. 29 "in thinking about this interview and the questions you have answered – how would you characterise the hospital IT environment as it pertains to the management of hospitals (as opposed to the management of individual patients)?"**

Table 25 - Q 29 . How would you characterize the environment?

Respondent	Answer Q 29
Human Resources Manager	A coastal environment - because lots going on, lots of systems, always a bit exposed to organizational and external needs and forces.
Manager Patient Safety and Quality	A coastal environment - we are exposed to elements and tides and we adapt
Manager of Performance and Activity	A snow scape is the closest. - "we adapt to our environment and what we have and the way we know (how) to use it". Is not lush, bountiful or easy but there is a lot of useful information out there.
General Manager	Barren desert or Coastal environment - harsh but not as harsh as desert. Ebbs and flows of $ governs what can be done. We adapt as best we can with available funds to do as much as we can / health is more adaptable than most (other industries). $$ are key.
Clinical Service Manager	No obvious - seen as adequate natural resources (? = information). People are in the way - they seek more of A when they need more of B.
IT Executive	A coastal environment - because attractive environment, many great aspects. But always exposed to external forces - even whilst running projects - and hence to changing needs and requirements.
Hospital Executive	They proffered - a campsite - everyone in tents (silos) - no central campfire, no meeting place, must be delivered provisions (including information) separately and individually. She sees this most as "camp director". Also mentioned piecemeal opportunities that pop up re $ but these are driven by/ contribute to lack of a coherent plan - means they cannot be

Respondent	Answer Q 29
	harnessed.

Again the analogy with the coastal environment was the strongest theme in response to Question 29. Several informants again (although there is an overlap of informants with CS 1) noted that sense of constantly being exposed to external forces and drivers – even in the midst of any given project.

Case Study 3 – Conjoined Metropolitan Hospital

The third CS was undertaken at a large hospital in the metropolitan area of a smaller city in state 2. The hospital had been recently refurbished, and its services include a busy Emergency Department, an Intensive & Coronary Care Unit, Medical and Surgical wards, a Maternity Unit and a voluntary Psychiatric ward. The facility is a 360 plus bed public and private hospital (100 of the beds are in the co-located private hospital). This hospital is run by a charitable organization with a national reach, which runs multiple hospitals across the country, in this sense it is a unique and important case study amongst the others.

Other important contextual information is that at the time of the visit, the State government was contemplating the transfer of responsibility for this facility to being under the State system. The other important piece of context is that in this city there is one other main hospital that is a public facility run by the state.

In relation to **Question 7** regarding which systems are **"a key part of the hospital IT environment",** informants at this site collectively identified all of the listed systems and then some as being a key part of the hospital IT environment. Several informants specifically mentioned the PAS system, and in a telling quote, one informant stated that the PAS was "the lifeblood of the hospital".

In terms then of which systems were seen as essential to managing hospitals **(Question 8)** – the PAS was mentioned several times and was seen as important - (the "wards

could not function without (the) XXX PAS system"). In addition, Financial and HR systems, and Executive dashboards and their variants (Performance management systems/ KPI display systems / Management decision support systems) were also mentioned.

In relation then to **Question 9 – "Do you think that there is one critical technology that is a must in terms of managing hospitals, or that acts as a cornerstone of that management – which do you think it would be? And why?"**, the PAS system rated highly, as well as Executive dashboards, HR systems and the telephone system. Regarding the PAS, informants felt that it was of vital importance to the context, one describing it as "the cornerstone" of hospital management systems, and noted safety and other adverse implications if it goes offline.

In relation to **Question 10: "Do you believe that there are any key relationships between that technology and other you have described?"** informants at site 3 identified relationships as follows:

- Executive dashboards housing and displaying all the KPI's that it gets from other systems.
- PAS and Bed board (Patient flow system) functions are related. The Bed board is critical in ED – is an instant snapshot of what is happening.
- Every effort is made to line up HR systems with Finance. HR feeds into the Payroll system. They are then "integrated" via the reporting mechanism. This allows visualisation of abuse of leave /OT; and of the relationship between OT/agency/"over-skill" – e.g. 2 ICU trained staff together on an open ward.
- There should be seamless integration between PAS and Clinical systems but this does not always occur
- PAS and Clinical systems - but need even more seamless integration. PAS is holder of the universal identifier (patient identifier) then used to follow the patient thru the processes of care and other systems.

Table 26 - Q 11. Do you think these systems you described in Question 10 (the preceding question) have been successful in that role of assisting the management of hospitals? (1 – totally unsuccessful thru to 10 = totally successful) ? and Q 12. In your mind, how have you established that level of success?

Respondent	Q 11 Answer	Q 12 Answer
Director Quality and Safety	7/10 overall but a range across systems	Issue is confidence in numbers. And access to numbers - still have to go finding them versus being pushed to them. And also of meaning of the numbers – junior management (eg- junior NUMs) need some training in interpretation and management world view. Clinical indicators - wrong data identified after submission; versus ED access block traffic light system - supports an escalation approach – and is working well
Operations Manager	5/10 - life would be very chaotic without them.	Of great assistance but still some way to go. Some of the paper trail is in turn lost. Usage is a good measure - some are "used every minute of every day". See comment prior re PAS – e.g. everyone from switchboard to Visiting Medical Officers (VMOs) uses the PAS (lots of VMOs here at this site - **Author note - arguably contributes to more logistic issues**) It produces patient lists and nurse – patient lists.
Director of Corporate Services	Mixed picture - re "doing things better" – e.g. Finance, Supply, Asset management <5; "doing better things" about 8 e.g. –	See left - plus - sometimes just more work because of the lack of integration between systems – e.g. -

Respondent	Q 11 Answer	Q 12 Answer
	Evaluation management system - good for the organization moving forward.	Supply not integrated with Finance; Asset management system not integrated with Maintenance system which is not integrated with Finance system - leading to double entry of data. Not matched to users- low computer literacy in some (eg logistics, supply) areas - in fact low education level - eg - even a poor understanding of productivity gains from tools for meetings, and time management in MS Outlook. An assumption is made that everyone is, or is becoming, computer literate.
CIO	A number of problems have been highlighted and these are being addressed. In some areas up to 7/10 - eg - in workload - have allocated staff better and hence manage finances better. Still need data consistency and code sets.	Incorporated into routine decision making. Still need to be more widespread. They have driven procedural and policy changes – eg - overtime rules. Usage is expanding beyond initial key decision makers and staff are now getting asked to answer more questions/deliver more reports. And now moving towards some real time or even predictive elements.
ED Manager	5 currently	"They do the job" BUT "we change our practice to suit the systems" – the systems could improve in terms of more integration and supporting more efficient functioning of the hospital. Technology there for much of this but local implementation has not been done **(Author note - reason not stated)**

Respondent	Q 11 Answer	Q 12 Answer
Director Ambulatory Care and Allied Health	5/10	Not higher because of lack of integration between systems. Still a lot of disparate data - needs to be massaged and brought together in a common view at least. Still some limitations to functionality – staff have to go into the HR system and build their own reports.

Table 27 - Q 13. Do you think these systems you described in Question 10 have changed in recent years in relation to their role in assisting the management of hospitals? (1= very adverse change, 3 = no change, 5 = very positive change) and Q 14. In what ways, good or bad, do you think these systems have changed in recent years ?

Respondent	Answer Q13	Answer Q 14
Director Quality and Safety	(? 4 ish) - in general good changes - well thought out.	Could have been more training for managers - but it is increasing dramatically – eg – at leadership training days. Could be more of giving managers what they want versus what people think that they want.
Operations Manager	Have improved - 4-5	More accurate and timely reports. Finance and Payroll - more accurate information. More accessibility and sharing of information - eg PACS and RIS. Access to view systems at other sites.
Director of Corporate Services	4-5	Leap was made 3- 4 years prior. Thru development of IT strategic plan and

Respondent	Answer Q13	Answer Q 14
		appointment of new (current) Chief Information Officer (CIO). More hardware and increasingly much better access to computers. Budget details are demonstrable and explainable – this allows better management.
CIO	4 - very good changes	More hospital staff using them (the systems), staff asking for more reports. Increasing amounts of integration has been achieved.
ED Manager	3-4 - has been improved	Better use of tools provided. Better access to reports. But staff are still adjusting practice and workflow – e.g. of running ED/shift handovers etc.- to suit system restrictions – they (the systems) could better support the management needs and workflow.
Director Ambulatory Care and Allied Health	? 3	Not as much improvement as in the clinical realm (e.g. - PACS /RIS). Still insufficient integration of systems. Still less than an optimal response to manager needs.

Table 28 - Q 15. What forces and factors from <u>inside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14? and Q 16. What forces and factors from <u>outside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14? And Q 17 – What is the relative contribution of these forces (internal and external)?

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
Director Quality		The organizational risk	50/50

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
and Safety	Main driver - access and demand management - how to do as much as we can with what we've got and all within budget. Recently an organisational tipping point was reached ? - size got to point where needed more formal management structure and approach than previously. Implemented an ongoing quality cycle to balance access and quality drivers. Implementation of an internal incident reporting system but also at other main hospital in the city. LOS and case mix - both internal and external.	management approach. Plus the influence of the parent business. Health organization insurers and their expectations - 1 each for public and private facilities. Implementation of an internal incident reporting system but also at the other main hospital in the city. LOS and case mix - both internal and external.	
Operations Manager	In Payroll and Finance - users demanding timely reports driven by business need - eg- advanced planning for bed staffing over summer. Other drivers – eg- in the in area of Payroll – are staff dissatisfaction and feedback. For the PAS and ED bed board - staff and management accountability and reporting.	Parent company and state health - accountability, transparency. Equivalent of a service level agreement (SLA) with state health re services to be delivered. Community expectation - "people certainly expect more" / want high standard care.	About 50-50
Director of Corporate Services	IT strategic plan. More investment in hardware. Understanding of business issues by staff – e.g. LOS;	Reporting requirements of state health and private parent company.	Mostly external drivers

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
	other staff influx from other organizations. Risk management approach mentioned by other interviewees.		
CIO	Need to improve staff retention. Inaccurate payment of staff - needed to resolve to improve staff satisfaction. Management changes/restructuring of responsibilities has led to more focused initiatives.	Block funding was a driver	70% internal
ED Manager	Cultural change – the last 2 CEOs have driven an approach of "proving what you do, not just saying what you do". Several new work programs. E.g. the 90 day review cycle/ work plan mentioned previously. With changes in corporate management – there has now been better engagement with, and receptiveness of, the IT department in the last 5 yrs.	Politically driven - public and private arms of state health (the 2 sites). More external requests for data.	Varies across the organization - in ED more public pressure - hence more external forces (perhaps 60%) - especially with only 2 main ED's in the city
Director Ambulatory Care and Allied Health	IT department staffing and set up (thought to be a positive force ?) Staff reluctance to push for change. There has been a mismatch between	? Maybe via the system-workflow mismatch. (caused by low vendor responsiveness or poor efforts by vendors in system set up)	About 50-50

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
	workflow needs and systems.		

In terms of interplay between these forces (Q 18) identified in Q 15 and 16, informants at this site identified a number of interesting possibilities. One informant noted that, in their opinion, internal drivers were just as strong as external ones - "we want to do better" and "we want better patient outcomes". Similarly, one said that there was still a way to go, but the fact that they were "wanting to manage in a better way" was a big driver from their perspective. Others however, noted the impact of a recent change in the board in the parent management company; and the ongoing influence of the other major hospital facility (publically run) in the city – in driving management behaviours and strategies, and hence in driving developments in the management information space in their own facility.

Table 29 - Q 19. What are the currently unmet needs of hospital managers (of all types) in relation to IT in your opinion? (a base assumption of the PhD is that there are some) and Q 20 – and why do you say that ?

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Director Quality and Safety	There is still a sense of "are we collecting the right data ?" Too much information is around – but it's not precise enough and there is not enough to help with predicting future events – especially regarding patient access and demand – e.g. Winter bed block strategy. Incorrect information still exists – e.g. "3 versions of the truth" or changes in the single version of the truth without reason.	Too much information - not precise enough. Not enough information to help with predicting future events Incorrect information

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Operations Manager	Timeliness - "we all want it (relevant information) yesterday". There is still duplication of data entry - PAS, FMIS and billing. So we need better integration and better accuracy and timeliness of information.	Not timely enough Duplication of data entry and implied accuracy risk Insufficient accuracy and timeliness
Director of Corporate Services	Incorrect information - because of incorrect inputs; insufficient or inadequate functionality – e.g. all plans of buildings, wiring etc. are not electronic (and are not even stored as pdf's in a common folder !!) - versus the industry standard. Lack of integration of systems.	Incorrect information Insufficient or inadequate functionality Lack of system integration
CIO	Incorrect information - a lack of understanding re the principle of garbage in and garbage out (GIGO) - there is currently a project on to standardise data elements across systems thru the organization. Unconfirmed information. Information available in too many locations. Not accessible in a consistent fashion.	Incorrect information Information not robust enough – trust issues Inconsistent means of access to information
ED Manager	Incorrect or discordant information - eg - PAS system can give 2 different results re “did-not- waits” (DNW) in ED. Difficulty in extracting information - eg – from the HR system. Poor support for workflow - although a very “point of care” example- triage nurse has 12 clicks to triage a patient. No one central point for accessing information from a managers	Incorrect information Difficulty extracting information from systems Inconsistent means of access to information

Respondent	Unmet Needs (Q 19)	Why (Q 20)
	perspective –there are 3- 4 data sources – e.g. Annual leave - One Staff; "Do not waits" **(Author note – patients who leave ED without being seen by a doctor)** – PAS; incidents – Riskman	
Director Ambulatory Care and Allied Health	Need more support for decision making. Need more support for predicting future events. Where can I find the information I need ? - "You only know what you know, not what you don't know". Perhaps part of the unmet need is insufficient training or lack of establishing a baseline.	Insufficient support for decision making Not enough information to help with predicting future events Insufficient training – in what (?) is unclear

Table 30 - Q 21 - and in which topic areas? and Q 22– and why do you say that ?

Respondent	Topic areas (Q 21)	Why (Q 22)
Director Quality and Safety	Across the board	Unclear
Operations Manager	PAS, FMIS and Billing	See Q 19 and 20 above
Director of Corporate Services	Finance, HR, Payroll, staffing - these systems should all talk to each other.	Insufficient co-ordination / integration between these systems
CIO	Patient access – e.g. PAS is dependent on clinical and administrative staff for data entry. Resource management (including HR) - incorrect information - less so than patient access but still some. Quality management - 2 versions of Riskman - one for parent	Too much dependency on clerical data entry Poor data quality in HR systems

Respondent	Topic areas (Q 21)	Why (Q 22)
	company and one for state health.	Duplicate systems in risk space
ED Manager	Some examples as prior - but the unmet needs are in many topic areas.	See Q 19 and 20 above
Director Ambulatory Care and Allied Health	No specific topic areas highlighted	Informant stated it is "the whole picture"

Table 31 - Q 23. In light of these unmet needs, in what ways do you think these systems may change in the next 5-10 years? and why do you say that ?

Respondent	Possible changes	Why
Director Quality and Safety	"Will be (a) dramatic change" - Smaller and more accessible devices (e.g. iPhone). Easier access to information - e.g. a button click to get complications of anaesthesia – e.g. Central Venous Catheter (CVC) complications on an individual patient. But (they) see these changes happening as part of organization or system wide changes in the state – the only question is whether this private parent company will be brought	**Author note – informant expressed a confidence in the inevitable march of technology.**

Respondent	Possible changes	Why
	along.	
Operations Manager	(we) Will see more integrated systems of all sorts to provide seamless inter-facility care as this is a 2 hospital region. Will reduce delays in care and delays in transfers – patients and information will flow as needed. Will thus deliver better outcomes and better quality of care, and greater job satisfaction as the system works better for Health Care Providers (HCP's) also.	**(Author note - Plans are in place. Need is there; Community expectation is there. Only 2 hospitals - should be doable)**
Director of Corporate Services	More portable devices - PDA's as a work tool. Integration - it has to happen **(Author note - almost a sense that it is inevitable).** Will be less errors amongst others.	See left
CIO	Is an active process for this organization - they will change. But the systems currently being used won't be the ones used in the future - in part arguably because they have no suitable development path.	Needs of sector will drive changes
ED Manager	Could expect to see 1 system across the state in some management areas - state health are eliciting requirements currently. Smart card access to systems and buildings. Better data standards and integrity may follow some of this also. May be common IT infrastructure	State health department is currently doing some preliminary work.

Respondent	Possible changes	Why
	(developed) also.	
Director Ambulatory Care and Allied Health	No response provided	No response provided

Table 32 - Q 24 . Ultimately do you think these unmet needs will be met in the next 5-10 years in light of the changes you think may occur ? (1= very confident <u>they will not</u>, 3 = unsure, 5= very confident <u>they will</u>)

Respondent	Score
Director Quality and Safety	Very confident (5) provided their private parent company and healthcare in general can keep up with the pace of change.
Operations Manager	Very confident - 5 - as there are current plans from state health to deliver some of this.
Director of Corporate Services	4- 5 - but timeline is dependent on funding
CIO	Low confidence - 1-2 because is a COTS environment largely
ED Manager	3- 4 - some degree of confidence.
Director Ambulatory Care and Allied Health	Will have more information

Table 33 - Q 25 . What <u>intra hospital forces</u> and factors do you think will drive towards your predicted outcome in the next 5-10 years ? and Q 26 . What <u>forces external to hospitals</u> do you think will drive towards your predicted outcome in the next 5-10 years ?

Respondent	Answer Q 25	Answer Q 26
Director Quality and Safety	Dollars the main limiter	Dollars ($) the main limiter. The

Respondent	Answer Q 25	Answer Q 26
		patients themselves - their needs, thoughts, ideas re how $ prioritised and spent. Australia generally moving more towards open disclosure also. The inevitable march of technology. Public health concerns – e.g. - obesity and its drain on health resources at all levels – equipment management and procurement issues, key performance indicators (KPIs) about obesity management etc; Obstructive Sleep Apnoea (OSA), gastric banding **(Author note - for obesity)** - then feedback to Australian Institute of Health and Welfare (AIHW).
Operations Manager	All busier - more patients to see, growth in cardiac and diabetes care needs. Need accurate data to prove demand, and outcomes, as system under increasing stress. Need clinical staff at bedside - not pulled away from it.	Dollars - government financial imperatives. Community requirements for better outcomes. Need for better usage of scarce resources.
Director of Corporate Services	Timeline is dependent on $$ available to be used.	Timeline is dependent on $$ available to be used. Government mandates – e.g. federal. Changes in training - general HCP's **(Author note - implies is leading to a different system and hence different management needs).** Adverse events and role of consumers - people coming into hospital better prepared and more articulate.
CIO	Computer literacy; reluctance of clinical staff to use computers; double data entry - parallel computer systems.	Low responsiveness to change of vendors. Compared with vendors in other industries - low levels of support - even with more $$ - support spread too thin and low sense of customer

Respondent	Answer Q 25	Answer Q 26
		service.
ED Manager	$$ supply thru state level (see right)	Strong eHealth leadership and $$ supply thru state level. BUT acknowledged risk of project /program failure given the IT history in this space especially involving governments.
Director Ambulatory Care and Allied Health	Drivers of efficiency - definitely external factors in this; and strong drive to address pt satisfaction	National quality in healthcare body - have 5 areas of preventable harm. Need for public hospitals to be more efficient. Need for improved clinical outcomes and management of risk (the community do not know quality when they see it). Funding on the basis of casemix and quality. An increase in fundamental level of investment.

Table F. Q 27. In thinking about the sorts of technologies important to the management of hospitals – can you identify things that take any of the following roles (component, product /application or support / infrastructure) ?

Only 3 informants offered a response to this question, although this was a more promising response than at several other sites. One informant viewed the component role as literally being filled by "components" (medical devices) such as telemetry monitors and ventilators. Another felt that components, in this topic domain, could be for example integration engines and reporting modules. Finally, the ED Manager felt that components could be for example, better business processes and rules. No informants offered any views on other roles in the TEM world view.

Q 28. In thinking about planning in this environment, from the perspective of your role (as a manager or clinician manager, product developer, hospital executive, funder etc.) how do you go about it? What frameworks do you use? What drivers do you take account of? What constraints do you have to bear in mind?

At this site, 2 informants offered no response to this question. Of the 4 who did, none appeared to offer up a firm organizational approach to planning in this specific domain. One referred to the clinical governance framework imposed by the parent organization – which is mainly based around risk. They suggested that this framework would guide most important decisions and initiatives in the health service.

Another respondent referred to various other plans as being important in this setting – the

- State health strategic plan
- Private (parent) company strategic plan, and the
- Organizational strategic plan.

In their view – the 4 following considerations were important in decisions in this space – cross referenced against the broader planning framework:

- what is the implication for patient care ?
- is the impact good or bad ?
- is this just a different way of doing things ?
- what is the immediate and long term cost ?

Another respondent felt that all IT initiatives must be aligned to the hospital strategic plan, and to some extent to the strategic plans of the parent company and the State health department. They also felt, however, that it was important to acknowledge the need for more specialised clinical systems in some areas, then with reporting from a central (Data) warehouse.

A final respondent offered a more innovative perspective on this issue. They suggested the paradigm of the "patient is king" to drive thinking in this space. In other words – what initiatives should be prioritised to keep the patient as king, and how should these be undertaken to achieve this outcome? They noted that constraints would still be financial and access to data/ information (especially if some users have dubious computer literacy).

Finally, I asked informants **Q. 29 "in thinking about this interview and the questions you have answered – how would you characterise the hospital IT environment as it pertains to the management of hospitals (as opposed to the management of individual patients)?"**

Table 34 - Q 29. How would you characterize the environment?

Respondent	Answer Q 29
Director Quality and Safety	A coastal environment - is OK - have some plants and creatures surviving OK. In sun sometimes (generally tracking OK) - but exposed to elements - "beholden to our masters"
Operations Manager	No response recorded
Director of Corporate Services	Not lush or barren, not coastal; Only some wildlife and flowers; analogy made between all hospital activities - IT one of many (lots of trees……**Author note - ?? competition for resources**)
CIO	A barren desert – they are always under the pump - sun, little water flowing in - $$, staff are specially adapted ("special creatures"). Could be a coastal environment (especially as - exposed to the elements and tides). They also suggested …..a busy beehive of activity - ?? random activity with no sense of big picture ?
ED Manager	A coastal environment: the ED is exposed to the elements - and not lush, not desert - and environmental conditions constantly going up and down **(Author note - is this more the point - variability in environmental conditions versus stability ?)**
Director Ambulatory Care and Allied Health	A coastal environment - as evokes ideas of being exposed to the elements, some low and high tides, always dealing with things, have to be adaptive ……another thought - a dry woodland - so much to do, so many decisions to make, not enough IT support **(Author note – lack of support = lack of rain ?)**

Case Study 4 – Large Regional Hospital

The fourth CS was undertaken at a regional hospital in a large regional city in state 3. Based on information from the hospital's website, demand on services there is increasing rapidly, with this particular city being one of the fastest growing regional cities in the state. The broader heath service has over 3,000 staff, and covers an area a quarter of the size of the state in relation to the reach of its services. The health service provides services in emergency, maternity, women's health, medical imaging, pathology, rehabilitation, community services, residential aged care, psychiatric care, community dental, hospice, palliative care, cardiology, cancer services and renal dialysis to the people of the region. This hospital is a public facility with the ability to treat private patients, and there is also a nearby a 100 plus bed private facility (which has no ED) providing a range of acute and non-acute, inpatient and outpatient services. Because of growth in demand, at the time of the site visit, the construction of a new hospital (to replace the facility being visited) had been approved by the State government.

In relation to **Question 7** in the interview schedule, informants at this site identified a large range of systems as being **"a key part of the hospital IT environment"** Several informants at this site identified all of the listed systems as being important, but in addition communications systems including telephony and email were seen as important. One informant noted "(we) must have people systems as (this) is a people business". In addition, the Clinician-manager in charge of Psychiatric services specifically mentioned the systems unique to Psychiatry, which include at least one with PAS type functionality.

In terms then of which systems were seen as essential to managing hospitals **(Question 8)** – The PAS system was again seen as important across this group. One informant stated that "You need all of them" but that they also need better "integration". Another informant specifically stated that the PAS is important - "if rubbish (goes) in (the) PAS then rubbish (goes) in all (the) others" and that "these systems are all hand in glove. You cannot manage the hospital without managing from the PAS upwards". Patient flow systems (i.e. – that track and monitor patient flow) and Bed-boards also got a specific mention from one informant.

In relation to **Question 9 – "Do you think that there is one critical technology that is a must in terms of managing hospitals, or that acts as a cornerstone of that management – which do you think it would be? And why?",** informants at this site mentioned a number of systems but again the PAS system was a common theme. For example one informant stated that a good Clinical information system was "the focal technology" but also noted that if you don't have for example, Finance systems, you cannot manage the hospital; and if you don't have a system to report to the Health Department, you can't get funded. The PAS system fulfils this role in no small part. Another mentioned communications systems as fitting the bill, but went on to note that that the PAS has core critical information on who is coming into the hospital, and that it is "responsible" for accurate patient identification, and this has safety implications. For the Manager in charge of Psychiatry, the 2 mental health-centric systems, including the regional triage system (equivalent to the PAS) were seen as the most important.

In relation to **Question 10: "Do you believe that there are any key relationships between that technology and other you have described ?",** informants at this site described various relationship between technologies in response to this question. One stated – "there are multiple relationships via topic" and "dependencies" between systems. In her sphere of responsibility, there are in excess of eight different software programs she needs to use or be aware of. Another informant noted that these systems "all dovetail with one another".

The IT Executive sees the key relationship is of network infrastructure to everything that sits upon it – e.g. – a medications management application may be the best in world, but is of no use if there is not adequate bandwidth, a PC fleet, or accessibility to printers. He had a particular focus on this (at the time of interview) as this heath service was about to build a new facility that will present great opportunities - but the network infrastructure must be "done right" to see these opportunities realised.

Two other informants could see the potential relationships between all those systems, and the way things "should be" – but felt that those connections were currently loose and inadequate. Specifically, one stated that it was desirable that they all be integrated but "invariably they are not"- further noting that all data related systems should be driven by the Universal Record (UR) number. That is to say, the linking field in every data set should be the universal patient identifier (patient UR number) - "UR will drive PAS, path results and those sorts of things".

Table 35 - Q 11. Do you think these systems you described in Question 10 (the preceding question) have been successful in that role of assisting the management of hospitals ? (1 – totally unsuccessful thru to 10 = totally successful) ? and Q 12. In your mind, how have you established that level of success?

Respondent	Q 11 Answer	Q 12 Answer
Community and Continuing Care Executive	8 – i.e. - relatively successful	Is not a 10 because - multiple systems, finance data is separate, incidents are separate, complaints are separate. There is not a big picture. Is an 8 because - patient identity is covered, patient details are covered, worklists are covered, basic reports for legal requirements and funding are covered.
Surgery and Nursing Executive	about 6 - "hospitals operate in spite of, not because of, a whole host of things"	Not a 10 because of mismatching/ lack of consistency around data. There should be a tight relationship between things. Counts for example - "should be a by-product of activity" Also another key limitation is the reliance on human skills in the coding process - contributes to a lag in accurate information and potentially in funding - ie - up to a 3 month lag in doing the work then knowing what it is worth. Also disparate data sources is a general issue - "sometimes need to triangulate sources of data to get the answer". Let alone a range of presentation formats. Can become "a cottage industry in itself" to get the data.
Director of Governance and Risk	Answer a little unclear but erring on the not highly successful. E.g. – we redo things already done elsewhere but not done at this site – e.g. - use of	Not great success - because not learning or reusing from other sites. Dollars are a major constraint. Much information but "no one has the pulse on it". Also tend to

Respondent	Q 11 Answer	Q 12 Answer
	Sharepoint at major specialist hospital in the capital city. **(Author note – there is a sense of reinventing the wheel)** But have used guideline management system from another rural centre hospital	then get loss of corporate knowledge with the departure of key staff. There is a loss of efficiency if people do not know, or need to second guess, where to find information
CIO	Lowish - less than 5	Has been some good change – e.g. - new PAS system coming in. Still some issues – e.g. poor network meaning on line staff education is limited (e.g. – Virtual Reality (VR))
Clinical Service Manager	Very successful ? 8-10. Payroll system good, new intranet based Policy and procedure system is good as is easy to access and cross reference policies with each other. Budget management support good - allows balancing of budget and highlighting of inefficiencies	See left. Plus if not 10 it is because support and training required (an issue when there are multiple systems) also because average mental health clinician is not "technically aligned" **(Author note – technologically savvy)** - their whole focus is person to person. There may be fear of change but they are pragmatic and will get on board if there is a demonstration of benefit

Table 36 - Q 13. Do you think these systems you described in Question 10 have changed in recent years in relation to their role in assisting the management of hospitals ? (1= very adverse change, 3 = no change, 5 = very positive change) and Q 14. In what ways, good or bad, do you think these systems have changed in recent years ?

Respondent	Answer Q13	Answer Q 14
Community and Continuing Care	3 - not much change but increased government	Nothing useful given answer at left

Respondent	Answer Q13	Answer Q 14
Executive	reporting requirements and without funds and vendors unable to provide (much help)	
Surgery and Nursing Executive	4-5 - has been a positive change	More accessible – e.g. - mobile devices; Can even access at home. "More data available in more understandable formats than previously"; "the advent of the GUI"; more intuitive systems.
Director of Governance and Risk	About a 4 - they have helped but some of this is not generic to hospitals	See left
CIO	Yes - 4 ish	Systems more open in their design, implies an acknowledgement by vendors that they need to be this way. Better adherence to standards – e.g. Health Level -7 (HL7), web services. More specialisation of systems - vendors not trying to do it all. GUIs have changed significantly but arguably no better is assisting with the capture of information - especially at point of care. More emphasis on accessibility – e.g. - in getting data out - report writing tools means business users can write their own versus being dependent on IT staff.
Clinical Service Manager	4 - far more positive than negative but still gaps	See previous responses to left

Table 37 - Q 15. What forces and factors from <u>inside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? and Q 16. What forces and factors from <u>outside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? And Q 17 – What is the relative contribution of these forces (internal and external) ?

Respondent	**Answer Q 15**	**Answer Q 16**	**Answer Q 17**
Community and Continuing Care Executive	Despite not much change - does acknowledge the internal drivers. Board governance and CEO - increased expectation. Needs from the quality agenda	Increasing access demand on health services. DH reporting needs as many programs are output based. Quality needs and benchmarking from DH and other external bodies/ drivers – e.g. – (XXXX –state-wide outpatient reporting initiative)	Now about 50-50- but has changed - used to be more external, now is shifting to internal - "how can we do things better?" But still wanting to do benchmarking for example (external driver)
Surgery and Nursing Executive	Limitation is specifically cost but some of these changes are highly desirable from a safety perspective. Some improvements in IT infrastructure including network have assisted.	Application development generally - a generational improvement. Increased literacy amongst users - expect more. Increased hardware capacity (e.g. - data storage) . General slow uptake of IT in health except in OT and OR (? Externally driven) - RFID devices in theatre especially offer promise in patient and asset tracking	Dominant forces are external
Director of Governance and	Lack of internal	Relative state of IT skills	Both at play - no clear

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
Risk	investment necessitating catch up investment. Lack of leadership / clarity in management around information resources – e.g. - local use of Content Management System (CMS) and management of intranet content - who is responsible ? - this has led to disablement	nationwide amongst nurses and doctors. External policy and program drivers thru DH – e.g. – (XXXX) - state-wide health ICT program	picture
CIO	In part a change in IT department skills sets – e.g. - better in report writing, less hardcore IT technology skills (**Author note - But is this chicken or egg ?)**	Move from mainframes to LAN and desktops - devolution of "power" from IT departments to business. Expectations of clinical staff – especially doctors- e.g. they come on site with iPhones and expect to use them in the hospital (**Author note- is a rural site and there are many Visiting Medical officers (VMOs) at this site**) - leaves a big gap between old doctors and new doctors in terms of IT / information services provided to them and expectations and change management. In the community / private - could get productivity gains from iPhones and could self-fund - here cannot increase income to cover. Broader forces	A lot of it external

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
		are government policy and strategy - nationally the role of National E-Health Transition Authority (NEHTA – **Author note – National Health ICT Standards Body**) .. forces a local reassessment of our needs, and environment and where we are	
Clinical Service Manager	Internal forces are new people into the health service who have seen benefits elsewhere – e.g. - new IT managers, new CEO, new board. Also leadership and vision from CEO and also $. Effect of (initial) small wins increasing subsequent buy in	External forces include improved system functionality – e.g. - copying of a genogram (**Author note - more of a clinically useful system feature**), or in e-recruitment system - rapid e turnaround of job ads and can copy templated job approvals and ads this saving time as a manager	A lot of it external - Especially for example from companies developing software and features for products in other industries then bringing them to health. Likewise for efficiencies demonstrated in other industries. iPhone development is another example

In terms of interplay between these forces (Q 18) identified in Q 15 and 16, informants at this site identified a number of interesting possibilities. One informant noted that some external drivers can have internal mirrors or effects – e.g. the DH XXXX report (a major state based health service performance report) may pique the interest of the CEO, and hence he or she may drive new or revised internal managerial information needs; as may an external accreditation process. Another informant noted that much technology innovation (except e.g. -PACS) in health is not specific to health - it is generic - and hence at least in relation to technology drivers, these are mainly

external. Another informant described the poor financial state of public healthcare and blamed this for a decision to reduce internal IT funding.

Table 38 - Q 19. What are the currently unmet needs of hospital managers (of all types) in relation to IT in your opinion? (a base assumption of the PhD is that there are some) and Q 20 – and why do you say that ?

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Community and Continuing Care Executive	Lack of hardware can be a barrier. Too much information (e.g. 80 page exec papers); duplication of content in different documents; no internal consistency even within a single report. The next step is even to be more organised across this rural city – e.g. - Aboriginal and Torres Strait Islanders (ATSI) patients presenting to multiple services; e.g. - the links with nearby large private hospital (no ED there hence inevitable patient cross over)	See left for practical examples on the ground of why they say this
Surgery and Nursing Executive	Gaps in the safety and quality space that clinical systems – Clinical Decision Support (CDS), e-prescribing - could assist with – e.g. Thru authority approvals for certain drugs. Also - anything that assists with the problem of doctor's handwriting. Also auditing of entries into the medical record. In the management space - we need management information being a routine by product of the process of care. Also need linking of time and attendance data with Payroll data - lots of clinical time spent as a result of not having this linkage.	See left
Director of Governance and Risk	We have information but it's impossible to access. Need for a culture change. Integration	See left

Respondent	Unmet Needs (Q 19)	Why (Q 20)
	/ technical issues seem to be a hold up.	
CIO	Unmet needs especially regarding data quality and they note the importance of this to funding. Have to tighten up data collection and data validation e.g. - by having software that is smarter re this plus the organization needs to be smarter – e.g. - around clinical notes - arguably data not currently being collected correctly. Not enough proactive information comes out of our systems currently. – e.g. - should be able to do predictive bed management based on the condition a patient comes in with – i.e. – "your LOS will be x ..." Either because not the right tools or not the right people.	See left
Clinical Service Manager	Application literacy - managers can be left behind with language and paradigms of new systems. Training - has been a drop in the number and accessibility of courses. And IT help desk is not there to perform a training function. Recent example of change-over of email system staff "left to fend for themselves"	See left- various practical and tangible examples

Table 39 – Q 21 - and in which topic areas ? and Q 22– and why do you say that ?

Respondent	Topic areas (Q 21)	Why (Q 22)
Community and Continuing Care Executive	As a rule are generic issues - some areas seem OK – e.g. Radiology with the introduction of PACS	See left

Respondent	Topic areas (Q 21)	Why (Q 22)
Surgery and Nursing Executive	See prior answers	See left
Director of Governance and Risk	Across the board. Concern is that there are ideas and possibilities there but they don't come to fruition	Nil specific - see left
CIO	Activity - see previous comments regarding patient flow which illustrate what we do. Also we do not link systems and processes to models of care - or putting it another way - we put in new systems with little regard to change of process. aiming for an approach that all support systems should be driven by the model of care. There is a lack of understanding of the dependency between IT and how that can or could improve workflow	See left regarding tangible examples
Clinical Service Manager	Especially financial information - the issues of application literacy – e.g. "variance" in the budget system. Otherwise general communication deficits re new packages / systems re implementation plan, and application specific training.	See left re some practical examples

Table 40 - Q 23 . In light of these unmet needs, in what ways do you think these systems may change in the next 5-10 years? and why do you say that ?

Respondent	Possible changes	Why
Community and Continuing Care Executive	Clinical systems will improve thru Commonwealth drivers. MIS will change - improved IT skills of staff but assumes large amounts of funding. Also need personnel to implement changes - this is not just an "IT Project"	See left regarding the rationale for plausible changes in their view
Surgery and Nursing Executive	There will be more patient self-management tools – e.g. - in combination with remote monitoring (see CDM net – **Author note – a prominent software system in a regional area**) also there will be increased patient health literacy and self-education **(Author note - both imply a change for managers and their information needs)**	Few specific reasons given as to why
Director of Governance and Risk	Definitely in the next 10 years - DW and a project repository will arrive. There will be more automation and seamlessness (between systems)	Few specific reasons given as to why
CIO	Systems will get smarter – e.g. - alerts as a general concept. There will be more integration of systems and they will get to match the models of care better. More decentralised and mobile systems and information will be more readily accessible – e.g. - exception	Few specific reasons given as to why

Respondent	Possible changes	Why
	reporting will be smarter; and "any device, anywhere and anytime"	
Clinical Service Manager	They will change. There will be more educated nurses using them - they will be innately better users of technology. PDAs will become dominant – e.g. doing paperless assessments in the field. There will be an intrinsic compatibility and consistency of functionality	Few specific reasons given as to why

Table 41 - Q 24 . Ultimately do you think these unmet needs will be met in the next 5-10 years in light of the changes you think may occur ? (1= very confident <u>they will not</u>, 3 = unsure, 5= very confident <u>they will</u>)

Respondent	Score
Community and Continuing Care Executive	Not confident of change
Surgery and Nursing Executive	Some needs will be met (ie - a 2-3 answer ?) - is a question of what is prioritised and resourced to happen
Director of Governance and Risk	3-4 Some will - but then other needs will arise (**Author note - implied that may or may not be met**)
CIO	4-5 - confident - for this health service
Clinical Service Manager	The changes will happen - 5 . "It has to happen"

Table 42 - Q 25 . What <u>intra hospital forces</u> and factors do you think will drive towards your predicted outcome in the next 5-10 years? and Q 26 . What <u>forces external to hospitals</u> do you think will drive towards your predicted outcome in the next 5-10 years ?

Respondent	Answer Q 25	Answer Q 26
Community and Continuing Care Executive	Unclear	Possible whole refurbishment of this public health facility may be a driver and an opportunity - but its early days - hard to know
Surgery and Nursing Executive	Nil proffered	A new facility is being built and this may allow some capital funding to assist with some unmet needs as described previously. But we all work in a public sector that is conservative by nature - referred to XXXX (previously mentioned state-wide ICT in health program) as "lead in (our) saddle bags". This may in turn stifle local innovation/ i.e. -"lowest common denominator effect"- state-wide program is the most acceptable and most defensible but not necessarily the best outcome for a given institution … "the closer the locus of control (is to your institution) the more likely you are to (be able to) control it". Plus the state (DH) moves at glacial speed
Director of Governance and Risk	Internal culture change - older generation retiring. Need to manage risk better. Rotating staff (given Hospital Medical Officers (HMOs) and some other medical staff come from the metropolitan area) But will need to show incremental success to	Being part of a regional geographic alliance is a positive driving force. As is globalisation – e.g. - some IT staff may not need to work on site - implication of outsourced services versus relying on dearth of staff in regional areas?

Respondent	Answer Q 25	Answer Q 26
	bring along sceptics	
CIO	Driven by internal change champions plus opportunities afforded by a new hospital site here	External drivers will be community and regional expectation. - could also be indirectly thru the electoral process – e.g. - local people want a local cancer centre versus having to travel to the capital city. Inhibitors though are privacy and consent issues, practitioner reimbursement issues (**Author note - ? More relevant to systems that are directly invoked in clinical care**) also establishment of a universal identifier (**Author note – is a National agenda**) will assist in driving to some of these outcomes
Clinical Service Manager	Same as statement prior re intra-hospital forces	The system will be better staffed. Nurses will be more skilled (including IT wise) consumers will demand more "why hasn't my letter got to the GP yet" and they will expect prompt communication and referrals There will be learning from other hospitals – e.g. CEO here came from another large regional centre hospital. KPIs and state-wide comparisons will drive change also

Table F. Q 27. In thinking about the sorts of technologies important to the management of hospitals – can you identify things that take any of the following roles (component, product /application or support / infrastructure)?

At this site, very poor responses were provided to this question, in part due to time limitations. The CIO / IT Executive put forward some suggestions for the support and/ or infrastructure role – namely broadband access. He also mentioned cameras and smart devices – e.g. telemetry, glucose terms, sphygmomanometers (blood pressure recorders) and PDA's as possible components - in his overarching vision of "care anywhere" and

unified communications. It is noteworthy that he has some regional IT delivery and telemedicine responsibilities in his role.

Q 28. In thinking about planning in this environment, from the perspective of your role (as a manager or clinician manager, product developer, hospital executive, funder etc) how do you go about it ? What frameworks do you use? What drivers do you take account of ? What constraints do you have to bear in mind?

As was the case at several sites, answers to this question sometimes tended to address the point through the lens of service planning or capital planning - perhaps reflecting the role of the informants. One informant stated "it depends on what question I'm asking ?" … i.e. - which topic and / or dimension of planning. Another stated that it is always difficult, and that the source and amount of funding available is a key issue. In addition, they noted that the constant trade-off is versus spending on something more directly related to patient care. They also noted that there is no standard project management (PM) methodology, and that there are many untrained project managers, and no common PM framework.

Another respondent noted that sometimes there are sometimes external drivers – e.g. – a key government outpatient reporting project implementation – that dictate planning priorities. In more general terms they stated that the "(the) Bottom line is how much money do you have to do anything?" They also bemoaned the absence of an IT governance group in the organization but noted that there now was one to deal with a new PAS implementation.

Finally, I again asked informants **Q. 29 "in thinking about this interview and the questions you have answered – how would you characterise the hospital IT environment as it pertains to the management of hospitals (as opposed to the management of individual patients)?"**

Table 43 - Q 29 . How would you characterize the environment?

Respondent	Answer Q 29
Community and Continuing Care Executive	Coastal and Snowscape - there are many opportunities and "good things" but also barriers and problems. Lush forest is "too optimistic"
Surgery and Nursing Executive	Woodland- millions of flowers blooming in the woodland - little order or relationships - "not too many bouquets"
Director of Governance and Risk	Coastal - sense of being exposed to tides - implies constant change – e.g. of staff (**Author note – remember the regional context and the dependency on rotational staffing from the city for some staff groups**) and heavy external influences. Snowscape - "specially adapted" staff / culture / approach
CIO	No response proffered
Clinical Service Manager	A coastal environment "if I had to pick" – (because of that sense of being exposed to) the elements ... Always that challenge of things happening that impact on the environment. Also acknowledged the concept of specially adapted wildlife and plant life (even though was in the snow scape analogy) - and in IT sense - strong sense of evolution / development of products to suit the healthcare niche (arguably from a more generic base)

Case Study 5 – "Virtual" Hospital

This CS is unique amongst the 5, and deliberately so. The intent of this case study was to build a view of an "archetypal" hospital management environment by interviewing stakeholders who work with multiple health services and hospitals, in some cases across both the public and private sectors, and in some cases across state and national boundaries. Despite this, all informants in this CS are physically based in state 3. KIs in this CS include a Health bureaucrat, a Clinical network (CN) manager, an IM and T (professional services) consultant and an IT vendor (specifically the CEO of a small-medium software company).

The Health bureaucrat is in charge of multiple program areas (e.g. – acute health services, emergency services, service performance and rural services) for public health services across an entire state (state 3), and hence brings a unique and senior perspective to the questions at hand.

The CN manager is in charge of disease specific (e.g. - stroke, heart disease, cancer) collaboration between health service providers across a large city in state 3. This collaboration involves multiple large hospitals, as well as private and community based providers of care in that disease setting.

The Professional services consultant previously worked for a large international company that provides consulting services, hardware and software to a wide range of industries. Their particular focus was in providing such services to healthcare. The IT vendor is the CEO of a software company that provides a management product to hospitals and other healthcare facilities both across Australia and internationally.

It can be seen that this group of individuals should be able to provide a unique and powerful view of the environment under investigation from outside of the context of any given hospital, in a complementary yet contrasting fashion to the other 4 CS'.

In relation to **Question 7** in the interview schedule, informants at this site identified a large range of systems as being **"a key part of the hospital IT environment".** One stated "many of these" in relation to the range of proffered systems. Another said "all of these" but clearly with an emphasis on PAS, HR and credentialing systems, EHR, CDS, electronic results viewing and analytic and predictive systems. Another also mentioned

the PAS prominently as well as Clinical systems, Executive dashboards, Patient flow systems and predictive systems. The final respondent – the IT vendor- stated "all of them" plus Risk management systems (notably this kind of system is included in their product space).

In terms then of which systems were seen as essential to managing hospitals **(Question 8)** – there was a fairly consistent view across all four informants that "the PAS is the key one (system)" as it contains "master data" and is core to the tracking of customers (patients). Other systems were mentioned including HR and Finance systems, needed to run the business – to track finances, pay employees, and for mandatory reporting. Executive dashboards were mentioned as "nice to have" but it was felt managers can do without them and have done for some time. Bed boards were seen as good for "improving operations", but were not seen as essential.

In relation to **Question 9 – "Do you think that there is one critical technology that is a must in terms of managing hospitals, or that acts as a cornerstone of that management – which do you think it would be? And why?"**, three of the four informants in this CS felt that the PAS was the key system in this regard. One said you "must know who people are" and "who you are treating", and that the PAS "organizes the rest of the hospital". Another stated that the PAS is "the beginning of understanding patients, flow, capacity, (and) case mix" and that you can use it to "manage waiting lists, appointments". Another comment was that if the PAS fails - "nothing else is possible".

The sole dissenting voice felt that email was the key system and that it is the "default communication medium for complex organizations". They went on to hypothesize that if you take it away for an hour then "everyone is screaming", versus say the billing system – stating that it is "no drama if (it is) offline for an hour".

In relation to **Question 10: "Do you believe that there are any key relationships between that technology and other you have described?" ,** a range of responses were obtained in relation to this issue. One informant stated that, in relation to the aforementioned systems, "they all **<u>should</u>** be linked" and that "we need to be able to link all of a patients different episodes of care together – e.g. - Community – Outpatients – Waiting List …. from (both) a management and a clinical perspective". In so doing

however, they were bemoaning the lack of such relationships in the current state of affairs.

Another informant felt that "(absolutely) ….. there are so many links" and that "many of these (systems) rely upon data they get from the PAS". They also felt though that some systems or data outputs are less reliant on the PAS – e.g. - morbidity (illness) and mortality (death) data.

Finally the IT vendor, who believed email was the critical management technology, stated that "email is an underpinning system to a lot of them (other systems)" and that there is an increasing "expectation on a lot of these systems ….. that there is some email functionality (integrated with or embedded in them)".

Table 44 - Q 11. Do you think these systems you described in Question 10 (the preceding question) have been successful in that role of assisting the management of hospitals? (1 – totally unsuccessful thru to 10 = totally successful) ? and Q 12. In your mind, how have you established that level of success?

Respondent	Q 11 Answer	Q 12 Answer
Professional Services Consultant	8 - "reasonably high" - can always think of something they could do better	**Enabled -** better master data management (MDM), management reporting, reduced clerical effort, deeper analysis of workflow **Downside-** sometimes systems used sub-optimally – e.g. unused parts of functionality- e.g. referral management in PAS; sometimes MDM not supported e.g. - a single master list of doctors; sometime unintegrated / limited functionality – e.g. – Hospital in the Home (HITH) as a ward
Manager Clinical Network	"Can be extremely useful". Very variable - PACS 10/10. Management decision tools can be misleading and	Sometimes initial teething troubles so systems don't get off the ground versus strong initial success. Sometimes slow

Respondent	Q 11 Answer	Q 12 Answer
	depend on organizational culture and context - can be a 9/10 and can be a 2/10. (including e.g. - analytic decision tools)	large programs - by the time systems are delivered the business has changed. Sometimes issues with systems e.g. - national agenda versus a local agenda - need to adapt and change system to suit local need - may lead to misalignment with local needs if not possible.
Manager of a Programs Area	Highly variable - Executive dashboards - 8- very well used. Multiple health services have done these on the cheap and by themselves. Bedboards - 2- poor utilization and "basic inputs just aren't up to scratch" (ie - data entry). Analytic and predictive systems - 1 - poor or simplistic science, poor quality outputs. DW - many places still don't have.	Because some systems aren't well used or aren't seen as high quality Poor systems outputs in some cases
CEO of a Software Company	6.5	Could be better because "there is a tendency to want to do the next big thing" rather than "orchestrating" well those systems that you already have. People don't have / spend the time to get all these systems working together. Is better to have a core number of applications working well than focusing on the next "big bang" because then - less staff and dollars to manage / worry about, and there's an "internal gain" - easier education of staff and reduced training load. Plus is also then easier to identify points of failure in systems

Table 45 - Q 13. Do you think these systems you described in Question 10 have changed in recent years in relation to their role in assisting the management of hospitals ? (1= very adverse change, 3 = no change, 5 = very positive change) and

Q 14. In what ways, good or bad, do you think these systems have changed in recent years ?

Respondent	Answer Q13	Answer Q 14
Professional Services Consultant	3- " I don't see a lot of change" but he also reflects on his own fairly shallow experience base	If there's been any change it's a more integrated view – e.g. clinical and management (Business Intelligence (BI) / DW) portals. ? Greater leverage off activities and systems
Manager Clinical Network	4 - "on the whole getting better but is piecemeal". No programmatic or overarching delivery approach so is slow and disco-ordinated in Victoria	More how not changed - "health does itself a dis-service in managing our business". Vendor know it is not a big business vs others. There is insufficient funding. "Low priority for technology (in) health".
Manager of a Programs Area	Varies with the system. **Patient flow tools -** limited change despite a lot of potential – e.g. - they still do manual audits to get data. **Predictive analytic tools -** even less change - unrealised potential. Mixed sense of success. **PACS** - uniform success - especially clinically. **PAS** - do not feel qualified to state although aware of some system failures. **HR / Finance -** unaware of great changes - but still crude cost attribution. **Executive Dashboards** - better across the board – a lot of activity and visible/useful outputs from such systems.	Varies with the system - in some cases limited change Still crude data outputs in some cases (e.g. – cost attribution) Better outputs in some cases
CEO of a Software	4	"Definitely changed the management of

Respondent	Answer Q13	Answer Q 14
Company		hospitals"; have "created internal pressure" - thru the expectation (reasonable or otherwise) of rapid response to emails. This has a flow on effect in the minds of the management team. But the risk is a mismatch between that sense of urgency and human / physical capacity to deliver.

Table 46 - Q 15. What forces and factors from <u>inside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? and Q 16. What forces and factors from <u>outside hospitals</u> do you think determined the level of change you have indicated in your answer to Q 14. ? And Q 17 – What is the relative contribution of these forces (internal and external) ?

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
Professional Services Consultant	Financial imperatives. Trying to save costs and increase revenue thru efficiency. Statutory reporting requirements, need to do clinical costing. Local needs for credentialing – e.g. - by Chief Medical Officers (CMOs), responses to coroner recommendations (but that is external)	Vendor driven changes - especially in the clinical space.	Heavily weighted to external forces.
Manager Clinical Network	Financial imperatives - but "inadequately driven by them". The biggest thing in Australia (deficient) versus overseas (prominent) is new	Very few in Australia versus her overseas experience. Because hospitals here (in State 3) much more self -	Heavily internal- especially versus her experience from the international arena where greater use of /

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
	models of care driving to improved access and reduced waits - and hence new KPIs, new levers and hence new tools to support this (as well as finance) - she sees these as lacking here	governed - and hence internal finance drivers versus external drivers. Not consumer push, not a strong government push versus her overseas experience	presence of drivers external to hospitals.
Manager of a Programs Area	Hospitals respond to signals around performance management - thru boards and CEO (in this State's context)	DH driving hospitals thru various strategies – e.g. - messages re expectations, performance management meetings. In turn from above has been shift in Commonwealth (CW) - State relations such that CW has more direct input thru funding. Also somewhat of an "intellectual dependence" on National Health Service (NHS) concepts and strategies in the State 3 health setting- this acts as a driver. There is also general community factors - burden of chronic disease, ageing population, general awareness of tighter financial environment	Mainly external - note that this is from his role perspective (state government beauracrat) but arguably the greatest change has been in those things that can be driven by DH vs for example IT innovation most relevant to clinical processes - least amenable to DH influence.
CEO of a Software Company	Financial imperatives- in particular the drive to "do more with less" - especially in public health. But this is	Quality and financial drive to internal change. From technology point of view - can buy more	60% external

Respondent	Answer Q 15	Answer Q 16	Answer Q 17
	not necessarily a good thing. We are our own harshest critics in public health - great quality outcomes in Australia (especially versus many overseas systems). Albeit often external (to internal) drivers of quality outcomes	technology "power" for less- this also drives internal change. In short - people cost going up, technology cost coming down - hence driving automation. Also societal pressures / culture change - e.g. connectedness, smart phones - drive internal changes also	

In terms of interplay between these forces (Q 18) identified in Q 15 and 16, informants at this site identified a number of interesting possibilities. One informant observed that often external forces are "very general" and by inference wide reaching. They noted that the "prevailing mood in the community can have a local effect". They also noted that "even some external forces can interact with and thru local ones". They then gave the example of – the need for a cancer hospital to do (elective waiting list) reporting to government, which is quite synergistic with the local need to treat cancer patients urgently

Another informant noted (at least in the public health system) the external (government) to internal (hospital) funding interplay; and that in turn the government expects that a hospital manages its finances appropriately. Yet another informant gave a more general answer, noting that "an extensive interplay exists".

The IT vendor described an external to internal effect in both financial imperatives and quality performance, as well as in the area of technology advances in the broader environment (external to internal influences). The vendor also expressed a view that there are "a lot of external messages driving things" in the environment – e.g. - marketing messages from vendors and manufacturers. In addition they believe that in the private sector there is peer pressure - "what are they (competitors /neighbours) doing?" An example is from this vendors user group (UG) – some health services are happy to hear what others are doing but not so happy to share ideas. The IT vendor went

on to say that he has seen a paradigm shift – e.g. – a major private healthcare provider publishing safety and quality data from this vendors system in a public way.

Table 47 - Q 19. What are the currently unmet needs of hospital managers (of all types) in relation to IT in your opinion? (a base assumption of the PhD is that there are some) and Q 20 – and why do you say that ?

Respondent	Unmet Needs (Q 19)	Why (Q 20)
Professional Services Consultant	Insufficient information - "they want a lot more but they need education about IT" "they don't know what they want". Insufficient training or education - re how they can go about an information gathering exercise	Insufficient information Managers under-educated re data, IT and how to use it
Manager Clinical Network	"Sufficient data but insufficient correct and appropriate information" It is the responsibility of managers to say what they need regarding information and how they need it. Implicit in this statement that there is an education gap - so managers need an education process so they know how "to ask the right questions of IT people, analysts and/or systems"	Lots of data, not enough information Managers under-educated re data, IT and how to use it
Manager of a Programs Area	Most pressing issue is integration of information. People tend to only see information needs as important from their isolated world view – e.g. - NUM, OR manager, ED manager. We need to be able to see across providers, hospitals, departments, sub systems	Lack of integration of information Lack of visibility of information across multiple contexts
CEO of a Software Company	"Too much information". The amount of "noise" managers need to deal with is	Lots of data, not enough information

Respondent	Unmet Needs (Q 19)	Why (Q 20)
	"phenomenal". There is a tendency for people to want to collect more and more data and expect some magical computer or process to sort it all for them. This vendor encourages brutal culling of requests / needs - "less is more". Also there is a relative lack of assistive technologies – e.g. - even pre-population of demographic fields in some applications. There is "too much for people to do" "they are time poor"	Lack of assistive facets to technologies – e.g. –pre - population of known data to save people time

Table 48 - Q 21 - and in which topic areas ? and Q 22– and why do you say that ?

Respondent	Topic areas (Q 21)	Why (Q 22)
Professional Services Consultant	More so an issue in the clinical and operational management domains (vs Finance and HR) e.g. - "what does next week look like" "how many beds to open / close at Christmas"; lack of detailed information re workflow	See left - note theme of looking ahead / prediction
Manager Clinical Network	Feels like it is the case in quality, patient access, capacity and demand. Respondent feels less able to comment re resources and finance	Based on conversations with managers re their lack of understanding of what is happening in their services. Seems reactive management versus proactive management e.g. – XXX (well known risk management system) - seeing things post event - versus looking at trends, undertaking forward planning and doing staff

Respondent	Topic areas (Q 21)	Why (Q 22)
		training.
Manager of a Programs Area	Varies with area -"integration of information" important in different ways. Finance - if we have no integrated view of cost how do we know what to invest in; Access - if no integrated view then may have pockets of capacity that we are unaware of; Quality – e.g. the issue of discharge medications and the hospital-GP interface	Depends on the area – e.g. – integration of data insufficient to allow an understanding of the relationships between cost and its drivers
CEO of a Software Company	"I think they (these unmet needs) are generic" - ie - across multiple topic areas. Partly because of top down pressure - do more with less, all the while the CEO saying "tell me more"	Example from requests to this vendor - how do we present data / report better to those up the management food chain ? How do we "turn it around faster" - ie - quicker data collection, processing and reporting

Table 49 - Q 23 . In light of these unmet needs, in what ways do you think these systems may change in the next 5-10 years? and why do you say that ?

Respondent	Possible changes	Why
Professional Services Consultant	"Quite plausible in 5 years" - incremental improvement – e.g. PAS, RIS, LIS; but not a true EHR - no economic incentive exists for this - as opposed to a clinical need. And not a case of "everyone else has one" as yet.	Unclear - perhaps economic incentives for “non- clinical” systems (See left) will drive more positive change than for “clinical systems”
Manager Clinical	Integration is the key. Need more	Has low confidence that positive

Respondent	Possible changes	Why
Network	information in and out of private sector as patients cross between the public and private sectors / facilities. Need more clinically based outcome information. Need choice but less piecemeal approach to systems and more central drive and coordinated planning. Need to see more training of managers regarding data, IT and how to use them. Overall themes of seeing how these changes may happen, that they are needed, but low confidence that they will happen.	change will happen
Manager of a Programs Area	Doubt positive change will happen	Where is the investment going to come from ? - look at expenditure on eHealth and relative low return on investment (ROI) to date (even ROI in terms of completed milestones on the local state funded e-health initiative)
CEO of a Software Company	The systems will definitely change - more "portable technology"- e.g. - tablets and smart phones. More deployment using "cloud type concepts". More pervasive and assistive technologies – e.g. - Google glasses - and we will "never think of being on the internet (or not)" … constant connectivity will just happen. The switch to portable devices is difficult for him as a vendor -750 K lines of code in a core application of his - not easy to port to the mobile deployment space	Broader technology drivers will assist – e.g. - mobility, the role of "the cloud"

Table 50 - Q 24 . Ultimately do you think these unmet needs will be met in the next 5-10 years in light of the changes you think may occur ? (1= very confident <u>they will not</u>, 3 = unsure, 5= very confident <u>they will</u>)

Respondent	Score
Professional Services Consultant	?? 4 - Possibly - younger generation coming thru will assist this (note the manager training / education issue alluded to earlier)
Manager Clinical Network	2 - maybe some natural evolution but a low chance unless major shift in drivers to external drivers - more impetus needed from government based on her overseas experience
Manager of a Programs Area	No – 1
CEO of a Software Company	???5 - "the change is inevitable but I don't think it will be a good thing". "there will be more messages coming in" … but how do I deal with them as an individual is the concern

Table 51 - Q 25 . What <u>intra hospital forces</u> and factors do you think will drive towards your predicted outcome in the next 5-10 years ? and Q 26 . What <u>forces external to hospitals</u> do you think will drive towards your predicted outcome in the next 5-10 years ?

Respondent	Answer Q 25	Answer Q 26
Professional Services Consultant	Hospital mergers and reconfigurations; new skills developed / brought in thru evolution	Continuing comfort with IT - Younger generation of staffing; New skills; cost - will act as a brake on clinical systems expansion (versus administrative systems); highly

Respondent	Answer Q 25	Answer Q 26
		educated specialist resenting imposition of systems on their autonomy.
Manager Clinical Network	Not many	Only hope really but dubious level of confidence that these drivers – e.g. - service reconfiguration, new models of care, financial and performance measures - will come to bear.
Manager of a Programs Area	Nil	Lack of investment - will be state and national government drivers if positive change does eventuate
CEO of a Software Company	Will be heavily externally driven. But based on his experience - one internal driver may be internal technical staff getting (possibly inappropriately) into the software development and support business by default inside hospitals as they do their own development	"no doubt it (such change) is commercially driven" It's a cyclical thing - vendors - can do this - users - like it - the business says - how can we take advantage of this - then suggest changes from, or engagement with, vendors. Politicians and bureaucrats jump on bandwagon - they don't lead - it's more the vendors dangling it (solutions) out there. The other driving force is the generational staffing change - younger professionals will just expect certain things from technology – e.g. - 10 yrs ago the thought of reporting an incident on the internet was unheard of (ie- logging on and doing it) - now it happens . There will be a new base level expectation - "of course we have all this stuff"

Q 27. In thinking about the sorts of technologies important to the management of hospitals – can you identify things that take any of the following roles (component, product /application or support / infrastructure)?

Again, in this CS, informants struggled to provide insights in relation to this question and in 2 cases no answer was offered.

One informant suggested that the PAS may fulfil a component role, and in turn the PAS and "scheduling" together may constitute a "product" in the TEM paradigm. They also postulated regarding the role of integration engines generally.

The IT vendor again offered a more comprehensive response. He suggested as follows:

- **Support and infrastructure role**
    - wifi - any hospital that does not have this is in a bad position.
    - the networks (internal and external) more broadly. But he felt that the overall move should be towards wireless networks – with fewer breakable parts.
- **Product and application role**
    - tablets versus PCs and laptops.
    - Also in this role – "apps" (as in Apple and Android apps) – versus in the past exe's (executables) then web deployment, and now apps on mobile devices. Will it change again he wondered? This is "challenging from a vendor perspective as you need to support multiple code bases"

Q 28. In thinking about planning in this environment, from the perspective of your role (as a manager or clinician manager, product developer, hospital executive, funder etc) how do you go about it? What frameworks do you use? What drivers do you take account of? What constraints do you have to bear in mind?

Somewhat disconcertingly the Health bureaucrat offered little insight in relation to this question. The Professional services consultant however observed that planning in this environment was "often not particularly structured". He observed that usually the drivers are:

- regulatory
- the wishes of executives in hospitals and
- "the seniority of the voice asking the question".

He described funding as a driver, but also noted that it tended to be a perverse driver. He quoted the example of people being prepared to happily use staff time on projects, even at a potentially higher cost as it is already budgeted for, rather than explicitly finding a smaller “new” amount from a budget. He felt that the environment in hospitals necessitates that work needs to be handled in an "agile" fashion, by managing a queue of requests in a general direction: "Let’s do what we can in this time frame without having anyone extra or spending more money".

The CN Manager noted that in their role they “are an assister of other organizations” and “only there as a facilitator” of those organizations, hence this question was seen as less pertinent to her. To the extent the question is relevant, the CN also has a brokerage role - looking at opportunities to join up needs and possible solutions. Ultimately however the primary organizations she supports need to make the decision on priorities, and specific actions, within any planning framework. Importantly, this is in contrast to her overseas experience in a similar roles, where the CN would specify and mandate the solutions for health services. This may well reflect an important role of different governance structures in influencing planning in this environment.

In relation to planning, the vendor stated he uses a "customer driven product strategy" expanding on that by saying "we develop (our products) to meet the market". The vendor went on to explain that based on what their user groups want, and the outcomes of collaborations with customers regarding what they want from the system e.g. - "we need a solution to this particular NSQHS (National Safety and Quality Health Service - new national hospital safety standards in Australia) standard, have you heard of it ?" - they then plan their next development directions. In short he said – “we view this as a service company rather than a technology company" - customer service and responsiveness is seen as critical to his business success. Even with this mindset however, he then stated that the constraints are financial. - imposed by hospital management and, in the public setting, also by the government and policy of the day. Furthermore he observed that if his company has government contracts, the global financial environment can ripple across or down to them as a company. This "can make planning challenging" – it’s not the lack of ideas or opportunities. From his perspective, the issue is what do you do next - do you do an app, a report scheduler, or instant messaging (IM) integration? Hence the importance of staying closely in touch with your market in his opinion.

Finally, I asked informants **Q. 29 "in thinking about this interview and the questions you have answered – how would you characterise the hospital IT environment as it pertains to the management of hospitals (as opposed to the management of individual patients)?"**

Table 52 - Q 29 . How would you characterize the environment?

Respondent	Answer Q 29
Professional Services Consultant	A coastal environment "if I had to pick one" - exposed to elements and tides "you have to like salt" - there are some inhibitory factors that are unmodifiable. But you do well if you are adapted. Desert is "not quite right (as an analogy) as some things do very well in hospitals"
Manager Clinical Network	She relates it The Eden Project in Cornwall. Linked ecosystems - hospitals or groups of hospitals in the setting of the broader wide world. "separate from the real world". The surrounding landscape is "artificial"
Manager of a Programs Area	A coastal environment - "(I)like the dynamic quality (of this analogy)" - underpinning the answer is the thought that there a number of major factors in the coastal environment that determine life in that environment
CEO of a Software Company	Very clear to this respondent - "pick your continent, Central Australia or North Africa". It's a desert - mostly in survival mode then when government finds more money or a particular issue is the topic of the day – funding flows, staff get put on, activity increases (across the sector) "It's almost a boom or bust thing" "This is 100% my view of the health system"

Literature Review

In this section of the thesis I present an overview of the relevant literature identified under each of the key questions outlined previously, remembering that Question Set 1 effectively establishes whether the HOME is a valid construct, and Question Set 2 examines something of the utility of the HOME, assuming a positive response from Question Set 1. As a reminder of the 2 Question Sets, they are as follows:

Question Set 1

- Does the TEM apply to a hospital environment? For instance – could it be conceptually related to the arid zone biome? (see Appendix 1)
- What are the key characteristics of the TEM in this context?
- What are its strengths and weaknesses?
- How valid and useful is the model for analysing an HMIS infrastructure?
- How does it compare with other IT planning lenses?

Question Set 2

- What is the definition of ecosystems success and failure in this environment?
- What are the factors affecting ecosystems success and failure in this environment?
- How can stakeholders benefit from the application of the TEM to the HMIS environment (e.g. - via an HOME model)?

In examining the results of the literature searching, I have presented the findings against each of the questions to be answered. Where the literature base has been substantial – for example in relation to TSFs- I have undertaken an initial thematic analysis to allow meaningful grouping of the evidence. In both cases, the results have been presented to the reader in a tabular format. As in the first part of this chapter, the case study findings, a deeper analysis with triangulation has been deferred to Chapter 5.

Question Set 1

Does the TEM apply to a hospital management environment?

I will consider this overarching question by assessing the literature in relation to each of the features of the original TEM.

Focal Technology (FT)

A TE is **"A system of interrelated technologies that influence each other's evolution and development."** Furthermore, this definition includes the concept that **"A specific technology ecosystem view is defined around a focal technology in a given context."**

There is some evidence from the literature that the focal technology in this proposed ecosystem (HOME), could be the Patient Administration System (PAS). Indeed it is arguably the core view (patient centred) that should be used in any analysis of technology and process in healthcare.

Table 53 – Literature regarding the Focal Technology Concept

Possible Evidence for a FT Concept (e.g. – PAS)	Author(s) and Year	Notes
ORIS (Operating Room Information System)	(Dexter et al., 2005)	They highlight the importance of an Operating Room Information System (ORIS) in allowing an analysis of operating room turnaround time and delays. This system would receive its core patient based information from the PAS
AIMS (Anesthesia Information Management System)	(Reich et al., 2006)	An AIMS (Anesthesia Information Management System) – that links to the PAS for the core patient related information (versus clinical information)
LIS (Laboratory Information System)	(Chien et al., 2007)	Paper regarding evaluation and improvement of turnaround time in a laboratory using LIS data. LIS will receive its core patient information from the PAS.

As outlined previously, the concept of technology roles refers to **"the influential roles that a technology can play with respect to other technologies in a given technology ecosystem."** Whilst the concept of technology layers refers to **the technologies playing the same role, with respect to the focal technology in a particular ecosystem view**. Such technologies are grouped in a technology layer.

More specifically, the TEM refers to 3 key roles in an ecosystem in this regard. They are:

- the component role - "describes technologies when they are used as components in more complex technologies" (e.g. – the hard disk drive)
- the product and application role - "describes technologies when they are built up from a set of components, and are designed to perform a specific set of functions or satisfy a specific set of needs" (e.g. – an MP3 player)
- the support and infrastructure role – "describes technologies when they work in conjunction or collaboration with (or as a peripheral to) other technologies" e.g. – a printer (Adomavicicus et al , 2006)

Table 54 – Literature regarding the Technology Layers and Technology Role Concepts

Possible Relationship to TLs and TRs Concepts	**Author(s) and Year**	**Notes**
ORIS (Operating Room Information System)	(Dexter et al., 2003) (Dexter et al., 2005)	They highlight the importance of an ORIS in allowing an analysis of operating room turnaround time and delays. This system would receive its core patient based information from the PAS
AIMS (Anesthesia Information Management System)	(Reich et al., 2006)	An AIMS (Anesthesia Information Management System) – that links to the PAS for the core patient related information (versus clinical) information. Acts as part of the same layer as the ORIS.
LIS (Laboratory Information System)	(Chien et al., 2007)	Paper regarding evaluation and improvement of turnaround time in a laboratory using LIS data.

Possible Relationship to TLs and TRs Concepts	Author(s) and Year	Notes
		LIS will receive its core patient information from the PAS. Acts as part of the same layer as the above systems
Possible component role – patient monitoring equipment	(Abousharkh and Mouftah, 2011)	Describe patient centered wireless sensor network. Whilst focused on management of individual patients, like any other such sensor-data can be grouped up from across a patient cohort in a granular or summary form, hence making it potentially useful to managers
Possible component role – wearable assistant for hospital ward rounds	(Adamer et al., 2008)	Development and testing of wearable "digital assistant" technology for clinical staff including doctors– in production use it could assist not only care delivery but in monitoring compliance with key processes and outcomes, consistent with the management world view
Possible infrastructure role – supporting better performance of an application layer with network upgrades	(Al Huwail and Barnes, 2011)	In this example from Kuwait – a nationwide diabetes management system (which "interfaces" with hospitals) is seen as having service failures due to suboptimal network infrastructure. Planned future improvements in network infrastructure are expected to remedy this situation.
The concept of TL's and TR's (and coevolution) is identified in an "information ecosystem" construct	(Yu, 2011)	An interesting quote form these authors "With the increasing use of information technology, information ecosystems have emerged. Information ecosystems not only include software products, but also include hardware products. For example, application software depends on system software, and both application software and system software depend on hardware devices. Together, they play important roles in an information ecosystem. This paper analyses the coevolution of (an) information ecosystem… " This describes similar concepts to TLs but notably this work has been developed without any reference to that of our primary authors (Adomavicius et al) despite being published well after their efforts

The table below highlights the range of candidate TSF's identified:

Table 55 – Literature regarding the Technology Shaping Forces Concept

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
Governance	Policy direction *	(Demiris et al., 2007)	E.g. - in Critical Access Hospitals (CAH) in US – driving capacity reductions to take advantage of new funding/government support arrangements
	Regulatory and funding requirements*	(Millar et al., 2008) (Pelletier et al., 2005)	
	Government initiatives and broader responsibilities *	(Chiu et al., 2007)	e.g.- "need" to comply with government computer system impositions – e.g. around quality indicators
		(Jossi, 2006)	e.g.- participation in disease outbreak programs / disaster management
		(Greenberg et al., 2005)	
		(Faguy et al., 2005)	
		(Barillo et al., 2005)	E.g. – participating in national demand management initiatives – in this case – capacity for burns beds. Notably same issue exists for critical care beds in

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
			Australia
Financial	Funding types and mechanisms	(Pelletier et al., 2005)	e.g.- capped payments for expected service levels, specific grants, research or commercial funding, patient billing (all even within a single public facility)
	Funding source	(Oliva et al., 2004)	e.g.- state funded versus private hospitals
	Financial viability of organizations*	(Demiris et al., 2007)	
	Interest rates*	(Fang et al., 2006)	
	Need to improve economic management	(Nakagawa et al., 2011) (Vicedo and Conde, 2007)	An example of the creation of new financial indicators – new indicators can mean new data collection and new reporting functionality, with inherent system change implications
	Capital vs recurrent expenditure and ROI	(Reddy et al., 2006) (Fang et al., 2006) (Awaya et al., 2005)	Example of PACS purchase e.g. – here with new pharmacy systems

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
	Complexities around costing health care investigations and treatments	(Beinfeld and Gazelle, 2005) (Oliva et al., 2004) (France et al., 2003) (Azoulay et al., 2007)	A change in the accounting approach used in a hospital can have a flow on effect to the affected management and reporting systems
	Reducing expenditure	(Fang et al., 2006) (Fung and Vogel, 2003)	Adding decision support to computerised prescribing could provide a total net saving of $44,000 - $586,000 over five years in Hong Kong hospitals – this could easily justify the investment as a managerial intervention although implemented at the point of care
IT Technical	Existing technical infrastructure	(Millar et al., 2008)	
	New ways to measure and monitor hospital financial performance	(Xavier, 2012)	
	New ways to support hospitals achieving clinical accreditation	(Alshraideh et al., 2012)	Example of a new system being developed to assist hospitals in obtaining clinical accreditation

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
	New ways to capture key clinical and other data	(Underwood, 2012)	In this example from a third world country, improved labour data collection can assist in driving improved safety at a management level and could in turn drive new central monitoring systems – versus entirely paper based collection processes
		(Tuttle et al., 2004)	New safety reporting systems
		(Edwards and Moczygemba, 2004)	A drive to improve record keeping to in turn improve safety - automation instead of handwrirting related error
	New computing platforms and paradigms* – e.g. – cloud computing	(Townsend, 2009)	Although not without security and access concerns
		(Ahmadi et al., 2012)	The relationship between personal health records and core hospital systems - especially pertaining to the impacts on hospital management – is only just evolving in some nations (including Australia)
Personnel	CIO	(Glaser and Williams, 2007)	"CIO is a critical contributor to organizational IT strategy "; the role is evolving

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
	General staff – IT skills and comfort level	(Demiris et al., 2007)	
	Workforce supply issues *	(Wideman and Gallet, 2006)	e.g. – in managing the radiology department
	In house programming skill	(Reich et al., 2006)	As a cost reduction mechanism
	Workload and work pattern issues of key staff	(Pelletier et al., 2005)	e.g.- documentation burden on nurses in aged care
	Potential for productivity gains	(Fang et al., 2006) (Barnum et al., 2011) (Awaya et al., 2005)	e.g. in radiology from PACS implementation e.g. – in pharmacy services e.g. – also in pharmacy services
	Training implications of technologies	(Faguy et al., 2005)	e.g.- training in new software linked infusion devices as part of organizational safety agenda

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
Safety and Quality	A perceived need to improve safety and resource management as a management driver for CPOE (Computerized physician order entry)	(Vicedo and Conde, 2007)	
	Quality and safety monitoring *	(Chiu et al., 2007) (Mekhjian et al., 2004) (Faguy et al., 2005)	
	Safety gains	(Faguy et al., 2005)	
	Safety Culture	(Grant et al., 2006)	
	Need for systematic large scale infection monitoring	(Thomas et al., 2004)	e.g. – post op orthopedic procedures – site infections
Healthcare Technical	New treatment modalities and services *	(Bandyopadhyay et al., 2005)	
	Changing patterns of imaging use	(Beinfeld and Gazelle, 2005)	e.g.- in suspected appendicitis, in transient ischaemic attacks

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
	Organizational context - rural/metro	(Demiris et al., 2007)	Questionable whether is a separate factor or encompasses some of the other organizational factors
	Level of IT support	(Demiris et al., 2007)	
	Clinical governance frameworks*	(Millar et al., 2008)	Rationale for documenting pharmacists interventions includes "to provide an incident or near-miss monitoring process as part of an organisation's clinical governance framework"
	Service levels	(Reddy et al., 2006) (Chien et al., 2007) (Dexter et al., 2005)	The example is of a radiology service – but applies to intensive care, emergency and pathology and is organizationally specific by definition
	Performance management frameworks*	(Greenberg et al., 2005)	
	Safety Culture – the need to improve it	(Grant et al., 2006)	The creation of a non-punitive adverse event performance

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
			environment
	New ways to describe and measure hospital activity	(LeBellego et al., 2006)	
Public expectation	Accountability and transparency around performance *	(Greenberg et al., 2005)	e.g.- of performance type data which is clearly in the scope of what HMIS' should provide
	Accountability and transparency around safety *	(Mekhjian et al., 2004)	
Service Environment (incl. Models of Care)	New best practice models of care	(Brand et al., 2010) (Bell, 2007) (Bolivar-Munoz et al., 2007) (Britt et al., 2006)	In this case – establishment of a new unit / service – a Medical Assessment and Planning Unit (MAPU)
Organizational Culture	The drive for an improved safety culture	(Grant et al., 2006) (Mekhjian et al., 2004) (Avery et al., 2005)	The need to impove the safety culture of an organization Also the desire to to impove the safety culture of an organization

Category of TSF	Specific type/example of TSF	Author(s) and Year	Notes
	The ability of the organization to adapt to change	(Trypuc et al., 2006)	The need to implement and sustain a major change management initiative could assist the drive for new management information systems to support it

*candidate ESF – Environment Shaping Force (**see Chapter 5 - Discussion**)

What are the key characteristics of the TEM in this context?

One of the limitations in answering this question is the limited range of available literature given that this research is believed to be the first effort at applying the TEM construct to this context. This is also true to some extent for the remainder of the questions in Question Set 1.

Really what this question is asking is – what does the literature say about the environment that the TEM is attempting to describe (through the existence of a postulated HOME), and in what ways does the literature do this?

Table 56 – Literature regarding the key characteristics of the TEM in this context

Key Characteristic	Author(s) and Year	Notes
Progressive, evolving clinical and informatics environment	(Haux, 2006)	A quote from Haux – "This progress, leading to aging societies, is of influence to the organization of health care and to the future development of its information systems" One impact put forward by Haux is "the need to explore new (transinstitutional) HIS architectural styles"
	(Reina-Tosina et al., 2002)	Novel ideas to improve business unit functioning

Key Characteristic	Author(s) and Year	Notes
Multiple dimensions that need exploring in relation to the "design-reality" gap as an explanation for HIS systems success / failure	(Heeks, 2006)	• *Information*: Information quantity, quality, and flow; informal information • *Technology*: Computer hardware, and software; telecommunications; other healthcare technology. • *Processes*: Information-handling; Decision making; actions/transactions; other healthcare processes; informal processes. • *Objectives and values*: Objectives of medical staff, non-medical staff, and other stakeholders; values of medical staff, non-medical staff, and other stakeholders. • *Staffing and skills*: Staff numbers; technical skills; management skills; healthcare skills; other skills; knowledge. • *Management systems and structures*: Management systems; management structures; Informal systems and structures. • *Other resources*: Initial investment; ongoing expenditure; time; other healthcare resources. These above dimensions are also reflected very heavily in our primary considerations of how a TEM may apply to the HMIS environment
The concept of an organizational "climate" when it comes to setting the scene for technical	(Zohar et al., 2007)	"…. Technical /administrative change must be augmented by global factors such as organizational culture and climate"

Key Characteristic	Author(s) and Year	Notes
/administrative change		This study found relationships between unit (department) and organizational climate, and the occurrence of adverse events
Massive technological change – including in mobile computing and wireless networking	(Acharya and Kumar, 2012)	"Massive advancement of mobile computing technology and systems has led to their integration in different aspects of our life. Mobile and pervasive environments built over wireless infrastructures have introduced new possibilities in the healthcare sector in the form of real time health monitoring and diagnosis systems" Healthcare is, and sits in, an environment of substantial change in recent years pertaining to technology
Adapts to external stimuli – in this case the desire to meet accreditation	(Alshraideh et al., 2012)	An expert system in development to assist hospitals to meet accreditation
Hospitals can be seen as dynamic entities that can extend their spheres of influence and interact with broader networks of providers	(Djellal and Gallouj, 2007)	"hospitals are regarded as combinative providers of diverse and dynamic services, able to go beyond their own institutional boundaries by becoming part of larger networks of healthcare provision, which are themselves diverse and dynamic."
A constant drive to improve	(Edwards and Moczygemba, 2004) (Reina-Tosina et al., 2002)	In this case by pushing for more automation to reduce handwriting related (and other causes of) error An example of improving the integrated functioning of a burns unit
Can be a challenging environment for vendors, system developers and system implementers	(Xue and Liang, 2007)	Although is talking about PACS specifically – is insightful onto the potential difficulties implicit in the environment
Highly variable environment in relation to hospital IT	(Tengilimoglu et al., 2006)	Based on a survey in Turkey – variability across many hospitals, even funded by the same government – via 2 different departments

What are its strengths and weaknesses ?

Table 57 – Literature regarding the strengths and weaknesses of the TEM

Strength or Weakness	Author(s) and Year	Notes
(An implied strength) Extensibility and the ability to consider multiple factors shaping technology in the hospital management environment, and also to consider multiple drivers of ecosystems (and computer systems contained within) success and failure	(Brender et al., 2006)	According to Brender et al – although was a broad look at all health ICT, regarding systems success and failure: "All success factors and failure criteria were considered relevant by the Delphi expert panel. There is no small set of relevant factors or indicators, but success or failure of a Health ICT depends on a large set of Issues" I would argue a potential strength of the TEM in this context is its ability to describe complexity both in terms of success or failure in the environment, but also of the factors affecting technology (TSFs, ESFs) in the environment.
(A strength) The ability of the model to reflect the diversity that Fichman et al refer to	(Fichman et al., 2011)	

How valid and useful is the model for analyzing an HMIS infrastructure?

Table 58 - Literature regarding the usefulness of the model for analysing an HMIS infrastructure

Dimension	Author(s) and Year	Notes
Appears useful as a means to deal with multi-factorial	(Kaplan and Harris-Salamone, 2009)	In this piece there is a recognition that whilst technical issues still hold up

Dimension	Author(s) and Year	Notes
complexity in the environment as described by Kaplan		some health IT projects, they describe "an emerging consensus that problems are due to sociological, cultural, and financial issues"
Mainly acts as a tool for risk assessment and mitigation on relevant projects	(Heeks, 2006)	Note the design-reality gap model of Heeks here and in later sections as a counterpoint to TEM. But very different intents also

How does it (the TEM) compare with other IT planning lenses?

In addition to some of the published work in this space that I described earlier (Segars and Grover, 1999, Porter et al., 1991, Millet and Honton, 1991), the table that follows (Table 59) shows some further results obtained through the broader literature review.

Table 59 - Literature regarding now the TEM compares with other planning lenses

Possible alternate planning lenses	Author(s) and Year	Notes
Financial lens	(Fang et al., 2006) (Glaser, 2003b) (Glaser, 2003a)	But is very much limited to the microsystem of radiology management (via PACS implementation); Financial lens – specifically looking at ROI and with more of an investment by investment or project by project basis;
3LGM2	(Winter et al., 2007)	3LGM2 too provides a mechanism for modelers to create models of information systems of hospital – these in turn can be used by information managers (loose term)
Value based lens	(Glaser, 2003b)	Assesses IT investment and development form a point of view of organizational return

Possible alternate planning lenses	Author(s) and Year	Notes
		(value to the organization) e.g. – medical error reduction, reduced costs, increased revenue, service improvement)
Categorical analysis	Quinn 1994 – quoted in Glaser (Glaser, 2003b)	Quinn proposes 6 categories of IT investment – infrastructure, mandated, cost reduction, new products and services, quality improvement and major strategic initiatives
"Systems Analysis"	(Kinney, 2007)	Proposes use of McKinsey Seven-S Framework and modified SWOT type analysis
Enterprise Architecture Interoperability Framework (EAIF)	(Figay and Ghodous, 2009)	Propose a new EAIF with a goal of achieving "pragmatic interoperability" between systems
Digital Ecosystem (DES) Design Methodology	(Hadzic and Chang, 2010)	They specifically examine how a DES design methodology can be used to systematically create a Digital Health Ecosystem (DHES).

Question Set 2

What is the definition of ecosystems success and failure in this environment?

In order to properly review the health and information literature in relation to this question, I will first consider what is meant by the terms "success" and "failure' as they pertain to ecosystems ? In order to do that, we must look back to the biological origins of the term "ecosystem" and consider the terms "success" and "failure" in that original context. Some analysis of this context, and the meaning of success and failure in it, has already been undertaken in Chapter 3 – Research Design, under the heading – "Research Questions". The findings of that section are relevant context in the interpretation of the references listed in the table that follows. There I proposed that ecosystems failure, in the context of the TEM, could be defined as **"temporary or permanent failure of provision of one or more services of a given ecosystem".**

Table 60 - Literature regarding the <u>definition of</u> ecosystems success and failure in this environment

Dimension	Author(s) and Year	Notes
System implementation failures are indicative if a lack of balance being obtained with the introduction of a new "species" into an existing ecosystem	(Kaplan and Harris-Salamone, 2009)	Even though this piece is looking very broadly across health IT (and other IT) projects - a very interesting and pertinent quote is contained within - when it comes to projects impacting multiple stakeholders and stakeholder groups - "failure is in the eye of the beholder"
Make the case for HIT project failure being a common phenomenon – seek to propose a tool to remedy this	(Heeks, 2006)	Inherent to this work is an assertion that – in the language of the TEM / HOME – the ecosystem is often out of balance

What are the factors affecting ecosystems success and failure in this environment?

Table 61 - Literature regarding <u>the factors affecting</u> ecosystems success and failure in this environment

Factor	Author(s) and Year	Notes
Social, cultural and financial factors	(Kaplan and Harris-Salamone, 2009)	Note the prior quote from this key piece of research regarding the non-technical factors influencing the success or failure of health IT projects.
Mismatch of development methodologies with the environment	(Heeks, 2006)	Heeks proposes a few reasons for HIS project failures at least - acknowledging that our world view in this research is broader than isolated groups of projects. These include: "Defining HIS failure and success is complex, and the current evidence base on HIS success and failure rates was found to be weak. Nonetheless, the best current estimate is that HIS failure is an important problem. The paper therefore derives and explains the "design–reality gap" conceptual model. This is shown to be robust in explaining multiple cases of HIS success and failure, yet provides a contingency that encompasses the differences which exist in different HIS contexts. The design–reality gap model is piloted to demonstrate its value as a tool for risk assessment and mitigation on HIS projects. It also throws into question traditional, structured development methodologies, highlighting the importance of emergent change and improvisation in HIS."
"Environmental turbulence"	(El Sawy et al., 2010)	These authors postulate the existence

Factor	Author(s) and Year	Notes
		of a phenomenon called "environmental turbulence". The direct implication is of a challenging environment in which systems are embedded, and which organizations need to overcome in order to gain advantage fro/m information systems.
IT department staffing / IT capacity in the organization	(Bahensky et al., 2011)	Small rural hospitals in the US struggle to get sufficient funding and staff to implement complex health IT projects
Identified 27 criteria that tend to be associated with failure in health IT projects	(Brender et al., 2006)	A range of factors identified, using Delphi method, varying with the kind of system under consideration. As they stated: " The aim is to gain information on factors influencing success and failure for Health Informatics applications from a group of medical informaticians. …Based on the presentations at a special topic conference on success and failure in Health ICT and analysis of the proceedings, we conducted a Delphi study on success and failure aspects…… A total of 110 success factors and 27 failure criteria were identified, distributed on categories like functional, organizational, behavioural, technical, managerial, political, cultural, legal, strategy, economy, education and user acceptance".

How can stakeholders benefit from the application of the TEM to the HMIS environment?

Table 62 - Literature regarding now stakeholders can benefit from the application of the TEM to the HMIS environment

Benefit	Author(s) and Year	Notes
Provides a potentially rich analogy and explanatory factors in understanding the complexity of systems success and failure in this environment as elucidated by Kaplan	(Kaplan and Harris-Salamone, 2009)	Despite best practice research findings being known, many health IT projects still fail

Considerations and Limitations

There are several important points to note in analyzing the results obtained and in considering the literature review process:

- the management of patients (out of scope), and the management of hospitals in their entirety, or of wards and business units; are at the ends of a spectrum. As mentioned in the initial statement around definitions, there are hospital staff who manage both patients and these other entities – where search results may provide an insight into this middle ground they have been included
- equally, where results provide insights into the hospital environment (e.g. – infrastructure or biomedical engineering issues), definitely in scope in this work, they have been included
- this work is focused on (but is not exclusive to) the software and business aspects of the HMIS environment – whereas the original work devotes significant conceptual space to the role of hardware, components and end user devices through its concept of "component" roles for technologies in particular.

CHAPTER 5 - DISCUSSION

In this section of the thesis I will examine the findings of the data collection (the literature review and case studies) in greater detail. Specifically, I will undertake triangulation of the results in several dimensions. I will triangulate across the answers to the different questions in the KIIs, and in terms of the various pieces of data from the case studies; but also in terms of triangulating across the 2 approaches to data gathering - the case study findings and the literature review results. This approach will be directed to each of the questions in the 2 question sets in turn.

Summary of Findings

Overview

One of the reasons this research is important is that some of the biggest problems facing hospitals, including for instance balancing access to care with demand for care, are primarily the responsibility of hospital managers, although clearly the solutions to the relevant problems can involve all parties in the care process. Technologies that can support hospital managers in this and other regards, are ultimately important in improving the functioning of hospitals and the patient experience. Worryingly, as Van Der Meijden et al (Van Der Meijden et al., 2003) stated "systems that support the process of healthcare without being directly relevant to patient care are less easily accepted" by healthcare professionals, as opposed to clinically relevant systems.

Another reason this research is important is the dynamic nature of the relationships between technologies and the environment in which they sit. Work by Mekhjian et al (Mekhjian et al., 2004) illustrates how the need for web based event reporting system then in turn led to system enabled metrics, that in turn allowed monitoring of processes around event reporting. The relationships between problems, and the technologies used to solve them, are indeed very dynamic. This research will allow a much greater understanding of the nature of those dynamics in relation to hospital management problems.

It can be seen from the nature of the informants in the Case Studies (Chapter 4 – Key Descriptive Features of Informants), and the range of contexts covered by the Case

Studies (Chapter 4 – Hospital Characteristics), that these will be a rich source of data in relation to the analysis that follows. This is based on the fact that of the 23 informants across the 5 CS', the majority (61%, n = 14) were at least 45 years of age, with the majority (61%, n=14) also having at least 20 years' experience in healthcare alone – thus representing a wealth of experience and insights on which to draw. In addition, although one could always ask for more data, these 5 in-depth CS' cover a range of geographies and contexts in 3 states of Australia, in both the public and private sectors, and across both regional and urban areas.

Question Set 1

Does the TEM apply to a hospital management environment?

In this section of the paper I will seek to prove the assertion made above that the TEM can be applied to the hospital environment, and in particular to the HMIS environment, which is the specific context of this work.

Focal Technology (FT)

There was a significant range of articles identified which, in various ways, support the concept of a focal technology if using the TEM lens in the HMIS environment. The PAS (patient administration system) is the most likely candidate for a focal technology in the HMIS environment.

As an example Reich et al (Reich et al., 2006) , in their article about an anaesthesia information management system (AIMS), highlight how the PAS acts as a focal technology in a "micro-ecosystem", for want of a better term. It acts as an information store that "loads" patient related information into the AIMS.

The CS findings also shed light on this question. In relation to what candidate technologies may serve the role of an FT in each of the case studies, the approach used was to align the concept of an FT with one that could act as a cornerstone of hospital management. Whilst other approaches could have been used, this one was felt to best align the theoretical construct of an FT, with the central role of the technology in the minds of hospital managers and other informants.

In CS 1 the HR system was put forward as a candidate for an FT as well as “finance systems”. It is important to note that there are typically several systems that could fall under this banner in any given hospital, depending on the remit of the finance department in that hospital. So for example this term may cover general ledger type systems, electronic ordering systems, payroll systems and supply systems. The PAS also got a mention, and even the Human Resources (HR) Manager acknowledged that health care is a ”people business", and that the PAS system is a vital system given its role in tracking patients through the hospital. Another informant also mentioned the PAS as being critical.

In CS 2, the outer suburban community based hospital, there was additional input on top of the input of the staff interviewed in CS 1. The picture here was that HR and finance systems again rated a mention obviously, but Executive Dashboards and the PAS system were also put forward as plausible focal technologies.

In CS 3, the conjoined hospital, the PAS system rated highly as well as Executive Dashboards, the HR system and even the telephony system. Regarding the PAS, informants felt that it was of vital importance to the context, one describing it as the “cornerstone” of hospital management, and noted safety and other adverse implications if it goes off-line.

In CS 4 informants mentioned a number of systems, but again the PAS was a common contender for a focal technology. An informant at this site mentioned communication systems as being a focal technology but also went on to note that the PAS has critical information on who is coming into the hospital and is "responsible for accurate patient identification”, and thus has safety implications. In the case of the Manager in charge of Psychiatry, 2 mental health centric systems were their candidates for a focal technology. It is important to note that the regional mental health triage system, which is equivalent to the PAS, was seen as the most important.

This them of the PAS being a crucial central system and a likely candidate for the FT in this context ties well with example from the literature as described - from Reich et al (Reich et al., 2006) but also with the article by Dexter et al (Dexter et al., 2005).

In CS 5, the virtual hospital, a range of candidate systems were again mentioned as being a key part of the hospital IT environment, and in turn essential to managing

hospitals. In relation to the FT, three of the four informants in this CS felt that the PAS was the key system in this regard. One stating that "you must know who people are" and "see you are treating". They also noted that the PAS "organises the rest of the hospital".

Another informant also stated that the PAS is "the beginning of understanding patients, flow, capacity, (and) case-mix" and that you can use it to "manage waiting lists and appointments" another comment was that if the PAS fails "nothing else is possible".

Technology Roles (TR's)

The original work on this by Adomavicus et al (Adomavicius et al., 2005) uses the concept of technology roles – particularly within the framework of a hierarchy. They in turn reference work by Rosenkopf and Nerkar (Rosenkopf and Nerkar, 1999) which examined evolution in the context of optical disk technology.

As outlined previously, they specifically refer to 3 key roles in an ecosystem in this regard. They are:

- the component role - "describes technologies when they are used as components in more complex technologies" (e.g. – the hard disk drive)
- the product and application role - "describes technologies when they are built up from a set of components, and are designed to perform a specific set of functions or satisfy and specific set of needs" (e.g. – an MP3 player)
- the support and infrastructure role – "describes technologies when they work in conjunction or collaboration with (or as a peripheral to) other technologies" e.g. – a printer (Adomavicius et al., 2005, Adomavicius et al., 2006)

Drawing on these initial concepts, in relation to the component role, there is very little work in the literature addressing, or providing indirect insights into what technological entities fill this role in relation to the HMIS context. However, work by Adamaer et al (Adamer et al., 2008) and Abousharkh and Mouftah (Abousharkh and Mouftah, 2011) raises the possibility of wearable assistants and patient monitoring equipment respectively, filling this role.

In regard to the product and application role it is arguable that the other technologies in the same technology layer as PAS systems (as described below in: *Technology Layers*

(TL's)) play a “product and application role” in this setting). Examples include systems like an AIMS or an ORIS.

Whilst in thinking about the support and infrastructure role in the HMIS setting, there is very little evidence in the literature to explicitly guide us. There are however, a few papers referencing elements such as network technologies (Al Huwail and Barnes, 2011) and w-fi, that may fill a role like this.

In the CS’, this issue was addressed directly – in Question 27- as well as indirectly in Question 10 – examining the relationship between plausible focal technologies and other technologies in the proposed HOME.

At Site 1, in relation to Question 10 which asks "do you believe that there are any key relationships between that technology and others you have described”, one informant noted that the "PAS populates the others with key information".

In relation to Question 27 one informant at this site identified technology infrastructure - for example cabling, servers and hard drives- as possible components in the component- product -infrastructure model put forward in the original TEM. This is somewhat at odds with the limited relevant literature described above. Other responses were difficult to align with the core underlying concept of the TEM.

In CS 2 in relation to Question 10 a key insight was the view among several informants of relationships between Executive dashboards being populated by underlying systems including Patient flow systems, HR and Finance systems. Otherwise there were a few insights provided. Responses to Question 27 provided no additional insights beyond those identified in CS 1.

In relation to Question 10 at Site 3, the concept of an Executive Dashboard being in the same layer as PAS was raised. No obvious additional insights were provided at this site however. For Question 27 at Site 3 only three of the informants offered a response. However one informant saw the component role as literally been filled by components- for example medical devices such as telemetry monitors and ventilators. This view does align well with the literature that is available- for example Abousharkh and Mouftah et al (Abousharkh and Mouftah, 2011). Another felt that with this topic in mind, components could for example, be integration engines and reporting modules.

In CS 4 the IT Executive saw the key relationship between artefacts in this environment as being between network infrastructure and everything is that sits upon it - for example – stating that a medication management application may be the best in the world, but it is of no use if there is not adequate network bandwidth to use it, an adequate PC fleet to access it from, or accessibility to printers. It is interesting that his description does have the similar theme (to that of the TEMs' TL's) of a "hard" technical layer acting as support (support and infrastructure role) to a "function provision layer" (product and application role) that sits upon it, and uses its services.

Obviously this insight reflects heavily the IT executive's technical leadership role in the organisation. Other informants found it difficult to offer insights that mapped well to the underlying theoretical constructs.

In CS 5, in relation to Question 10, relationships were noted between systems and artefacts in the ecosystem, but not in a way that is easy to map to the point of theoretical constructs of the TEM. Again in relation to Question 27 it was difficult to elicit meaningful responses. One informant suggested that the PAS, and scheduling functionality, may together constitute a product in the TEM paradigm, and they also mentioned the possible role of integration engines in this regard. The CEO of the Software Company in this CS offered a more comprehensive response. They suggested in relation to the support and infrastructure role that Wi-Fi is a key part, as were the internal and external networks. In relation to the product and application role they mentioned end user devices including tablets, PCs and laptops, and also "apps" as examples of entities fulfilling this role. They expanded on this by reflecting on the historical role of "exes" (or executables) and web deployment of software, now transitioning to the routine use of "apps" for software deployment.

Although the original TEM appears to be premised around the concept that any technology can act as a focal technology (FT) – from which point the analyst or researcher can then apply all the remaining constructs of the TEM, I haven't assumed that in this research. Rather, I have sought evidence from the literature and the CS', of an important technology that is a plausible candidate for the FT role. To do otherwise would not have allowed this work to fulfil its function – namely to challenge

and attempt to validate the original model put forward by Adomavicius et al (Adomavicius et al., 2005).

It is very reassuring that there is strong evidence from the data sources (the literature and the CS') that such a technology exists – and it is the patient administration system or PAS. The PAS is a technology core to the functioning of any hospital. The reason for this is that the PAS is the primary patient tracking and registration system, as well as therefore supporting the "hotel" type functions of a hospital. Notably, in many healthcare services the PAS performs this role whether the patients are in a physical ward within the grounds of the hospital, or in a virtual ward - such as hospital in the home.

In this latter scenario, as the name implies, patients are sick enough to require specialist hospital treatment, but well enough to receive that care through healthcare staff who visit them in their homes. Irrespective of this, such patients are usually considered as having been "admitted" to the hospital and so are registered in the PAS system for the duration of their stay. In many cases this is for the purposes of keeping track of patient loads, for medico-legal purposes, or for funding purposes. In some cases this practice may be for all 3 reasons. Importantly though, in most hospitals, this "primary patient tracking system" will then also feed relevant details about patients (being the source of truth regarding the identity of the patient) to other important systems such as the Pathology system. Clearly even patients cared for at home may also need the services supported by these other systems that "feed off" the PAS.

So in summary, this important technology which is "focal" in its role in hospital functioning, also can assume the role of the "focal technology", from which I can then seek to validate or refute the remainder of the constructs implicit in the TEM.

Technology Layers (TL's)

The principle technology layer identified in the research is the "patient" layer – or in non-health terms – the transaction processing (TP) layer. So whilst an excellent candidate for the FT is the PAS, of which there are numerous commercial incarnations, other technologies in this layer include:

- Radiology Information Systems (RIS')
- Laboratory Information Systems (LIS')

- Emergency Department Information Systems (EDIS'), and others.

The common thread here is that all provide TP type functionality relevant to their local departments – and all will, or should ideally, relate to the PAS in the hospital organization.

The only notable flaw in this argument, and it is a minor one, is that EDIS' may also contain clinically relevant information that extends beyond what is conceptually TP type information (ie – in this case TP type information includes when the patient entered the Emergency Department (ED), what trolley are they on now, when were they discharged)

In the article by Reich et al (Reich et al., 2006) around their AIMS, it can be argued that the PAS and the AIMS are an example of 2 systems in the same TL- consistent with the principle outlined above. In other work, Dexter et al (Dexter et al., 2005) highlight the importance of an Operating Room Information System (ORIS) in allowing an analysis of operating room turnaround time and delays. It too sits is such a layer and receives its core patient information from the PAS.

In relation to the issue of technology layers and the main layer identified in this research through literature – the TP layer- there were several insights offered in the case studies. In CS 1 one informant noted that the "PAS populates the others (information systems) with key information". CS 2 however, offered no additional insights.

In CS 3, the relationships in this layer were symbolised by the response of one informant who stated that it (the PAS) was "the lifeblood of the hospital". Informants at this site also noted that the PAS is the holder of the universal patient identifier which is then used to "follow the patient" through processes of care and other systems.

In CS 4 the concept that the PAS is critical in providing information (about the patient) to other systems was again mentioned. It was described as being responsible "for accurate patient identification" and as having critical information on who is coming to the hospital -with the inference that it (the PAS) is the source of truth on this matter and that it is responsible for passing its "truth" onto other systems in the same layer.

In CS 5 that relationship was reinforced even further with one informant saying "there are so many links (between the key systems, including the PAS)" and that "many of the systems rely upon data they get from the PAS".

Clearly both the literature and the CS' support the concept of a TL existing at the TP level – this layer contains technologies that fulfil the product and application role as defined in the original TEM. It is interesting to compare the "collaborative" and complementary way in which these technologies work in the proposed HOME, as opposed to the concept expressed by the original authors (Adomavicius et al., 2006) that "Technologies in the product and application role compete with other technologies in this role"(pp 2-3).

In considering the evidence presented above (in the section on Technology Roles) there is also some evidence of a TL consisting of "component" technologies such as patient monitors, wearable assistants and some other technologies (e.g. – integration engines, servers) acting in this role. In addition there is some (but not strong) further evidence of a network technologies including Wi-Fi acting in a "support and infrastructure role", and hence occupying such a later together.

Overall this summation also fits reasonably (but not perfectly) with the original concepts. As Adomavicius et al (Adomavicius et al., 2006) pointed out, "The distinction between the component role and the support and infrastructure role is that components are necessary for the design and are part of the physical structure of another more complex technology, whilst support and infrastructure technologies simply work in combination with other technologies" (p 3).

Technology Shaping Forces (TSF's)

It can be seen from the results presented above, that there are a significant number of references in the health literature (within the scope implied by the previously stated methodology) that are supportive of the assertion that the TEM can be applied to the hospital environment. There are also references alluding to the way in which the TEM can be applied.

In relation to the identification of TSF's in the health literature – particularly in relation to the HMIS context- this was undoubtedly the most clearly supported dimension of the TEM that was found in this research. Many articles highlighted plausible TSF's in a range of contexts –from hospital supply and logistics collaboratives in Canada (Rosser, 2006) to small rural hospitals in the US (Demiris et al., 2007).

In the sections that follow I will outline TSF's, and their plausible higher-level counterparts ESF's, (Environment Shaping Forces) based on the findings from Chapter 4. As per previously published work (Bain and Standing, 2009), the TSF's were identified under a number of key headings, including:

- Governance
- Financial
- IT Technical
- Personnel
- Safety and Quality
- Healthcare Technical
- Public Expectation
- The Service Environment (including Models of Care) and
- Organizational Culture

Governance

In both the literature and the CS' there is evidence of the important role of governance in the healthcare setting, particularly in public health. In turn governance, be it at a health network level, or at a hospital level, or referring to government and its policies; plays a huge role in influencing the environment under consideration.

Firstly, let us consider the evidence from the Case Studies. The relevant Questions in each CS are Questions 13-18 inclusive. In CS 1 overall, informants described external forces as being critical to driving change in their HMIS'. Examples of these external drivers include the imposition of mandatory external systems (e.g. - an Incident Management System (IMS), and a new state-wide payroll and finance solution). These are clear examples of government policies and programs affecting relevant change within a given public hospital.

Despite the overlap in information between CS' 1 and 2, the picture created above in CS 1 was augmented in CS 2. Notably, at this public hospital, informants reiterated the

picture described above but also noted the effect of Department of Health and local health service reporting requirements on driving local change.

In CS 3 - where the public and privately funded systems both intersect - again the role of government as an external force driving change was noted. Specifically the reporting requirements of both the state government and the private parent company were thought to drive change in the HMIS environment. The ED Manager at that site specifically noted that in terms of external effects, changes in the HMIS environment were politically driven, including through the need to meet more requests for data.

At the regional hospital (CS 4), again informants noted the impact of government policies and programs on their local HMIS environment. For example, the Community Care Executive noted the impact of Department of Health (the Department) reporting needs as many care programs are output based (that is to say – measured and funded on the number and types of services delivered). The same informant also noted quality and benchmarking needs from the Department. Whilst the Director of Governance also specifically noted external policy and program drivers enacted through the Department.

In the virtual CS (5) there was a more mixed view presented. The Health Beauracrat obviously acknowledged how both Commonwealth, and in turn, State governments influenced the HMIS environment. Interestingly though, the Clinical Network Manager in referencing their international experience, felt that government played a much smaller role in influencing the environment in Australia, compared with the other country they had worked in (which has major similarities with the Australian public health system).

There are also a number of sources in the literature that add to this picture. In their work, Balogh and Cook 2006 (Balogh and Cook, 2006) examine the case of a UK health trust seeking to achieve voluntary accreditation under the US derived Magnet framework. Magnet is a "non- compulsory system which externally reviews the ability of the organization to undertake quality improvement to reach a set of predetermined standards ((Scrivens, 1995) p. 142)."

These authors go on to state explicitly that existing data collection and analysis processes were altered as part of the push for Magnet accreditation – "The Clinical Audit Department changed its data collection practices as a result of the Magnet project. The data collected and the systems developed for this also contributed considerably to

quality-related initiatives both internal and, most importantly, national." As Scrivens states (Scrivens, 1995), the ability of health services undergoing accreditation to demonstrate that progress is being made towards meeting standards is vital. Collecting and using data is a critical foundation in order to achieve this.

A quite recent and highly instructive example of the impact of government policy in the proposed HOME in the Australian context is the introduction of the National Safety and Quality Health Service Standards (NSQHS) in 2012. A key document regarding the NSQHS (ACSQH, 2012) was released in October 2012. The standards cover 10 areas:

1. Governance for Safety and Quality in Health Service Organizations
2. Partnering with Consumers
3. Preventing and Controlling Healthcare Associated infections
4. Medication Safety
5. Patient Identification and Procedure Matching
6. Clinical Handover
7. Blood and Blood Products
8. Preventing and Managing Pressure Injuries
9. Recognising and Responding to Clinical Deterioration in Acute Health Care
10. Preventing Falls and Harm from Falls

The rationale for the NSQHS is to protect the public from harm and to improve the quality of health service provision. It is self-evident therefore that the implementation of, and ongoing monitoring of compliance with, the standards is directly related to MIS' in hospitals.

Let us take a specific example. In Standard 1 - which is seen with Standard 2 as an overarching framework for the implementation of the other 8 standards- there is a requirement for organizations to provide (p 16) "Regular reports on safety and quality indicators and other safety and quality performance (which are to be) monitored by the executive level of governance".

Another example of the environmental shaping forces at work on the proposed HOME is the work by Vest, Yoon and Bossak (Vest et al., 2013). In this 2012 paper the authors examine the effect on the electronic health records (EHR) market of health information technology certification and the US meaningful use legislation. The authors used a well-known industry database of 3447 hospitals as a primary data source. They then

examined on a regional basis the percentage of hospitals using paper records, developed a picture of the local EHR vendor competition, and the number of vendors. They examined changes over time in relation to these markets. They drew a conclusion that the EHR market is definitely changing. Notably they felt it was changing most dramatically for those organisations unable to handle technological transformation. They directly attributed these changes to the overarching effects of HIT certification and meaningful use legislation, and noted that this is not a uniform effect for all hospitals or the entire US nation. In other words, they concluded that if organizations were unable to adapt to new legislative requirements around information and its collection and use, then they would be at a disadvantage.

Eadie (Eadie, 2012) also wrote, in relation to key international reports on governance and patient safety, that "Healthcare professionals have an ethical and professional responsibility to report medical errors. Doctors in particular are duty bound to consider the best interests of their patients and 'do no harm'. Medical errors are rarely due to individual human error but are often systems based and in many cases are avoidable. Reporting and learning from medical errors improves the safety of patients. It has been over ten years since the reports "To Err Is Human" and "An Organisation with a Memory" highlighted the scale of preventable medical errors. These statistics, stimulated worldwide health organisations to prioritise patient safety. Both reports recommended the implementation of a voluntary near-miss reporting system and mandatory reporting of serious adverse incidents that had caused physical or psychological harm or death." This quote clearly illustrates the potential effect of governance imperatives on the implementation and usage of systems to support hospital management.

Financial

With regard to financial factors as TSFs in this environment, the CS' revealed some valuable insights.

In CS 1, the Manager of Patient Safety noted the impact of funding dedicated to specific systems - in this case the IMS- as a driver of change in the environment. At the same site, the Nursing Executive described the need for greater understanding of, and accountability around, budgets as a driving force internal to the hospital. In CS 2, as in

CS 1, the enticing role of funding attached to the use of mandated "standard" or common systems, in the public health setting, was noted.

At the conjoined (public-private) site, in CS 3, the CIO identified block funding (as opposed to case-mix funding) as a driver of change in the HMIS environment. Notably also, in looking forwards (Question 25), the Director of Quality and Safety at this site saw funding as the main limiter of whether expected future changes in the HMIS environment at this site will occur.

The findings outlined from CS 1 and 2, when compared with those just outlined from CS 3, raise an interesting notion of different directions of effect of TSFs. So, in both cases money is being seen as a driver of change in the environment, but in CS' 1 and 2, the examples described show how the presence of adequate funding can be driver of positive change in the environment, whereas in CS 3, the absence of money is seen as an inhibitor of change. This concept of TSF directionality is one I will come back to later. It has a potential relationship to the TEM concept of "paths of influence", although I will not explore that further in this research.

At Site 4 (CS 4), the Executive of Nursing and Surgery described cost as a key limitation of seeing changes in the HMIS environment. Importantly, in the case of that informant, they felt that the systems in the HMIS had only been moderately successful (6/10) in terms of assisting in the management of hospitals. By way of context, they also made a critical observation: "hospitals operate in spite of, not because of, a whole host of things". The Director of Governance at this site - equally unenthusiastic regarding the positive effect of the HMIS - also saw a lack of internal investment in systems as a key factor. This observation also reinforces the abovementioned concept of directionality of TSFs.

In CS 5, the Clinical Network Manager (CNM) certainly described insufficient funding of the HMIS environment, citing the existence of a "low priority for technology (in) health". The Professional Services Consultant certainly described financial imperatives as a key driver of what they saw as the overall positive impact (8/10) of these HMIS' on hospital management. This too was reiterated as a driving force by the CNM, although they felt this effect should be stronger in nature. The health beauracrat certainly felt that hospitals respond to "performance signals" - which by inference includes financial

performance. Even the CEO of the software vendor acknowledged the important role of financial imperatives in the environment, and the need to "do more with less".

It is not surprising that the cost of care provision is a key background factor in the hospital management environment. The literature contains a number of pieces of research that paint a picture of this. Let's, for example, consider the case of patients with the disease ulcerative colitis (UC), an inflammatory condition of the bowel. In their work Bickston et al (Bickston et al., 2008) specifically examined the costs of care in patients with this condition which can affect up to 1 in 500 people. They stated that "Patients with 2 or more claims for UC had mean [median] all cause (not disease-specific) health care costs in 12 months in 2005 dollars ($13,233 [$5,190]) that were more than 4 times higher than the mean [median] costs for members without these diagnosis codes ($3,214 [$753])." Worryingly, this is a detailed study of just one chronic disease. Clearly when hospital managers have to balance service provision against the financial bottom line, across many types of diseases, their information needs are complex and diverse. These needs will in turn drive the acquisition, implementation and usage of systems to enable those needs to be met.

So in integrating these world views from both the CS' and the literature, the need to save money and operate more efficiently can act as a TSF on the environment. In addition, the relative provision of funding can be a facilitating or inhibitory factor of progress in the environment – eg – through the funding of new systems. It shouldn't surprise us then that "economic forces" were described as being important to the "evolutionary outcomes of technologies"(p 3), along with social and governmental forces, and technical forces, in one of the earlier papers by Adomavicius et al (Adomavicius et al., 2006).

IT Technical

In both the CS' and the literature, the role of IT technical issues as a group of TSFs was evident. As just mentioned also, technical forces were identified as a broad group of TSFs in the original TEM work. These observations should not be surprising however, as this intuitively makes sense - that broad, or local, technical innovations could and would influence an environment in which technology and its use is a key consideration.

Firstly let us consider the evidence from the CS'. In CS 1, respondents identified more

relevant locally developed functionality, consistency of user names and passwords, use of the Windows platform (versus disk operating system (DOS) based systems), and improved intra and extranets as examples of IT technical factors that have influenced the HMIS environment. On the whole these influences were seen as having a positive effect.

In CS 2, similar factors were identified as in CS 1. In addition however, informants in CS 2 described improved levels of system tailor-ability and improved reporting as relevant IT Technical factors, and hence plausible TSFs.

In CS 3, at the conjoined site, the need for, and then the provision of, improved reporting was described as a driver of positive change in the environment (Operations Manager). The implementation of new key systems – e.g. - the new incident reporting system (Director of Quality and Safety) was also seen as a positive driver of change. Finally, the Director of Corporate Services highlighted the positive effect of a greater investment in hardware.

At the regional site (CS 4) the Nursing and Surgery Executive described the positive impact on the HMIS environment at that site of improvements in IT (including network) infrastructure. Another informant described the positive impact of new functionality (e.g. - recording / copying of a genogram - albeit more of a clinical system feature) and new systems (e.g. -an e-recruitment system).

Finally in the virtual CS (CS 5), not surprisingly the vendor CEO offered the greatest insight on this issue. They described the net effect of increasing computer power at ever reducing cost, and hence the generic effect of automation of systems and processes, and their impact on the HMIS environment.

Let us now examine the literature in relation to IT Technical factors as TSFs. The work by Bagayoko et al (Bagayoko et al., 2006), highlights the potential issues for hospital managers around the introduction of collaborative technologies -in this case tele-education and tele-consulations over the Internet. Although this case study research was set in relatively underdeveloped areas of Africa, some of the issues for hospital managers are transferrable. Those issues include:

- accreditation of educational content, and tracking of staff compliance and achievement in the education space

- measurement of activity - numbers and duration of consultations, versus those through traditional service delivery vehicles such as outpatient clinics or inpatient admissions
- tracking of the financial impact - both revenue and cost - of such an initiative.

It should be noted that the impact of the introduction of a new telemedicine service into a hospital, could of course also be examined through the lens of "New Models of Care".

Also in relation to the impacts of new technology, the analysis and review of a medication administration system by Barber et al (Barber et al., 2007) provides an excellent example of how the introduction of a transactional system - in this case an EMAR (electronic medication administration record) system - can act as an influencing factor in the hospital management environment.

Let me explain further. One of the presumed benefits of such a system, and this is a widely supported view (Turner et al., 2004, Appari et al., 2012, Cartmill et al., 2012) , is that such systems reduce the frequency of medication incidents. Such incidents include non-timely administration of a critical drug, or patients being given the wrong drug, or the wrong dose of a drug, or the correct drug via an incorrect route. An example of this last kind of incident is a patient being given a drug by mouth when it was intended that it be given intravenously.

In the traditional setting, prescribing decisions and the occurrence of incidents related to prescribing may only have been recorded on paper, or potentially in pharmacy or clinical systems as a secondary process. One of the advantages of the EMAR system is the potential ability to automatically access data about prescribing systems and the effects of prescribing, directly from the EMAR system. This data could be fed automatically into risk and incident systems, or into a data warehousing and reporting environment.

It should be self-evident therefore what the influence of the introduction of this transactional EMAR system may be on the hospital management environment, and on these latter mentioned management information systems.

In their work Bloomfield and Feinglass (Bloomfield and Feinglass, 2008) (this also had relevance to the core initial arguments regarding technology layers) make a case for the

importance of an anaesthesia information management system (AIMS) in the management of patients undergoing anaesthesia. Amongst the many actual and potential benefits they ascribe to such systems are the ability to aid billing, and to document and monitor the quality of care. This again illustrates an example of a driving force for change, or even evolution, of systems in the hospital management space. More specifically, if an AIMS system were introduced into a hospital environment it would necessitate a review and rethink of existing financial, billing, quality and reporting systems in terms of use cases, workflow, data flows, and reporting outputs of these existing systems (assuming an intent to fully leverage the potential benefits of the AIMS). At an even more basic level, the authors make the assertion that "For many hospital administrators and chief executive officers, the operating room is a black box". Assuming this to be true, it is obvious that the deployment of such a system, irrespective of the more detailed issues outlined above, would act as a significant "influence" - good or bad- in the hospital management environment.

Utilisation of in hospital support services - both clinical e.g. - investigation ordering, and non- clinical e.g. - porter services or meal services - is an area of great importance to hospital managers and executives, in no small part due to the cost of such services, although they can also be income generating in some hospital systems. Buck, Connor et al (Buck et al., 2011) report on the usage of a monitoring system for clinical utilization of pathology services. Their findings illustrate substantial utilisation of specialist pathology consulting services, across a range of clinical settings, in the study hospital. Such a system would be an important contributor to business intelligence around pathology utilization in the hospital management environment.

Arnetz et al (Arnetz et al., 2011) describe the utilization of a system for monitoring workplace violence in hospitals. This is interesting both in terms of the solution and it's benefits, but also in terms of highlighting yet another problem confronting managers of the hospital environment.

So in summary, both the literature and the CS' provide evidence that support the view of the original authors around the TEM – that technical forces as a group can act in very profound ways on a TE, and in this case specifically on the proposed HOME.

Personnel

Not surprisingly, given health is a business focused on service delivery to people, and primarily by people; issues and needs in relation to healthcare personnel were an important theme identified throughout both the CS data, and the literature, when it comes to plausible TSFs.

Let us firstly consider CS 1. The IT Executive at this site specifically felt that increasing skill level of hospital managers with relevant technologies was a positive influencing factor on the environment. Whilst CS 2 did not offer much in relation to this view, in CS 3 several views were put forward that supported the idea that personnel can act as a TSF. Specifically the Operations Manager at that site noted, for example in relation to payroll systems, staff dissatisfaction had an influencing effect. In addition, the Corporate Services Director noted the positive effect of new staff coming in from other organisations and bringing their individual experiences with them. Finally, the ED Manager noted the specific individual philosophies of the 2 most recent CEOs which were about "proving what you do, not just saying what you do" when it came to their expectations of their Executives and Managers.

At Site 4 (CS 4) the Continuing Care Executive noted the impact of CEO expectation on the environment, whilst the CIO noted the role of a change in IT department skill sets away from more "hardcore technology" skills, towards more business focused skills like report (reporting application) writing. The Clinical Service Manager also noted the positive effect of an influx of new people into the health service, who had seen positive initiatives and benefits elsewhere, citing the CEO and new IT managers as examples. Finally in CS5, and as previously noted, the vendor CEO observed the cost of labour versus that of automation, as an influencing factor, in this environment.

There are some examples in the literature in relation to Personnel as a TSF. Glaser and Williams (Glaser and Williams, 2007), for example, absolutely note the role of the CIO in the hospital environment. In their view the “CIO is a critical contributor to organizational strategy”. This is analogous to the crucial role of the CEO mentioned in several of the case studies, as an important influencing factor in this environment.

Safety and Quality

Safety and quality issues and needs were an important theme identified throughout both the CS data, and the literature, when it comes to plausible TSFs.

In CS' 1 and 2 no clear reference was made to Safety and Quality issues. In CS 3 however, the Director of Quality and Safety describes the role of an ongoing quality cycle at the organization - balancing access and quality drivers of care- as a positive factor influencing the HMIS environment. The same informant also noted the interest of the organisation's insurer as a positive driving factor in their HMIS environment. The prime interest of the insurer will be of course to ensure a minimal number of claims are made against the hospital – but this is best achieved through the practice of high quality and safe healthcare.

In CS4, the Continuing Care Executive specifically mentioned the needs from the quality agenda as a positive driver in this environment. They also described external pressures to be and appear "high performing" in benchmarking exercises, including quality benchmarking, with the health department and other external bodies. The Surgery and Nursing Executive also mentioned the needs of the safety agenda as a positive driver in this space.

In CS 5, the vendor CEO identified external forces acting on hospitals and on this environment to improve quality, as a factor in shaping this environment and technologies within it.

The literature shows that there are multiple dimensions of care that are deemed important enough to analyse, and hence to measure and monitor in an ongoing fashion from a broader organizational perspective. For example, the work of Agodi et al (Agodi et al., 2007) examines the issue of nosocomial (hospital acquired) infection in urology (the study and treatment of diseases of the urinary tract – kidneys, bladder and so forth) patients in an Italian hospital. They concluded that the appropriate use of preventative antibiotics and closed urinary drainage systems would be useful interventions to reduce the incidence of hospital acquired infections.

The relevance of this paper in the context of this research is that it highlights one of a multitude of the dimensions of care that are potentially of interest to builders and users of management information systems in the hospital context. In effect these dimensions

are potentially as varied as the number of clinical services that are provided at a given hospital. For example preventative antibiotic usage is also of interest in cardiothoracic and bowel surgery, but then something like the falls rate of hospital patients is especially important in general and geriatric medicine.

The other critical point of note here is that as this new evidence comes to light, there is an increasing burden on the organization to accept the implications of the research and to participate in the implementation of the recommendations of such research. Whilst this pressure may be resisted at first, eventually the weight of such pressure - through government and regulatory imposition, through public pressure, or through the appropriate demands of clinical service providers - will become too much for organizational management to resist, and the necessary changes will be implemented.

More specifically however, this means that performance monitoring systems and quality or incident systems need to be able to be updated to reflect the capture of measures that are of most relevance to the business at that particular point in time. Another example of this is the work of Thomas et al 2004 (Thomas et al., 2004) which talks about the need for long-term surveillance of treatment, and in particular the example of infections in post-op orthopaedic procedures. The implications of the work for hospital managers are that data is needed to monitor such complications and to enable a thorough understanding of the issues at hand. Such data can be collected or displayed in computer systems and in fact should be for optimal management.

Another example in this area is the case study described by Aulbach et al (Aulbach et al., 2010). In this US case study, a reaction to an inappropriate blood transfusion in an individual patient acted as a strong facilitator of a multipronged system improvement activity, which included technology, to better manage the safe delivery and infusion of blood to patients in that hospital. The specific technology was wireless barcode technology for point of care patient identification.

Healthcare Technical

Issues and needs in relation to healthcare technical issues were an important theme identified - more so in the literature - when it comes to plausible TSFs. By way of clarification, I am classifying any factor to do with the science of healthcare and its delivery as a "healthcare technical" factor.

None of the CS' offered any particular insights here. However, an interesting paper is that by Amir et al (Amir et al., 2010) which examines the use of a new technology in the analysis of SDB (sleep disordered breathing). The interesting point of this paper is it highlights yet another force acting in the hospital arena that can affect the kinds and sources of information hospital managers need, and seek, in order to run their services. That force is one of technological change. There are myriad new diagnostic, treatment and management technologies that have come into standard hospital practice in recent years or show promise in so doing (Bermejo Vicedo et al., 2007, Awaya et al., 2005, Loekito et al., 2013, Adamer et al., 2008, Greenberg et al., 2008), this is another example of such a technology. This technology would represent a significant opportunity for a hospital so determined to

- a- provide more frequent diagnosis of SDB patients and to
- b- do so using lower tech, cheaper and more readily available hardware.

In order to automatically monitor the frequency of such diagnoses - a key management imperative given that such diagnoses may generate income (either from the process, or the outcome, of treating the patient) - it is very feasible to automatically import elements of the diagnostic data into a central reporting system. Hence existing management reporting systems or data warehouses may need to be modified to receive such data in a seamless fashion. This is yet another example of how changes in the "surrounding environment" can drive evolution in hospital management information systems in the way outlined in the proposed HOME.

Breen and Zhang (Breen and Zhang, 2010) describe the effective introduction of an automated checklist in the context of radiotherapy treatment planning. This was introduced by utilizing a scripting function within their radiotherapy treatment planning system. Drawing on the work of others (Cionini et al., 2007), they assert that "Automated tools, together with appropriate structure and documented processes, can improve speed and reduce human error" (although this quoted work is also in the specific domain of radiation therapy).

Public Expectation

As health - in a system sense - is about meeting the wellness and illness needs of the population, it's not surprising that issues and needs in relation to the expectations of the

public were an important theme identified throughout both the CS data, and the literature, when it comes to plausible TSFs**.**

In CS 1, the Manger of Performance described the roles of the media and public pressure as factors driving positive change in the HMIS environment from their perspective. In CS 2, one respondent noted the impact of public expectation about healthcare services as a driver of reporting requirements in hospitals. In turn obviously systems are and would be, driven to change in order to meet those requirements.

In CS 3, the role of public need and expectation was given prominence by the Director Quality and Safety who saw access and demand pressure as the main driver of changes in the HMIS environment there - through the need to provide as much service as possible with the available resources. At the same site, in describing relevant external forces operating on the HMIS, the Operations Manager made the telling observation that "people certainly expect more" in relation to community needs and expectations of that hospital.

In CS 5 - the virtual case study- the Vendor CEO described societal pressures and wider cultural change as having an impact on the HMIS environment. This informant expanded on this point by referencing the greater "connectedness" (in the sense of people being “online” more) in the broader community, for instance through the widespread uptake of smart phones, as an influencing factor in the environment.

With regard to lessons from the literature, Greenberg, Angus and colleagues (Greenberg et al., 2005) describe a program of work to produce public reporting of cancer indicators – including those meaningful to patients such as waiting times and service satisfaction levels - in the Canadian province of Ontario. This development was in no small part driven by public expectation regarding cancer services and their outcomes for patients. As noted earlier, Mekhjian et al (Mekhjian et al., 2004) also describe the implementation of a clinical event reporting system in a large health service, and whilst they cite the desire to change organizational culture around error reporting as a clear driver, clinician fears around malpractice suits (due to greater public expectation and awareness) is also described as a driver.

The Service Environment (including Models of Care)

Let us now consider the evidence from the literature around models of care and their potential to impact on the hospital management environment. A good definition, as outlined by the Western Australian Heath Department (Unknown, 2014), is as follows: "A 'model of care' broadly defines the way health services are delivered. It outlines best practice care and services for a person or population group as they progress through the stages of a condition, injury or event. It aims to ensure people get the right care, at the right time, by the right team and in the right place. The model describes:

- types of activities to be delivered to patients by a provider, health professional, or care team
- types of services to be provided by an organisation
- the appropriate stage for an activity or service to be delivered
- the location or context that the activity or service will be provided in
- the health care team and community partners that will provide the service
- the policy framework for the model of care"

Models of care then, can be thought of almost as the health equivalent of "business models". A key difference is that although the cost and revenue implications of the models are important, there is a much greater emphasis given to the scientific evidence base behind them, and their benefits to patients and carers.

There are numerous examples in the literature regarding the range of factors affecting the service delivery environment in healthcare, for example the work by Bell (Bell, 2007). Such factors implicitly affect how that service delivery environment will function, and hence how managers (both inside and outside hospitals) will need to adapt and respond to any changes.

Bell specifically examines the issue of the transition of adolescent dialysis patients into adult care. In short, this paper is one of a multitude in the literature that shed a light on the demand pressures facing those responsible for managing hospital services. Specifically in this case, the author's research points to the need for a transition program for adolescent patients with chronic kidney failure (and hence needing dialysis), as they move from care settings aimed at adolescents to those designed and structured around the needs of adults. It is therefore incumbent upon those responsible for managing these adult services to be familiar with the needs of such a patient group and the financial,

staffing and logistical aspects of providing such a service if they choose to be guided by this research.

The difficulty truly arises however when one considers the vast amount of evidence in the literature that points to a whole range of demand pressures on those providing these hospital based or affiliated services. There are at least as many sources of such pressures as there are parts of the human body.

Bolivar-Munoz et al (Bolivar-Munoz et al., 2007) provide yet another example of the demand pressures on healthcare systems and hospitals in particular, in their analysis of patterns of emergency transport for patients with ischaemic heart disease (damage to the heart muscle due to narrowing of the arteries supplying blood to the heart) in Spain. They quote an important statistic - namely that 12% and 10% (in men and women respectively) of all mortality is from this disease (Boix et al., 2003). They further go on to describe how timely hospital based treatment with blood clot dissolving drugs (thrombolytics) is considered a key means of reducing mortality (Morrison et al., 2000). The implication of this research in the context of the hospital management environment, is that these authors describe a suboptimal pattern of use of healthcare services by a key patient group, and they advocate better systems to meet these patients' needs, and better ways of educating patients regarding how to use these services. Healthcare managers need to be able to adapt their own service provision to meet such needs – this can very clearly have an effect on the management environment in their institutions.

Britt et al (Britt et al., 2006) provide an interesting analysis of the effect of telemedicine services, and the availability of specialist newborn care, upon referral and transfer patterns for mothers and their babies both pre and post-delivery. This work is one of many examples of how service configurations - both in a local hospital sense, and in a broader sense - can affect the issues confronting managers at an individual hospital.

In their research, Albright et al (Albright et al., 2010) examined the issue of the models of care in acute stroke. Using a modeling approach they calculated the coverage of large population cohorts in regards to access to Primary Stroke Centres (PSC's). This was done on the basis that PSCs are best placed to deliver optimal specialist stroke care and that there is scientific evidence to support this contention.

The relevance of this work is to demonstrate how policy and practice change, for example by implementing a new model of care, could impact on hospital referral patterns and service configuration. Studies such as these can be drivers of such hospital level changes directly, or through intermediaries such as governments or funding bodies, depending on the specific situation. Again in turn, the systems used to manage hospitals do, and need to be, able to adapt in order to continue to meet the needs of hospital managers.

Let us now examine the evidence from the CS's. With regard to the influence of changes in the service environment (including models of care) on the proposed HOME, CS 1 offered no particular insight.

In CS 2 however, the IT Executive (in Question 15) felt that one of the drivers to recent change, which in their view was of a somewhat mixed picture, was the nature of the business. In particular they refer to the fact that organisations now need to work across multiple physical sites, and that they felt in the case of their organisation, this change had driven a better intranet and extranet, and more supportive tools for managers.

In CS 3, at the conjoined metropolitan hospital, the Director of Quality and Safety shed some light on this issue in their answer to Question 26. With regard to forces external the hospitals that would drive towards the predicted outcome of healthcare managers needs being met (i.e. an appropriate level of ecosystem services being provided) this informant predicted that public health concerns, for example obesity, would have an impact on the mechanics of service delivery in order to meet the needs of this growing group of patients in the community. In turn they were using this as an example of how a change in service model would act as a driver of change in the proposed HOME (through new system and information needs), in order to deliver that that predicted positive outcome. This overlays well on the concept of changes in care models affecting the hospital management environment, and manager information needs, as highlighted in the literature above.

In CS 4, the response of the Surgery and Nursing Executive to Question 23 indicated support for the idea that models of care changes will drive improvements in the environment. For instance they predicted that there will be more patient self-management tools in combination with remote monitoring and used the example of CDM net in Victoria (Unknown, 2013b). Importantly however, they felt the likelihood

of managers information needs regard being met was questionable scoring a 2-3/5, but importantly stating that in their mind, it is a question of what is prioritised and resourced to happen.

The CNM in CS 5 felt that the biggest factor inside hospitals driving towards change in recent times (and they rated the level of change has 4/5 i.e. positive) was new models of care driving to improve access and reduced patient waits.

The same informant, in the answer to Question 25 with its forward facing view about what forces external hospitals will drive towards their predicted outcome of met or unmet needs in the future, mentioned that service reconfiguration and new models of care along, with financial and performance measures, will be drivers of positive change in it. This is despite their lack of belief that it will occur in the current environment. Again, these views align well with the patterns seen in the literature.

Organizational Culture

Throughout both the CS' and the literature, the effect of organizational culture in hospitals was seen as relevant, particularly when considering potential technology shaping forces in the HOME.

In CS 2, the Hospital Executive described an increased the sense of organizational accountability and need for measurement at that hospital as a positive driving force. This observation talks to a cultural driver at that site. At the conjoined site (CS 3), the Operations Manager described the positive impact of the need for accountability and transparency expected by both the parent private company, and the state health department with which the organization effectively has a service level agreement (SLA). Also at this site the ED Manager specifically mentioned the impact of culture change facilitated by the last 2 CEOs, describing a mantra of "proving what you do, not just saying what you do", as described previously. The other key quote from this site visit was "we want to do better" and specifically, "we want better patient outcomes". Achieving these "cultural imperatives" is underpinned, in no small part, by better information provision to operational managers and executives.

At the large regional hospital (CS4), the Director of Governance, who felt that the HMIS environment had not clearly improved in recent years, made an interesting

observation that spoke to organizational culture at that site. That informant described a lack of leadership around the use of certain systems in that hospital.

These contrasting findings above - of positive cultural influences at some sites and negative cultural influences at others sites – again supports the concept of directionality of TSFs first discussed in relation to financial TSFs.

In the virtual case study (CS 5), the CNM made an interesting observation (Question 11) regarding the success or otherwise of HMIS', stating that management decision tools can be "misleading" and (their effectiveness) can depend on organizational culture.

With regard to the evidence in the literature, in the work by Avery et al 2005 (Avery et al., 2005) they describe the implementation of a web based reporting system. One of the influences they describe on the implementation and nature of the system is the organizations culture of "non-punitive error management and reporting, focusing on systems rather than individuals". So in this particular case, one of the factors influencing the implementation of a management system, and a key beneficiary of that system, was organizational culture. In the paradigm of directionality of TSF's, clearly this was a positive influencing factor

The Interplay between TSFs

In this section of the thesis I will examine the interplay between some of the TSFs outlined above as impacting on the hospital management environment and hence on the proposed HOME.

It is already clear from some of the literature described to date that the environment in which hospitals sit can be described as complex with a host of "moving parts", pressures, drivers and expectations, with intertwined relationships between many of these things (Xue and Liang, 2007, Brender et al., 2006, Fichman et al., 2011). Let us now consider a couple of more detailed examples that underline that complexity, and draw attention to the interplay – real or potential - between TSFs.

An interesting article about mental healthcare in Madrid highlights the issue nicely (Ferre Navarete and Palanca, 2005). In their description of the mental health services in that city, the authors describe the dual and related impact of a deliberate government strategy to improve mental health care, which was backed by dedicated funding. Here is

a very good example of 2 TSFs (or arguably in the case of the strategy especially, it could even be considered an ESF) both acting synergistically to impact the hospital environment (as part of the broader mental health care system) when either of them individually would have impacted hospitals in some way.

Another example is found in the work of Fiore et al (Fiore et al., 2005). In this piece the authors describe a survey of 65 Queensland Health rural and remote hospitals using pharmacy supply nurses. In this setting, the nurses replace the role of pharmacists in dispensing medications, given the remote locations involved, and limited staffing available. This paper highlights how those managing in this environment, and the environment itself, is beholden to 2 synergistic and related forces operating on it – the forces of limited staff availability, and heightened concerns about potential safety issues. Again – either of those forces alone could significantly impact the environment, let alone both in concert. Clearly such forces could and would have a direct impact on the information needs of those managers, and the systems they may need access to in order to undertake their management responsibilities.

With regard to the relationship between TSFs there are also some interesting insights to be learned from the CS'. In the example of CS 1, which is based in a large metropolitan hospital under centralized local health network control, the Manager of Patient Safety and Quality made an interesting observation regarding the good and bad of a centralised model. They noted that sometimes it is an advantage that funding comes with the standardisation of systems via central imposition. So in this particular case the forces of finance and financing of systems, and governance of the health service, act in a synergistic fashion on the technology environment. Importantly in relation to Question 13, the same informant described that the change in the level of assistance of these systems for hospital management has been very positive in recent years, rating that a 5.

Another important example of the interplay between TSF's was noted at this site. That was the role of the case-mix funding system paradigm (funding health services based on the mix of patients they treat) in public health, which was imposed as part of government policy. This in turn leads to a greater need to understand budget, which in turn acts as a driver to improve the systems that assist with budgetary management.

At the same site and with more forward facing view, the Human Resources Manager felt, in Question 23, that IT systems will become more integrated particularly in the

example of FMIS' and HR systems, as long as funding follows. This response is illustrative of the synergistic the role of technology development and funding to support it.

Also in relation to Question 23 with its implied forward facing view, the IT executive at this site said they saw a very bright future for the evolution of the systems - providing funds flow, they predicted more tightly integrated systems. They also predicted other technology advances such as more wireless coverage, augmented by the provision of funding. This illustrates the concept of further technology development, including more systems being developed, and augmentation of wireless coverage, by the provision of funding – so several TSFs interacting in a particular way.

In CS 2, at the community-based hospital, there were further interesting insights offered in relation to this issue, noting however, the overlap with some participants in CS 1. Despite this overlap, the picture from CS 1 was augmented by CS 2. In particular in relation to Question 23, the response of the Hospital Executive indicating an expectation of greater summation (aggregation of data) ability and integration of systems over time, supports the view noted above in CS 1. In Question 24 that informant's optimistic view is that if the necessary support is provided, these positive changes will happen. In Question 25 this informant identifies several potentially synergistic factors as likely to drive this positive change - they quote the pressure of user needs, the organizational need to staff wards properly, and the need to reduce the reporting burden on the relevant staff.

CS 3, at the conjoined metropolitan hospital, offered further insights with regard to the relationship between TSF's. Let us examine the responses of the Director of Quality and Safety to illustrate this. In Question 13 this informant describes quite positive changes overall in relation to the assistance provided by relevant systems in recent years. They believe in relation to internal driving factors that access and demand management - i.e. how to do as much as they can with what they've got, and all within budget, in relation to treating patients – has been a key driving factor. In addition however, they describe a change in organizational size such that it recently reached a "tipping point" where it needed more formal management structures and approaches than previously required. Implicit in this response is that more sophistication of data collection in relation to hospital management, in order to support subsequent management decisions and reporting, has been required.

Looking forward, in Question 24, the same informant was very confident, provided certain factors are in place - including adequate and timely support from the parent company of this organization - that outstanding needs will be met in next 5 to 10 years in relation to support for a hospital managers around information use and processing. In Question 26, they then described a series of external forces that although somewhat independent, would act in the synergistic fashion to drive towards a predicted outcome in the next 5 to 10 years. These include the provision of funding and how the community sees that funding being best spent, public health influences on where to spend money, and also the inevitable march of technology. To illustrate the point further, the Director of Allied Health at this site believes that looking forwards managers will have more information available to them in relation to the current unmet needs, and then goes on to state in Question 26 they believe a number of key forces operating in concert will drive this outcome. These include the needs of public hospitals to be more efficient; and the need to improve clinical outcomes, and to improve the management of risk. They also see an increase in the fundamental level of investment as likely to occur to support this. Clearly both these respondents outlined examples of TSFs operating in concert to achieve an actual predicted outcome.

In CS 4, at the Large Regional Hospital, there were yet more insights available in relation to this issue. As an example, in Question 13, the Surgery and Nursing Executive at the site, indicated they have seen a very positive change in how the systems have supported hospital management in recent years. They also describe ways in which this has happened including greater availability of mobile access points and the advent of the "GUI" (Graphical User Interface) and "more intuitive systems". They went on to indicate in Questions 15 to 17 that some of the forces operating on the environment that have driven this outcome, are improvements in local IT infrastructure, improvements in application development generally, improved computer literacy amongst users, and increased hardware capacity (meaning data storage).

The Clinical Service Manager at this site also offered some insights in relation to this issue. In Question 13 and 14 they described a far more positive environment in recent years despite ongoing gaps. In Questions 15 to 17 they described multiple internal and external factors acting in concert to improve the environment. These included internal forces such as the injection of new staff into the health service (e.g. – new IT staff and a new CEO), also a new vision from that CEO, and investment. In relation to external forces they described improved system functionality and improved workflow support,

for example in the e- recruitment space. Looking forward also, the Surgery Nursing Executive was not greatly confident that positive change will occur whereas the Clinical Service Manager was quite confident that "it (positive change) has to happen". In the case of the Clinical Service Manager, they believed that nurses will become more skilled with respect to technology, that healthcare consumers will demand more, and that the increasing and ongoing inflow of staff from other hospitals, will drive the environment in the direction of the positive change they believe will ultimately occur.

Now let us consider CS 5, at the virtual hospital. In this CS let us focus on the responses of the Manager of the Programs Area. This informant believes that the ability of these systems to meet needs has improved in recent years although they believe there is a degree of variability in this regard. So for example, they believe Executive Dashboards rated an 8 in terms of their role in assisting management of hospitals, whereas Bedboards, and Analytic and Predictive Systems rated a 2 and a 1 respectively.

In response to Questions 15-17, this informant went on to describe several supportive and synergistic factors that act as TSF's. They described how hospitals respond to signals around performance management, which in turn can be provided to them by the governance structures be they at board level or at a Department of Health level. So in effect strategic initiatives are put in place by various levels of governance of the hospital, and drive the need for improved performance management and performance measurement. These in turn drive the information needs in support of these objectives, and in turn the development or acquisition of information systems to meet these information needs.

In Question 19 the CNM noted that "we have quite sufficient data but insufficient correct and appropriate information" further stating "I believe that it is the responsibility of managers to indicate to those who can assist, (exactly) what and how they and what information is required and how the managers needed information."

Interestingly the CEO of the Software Company also said there is "too much information" confronting managers in the existing environment and that "(the amount of) noise managers need to deal with is quite phenomenal".

In Question 23 the CNM stated that integration is the key. They went on to describe a need for more information flow into and out of the private sector, as patients cross

between the public and private sectors. This informant also described the need for even more clinically based outcome information. Having said that, they lacked a degree of confidence that these outstanding needs will be met in next 5 to 10 years. They went on to state though, that investment and key state and national government drivers would act together to achieve this outcome, if indeed it is achieved at all.

So in summary, in each of the CS examples I have followed-through, one or two respondents in each case indicated how they believe the current state has been arrived at, as it pertains to those TSF's acting in the environment; as well as how they believe the future may evolve, and which TSF's they believe will act in concert or in synergistic fashion to achieve their predicted outcome.

Environment Shaping Forces (ESF's)

As a follow on from the analysis above with regard to the relationships between TSF's, there is also the opportunity to extend the existing TEM based on the evidence in the health literature and CS'. In biological ecosystems there are forces, especially global forces, outside of the ecosystem such as global climate, and the effect of a depleted ozone layer, that are not specific to or contained within a given ecosystem. There also appears to be what I am calling "environment shaping forces" (ESF's) – in the technology ecosystems world view. I have already published some preliminary work regarding the concept of ESF's from this research (Bain and Standing, 2009).

In terms of the kinds of TSF's identified, they are categorized in Table 55 (see **Chapter 4 - Results**) and represent an interesting insight into the complexity of the business, policy and technical environment that is the HMIS environment. From a subset of references documented in that table, some candidate ESF's are identified which are marked with an asterix. Interestingly, candidate ESFs can be argued for in every TSF category except for the "Organizational Culture" category. On one level this makes sense, as although the culture of a hospital may well be influenced by outside factors, I would argue that more than anything it is influenced by the staff and history of the institution. Another plausible explanation however is simply that no literature has been identified to support the contention of ESF(s) in the "Organizational Culture" category, at least at this point in time.

This dimension (TSFs) of the TEM has offered an opportunity to extend the existing model, by examining the ways TSF's themselves affect each other, as well as their effect

on technologies and the TE as a whole. In order to more fully explore the concept of ESF's, let us again consider the work of Oliva et al (Oliva et al., 2004) in assessing the direct healthcare costs of diabetes in Spain. This analysis of the costs borne by the health system in Spain through the burden of diabetes, is a fairly comprehensive example of such forces. Oliva et al outline how the increasing prevalence of diabetes has multiple ripple effects through the health industry – and specifically through hospitals in that country (somewhere around 35% of direct healthcare costs, billions of dollars annually, are from hospital incurred costs).

Now clearly such a burden has an effect on the practice of hospital management in its various dimensions – in turn this burden (and remembering that this is just one, albeit one very important, chronic disease) will therefore have an effect on information systems that can support that management practice. In referring back to the TEM world view however, it is not clear that this burden is in and of itself a TSF; just as climate change is not a direct effector on the life expectancy of a species in its ecosystem – rather it is the intermediate effects of climate change such as lack of moisture and increased temperature that more directly effect a species. Hence I would argue that ESF's (Environment Shaping Forces) are a useful and essential extension to the core concepts of the TEM, and that ESF's act on an ecosystem at a day to day or micro level through intermediaries (TSF's).

Painting a similar picture, although from quite a different angle, is the work by Bandyopadhyay et al (Bandyopadhyay et al., 2005) that describes the implementation and evaluation, although primarily from a customer (patient) satisfaction perspective, of a direct access surgery service in the UK. In this case, a clearly identified driver for a redesigned service to patients (a direct access minor surgery service) was demand for service in the described institution. This demand pressure, and concerns around demand management, is recognized as a generic phenomenon in healthcare internationally (Kalucy et al., 2005, Johnston et al., 2006, Unknown, 2007, Reuille, 2004, Breslow et al., 2004, Miwa et al., 2006) – it is not a unique factor operating on that service, and hence on the technology that supports the management of that service or hospital. In other words it is an ESF, and not a specific TSF in that local context.

Let us now examine the evidence from the case studies pertaining to plausible ESF's. As previously outlined, in CS 1 as identified in Q 15 and 16, informants at this site identified a number of interesting possibilities. Most powerfully, one respondent noted

that a lot of drivers are internal instantiations of external (e.g. – DH and HN) imperatives – e.g. - patient access imperatives. Another example quoted was that case mix drivers from external to the organization led to a greater need to understand budget. This in turn acted as a driver to improve those systems (e.g. - HR and Finance systems) that primarily assist with budgetary management. A different kind of interplay was described by one respondent where new externally available technologies influence internal implementation and upgrade decisions – thus driving internal improvements in relevant systems. CS 2 offered nothing additional on this issue to these findings from CS 1.

In CS 3 informants identified a number of interesting possibilities. One informant noted that, in their opinion, internal drivers were just as strong as external ones - "we want to do better" and "we want better patient outcomes" as I described previously. Similarly, one said that there was still a way to go but "wanting to manage in a better way" was a big driver from their perspective. Others, however, noted the impact of a recent change in the board in the parent management company; and the ongoing influence of the other major hospital facility (publically run) in the city – in driving management behaviours and strategies, and hence in driving developments in the management information space in the case study facility.

In CS 4, one informant noted that some external drivers can have internal mirrors or effects – e.g.- the DH XXX report (a kind of government initiated performance report) may pique the interest of the CEO, and hence may drive new or revised internal managerial information needs; as may an external accreditation process. Another informant noted that much technology innovation (except e.g. - PACS) in health is not specific to health - it is generic - and hence at least in relation to technology drivers, these are mainly external. Another informant described the poor financial state of public healthcare, and blamed this for a decision to reduce internal IT funding.

Finally, in CS 5, one informant observed that often external forces are “very general” and by inference wide reaching. They noted that the "prevailing mood in the community can have a local effect". They also noted that “even some external forces can interact with and thru local ones”. They then gave the example of the need for a cancer hospital to now do elective (non-emergency surgery) waiting list reporting to government, which it previously did not have to do. This is quite synergistic with the local need to treat cancer patients urgently.

Another informant noted (at least in the public health system) the external (government) to internal (hospital) funding interplay; and that in turn the government expects that a hospital manages their finances appropriately. Yet another informant gave a more general answer, noting that “an extensive interplay exists”.

The CEO of the Software Company described an external to internal effect in both financial imperatives and quality performance, as well as in the area of technology advances in the broader environment (external to internal influences). The vendor also expressed a view that there are “a lot of external messages (that are) driving things” in the environment – e.g. - marketing messages from vendors and manufacturers. In addition they believe that in the private sector there is peer pressure - "what are they (competitors /neighbours) doing?" An example is from this vendors user group (UG) – some health services are happy to hear what others are doing, but not so happy to share ideas. The vendor CEO went on to say that he has seen a paradigm shift in this regard – e.g. – a major private healthcare provider publishing safety and quality data from this vendors systems in a public way.

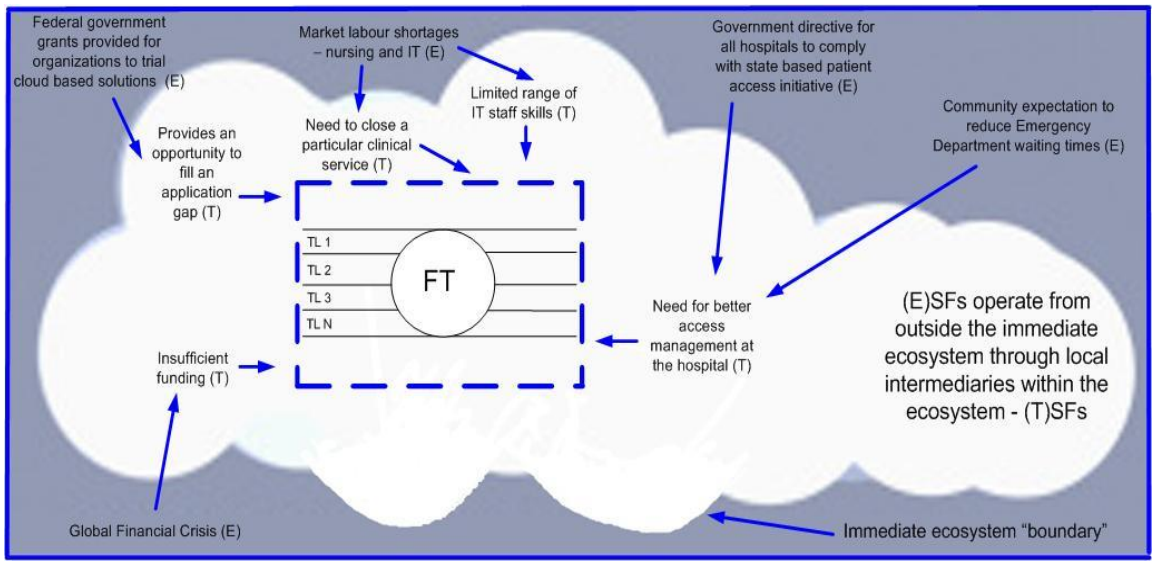

Figure 5- Relationship between ESFs and TSFs

In Figure 5 (see previous section) are a number of examples of how ESFs can act through TSFs (their local intermediaries) to impact upon a given HOME. This proposed extension to the base TEM is supported by the evidence from both the literature and the CS'. In addition, it is quite consistent with the statements of Adomavicius et al in describing their view of the TEM as a lens to be applies to a particular focal technology and context. In fact this view **reinforces** the need for an extension such that the effect of general external forces (ESF's) can be individually contextualised to the particular focal technology and context (in a specific ecosystem view), through the roles of the relevant local equivalents (TSF's) – acting inside the immediate ecosystem boundary.

Summary - Does the TEM apply to a hospital management environment?

- The PAS is a plausible FT – there is good evidence to justify this
- There are a number of describable TLs and TRs
    - Fulfilling the C role and sitting in the same layer are the following technologies – Patient monitors, PDA's, Servers and Integration engines (weaker evidence),
    - Fulfilling the P and A role and sitting in the same layer are the following technologies – PAS, LIS, RIS, AIM and ORIS. In addition it can also be argued that Executive dashboards and Reporting systems sit in this layer.
    - Fulfilling the S and I role and sitting in the same layer are – Network services generally and Wi Fi services specifically
- There are numerous TSFs, some of which are also relatable to more broadly acting ESFs – these (ESFs) are a justifiable extension to the base model
- There is potential interaction between ESFs themselves, between TSFs themselves and between ESFs and TSFs
- The concept of directionality of TSFs can be recognized

If so then how does it (the TEM) apply (to the hospital management environment) - for instance, could it be conceptually related to the arid zone biome?

An initial analogy that may have adequately represented the proposed HOME (Appendix 1) was that of the arid zone biome. This was postulated to be on the basis that there are few species (truly integrated technologies), that operate in a dry and barren environment (arguably lacking in innovation and primarily concerned with basic organizational functioning) which has very little rainfall (poor funding dedicated to this area compared with say clinical systems or more “sexy” applications like PACS)

Interestingly, the dominant view amongst all KIs when looking across the 5 CS', was that the biological analogy best applied to the HOME was the coastal ecosystem, with its sense of being exposed to the elements of tides and winds (arguably the many forces acting on hospitals from outside their walls) and needing to be especially adapted to survive the water, wind and salt in the environment (constant demands of, and changes imposed by, funders, policy and law makers; and the constant and growing pressure to deliver more services with relatively less money).

Certainly the literature contains several papers that support this concept. The sorts of "environmental" pressure alluded to here are evident in papers describing financial forces (Pelletier et al., 2005, Oliva et al., 2004, Fang et al., 2006), governance forces (Demiris et al., 2007, Chiu et al., 2007) and service level expectations (Reddy et al., 2006).

An initially confronting feature is the *complexity* of the environment. It would appear clear from this review of the health literature and subsequent analysis, that the perhaps the core of this is that the HOME has many, many species in it, and forces operating on it, possibly reflecting a range of climates- but without extremes that minimise the number of species that can survive.

The *role of government* in terms of policy, compliance and funding is critical in this ecosystem, even in private hospitals, as the state usually has overarching responsibility for the quality and outcomes of care irrespective of the nature of the institutions in which it is delivered.

Put simply, perhaps the biological ecosystem that is the best analogy for the HOME is one that

- has many, varied species
- enforces that the species within it are especially adapted for survival
- endures a wide variety of climatic conditions
- provides a large range of services to a large key "user group" and
- exists in a very constrained (arguably geographic) location
- is open to severe external forces

Clearly this assessment represents an initial postulation at this stage in the evolution of this area of knowledge. Further work, beyond the scope of this PhD should be undertaken to validate this initial proposal. In particular, further validation of this postulation against known biological ecosystems needs to be carried out.

Summary - How does the TEM apply to a hospital management environment?

- The biological ecosystem that is the best analogy for the HOME is one that
  - has many, varied species
  - enforces that the species within it are especially adapted for survival
  - endures a wide variety of climatic conditions
  - provides a large range of services to a large key "user group" and
  - exists in a very constrained (arguably geographic) location
  - is open to severe external forces.
- Quite plausibly the HOME is analogous to the "coastal ecosystem"

What are the key characteristics of the TEM in this context?

Really what this question is asking is – what does the literature say about the environment that the TEM is attempting to describe (through the existence of a postulated HOME), and in what ways does the literature do this?

When one considers many of the CS responses, particularly in relation to Questions 11 and 13, there are some interesting patterns that emerge regarding the plausible characteristics of a TEM in this context (or in other words of a HOME). In the answers to Question 11 there were a wide range of responses in terms of a score out of 10 (how successful have their HMIS' been in assisting the management of hospitals?) both across systems and across sites - such that even individuals provided scores from 2 (not very successful) to 10 (highly successful) depending on the system(s) they had in mind.

The other interesting pattern, in relation to Question 13 (do you think these HMIS' have changed in recent years ?) was that again, across systems and across sites, the answers typically ranged from a 3-5 (no change, through to very positive change).

The overall conclusion to be drawn from these patterns of responses is that in the eyes of the KIs, the proposed HOME has evolved in a positive fashion in recent years, but that the nature of that evolution has been patchy in its effect. It could be argued that this is analogous to say all the trees in a given ecosystem being stunted in their growth, whilst all the smaller plants and grasses, and the animals, continued to thrive.

As mentioned previously, there is an insightful quote from the Surgery and Nursing Executive at site 4 that stated "hospitals operate in spite of, not because if, a whole host of things". This quote in some ways summarizes the patterns of answers to the questions described above.

This concept of an evolving environment is also supported by the findings in the literature (see Table 56). For example Haux (Haux, 2006) alludes to the ever changing healthcare landscape, and especially now in the context of an ageing society. He refers to the "steady increase of new technologies to be included" in the health information system environment as part of that evolution. Acharya and Kumar (Acharya and Kumar, 2012) describe the "massive advancement of mobile computing" in recent years and how it, with developments in mobile computing had led to "new possibilities in the healthcare sector".

When one cross references the CS findings above with these examples from the literature, the picture emerges of a modelled environment which can adapt to change- for example by incorporating new technologies - and that does indeed adapt. However arguably these adaptations are not all positive or complete in their final instantiation.

In looking back at the key article by Heeks (Heeks, 2006), perhaps the state of affairs described above occurs because of the sorts of factors outlined in his "design-reality gap" construct.

Summary – What are the key characteristics of the TEM in this context ?

- The TEM in this context (the HOME) is characterised by
  - a strong need to be able to evolve
  - a history of such evolution
  - a tendency to evolve in various dimensions to differing extents and with differing outcomes (sometimes positive, sometimes negative)

What are its strengths and weaknesses?

The strength of the proposed HOME, as outlined in answering previous questions, is that it provides a detailed model of the various key parts of the hospital management

environment, and particularly as it pertains to its technological components and the various forces operating on them.

The flexibility of the model appears to be good. In saying that I am specifically referring to the fact that the model that has been established, has been formulated from not only a wide range of literature, but also from 5 different CS' with a high degree of variability of context (with the possible exception of CS 2).

Herein lies a weakness as well however. The fact that each CS revealed a somewhat different view of what a HOME could be (as opposed to 5 quite homogeneous views), it ultimately will still need further validation of the output of this research, in new and different hospital environments, to feel increasingly reassured about the broad based applicability of the core construct. In some ways however, this is the very nature of IS theory.... this new theoretical model will be examined, refined and potentially expanded upon; just as this research has performed these very functions in relation to the original TEM. The pattern just described above however, does clearly point away from the existence of a hospital management technology **biome** at this stage.

The work by Brender et al (Brender et al., 2006) that looks at systems success and failure in health ICT suggests a particular strength of the HOME. Their findings were of a large range of factors affecting the success or failure of such systems. The HOME as described to date in this thesis allows a theoretical setting for much of that complexity to be explored. As per the original TEM, there is no a-priori limit imposed by the model on how many technologies can be viewed within it, or on the numbers of TSFs or ESFs involved, or indeed their directionality.

Similarly, the diversity of the environment asserted by Fichman et al (Fichman et al., 2011) can be well explored by the HOME.

Summary – What are its strengths and weaknesses?

- The TEM in this context (the HOME) has some of the following strengths
  - deals well with the complexity of the real world
  - has a high level of flexibility and is adaptable to multiple settings (at least based on the evidence to date)
- and at least one weakness
  - needs further validation in a broader range of hospital settings

How valid and useful is the model for analyzing an HMIS infrastructure ?

I believe the picture created around the proposed HOME in answers to all the previous questions leads us to conclude that the TEM ((through its context specific instantiation as the HOME) is both a valid and useful model for analysing an HMIS infrastructure. It is important to note here that I am using the term infrastructure in a broad sense and am not limiting its meaning to the traditional one in this context of hardware, cabling, wifi and networking.

In the course of the thesis I have outlined how the evidence points to a FT, and several related technologies all sitting in a P and A technology layer. In addition I have highlighted other TL's (the C layer, and the S and I layer) with their own roles as evidenced by the research findings. Importantly also the key concept of TSFs has not only been found to hold true but has also been extended to include the important related concepts of ESFs, and directionality of TSF's.

This last point is critical given the CS findings suggesting - at multiple sites - that informants believe the environment I have examined to be heavily driven by forces outside of their immediate hospital context - such as government policies and regulation, and of funding from parent companies, insurers and government. Given that such forces will operate - for example in the public health system - on many hospitals, they fit the bill well as ESFs. This extension means the HOME is particularly well placed to be of use in examining an HMIS infrastructure. As highlighted previously, there is a strong literature base supporting the above CS findings.

It is also important to note that, based on the 5 CS' in this research, and the fairly exhaustive review of the literature; there are no glaringly obvious other frameworks through which to specifically analyse the HMIS environment in this way. Similarly there appear to be no commonly used (as opposed to "potentially able to be used") planning tools to assist with planning in this environment. This later point will be explored in more detail in a latter question. Given the above findings, this increases the usefulness of the model in this space.

Summary – How valid and useful is the model for analysing an HMIS infrastructure ?

- Based on the evidence in this research, the HOME model is very comprehensive, and supports deep and broad analysis of the HMIS infrastructure in any given hospital

- It is necessary next step in using the HOME model to further expand its theoretical foundations, and to assess its practical application in a prospective sense.

How does it (the TEM) compare with other IT planning lenses?

There are some articles from the literature that outline different world views or approaches, pertaining to how organizations can, or should, go about making IT

planning decisions. There is however, very little evidence of a systematic approach to this issue from the hospitals described in the CS'

There is an argument that says that many organizations do not have a robust and established mechanism for planning their IT and IS developments and investments (Hosseini, 2005). Albeit this article comes from the non–health literature, it is a useful counterpoint to the limited literature in this area in the health domain. In this article, the authors state: "Despite advances in the development of new applications, many organizations are not able to embrace these new technologies mainly due to not having devised an appropriate plan to position themselves technologically and organizationally to incorporate these technologies. In many instances, organizations are even crippled to take advantage of the new competitive systems, because they lack the right standards and or suffering from old, mismatched and antiquated systems that they cannot get rid of easily. The road map will provide organizations with specific technical requirements for the immediate needs as well as a migration path to "plug in" the component and the products the business is moving towards."

In support of this argument, Demiris et al (Demiris et al., 2007), in their survey of US Critical Access Hospitals, found that half of their respondents (total n = 27 hospitals) did not have an IT plan. It is important to note however, that this survey was focused on small hospitals by definition.

As a counterbalance to this view however there are many organizations, including some hospitals, which have not only established roadmaps or other planning frameworks, but have also published them publicly. In fact, a 1999 article by Gottschalk (Gottschalk, 1999) even analysed the strategic IT plans of 190 companies. Again, this is not a health specific piece of research, but it goes to indicate that IT strategic planning is not such an unusual concept and perhaps suggests that there is a gross lack of evidence of the existence, or at least the published evaluation, of such plans in the health IT context.

In relation to the case study evidence, I note that the there was a dearth of insights provided into how organizations, and individuals within organizations, go about planning in the hospital management environment. The one notable exception was Site 1 that actually was able to provide an artefact that demonstrated (in a high level way) their approach to planning when it came to technology in the organization.

From the literature review, the work by Hadzic and Chang (Hadzic and Chang, 2010) is clearly the most closely related conceptually to the use of the HOME model as an IT planning lens. By way of illustration they state: “Various digital health species (DHS) can be designed and interconnected to form a collaborative network and link different hospitals, health services, general practitioners, pharmacies, health systems, health information resources etc., thereby producing outcomes that are highly beneficial for all parties involved.” The parallels should be quite clear form this quote. It would be an additional interesting piece of research to examine in detail the relationship between these 2 conceptual models in greater detail, especially in relation to how they may work in assisting real world health IT design and planning decisions.

Summary - How does the TEM compare with other IT planning lenses?

- There are very few relevant planning lenses that have been identified in this research with which to compare the HOME model
- The most closely related is described in the work by Hadzic and Chang
- The view to date from this research is that the HOME could well fill an important gap in this space, both conceptually and practically

Question Set 2

What is the definition of ecosystems success and failure in this environment?

Based on the previously stated definition of ecosystems success and failure, namely the temporary or permanent failure of an ecosystem to provide its services, there are a lot of useful insights available from both the CS' and the literature in relation to this issue.

Firstly, however, before I can define success or failure in the HOME context, there must be a consideration of what are the services than can be plausibly expected from this ecosystem.

A reasonable place to start in this regard would be to consider what services the "recipients" currently receive or think they ought to receive from the ecosystem. In this case the most obvious recipients are those key informants with which I spoke - namely, the operational managers, clinical managers, quality and safety staff, executives, bureaucrats and technologists that comprise the group of informants interviewed in the CS'.

In turn, a good place to start in trying to understand ecosystems services as they pertain to the proposed HOME is in the responses to Q 13 and 14 in each CS. In CS 1, 5 of the 7 informants (Q13) clearly felt the environment had improved in recent years. In ecosystems terms, the inference therefore, is that they are receiving the services they require from the ecosystem. Let us now consider what those services look like. Some plausible services they described are

- accessible, readily used technologies
- systems tailorable to the needs of individuals
- less dependence on paper and more automation
- more workflow support
- more personalised information tailored to support action (Manager Performance and Activity)
- more functionality in systems

CS 2 did not really add to this list but in CS 3, 4 of the 6 informants again felt that the environment had improved in recent years. Plausible examples of service here included:

- more accurate and timely reports

- again the theme of accessibility was mentioned - including to more systems and at more sites
- better access to computers
- greater integration between systems.

At Site 4 (CS 4) some similar candidate services were evident:

- greater accessibility of systems and data – e.g. - through mobile devices
- systems that are more intuitive to use
- data in more understandable formats
- more open design of systems that use appropriate standards e.g. - HL7
- improved GUIs
- more specialisation of systems (vendors not trying to "do it all")

CS 5 reinforced some of the above candidate ecosystems services from the HOME. E.g. - more integration between systems.

Having established plausible ecosystems services that the HOME could argued to supply, let us now explore the findings of the CS' for examples of failure of the HOME to provide these services (thus representing ecosystem failure in this context). Responses to Questions 13 and 14 will again offer some insights into this issue, especially where informants felt that the environment had not "improved" in recent years, as will the responses to Questions 19 and 20 which specifically focuses on the unmet needs of hospital managers.

In relation to Question 13 in CS 1, the Clinical Service Manager noted the issue of arguments over data integrity in relation to FTE figures. In relation to Questions 19 and 20 the following were some plausible examples of ecosystem failure:

- too much data for managers, and not enough information which is not personalised enough for consumption by them
- this is compounded by too many systems with which managers need to interact to obtain this information
- in turn there is a mismatch between the current skills of users (e.g. – NUMs) and the demands placed upon them in relation to systems use
- there is also inadequate training on, and support for, key systems and finally,

- workflows are not always well supported by these systems.

In CS 2, in addition to the findings above, another possible example of HOME failure was inadequate help desk support for systems.

At the third site (CS 3), the Director of Ambulatory Care described ongoing problems with insufficient integration of systems (Questions 13 and 14). In Questions 19 and 20, some of the following were put forward as failures of the HOME:

- arguably too much data is collected and it is difficult to obtain precise information and the specific information needed amongst all the "noise" - especially in relation to predicting future events
- there are still issues with timeliness of information
- there is doubling up of data entry into systems
- insufficient functionality
- lack of integration of systems
- disparate access points for information
- disparate versions of the truth in relation to information
- poor workflow support
- insufficient training of users

In CS 4, responses to Questions 13 and 14 did not add much in relation to HOME failure, but there were some important insights from responses to Questions 19 and 20:

- lack of hardware (in a broad sense - including. end user devices)
- too much information
- unclear sources of truth and repetitious data
- insufficient system integration / implied data linkage – e.g. - time and attendance data with payroll data
- extra work required to obtain information (e.g. through auditing of the medical record) when it could be a by-product of the care process
- insufficient data quality
- poor primary data collection
- poor support for prediction – e.g. of bed occupancy
- poor application literacy leaving managers "left behind"- perhaps associated with a reduction in available training courses

Finally, in CS 5, in relation to Questions 13 and 14, the CNM mentioned "failures" in some sub areas of the HOME. For example, they felt that there was insufficient functionality and or business rule support in PAS' and Finance systems. Again, Questions 19 and 20 provided significant insights on this issue. The informants highlighted the following plausible examples of ecosystems failure:

- insufficient correct and appropriate information provision to users (versus data- there is often lots of this)
- insufficient training for users
- insufficient education for managers about how to use data and what questions to ask of the data and analysts
- insufficient integration of information to give a view across the scope of management of some roles – e.g. - across community care and ED for some managers / executives
- lack of functionality - e.g. - even basic pre population of demographics into systems
- too much data collection and resultant information - hard to filter out the noise

There are some examples in the literature of plausible examples, that are also consistent with the biological correlate previously established- of ecosystems success and failure in the HOME.

Heeks (Heeks, 2006) makes the case for health IT (HIT) project failure being a common phenomenon, and proposed a tool to remedy this situation. Kaplan and Harris-Salamone (Kaplan and Harris-Salamone, 2009) also described numerous examples of HIT system implementation failures. System failures can be defined in various ways, but in the context of this research, such failures are both drivers and examples of, partial (usually) or complete (rarely) ecosystem failure, depending on the specific circumstances.

Summary - What is the definition of ecosystems success and failure in this environment ?

- Based on the findings of this research, ecosystem (HOME) success in this context is the reliable provision of access to the required or expected ecosystem services. In the HOME such services include:
  - reliable access to necessary systems (e.g. – reporting systems)
  - access to usable and accurate information to support hospital managers needs
  - access to just the right amount of such information
  - timely access to such information
  - usable functionality in the relevant systems
  - support for managerial and administrative workflows
  - tailorable interactions with systems (e.g. – user driven GUI customisation)
- Ecosystem failure conversely, is when these services are not provided reliably, fully or at all.

What are the factors affecting ecosystems success and failure in this environment?

An important consideration in answering this question of what are the factors affecting ecosystems success and failure in the hospital management environment is to not confuse these factors, with the concept of environment, and technology, shaping forces. An important distinction here, I would contend, is that environment, and technology, shaping forces operate at a higher level (and ESFs globally thru TSFs locally). Whilst these may in turn influence the perception or actuality of success or failure of the ecosystem, they operate at this higher level and only impact locally through intermediaries. These intermediaries are ultimately the more precise, or local, factors

affecting ecosystems success or failure in the environment. Figure 6 below, offers a visual framework through which to explore this issue.

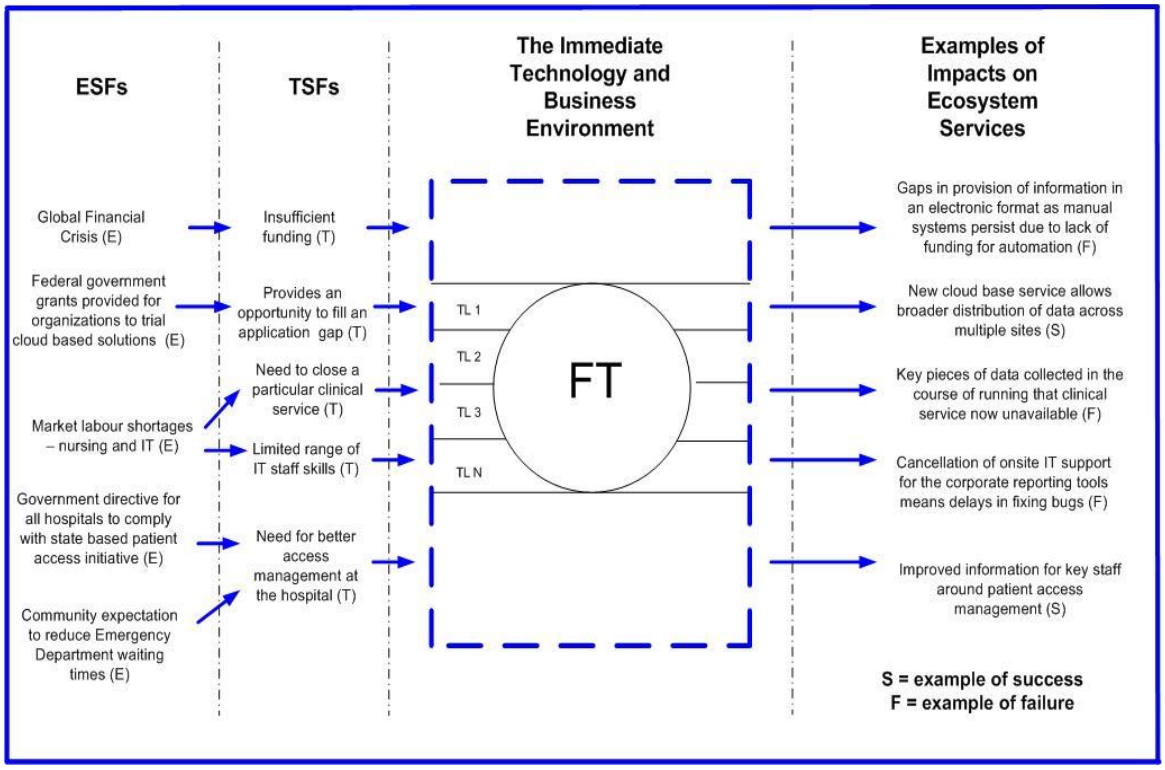

Figure 6 - ESFs, TSF, and Ecosystems Success / Failure Drivers

Let us now consider this issue with some evidence from the literature. If I take the example of the work by Bahensky et al from 2009 (Bahensky et al., 2011) , they offer some interesting insights into health IT implementation in US Critical Access Hospitals (CAHs). In this particular research they establish a clear relationship between having appropriate IT staff in a given hospital and the types of technologies that may be ultimately used in that hospital. In their survey of IT capacity at these at CAHs, they found that many such hospitals report having difficulty expanding upon health IT functionality is due to the challenges of finding appropriate qualified and experienced IT staff, in particular staff with exposure to the health industry.

Bringing that back to the question at hand, even though good systems may be in place that in theory can support managers in their jobs – hence this part of the ecosystem could in theory provide appropriate services to the users- the lack of appropriately experienced staff may mean that the system is a optimally implemented, or not well supported, or not supported in a way that fits with the business needs of hospital managers. This is an example of a factor that could potentially affect the success or failure of an ecosystem of a hospital management technology ecosystem or part of it. If I cross reference this with Figure 6 above, it could be argued that that a global (in the

sense of beyond the hospital) shortage of relevant staff (ESF) could lead to a local inability to employ relevant staff (TSF). The resultant local factor could be expressed as no one being available on site to run a key help desk function, (local factor driving failure). As a result that that function is then foregone or replaced by a less optimal function (e.g. – off site telephone support). In turn this could well result in failure of an existing ecosystem service (constant, reliable access to a key system).

With respect to the factors affecting ecosystem success and failure in the proposed HOME, the case studies shed a great deal of light on these. In CS 1, particularly when referencing questions 10 to 12, the informants provided some useful insights. The Human Resources Manager described shortfalls in the current environment stating that "the programs rule us". They described the lack of functionality which they attributed to insufficient funding. The Manager of Patient Safety and Quality referenced insufficient training to users, and the Manager of Performance and Activity referenced a lack of knowledge or skill mix and experiencing decision-makers, the implication here being that even with the best systems in the world, inadequately trained users or inadequately skilled users may not make the best of them.

The Clinical Service Manager referred to a problem with data entry errors, which when extrapolated to decision-making can cause major financial shortfalls. The IT Executive made a statement which really supported that of the Manager of Performance and Activity, namely that sometimes there is a lack of understanding and training regarding how to use systems. Each of the things mentioned above can plausibly act as factors affecting ecosystems failure in this environment.

It was not all the gloom and doom however; the informants in CS 1 also noted some positive change in the environment in recent years. The Human Resources Manager referred to a greater embracing of technology driven by the demographics of staff - i.e. younger staff coming in and thus reflecting a broader societal uptake of technology. The Manager of Patient Safety and Quality referred to increased user-friendliness of systems, and the Manager of Performance and Activity referred to improved governance structures around the systems, so that feedback from users regarding relevance and utility of information could be provided.

Examining responses to Question 19, it seems that inadequate funding is an influencing factor towards ecosystems failure. It was mentioned by the Human Resources Manager

who specifically noted that there was a prioritization of functionality provided to users because of cost and other trade-offs. Another driving factor towards failure identified by the same informant was the lack of support and training for users who might have to interact with multiple systems, and the fact that they also need multiple logins. Insufficient financial and other support for training was also raised by the Manger of Performance and Activity. The Manager of Patient Safety and Quality also noted the downside of a wide "dispersal" of systems such that managers need to look across multiple places to obtain the full range of information they need to do their jobs.

The General Manager described the phenomena of low accessibility to information, and "clunkiness" of systems, versus for example, easily navigable web-based systems. The same informant described the work environment as not being like the home environment in relation to the available technologies, and the ease of interaction with them. The implication here is that tools available in the workplace are not as easy to use and intuitive as those available in the home environment. The Clinical Service Manager noted the lack of ability for her less trained and skilled users (in relation to technology) - for example, Nurse Unit Managers (NUMs)- to drill down in relation to information issues on their own, without the need of support from analysts. They also described the phenomena also of "too many gauges and not enough levers".

Finally, the Nursing Executive described the phenomenon of not enough personalised views of information tailored to an individual's role or ability; and the IT Executive described the phenomenon of too much data and not enough information – this "(unprocessed) data overload" is a theme that resonated with many informants across multiple CS'.

Let us now consider the CS at the Outer Metropolitan Hospital (CS 2). Again some very useful insights were obtained from this site in relation to the factors driving success or failure of the proposed HOME. Again the responses to Questions 11 and 12 are a good starting point from which to consider these factors driving success and failure in the ecosystem.

The main insights to be gained here (to add to those from CS 1) are from the Hospital Executive. They noted that the ability of the systems under consideration to assist in the management of hospitals and varied enormously with the system. This informant felt that a lack of integration between systems, and an inability to deal with variations in

standard situations (e.g. – how do you enter details regarding temporary nurses; how do covering managers use the systems) as factors driving towards failure where failure occurred. In relation to success, factors affecting success were identified as the precision and reliability of information to fit with management needs.

At the conjoined metropolitan hospital in CS 3, the Director of Quality and Safety identified several important factors affecting success and failure. Firstly they identified data integrity and quality is an important driver of confidence in the information being presented by the environment (success). They also noted that accessibility of information was a driver of relative success or failure, commenting that it was easier to have “numbers” and other results pushed to them (e.g. – via email) rather than having to chase the results themselves.

The Director of Corporate Services again noticed noted a mixed picture, in their opinion, in relation to the relative success of the systems in supporting hospital management. They noted the lack of integration between systems as a driver of failure, leading to double data entry on occasions. In addition a mismatch between computer literacy and the level of interaction expected with systems was a driver of failure in the proposed HOME. They felt that underpinning this, an assumption is made that everyone is or is becoming computer literate. In fact in their particular domain of control, there are numerous staff members who come from relatively un-educated backgrounds.

The ED Manager at Site 3 made an interesting observation as an indication of a factor driving towards failure. They noted "that we change our practice to suit systems", despite the fact that they believe that in relation to the systems "they do the job". They believe that better integration between systems and supporting more efficient functioning of the hospital, would be factors driving towards a picture of ecosystems success. In relation to Question 13 the Director of Quality and Safety felt that these systems have improved in recent years in their ability to assist the management of hospitals – rating the change a 4 out of 5 i.e. a clear positive change. In expanding on this in Question 14, one of the drivers towards positive change they identified could be more of giving managers what they want, as opposed to what people think that they want. This talks to the likely inadequacy of the requirements elicitation and documentation processes, and even to concepts such as the potential benefits of participatory design.

Also in relation to Question 13-14, the Director of Corporate Services noted positive change in the range of 4-5. They specifically commented on more hardware and better access to computers as a driver of this improvement.

At the Large Regional Hospital in CS 4, additional insights were provided. The Director of Governance and Risk provided some interesting insights, given they particularly felt that the systems had not improved in their support of hospital management. They raised factors such as the loss of corporate knowledge that the departure of key staff had brought. They also raised the issue of the subsequent loss of efficiency as people (Manager-users) who do not know regarding important information sources, will need to second-guess where to find information. Here, the plausible factors driving the perceived failure of the HOME are that loss of corporate knowledge, as well as a lack of transparency about where to find information.

In response to Question 13 the Surgery and Nursing Executive at this site described how now, more data was available in more understandable formats than previously possible. They believe that this presentation of data in more usable ways has been a driver of relative success, given that they rate the change in the environment in recent years a 4 to 5 -meaning quite a positive change.

In CS 5 (the Virtual CS), more useful insights were provided. For example the CEO of the Software Company felt that the ability of the relevant systems to support the role of hospital managers at this time was about 6.5/10 When questioned on this further they felt that a key driving factor of the perceived relative failure of the environment, was the fact that people spend time on "the next big thing" rather than orchestrating well the systems that already exist in a given environment. Expanding on this, they felt that people don't have the time to do this “orchestration”, nor spend time on it (this activity of orchestration) when they do have time. Their (the CEO’s) philosophy was that it’s better to have a core number of applications working well, rather than focusing on the next big thing, as then there are fewer staff and dollars required to manage the environment. In addition it is also then easier to keep staff educated regarding the systems, and it reduces the training load.

Summary - What are the factors affecting ecosystems success and failure in this environment?

- In effect these are the most local intermediaries of TSFs (which are themselves intermediaries of ESFs in many cases)
- They include but are not limited to things such as
  - direct funding shortfalls for individual technologies
  - lack of staff training in specific technologies or pieces of software
  - using off site support models for particular products – which in some cases may cause delays in an individual's access to help or even mean it is not available at all (e.g. – if the support office is based in a different time zone)
  - incomplete implementations of a given software product – e.g. – not buying, or not implementing, all the useful modules for various reasons

How can stakeholders benefit from the application of the TEM to the HMIS environment (via a HOME model)?

In this section of the thesis let us consider how stakeholders can benefit from the application of the TEM to the HMIS environment - via the validation of the existence of HOME model.

In order to do this let us first consider who the stakeholders might be – I have spoken to many examples of them through the case studies. Obvious candidates for the stakeholders are the hospital executives and managers who are predominant users of the services of the ecosystem. Government bureaucrats at different levels from federal to state to local health service area level are all potential stakeholders. Hospital IT departmental staff, and staff in hospitals using data for analysis are key stakeholders.

The IT community more broadly - particularly the vendor community – are also key stakeholders in this environment.

What of the role the patient in all this? Patients, I would argue, are only indirectly stakeholders of this environment as patients do not tend to interact directly with the sorts of systems and outputs that I have examined through the course of this thesis. Rather patients indirectly receive healthcare services – be they good or bad - off the back of the environment managed by the managers mentioned above. This is a somewhat simplistic view however, as there are multiple other drivers, somewhat out of the hands of these managers, that affect the relative level of care patients receive. Also it should be noted, that in Australia the standard of healthcare is excellent on the whole. Obviously the key factors out of the hands of the managers and executives at a hospital level are the skills and abilities of the individual clinicians providing that that care. Managers do however have a strong influence over how resources are used and distributed in relation to providing care.

Whilst many of the assertions that follow will be tested under that bright lights of real world examination, and also through further research efforts, I would argue that there are several ways that immediately come to mind in which stakeholders may benefit from the proposed HOME model. Firstly the model provides a conceptual framework describing this entire ecosystem, the systems within it, the forces operating upon it, the factors affecting its success or failure, and indicators of that success or failure. The key stakeholders of the environment have never had such a model at their disposal previously.

As a result, these stakeholders will be able to better identify and understand the driving factors of evolution in the environment. I do note however, that this is where further examination of the relationship between this work and the concept of "paths of influence" should be undertaken in the future. Despite this, the relevant stakeholders with their different perspectives, will be able to use a common understanding of the technology and environment and technology shaping forces working on the environment, and in addition of the drivers of local ecosystems failure of success and the indicators. So drivers such as financial and governance drivers, and the level of integration of systems; in turn affecting success or failure indicators such as ease of access to integrated information, use of information and so forth.

Let us examine the concept of success or failure further as it pertains to stakeholders. This is the first time that particularly the end users of services of the ecosystem - that is to say hospital managers and executives – will be able to refer to objective success or failure indicators as established in this research, through which to articulate to relevant others the extent to which the individual ecosystem in their hospital or hospitals is functioning well. So for instance they can reference this research, and the conceptual model encompassed in it, when talking about lack of timely access to information, lack of integrated systems and information, multiple logons to disparate systems, and so forth; rather than risk having their concerns seen as a listing of vague complaints from a wishfully thinking workforce.

To extend this concept further, this research acts as a reference base that these key stakeholders can use in mounting arguments for programs of work around, or investment in, the environment. So for instance, there are several examples elucidated in this research where lack of funding is specifically seen as a reason for failure of the particular service to be provided - for example there has been specific reference made regarding the trade-offs in functionality provided to managers because of inadequate investment. Whilst the real world is often constrained by financial issues, this research is now independent evidence that these managers can use, that highlights how the trade-off choices made in this context can have a major impact on the services provided to them from the ecosystem. They can use this research to translate their concerns into evidence and language that funders may understand, thereby increasing the likelihood of having their concerns addressed.

An example from the literature allows a further exploration of these issues. The work by Anema et al (Anema et al., 2013) on hospital information systems and indicator data collection in Holland which was published in 2013, is of significant relevance. These researchers used a survey of 42 hospitals and data from a Dutch national quality database, to assess the issue of data integrity and systems to support national indicator production. As background to their work they make an interesting observation that for performance indicators (PIs or KPIs) in health care to be reliable, as in in any industry, the data underlying the indicators needs to be complete and accurate, consistent and reproducible. They note the lack of regulation of the underlying the systems in the hospitals of that country, and hence the likely heterogeneity in relation to how data is collected for indicators and computed prior to transmission in system based on self-reporting. They quite rightly point out that this may affect the veracity of the national

benchmarking initiative. These issues would also apply to any similar initiative in the Australian context, or in many other countries. An important caveat here, however, is that these researchers are talking about self-reporting of indicators, versus the generation of indicators centrally through mandated centralised data submissions against defined criteria.

The findings of the research where indeed that, when looking across a number of clinical areas, including hip and knee replacements and cancer care – in particular breast cancer care - there was quite a degree of heterogeneity in the indicators and their generation. This finding led to the conclusion that in some cases the indicator results were next to useless. Despite this study focusing on a self-reporting system, the authors make an interesting point that even when many quality indicator programs are heavily managed by a coordinating organisation (for example a local state government), the central control and standard-setting can only have its full impact when the underlying information systems in hospitals that source the data, have comparable data structures within their IT systems.

In the discussion section of their paper these authors conclude that the Dutch hospital data infrastructure (as it pertains to performance indicators) is heterogeneous. The relevance of this research is that the systems that collect, and potentially compute and transmit the data to a central body in this kind of an arrangement, are the same local systems I have considered in the hospital management technology ecosystem.

This is an important finding in relation to do this thesis. It provides an example of how if one looks at hospitals across a city, or across the country, the data systems under consideration here (inside hospitals) may vary quite substantially. Thus it highlights the potential role of the HOME as a unifying worldview through which to you view the systems and the individual contexts in which they sit. In turn, the HOME could allow an understanding, in a common way, of the drivers of the evolution of the relevant systems, and of the services these systems provide.

Summary - How can stakeholders benefit from the application of the TEM to the HMIS environment (via an HOME model) ?

- This is the first time a comprehensive model like this has been constructed for the use of the various stakeholders in this particular setting
- This means that the stakeholders will be better able to identify and understand the factor driving success and failure in this ecosystem
- As a result they will be better able to consider the viability of investment in this environment
- The HOME can also act as a unifying world view through which to examine diverse systems, and potentially also across diverse settings

The Research Model

In this section of the thesis I will revisit the research model proposed in **Chapter 3**, in light of the abovementioned findings.

Let us again recall the conceptual framework put forward in **Chapter 2 – Literature Review** – it was of the HOME model. I stated then that the aim of the thesis was to test the "hypotheses" that:

- **The Hospital Management Technology Ecosystem (HOME) is an identifiable entity with**
    - **At least one focal technology able to be identified**
    - **Several TR's able to be identified**
    - **Several TL's able to be identified**
    - **A range of TSF's able to be identified**
- **The existence of this HOME then acts a validation of the core TEM**
- **The HOME also demonstrates characteristics that allow the expansion of the core TEM**

.

In Figure 7 that follows I have produced a pictorial representation of the HOME model based on the findings of the research. In a sense this is a pictorial summary of the outputs of this research. It can be seen in this pictorial summary that each of these postulations has evidence in support of it.

Importantly, because Figure 7 is a pictorial summary, it does not represent all the detail of the model as outlined in previous parts of this thesis. For example, it omits the actual or potential relationships between TSFs, directionality of TSFs, and the detailed context specific instantiations of TSFs - being the factors driving success or failure of the HOME in a specific hospital context.

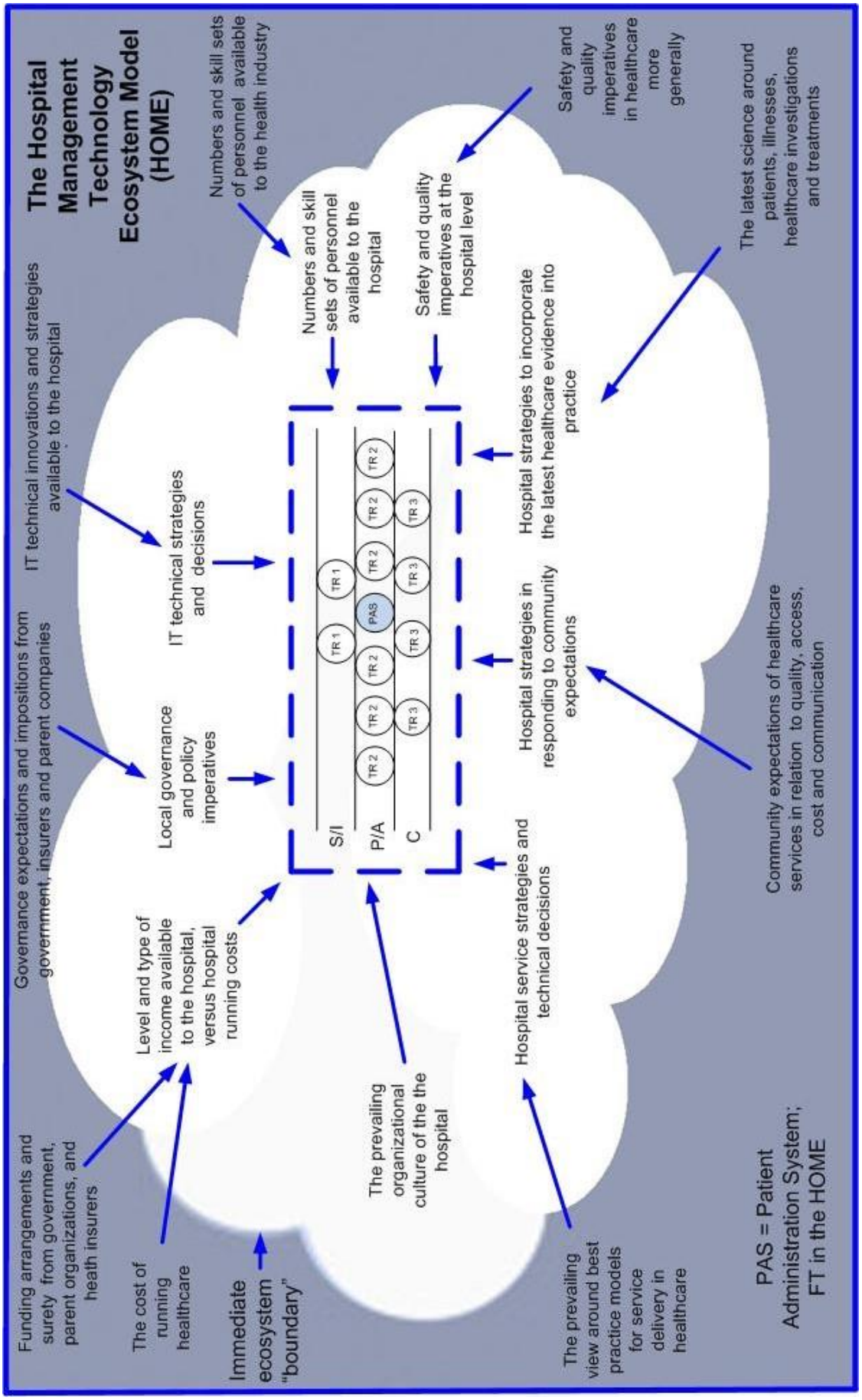

Figure 7 – Final Research model for the HOME in light of Findings

There is a substantial amount of detail that could have been included in Figure 7 in order to display the entire HOME model in one diagram. However in order to allow the content to be easily visualised and understood, I have also extracted some of the detail regarding the 3 technology layers contained with the HOME, and the various identified elements within those layers, and have represented it in Figure 8 below.

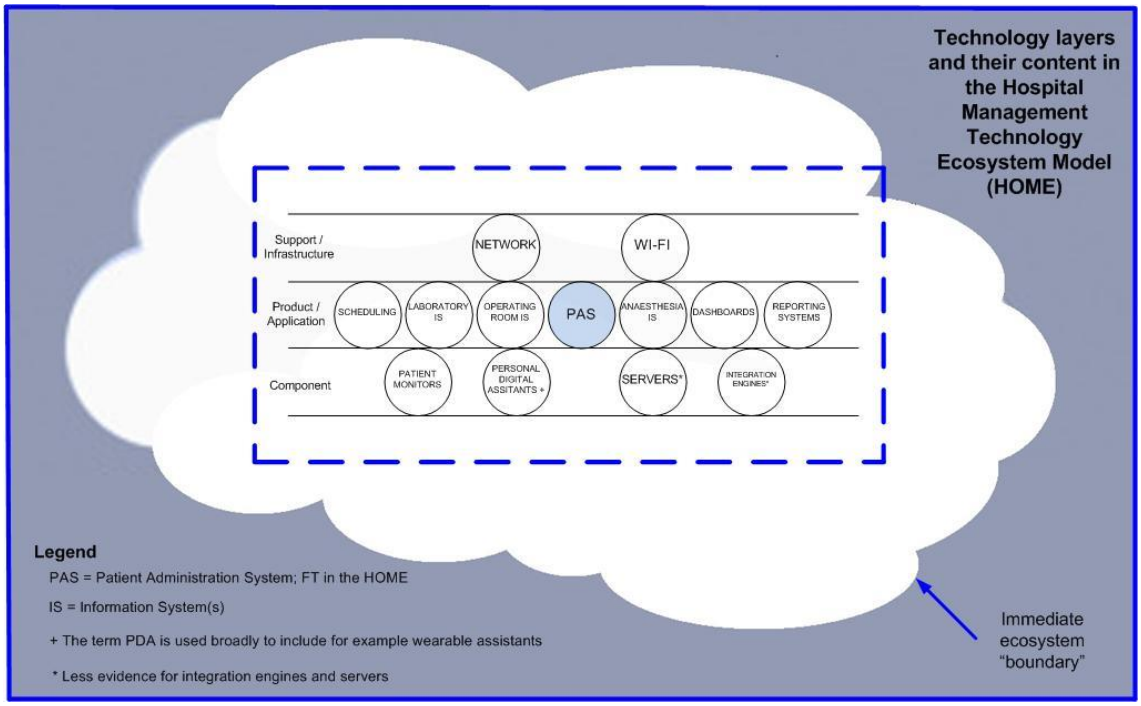

Figure 8 – The content of the technology layers of the HOME model

Figure 8 above outlines how there is evidence in support of 3 layers in the HOME model, with layers aligning to the roles identified in the original TEM.

CHAPTER 6 - CONCLUSIONS

In this, the final section of the thesis, I will take stock of what has been learned from the research, and reflect upon its contribution to the broader ISR discipline. Let me start by summarising the findings of the work.

Summary of the Thesis

In this thesis I have sought to examine the relevance of the technology ecosystems model to the health management context.

The work started by setting the scene regarding the role of hospitals in the broader healthcare system, and on the complex nature of managing hospitals within that system. It noted that both in private and public parts of the system there are complex decisions that need to be made on a daily, hourly, or even minute by minute basis by hospital managers, in order to deliver the best care within the desired time frames and resources, and in a cost efficient manner.

I have used a research approach heavily influenced by the interpretivist paradigm, although it also has elements of positivism. Clearly the use of biological analogy, as predicated by a consideration of the core technology ecosystems model, fits with the former. But also in using "thematic" analysis from case studies and the literature I have followed a similar paradigm. The positivist elements consist of an examination of the facts surrounding participants, their organizations and their characteristics, both at an individual level and at a hospital level.

The data collection and analysis approach used a mixture of CS findings and lessons from a literature review, that were triangulated in order to reach meaningful conclusions. The CS' were undertaken at 5 sites in Australia – 4 physical and 1 virtual. The literature review involved an examination of the IM, IT and IS IT literature sourced from key locations including the ACM and IEEE libraries. The heath care literature was sourced from the most definitive single healthcare literature source – PubMed. The resultant data was used to answer 2 core questions sets designed to comprehensively address the issues at hand.

In short the thesis has allowed us to arrive at several conclusions based on the approach outlined above. In summary the postulation that the technology ecosystems model is a valid one, and that it can be applied to the health management technology environment is confirmed through the findings of this thesis.

The research presented in this thesis is important as it seeks to provide a greater understanding of the hospital management environment, as it pertains to information technology and its use. The reason the research is important is that this:

- is a novel area of research from an IS perspective
- is one of the first attempts to validate the TEM outside of the work of its original proponents
- shows that the management if hospital is well recognised as a challenging area all across the world. It will also only get more challenging as demand for health services increases all across the globe, in conjunction with a parallel pressure to spend less on healthcare in relative terms in many countries and
- information technology can have an assistive role in supporting managers to acquire, process, store and display the information they need, to in turn support analysis and decision making in this complex and high pressure environment.

In the thesis I have examined the hospital management technology environment through the use of a series of case studies in the Australian context, and a review of both the information and health related literature internationally. I established the validity if the core TEM, through the establishment of a HOME, specific to hospital management. In so doing I have also described the HOME in great detail and established plausible extensions to the TEM theoretical construct - namely ESFs, directionality of shaping forces, and ecosystems services. I have not examined the TEM related concepts of technology evolution and paths of influence in any great detail in this work

In summary, this research has shown the TEM to be a valid construct, as evidenced by the establishment of the existence of a HOME and the creation of a model to describe it – the HOME model, itself an extension of the base TEM.

Key Findings of the Research

The key findings of the research can be summarised by the following points:

- The hospital environment is a complex one which is very difficult to manage and sits within an even bigger and more complex system (even within national boundaries, let alone across them) – namely the broader healthcare system.
- the TEM appears to be a valid model for analysing business and technology ecosystems
- TSFs exist and interact between each other
- TSFs can have directionality (effecting positive or negative influences on the environment)
- the core constructs of the TEM can be extended to acknowledge the existence of Environment Shaping Forces (ESF's) – these cause effects thought intermediaries – TSFs (and local drivers of success or failure in turn)
- the core constructs of the TEM can also be extended by an acknowledgment that, just as biological ecosystems provide services to human beings, so too can technology ecosystems as defined by the base TEM
- using the original TEM, a HOME can be identified in the hospital setting
- the HOME model appears to be a valid construct although it is stronger in some dimensions more so than others
- the HOME model allows the rich complexity of the real world business and technology environment of hospital management to be described, and hence better understood. This is particularly true in relation to the role of technologies that support managers in that environment
- the HOME, or any given HOME, provides services to human beings. In turn it operates with varying levels of success - from complete success through to complete failure- in regard to providing those services
- the HOME is possibly analogous to the coastal ecosystem (as defined in the thesis) in biological terms.

Limitations of the Study

Methodological Considerations

One of the key academic and theoretical considerations to be addressed, specifically in response to the proposal review by my peers was, what kind of research framework is being applied in this work. For example, is it using an interpretivist paradigm, or is it more positivist in its approach?

As stated previously, it could be argued that the use of the ecosystem analogy is interpretivist in nature, but that the use of the analogy in the way I have used it here is more aligned with critical research (Ngwenyama and Lee, 1997) as advocated by Jurgen Habermas.

It was the stated contention of this thesis that, as in other fields, the research philosophy adopted does not need to be seen in such black and white terms. Furthermore, it was my contention that rather than the research philosophy necessarily defining the approach, the problems or questions being addressed, and the context of those problems or questions, could equally define the approach used.

In reflecting now on this approach, I believe that it was a valid choice and has allowed a certain freedom of exploration of ideas and concepts that arguably a more rigidly positivist approach for example, may not have. I would say however, that in terms of further validation of this work, subsequent research could then benefit from taking a more traditional positivist approach as a counterbalance to validate the core extensions to existing theory that are at the centre if this thesis.

Another important point in terms of both a limitation of this research, and further research opportunities in the future, is the potential to investigate the role of "paths of influence" which were a part of the earlier TEM work (Adomavicius et al., 2007b). This concept underpins the use of the TEM as a lens through which to specifically examine technology evolution. Although there was much information gathered in the CS' that could shed light onto how technology in support of hospital management has evolved and will continue to evolve, it has been a deliberate strategy of the research not to investigate further the concept of "paths of influence". This was a conscious decision given that the focus of the work has been heavily on providing robust validation of the

original TEM through its instantiation in the specific context of hospital management. There is no doubt however, that there is a rich vein of research that could be subsequently explored in relation to this newly established HOME context by examining this key concept. This will only add to the future strength of the HOME model as an analytical lens through which various stakeholders could examine the past, and future, evolution of technology in the hospital management context.

Generalizability of the Research

One consideration to be factored into any research is the degree to which the findings of that research are generalizable beyond the sampling frame, case study context or other scoping parameter of the work.

In this case – the starting point for the research, the original TEM work of Adomavicius et al comes from a non – Australian context. The subsequent literature reviews performed in this research have an international scope, but the CS analyses are limited to several Australian states. Where does that leave us then in terms of the generalizability of this research?

Although a range of hospital settings have been examined from rural facilities to large metropolitan facilities, and from fully public facilities to privately run facilities, obviously not every hospital context can be examined in the confines of a single Ph.D. Certainly further research could be done in examining the HOME model in more and more hospital settings, in order to see if the findings remain valid across a broader environmental context. This also applies to the geographical context of this work - all of the case studies have been undertaken within 3 Australian states. Therefore it could be argued that are not even the entire Australian system has been examined, let alone international healthcare systems. This is an unfortunate practical constraint upon the work of one individual. However, to counterbalance this, the literature that has been examined is drawn from a huge range of international literature sources.

It was certainly my intention in undertaking this research to produce, if possible, both an extended TEM model and a series of learning's and initial principles, that can be used by relevant stakeholders the world over.

Research Implications

In this section of the thesis I will examine the overall implications of this piece of work to the field of research.

The Power of Analogy

So what is the contribution of this work? I would argue that this work reinforces the notions implicit in the work of Chua and Wareham (Chua and Wareham, 2008) and Esterhay (Esterhay, 1994) , that metaphor and analogy can be powerful analytic tools in the IS and IT context. In many ways this should now be self-evident to us – consider the metaphor of a "window" that many of us use on a daily basis in working with computers and information systems of various types.

More than that however, this work highlights the power of analogy and metaphor in exploring and examining yet to be defined constructs and concepts. Importantly I would argue that this work has been open minded that the TEM may have been "good" or "bad" and should have some objective assessment applied to it – rather than assuming, as in the base research, that the analogy is valid and useful before building further constructs from it

A New View of Technology Ecosystems?

I would argue that it is very clear that as a result of the research outlined above, I can now point to a new and extended view of technology ecosystems as defined by Adomavicius et al. In the section of the thesis that follows I will go on to justify that statement.

Model Breadth

With regard to the breadth of the TEM, in light of the HOME, I would argue that this has been dramatically increased. The establishment of the HOME further expands the number and types of business settings to which the TEM has been applied.

In addition, the underlying theory of the TEM has arguably also been substantially expanded from the findings of this research

The concept of ecosystems services established in this research clearly adds a broader, reusable dimension to the constructs of the TEM - thereby increasing the breadth of the model. Any further work that frames itself around the TEM can now examine the context they are exploring in relation to the services plausibly provided by that ecosystem. It makes logical sense that an important part of examining any ecosystem - with the intent of Adomavicius et al in mind - is understanding the impacts on the users or stakeholders (individually or in groups) of that ecosystem. Let us consider this in the context of the digital music analysis of the original authors. In that example, such services could include the ability to easily retrieve stored pieces of music, or to purchase new pieces of music reliably upon demand.

I would limit my conclusions though by saying that I have not really been able to establish a good justification to claim to existence of a hospital technology management biome (containing all the HOME's). That is to say whilst I have established the existence of an "archetypal", if you will, HOME, by examining the 5 CS' and the literature, I have not yet been able to describe a commonality to "all" HOME's sufficient to claim the existence of such a biome. I believe that what would be required to do this is to now take this base HOME and seek to validate it against a different group of hospitals to see if its constructs and explanatory power hold true when applied even more broadly.

Model Depth

In regard to the depth of the TEM, in light of the HOME, I would again argue that this has been dramatically increased. I make that statement in light of the deeper analysis contained here of how the proposed HOME explains the hospital management context in relation to technology, and in particular the forces and entities at play in that context, in a way that no previous research on the TEM has achieved.

A very specific example of how the depth of the TEM has been increased in a theoretical sense is the concept of ESF's. In this case I have taken the original concept of TSFs and expanded it substantially through an examination of the available evidence. Again this means that anyone referencing the TEM in future can also use ESFs as a concept - in conjunction with the concept of TSFs - to understand factors influencing the environment. Applying this to the original digital music context, this means for example that global technology factors (a current example is the evolution of "cloud"

technologies) or the global financial environment, can be considered as influences on the specific environment, whilst also acknowledging (correctly) that they can at the same time influence other ecosystems. This holds true whether these other ecosystems are closely related to the digital music ecosystem (eg - a personal entertainment device ecosystem) or not (eg - a manufacturing control ecosystem)

In addition, the exploration in the thesis of the concept of what constitutes ecosystem success or failure in this environment enriches the underlying TEM. Indeed as does the exploration of factors driving that success or failure.

Contribution of the Thesis to the IS Discipline

In this final section of the thesis, lets us consider how this research has made a contribution to the broader IS discipline.

The original TEM provides a novel and relatively robust- particularly in light of the findings of this research- means of describing a business' ecosystem, including the constituent technologies, the forces acting on them, and the surrounding "environment". With that in mind, this research makes several important contributions to the IS discipline.

Firstly, as implied above, it validates the original work as it is one of, if not the, first time that there has been attempt to validate the core TEM outside of the work of the original group of proponents.

Secondly, this research has increased the breadth of the original model by establishing several plausible extensions to it. The establishment of the concept of ESFs allows more accurate modelling of the forces acting on any given ecosystem, using the TEM as an analytic or predictive tool. The extension of the model to include the biological construct of ecosystems services allows the relationship between an ecosystem, its "internal components", and the humans interacting with the ecosystem, to be modelled more accurately. Again this adds to the broader IS discipline by increasing the utility of the TE modelling approach.

Thirdly, the specific establishment of the HOME model allows future researchers a pre-established framework through which to examine the specific environment of hospital management, and indeed to use the findings in this thesis as a baseline against which further comparisons can be made, using either the expanded TEM, or other theoretical frameworks and approaches.

In relation to the contribution of the thesis to the IS discipline more broadly there is also the fact that the approach used here and the findings, are supportive of case study research. In addition they are also supportive of the potential utility of not strictly following one philosophical paradigm. To be specific, a mixture of interpretivist and positivist elements in the approach to the research, as supported by the opinions of IS experts, appears to have been a valid approach.

When one considers the work of Watson and Straub (Watson and Straub, 2007) who postulated that the IS discipline is currently in a third era of networking – and soon to transition to a fourth- this thesis is placed in an interesting position. They describe this third era as being "built on public networks, which enable firms to interact electronically with individual customers and investors, and to interact in new ways with governments."

To further set the scene, these authors state that "We are in the midst of a revolution in software, databases, applications, and networks powering the Internet. These information and communications technologies (ICT) are just the latest manifestation of an evolutionary movement to manage the growing volume of information represented as binary digits, or bits." This thesis supports the core concepts of the original TEM – that include the various influences (business, technology and social) on a given ecosystem, as well as the core concept of evolution in an ecosystem. It goes without saying therefore, that the world view put forward by these authors (Watson and Straub) is supported by this work, and furthermore, that the TEM is a valid construct through which to examine such environments in these third and fourth eras they have outlined.

A final and vital contribution of this thesis to the IS discipline is the in-depth analysis provided of the hospital management environment. Unless they are from a strong healthcare background, subsequent business, management, IS or IT researchers will typically not have such an in-depth understanding of the hospital management

environment as provided by the CS' in this thesis. It is important to remember that of the 23 key informants, the majority of them are senior managers, senior technologists and other key senior stakeholders. Many of them also have had a long history of working in healthcare. Together they have contributed extensively to a summarized view of how their individual institutions sit in the broader healthcare context. This in turn provides a very rich picture of the hospital management environment in Australia, and to some extent internationally. Subsequent researchers in any of the above disciplines will be able to draw on this picture both in terms of extending this piece of research, and to inform other pieces of research that seek to examine this environment in some way.

Implications for Practice

In this section of the thesis, I will examine how the abovementioned findings can be related to the practice of healthcare management, information systems development, and strategic planning in the hospital management domain as it pertains to the relevant technologies.

Who can the model assist in a practical sense ?

When one reflects on some of the responses of the KIs in the CS', and the evidence from the literature, there are a number of stakeholders in the HOME that could be assisted by the model. How they are assisted will vary with their role and is explored a little further in the next section of the thesis. Such roles include:

- Hospital operational managers
- Hospital C-level executives
- Hospital project managers and IT staff
- Software vendors and
- Governments and health beauracrats.

How will that new view assist in developing effective HMIS'

The picture created by these findings is of an environment that is fundamentally influenced by external forces, where the PAS is a plausible focal technology. This is an interesting finding when one compares it with the findings of the initial literature review. The findings tend to reinforce each other.

There are many potential implications of this description of the HOME, just some of these are outlined below:

- If hospital management information systems are developed in house, they would be best to use flexible development methodologies. These include:
    - Iterative approaches to development and implementation of systems
    - Risk based approaches to the development and implementation of systems
    - Modular systems
- Equally however, the same could be said of externally developed systems if vendors are to succeed in this marketplace
- Centralised deployment is best to account for system updates (arguably this means web based systems could be preferable)
- Contracts /purchasing arrangements need to reflective of the above
- There needs to be a strong external focus to stakeholder engagement – what is on the horizon as "external forces" that will or could shape system needs and hence development and purchasing decisions?

These things need to be tested in time as having validity but certainly make logical sense if this work has described the environment in an accurate fashion.

Further Research

This section of the thesis will address key areas highlighted by the research that should provide those that follow, with a meaningful starting point around extensions to the TEM more generally, as well as in relation to the HOME model.

Ecosystems Services

Over the period of time consumed by this research, the concept of "ecosystems services" provided to "customers" of a given ecosystem- has received even more international attention and credence. This is embodied in the development and purchase of carbon credits and similar ecologically related financial mechanisms.

The relevance of these concepts to this research is particularly in looking to the future application and extension of the TEM, in information systems development and research.

For example, just as it could be argued that the recognition of the concept of ecosystems services has led to investment in certain ecosystems – e.g. in the well-known example of the Amazon rainforest – perhaps the recognition of the importance of the services provided by technology ecosystems could lead to increased investment in those ecosystems. Arguably this phenomenon can already be seen as occurring – for example in profit driven industries – e.g. banking, finance and manufacturing, (as opposed to public health) – with well-established IT systems and infrastructures that are integral to the functioning of modern businesses in those industries.

The Biome Concept

As identified early in the course of this thesis, the original work by Adomavicius et al focused on an ecosystem view of the technological environment, and arguably a more useful biological analogy is that of the biome. Having said that, the original work does specifically state that each ecosystem is to be viewed in relation to a "focal technology ..... in a specific context". As indicated in the section above "A New View of Technology Ecosystems", a vital next step in research on this topic is to validate the HOME in other hospital settings to see if the broader concept of a biome is a viable one. I would argue that such a biome, if it can be identified, would be an order of magnitude again more useful to both theorists, and real world practitioners, in the hospital management space.

Further testing of the TEM Concept

Further local contextualization as a test of the core TEM concept is to be encouraged, and in fact is essential if the concept is to see its full potential realized. This work is a more than adequate base from which other researchers can explore the relevant issues through a range of methodological lenses. In addition there are other ideas raised previously by the original authors (Adomavicius et al., 2006), for example the idea of "enemies" (e.g. – predators or parasites in the biological analogy) in ecosystems (p2). This could also be an interesting area of exploration in subsequent research, particularly

for example if one is a vendor in this environment, and seeking to understand the competitive nature of the environment in richer terms.

Another interesting and related area of the TEM that would be suitable for future exploration, is the contention of the original authors that technologies in the product and application role compete with each other (Adomavicius et al., 2006). The findings of this research suggest that the opposite can be true (see the section in the Discussion on Question Set 1). Maybe both states can occur, and the exact nature of the relationship may depend on the specific technologies under consideration, and / or their context of use.

Synergies with other Key IS Theories

In this setting I am specifically thinking of theories such as the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh (Venkatesh, 2013), and the Information Systems Success (ISS) Model of DeLone and McLean (DeLone and McLean, 2003) as key examples.

Let us consider these models individually as they relate to the HOME. If I examine the UTAUT as described by Venkatesh, there are synergies between concepts expressed in it and those expressed in the HOME. One of the key concepts of UTAUT is that of use behavior, and the model talks of multiple factors eventually driving this behavior. I note that the HOME also describes, at an environmental level, factors that will ultimately affect the utility of the environment and hence whether people will use the systems contained in it or not. At that high level there are clearly areas of overlap that should be investigated further. A more specific example is the concept of facilitating conditions impacting on use behaviour as described in the graphical representation of the UTAUT (Venkatesh, 2013). Some of these facilitating conditions will also be conditions describable from a HOME perspective.

It appears therefore, that there may be a plausible relationship between the 2 theoretical models such that the HOME will describe the broader environment - it sets the scene if you like, for how the UTUAT describes whether an individual will or won't use a given system within the context of the broader HOME. This is an area that seems ripe for further exploration.

Let us now consider the relationship between the HOME and the ISS. On review of the diagrammatic representation of the original ISS by DeLone and McLean , there are concepts of system quality and information quality, driving towards use and end user satisfaction respectively. The most obvious relationship between the two models in is that the HOME will describe drivers for, and elements of, system quality and information quality in a given environment. In other words, it could be argued that the environment (as described by the HOME model) influences system quality and information quality, and then at that point the ISS "picks up" the impact of that environment on the use of an individual system by an individual user.

Again it can be seen there are immediately apparent relationships between the two models and, moving forward, there are many potential research opportunities to better describe that relationship.

REFERENCES

ABOUSHARKH, M. & MOUFTAH, H. 2011. Service Oriented Architecture-based Framework for WBAN-enabled Patient Monitoring System. *Second Kuwait Conf. on E-Services and E-Systems.* Kuwait.

ACHARYA, D. & KUMAR, V. 2012. Mobile broadband-based healthcare management: advantages, issues and challenges. *Int. J. Computers in Healthcare,* 1**,** 254–268.

ACSQH 2012. Hospital Accreditation Workbook *In:* ACSQH (ed.). Sydney.

ADAMER, K., BANNACH, D., KLUG, T., LUKOWICZ, P., SBODIO, M., TRESMAN, M., ZINNEN, A. & ZIEGERT, T. 2008. Developing a Wearable Assistant for Hospital Ward Rounds: An Experience Report. *Internet of Things (IOT).* Zurich.

ADOMAVICIUS G, BOCKSTEDT J, GUPTA A & KAUFFMAN R 2005. Technology Roles in an Ecosystem Model of Technology Evolution- Working Paper 05-04. . MIS Research Centre, University of Minnesota, Minneapolis, MN. .

ADOMAVICIUS G, BOCKSTEDT J, GUPTA A & KAUFFMAN R. Understanding Patterns of Technology Evolution: An Ecosystem Perspective. 39th Hawaii International Conference on System Sciences. , 2006 Hawaii.

ADOMAVICIUS, G., BOCKSTEDT, J., GUPTA, A. & KAUFFMAN, R. 2005. Technology roles in an ecosystem model of technology evolution. Minneapolis, MN: MIS Research Center, University of Minnesota.

ADOMAVICIUS, G., BOCKSTEDT, J., GUPTA, A. & KAUFFMAN, R. Understanding Patterns of Technology Evolution: An Ecosystem Perspective. 39th International Conference on System Sciences, 2006 Hawaii.

ADOMAVICIUS, G., BOCKSTEDT, J., GUPTA, A. & KAUFFMAN, R. 2007a. Identifying Evolutionary Patterns and Cycles in Technology Ecosystems: A Theory-Based Developement of Constructs and Methodologies Minneapolis, MN 55455: Department of Information and Decision Sciences, and MIS Research Center, Carlson School of Management, University of Minnesota.

ADOMAVICIUS, G., BOCKSTEDT, J., GUPTA, A. & KAUFFMAN, R. 2007b. Technology roles and paths of influence in an ecosystem model of technology evolution. *Journal Information Technology and Management,* 8**,** 185-202.

ADOMAVICIUS, G., BOCKSTEDT, J., GUPTA, A. & KAUFFMAN, R. 2008a. Making Sense of Technology Trends in the Information Technology Landscape: A Design Science Approach. *MIS Quarterly,* 32**,** 779-809.

ADOMAVICIUS, G., BOCKSTEDT, J., GUPTA, A. & KAUFFMAN, R. 2008b. Understanding Evolution in Technology Ecosystems. *Communications of the ACM,* 51**,** 117-122.

AGARWAL, R., GAO, G., DESROCHES, C. & JHA, A. 2010. The Digital Transformation of Healthcare: Current Status and the Road Ahead. *Information Systems Research* 21**,** 796-809.

AGODI, A., BARCHITTA, M., ANZALDI, A., MARCHESE, F., BONACCORSI, A. & MOTTA, M. 2007. Active Surveillance of Nosocomial Infections in Urologic Patients. *European Urology* 51**,** 247-254.

AHMADI, M., JEDDI, F., GOHARI, M. & SADOUGHI, F. 2012. A Review of the Personal Health Records in Selected Countries and Iran. *Journal of Medical Systems,* 36**,** 371-382

AL HUWAIL, D. & BARNES, R. 2011. Diabetes care in the age of Informatics: Kuwait-Scotland Health Innovation Network. *Second Kuwait Conf. on E-Services and E-Systems.* Kuwait.

ALBRIGHT, K., BRANAS, C., MEYER, B., MATHERNE-MEYER, D., ZIVIN, J., LYDEN, P. & CARR, B. 2010. Acute Cerebrovascular Care in Emergency Stroke Systems. *Arch Neurol,* 67**,** 1210-1218.

ALMADA A, DIAS A, SILVA J, DOS SANTOS E, PEDROSA P & CAMARA A. Exploring Virtual Ecosystems. Workshop on Advanced Visual Interfaces. , 1996.

ALSHRAIDEH, M., ABU-ARIDA, A. & HAYAJNEH, F. Expert system for hospitals' multi standard accreditation Jordanian study 5th WSEAS congress on Applied Computing conference, and the 1st international conference on Biologically Inspired Computation, 2012. 199-205.

AMIR, O., BARAK-SHINAR, D., AMOS, Y., MACDONALD, M., PITTMAN, S. & WHITE, D. 2010. An Automated Sleep-Analysis System Operated through a Standard Hospital Monitor. *Journal of Clinical Sleep Medicine,* 6**,** 59-63.

AMMENWERTH, E., ILLER, C. & MANSMANN, U. 2003. Can evaluation studies benefit from triangulation? A case study. *International Journal of Medical Informatics,* 70**,** 237-248.

ANEMA, H., KIEVIT, J., FISCHER, C., STEYERBERG, E. & KLAZINGA, N. 2013. Influences of hospital information systems, indicator data collection and computation on reported Dutch hospital performance indicator scores. *BMC Health Services Research* 13.

APPARI, A., CARIAN, E., JOHNSON, M. & ANTHONY, D. 2012. Medication administration quality and health information technology: a national study of US hospitals. *J Am Med Inform Assoc.* , 19**,** 360-7.

ARNETZ, J., ARANYOS, D., AGER, J. & UPFAL, M. 2011. Development and Application of a Population-Based System for Workplace Violence Surveillance in Hospitals. *American Journal of Industrial Medicine,* 54**,** 925-34.

AULBACH, R., BRIENT, K., CLARK, M., CUSTARD, K., DAVIS, C., GECOMO, J. & ONG HO, J. 2010. Blood Transfusions in Critical Care: Improving Safety Through Technology & Process Analysis. *Crit Care Nurs Clin N Am* 22**,** 179-90.

AVERY, J., BEYEA, S. & CAMPION, P. 2005. Active error management: use of a Web-based reporting system to support patient safety initiatives. *J Nurs Adm,* 35**,** 81-5.

AWAYA, T., OHTAKI, K., YAMADA, T., YAMAMOTO, K., MIYOSHI, T., ITAGAKI, Y., TASAKI, Y., HAYASE, N. & MATSUBARA, K. 2005. Automation in drug inventory management saves personnel time and budget. *Yakugaku Zasshi,* 125**,** 427-32.

AZOULAY, A., DORIS, N., FILION, K., CARON, J., PILOTE, L. & EISENBERG, M. 2007. The use of the Transition cost accounting system in health services research. *Cost Eff Resour Alloc,* 5.

BACHMANN, M. 2010. Cost-effectiveness of community-based treatment of severe acute malnutrition in children. *Expert Rev Pharmacoecon Outcomes Res,* 10**,** 605-12.

BAGAYOKO, C., MULLER, H. & GEISSBUHLER, A. 2006. Assessment of Internet-based tele-medicine in Africa (the RAFT project). *Computerized Medical Imaging and Graphics,* 30**,** 407-16.

BAHENSKY, J., WARD, M., NYARKO, K. & LI, P. 2011. HIT Implementation in Critical Access Hospitals: Extent of Implementation and Business Strategies Supporting IT Use. *J Med Syst* 35**,** 599-607.

BAIN, C. & STANDING, C. 2009. A technology ecosystem perspective on hospital management information systems: lessons from the health literature. *International Journal of Electronic Healthcare* 5**,** 193-210.

BAIN, C., TAYLOR, P., MCDONNELL, G. & GEORGIOU, A. 2010. Myths of Ideal Hospital Occupancy. *MJA,* 192**,** 42-43.

BALOGH, R. & COOK, M. 2006. Achieving Magnet accreditation in the UK: a case study at Rochdale NHS Trust. *Journal of Nursing Management,* 14**,** 366-76.
BANDYOPADHYAY, D., TURNPENNY, B. & DEWAR, E. P. 2005. Direct Access Minor Surgery service--patient satisfaction and effectiveness. *Ann R Coll Surg Engl,* 87**,** 248-50.
BAPTISTA A. Understanding Ecosystems through Observation and Simulation. IEEE Symposium on Large-Data Visualisation and Graphics., 2003.
BARASA, E., AYIEKO, P., CLEARY, S. & ENGLISH, M. 2012. Out-of-pocket costs for paediatric admissions in district hospitals in Kenya. *Trop Med Int Health.,* 17**,** 958-961.
BARBER, N., CORNFORD, T. & KLECUN, E. 2007. Qualitative evaluation of an electronic prescribing and administration system. *Qual Saf Health Care,* 16**,** 271-8.
BARILLO, D. J., JORDAN, M. H., JOCZ, R. J., NYE, D., CANCIO, L. C. & HOLCOMB, J. B. 2005. Tracking the daily availability of burn beds for national emergencies. *J Burn Care Rehabil,* 26**,** 174-82.
BARNUM, D., SHIELDS, K., WALTON, S. & SCHUMOCK, G. 2011. Improving the Efficiency of Distributive and Clinical Services in Hospital Pharmacy. *Journal of Medical Systems,* 35**,** 59–70.
BARROS A, DUMAS M & BRUZA P 2005. The Move to Web Service Ecosystems. *BPTrends.*
BAY, O. & ERGUL, N. 2004. Computerized control of the procedure for detecting and removing airborne particles in operating rooms. *J Med Syst,* 28**,** 117-27.
BEINFELD, M. & GAZELLE, G. 2005. Diagnostic imaging costs: are they driving up the costs of hospital care? *Radiology,* 235**,** 934-9.
BELL, L. 2007. Adolescent dialysis patient transition to adult care: a cross-sectional survey. *Pediatr Nephrol* 22**,** 720-726.
BENKLER Y 2001. The Battle over the Institutional Ecosystem in the Digital Environment. *Communications of the ACM* 44**,** 84-90. .
BERG, M. 2001. Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics,* 64**,** 143-156.
BERKMAN CENTER 2006. Roadmap for Open ICT Ecosystems. .
BERMEJO VICEDO, T., PEREZ MENENDEZ CONDE, C., ALVAREZ, A., CODINA, C., DELGADO, O., HERRANZ, A., HIDALGO CORREAS, F., MARTIN, I., MARTINEZ, J., LUIS POVEDA, J., QUERALT GORGAS, M. & SANJURJO SAEZ, M. 2007. [The application of new technologies to hospital pharmacy in Spain]. *Farm Hosp,* 31**,** 17-22.
BESSON, P. & ROWE, F. 2012. Strategizing information systems-enabled organizational transformation:A transdisciplinary review and new directions. *Journal of Strategic Information Systems,* 21**,** 103–124.
BHUTTO, A. 2008. *A Dynamic Technological Capability (DTC) Model for the Next Generation of Technology Evolution.* Doctor of Philosophy, Nottingham University.
BICKSTON, S., WATERS, H., DABBOUS, O., TANG, B. & RAHMAN, M. 2008. Administrative Claims Analysis of All-Cause Annual Costs of Care and Resource Utilization by Age Category for Ulcerative Colitis Patients. *J Manag Care Pharm.,* 14**,** 352-62.
BLOOM, A., CHAPIN, F. & MOONEY, H. 1985. Resource limitation in plants – an economic analog. *Annual Review of Ecology and Systematics,* 16**,** 363-392.
BLOOMFIELD, E. & FEINGLASS, N. 2008. The anesthesia information management system for electronic documentation: what are we waiting for? *J Anesth,* 22**,** 404-11.
BOIX, R., ARAGONE´S, N. & MEDRANO, M. 2003. Trends in mortality from ischemic heart disease in 50 Spanish provinces. *Rev Esp Cardiol,* 56**,** 850-56.

BOLIVAR-MUNOZ, J., DAPONTE-CODINA, A., PASCUAL-MARTINEZ, N., BARRANCO-RUIZ, F., SANCHEZ-CRUZ, J., MARTIN-CASTRO, C. & GIL-PINERO, E. 2007. Use of emergency transport by patients with cardiopathies: a focus group study. *International Journal for Quality in Health Care,* 19**,** 407-413.

BRAND, C., KENNEDY, M., KING-KALLIMANIS, B., WILLIAMS, G., BAIN, C. & RUSSELL, D. 2010. Evaluation of the impact of implementation of a Medical Assessment and Planning Unit on length of stay. *Australian Health Review,* 34**,** 334-339.

BREEN, S. L. & ZHANG, B. 2010. Audit of an automated checklist for quality control of radiotherapy treatment plans. *Radiotherapy and Oncology* 97**,** 579-584.

BRENDER, J., AMMENWERTH, E., NYKÄNEN, P. & TALMON, J. 2006. Factors Influencing Success and Failure of Health Informatics Systems - A Pilot Delphi Study. *Methods of Information in Medicine,* 45**,** 125-136

BRESLOW, M., ROSENFELD, B., DOERFLER, M., BURKE, G., YATES, G., STONE, D., TOMASZEWICZ, P., HOCHMAN, R. & PLOCHER, D. 2004. Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcomes: an alternative paradigm for intensivist staffing. *Crit Care Med,* 32**,** 31-8.

BRITT, D., BRONSTEIN, J. & NORTON, J. D. 2006. Absorbing and transferring risk: assessing the impact of a statewide high-risk-pregnancy telemedical program on VLBW maternal transports. *BMC Pregnancy and Childbirth,* 6.

BUCK, T., CONNOR, I., HOROWITZ, G. & ARNAOUT, R. 2011. Call Wall - Tracking Resident Calls to Improve Clinical Utilization of Pathology Laboratories. *Arch Pathol Lab Med,* 135**,** 920-924.

CAPRA, F. 1996. *The Web of Life: A New Scientific Understanding of Living Systems,* New York, Anchor Books, Doubleday

CARDON, M., ZIETSMA, C., SAPARITO, P., MATHERNE, B. & DAVIS, C. 2005. A tale of passion: New insights into entrepreneurship from a parenthood metaphor. *Journal of Business Venturing,* 20**,** 23-45.

CARLSON, J. 2012. Caught in the middle. Under tough scrutiny from the CMS over which patients should be admitted for care, hospitals are frustrated--and patients are fighting back. *Mod Healthc.,* 42**,** 6-7.

CARLSSON B & JACOBSSON A. On Contamination in Information Ecosystems: A Security Model Applied on Small and Medium Sized Enterprises. 38th Hawaii International Conference on System Sciences., 2005 Hawaii.

CARTMILL, R., WALKER, J., BLOSKY, M., BROWN, R., DJURKOVIC, S., DUNHAM, D., GARDILL, D., HAUPT, M., PARRY, D., WETTERNECK, T., WOOD, K. & CARAYON, P. 2012. Impact of electronic order management on the timeliness of antibiotic administration in critical care patients. *Int J Med Inform,* 81**,** 782-91.

CAVAYE, A. 1996. Case study research: a multi-faceted research approach for IS. *Information Systems Journal,* 6**,** 227–242.

CHIEN, T. I., LU, J. Y., KAO, J. T., CHENG, Y. C. & LEE, Y. F. 2007. Evaluation and improvement strategy of analytical turnaround time in the stat laboratory. *J Formos Med Assoc,* 106**,** 558-64.

CHIU, W. T., YANG, C. M., LIN, H. W. & CHU, T. B. 2007. Development and implementation of a nationwide health care quality indicator system in Taiwan. *Int J Qual Health Care,* 19**,** 21-8.

CHUA, C. & WAREHAM, J. 2008. Parasitism and Internet auction fraud: An exploration. Information and Organization. *Information and Organization,* 18**,** 303-333.

CIONINI, L., GARDANI, G., GABRIELE, P. & AL, E. 2007. Quality indicators in radiotherapy. *Radiother Oncol,* 82**,** 191–200.

CSIRO SUSTAINABLE ECOSYSTEMS. 2004. *Ecosystem Services Project* [Online]. Available: http://www.ecosystemservicesproject.org/html/overview/index.htm [Accessed 22/6/2006.

DE TOMMASI, M., CISTERNINO, V. & CORALLO, A. A Rule-Based and Computation-Independent Business Modelling Language for Digital Business Ecosystems. KES'05 - 9th international conference on Knowledge-Based Intelligent Information and Engineering Systems, 2005. Springer-Verlag, 134-141

DELONE, W. & MCLEAN, E. 2003. The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems,* 19**,** 9–30.

DEMIRIS, G., COURTNEY, K. & MEYER, W. 2007. Current status and perceived needs of information technology in Critical Access Hospitals: a survey study. *Inform Prim Care,* 15**,** 45-51.

DENYER, D., KUTSCH, E., LEE-KELLEY, E. & HALL, M. 2011. Exploring reliability in information systems programmes. *International Journal of Project Management,* 29**,** 442-454.

DEXTER, F., ABOULEISH, A. E., EPSTEIN, R. H., WHITTEN, C. W. & LUBARSKY, D. A. 2003. Use of operating room information system data to predict the impact of reducing turnover times on staffing costs. *Anesth Analg,* 97**,** 1119-26, table of contents.

DEXTER, F., EPSTEIN, R., MARCON, E. & LEDOLTER, J. 2005. Estimating the incidence of prolonged turnover times and delays by time of day. *Anesthesiology,* 102**,** 1242-8; discussion 6A.

DJELLAL, F. & GALLOUJ, F. 2007. Innovation in hospitals: a survey of the literature. *Eur J Health Econ,* 8**,** 181-193.

EADIE, A. 2012. Medical error reporting should it be mandatory in Scotland ? *J Forensic Leg Med.* , 19**,** 437-41.

EDWARDS, M. & MOCZYGEMBA, J. 2004. Reducing medical errors through better documentation. *Health Care Manag (Frederick),* 23**,** 329-33.

EL SAWY, O., MALHOTRA, A., PARK, Y. & PAVLOU, P. 2010. Seeking the Configurations of Digital Ecodynamics: It Takes Three to Tango. *Information Systems Research,* 21**,** pp. 835–848.

ENNS, H., HUFF, S. & HIGGINS, C. 2003. CIO Lateral Influencing Behaviours: Gaining Peers' Committment to Strategic Information Systems *MIS Quarterly* 27**,** 155-176.

ESTERHAY, R. 1994. User metaphors for health care professional workstations. *International Journal of Bio-Medical Computing,* 34**,** 95-113.

FAGUY, P., GAUTHIER, L. & DUFFET, M. 2005. First do no harm: Hamilton Health Sciences' experience as first hospital in the world to fully implement Medley Medication Safety System. *Healthc Q,* 8**,** 116-9.

FANG, Y. C., YANG, M. C. & HSUEH, Y. S. 2006. Financial assessment of a picture archiving and communication system implemented all at once. *J Digit Imaging,* 19 Suppl 1**,** 44-51.

FENSHAM, R. & HOLMAN, J. 1999. Temporal and spatial patterns in drought-related tree dieback in Australian savanna. *Journal of Applied Ecology,* 36**,** 1035-1050.

FERRE NAVARETE, F. & PALANCA, I. 2005. Mental health care in Madrid. *Eur Psychiatry,* 20 Suppl 2**,** S279-84.

FICHMAN, R., KOHLI, R. & KRISHNAN, R. 2011. Editorial Overview - The Role of Information Systems in Healthcare: Current Research and Future Trends *Information Systems Research,* 22**,** 419-428.

FIGAY, N. & GHODOUS, P. Innovative Interoperability Framework for Enterprise Applications within Virtual Enterprises. MEDES '09 - International Conference on Management of Emergent Digital EcoSystems 2009 Lyon, France.

FIORE, S., SOUZANI, S., D'AMORE, R., BEHAN, K., CUTTS, C. & LA CAZE, A. 2005. Support needs of supply nurses in rural and remote Queensland. *Aust J Rural Health,* 13**,** 10-3.

FLEMING, M., BAIN, C., SHARMA, R. & RAIKUNDALIA, G. 2009. An Australia Wide Survey of Workforce and Workflow for Cancer Multi-disciplinary Teams. *Clinical Oncology Society of Australia 35th Annual Scientific Meeting. Cancer Services and Our Community- Awareness, Access, Action. .* Asia-Pacific Journal of Clinical Oncology.

FRANCE, N., FRANCIS, G. & LAWRENCE, S. 2003. The costs of New Zealand pathology. *Health Policy,* 64**,** 131-41.

FREED, D. 2006. Certain death: ten predictors of hospital information system failure. *Health Care Manag (Frederick),* 25**,** 26-33.

FUNG, K. W. & VOGEL, L. H. 2003. Will decision support in medications order entry save money? A return on investment analysis of the case of the Hong Kong hospital authority. *AMIA Annu Symp Proc***,** 244-54.

GASKIN, S., GEORGIOU, A., BARTON, D. & WESTBROOK, J. 2012. Examining the role of information exchange in residential aged care work practices - a survey of residential aged care facilities. *BMC Geriatr,* 12.

GLASER, J. 2003a. Analyzing information technology value. *Healthc Financ Manage,* 57**,** 98-100, 102, 104.

GLASER, J. 2003b. Strategies for increasing delivery of IT value. *Healthc Financ Manage,* 57**,** 88-90, 93.

GLASER, J. & WILLIAMS, R. 2007. The Definitive Evolution of the Role of the CIO. *J Healthc Inf Manag,* 21**,** 9-11.

GOH, J., GAO, G. & AGARWAL, R. 2011. Evolving Work Routines: Adaptive Routinization of Information Technology in Healthcare. *Information Systems Research* 22**,** 565-585.

GONZÁLEZ-MOLERO, I., DOMÍNGUEZ-LÓPEZ, M., GUERRERO, M., CARREIRA, M., CABALLERO, F., RUBIO-MARTÍN, E., LINARES, F., CARDONA, I., TERESA-ANARTE, M., DE ADANA, M. & SORIGUER, F. 2012. Use of telemedicine in subjects with type 1 diabetes equipped with an insulin pump and real-time continuous glucose monitoring. *J Telemed Telecare* 18**,** 328-332.

GOTTSCHALK, P. 1999. Implementation predictors of strategic information systems plans. *Information & Management,* 36**,** 77-91.

GRANT, M. J., DONALDSON, A. E. & LARSEN, G. Y. 2006. The safety culture in a children's hospital. *J Nurs Care Qual,* 21**,** 223-9.

GREENBERG, A., ANGUS, H., SULLIVAN, T. & BROWN, A. 2005. Development of a set of strategy-based system-level cancer care performance indicators in Ontario, Canada. *Int J Qual Health Care,* 17**,** 107-14.

GREENBERG, C., DIAZ-FLORES, R., LIPSITZ, S., REGENBOGEN, S., MULHOLLAND, L., MEARN, F., RAO, S., TOIDZE, T. & GAWANDE, A. 2008. Bar-coding Surgical Sponges To Improve Safety: A Randomized Controlled Trial. *Annals of Surgery,* 247**,** 612-616.

GREENFACTS 2005. Millenium Ecosystem Assessment (2005) Ecosystems and Human Wellbeing: Biodiversity Synthesis. .

HADZIC, M. & CHANG, E. 2010. Application of Digital Ecosystem Design Methodology Within the Health Domain. *IEEE Transactions on Systems, Man and Cybernetics - Part A: Systems and Humans* 40.

HAUX, R. 2006. Health information systems - past, present, future. *Int J Med Inform,* 75**,** 268-81.

HEEKS, R. 2006. Health information systems: Failure, success and improvisation. *International Journal of Medical Informatics,* 75**,** 125-137.

HOILE C, WANG F, BONSMA E & MARROW P. Session 5B: mobile software agents: Core specification and experiments in DIET: a decentralised ecosystem-inspired mobile agent system. First International Joint Conference on Autonomous agents and Multiagent Systems: Part 2, 2002.
HOSSEINI, J. Strategic Technology Planning for the e-Commerce Enabled Enterprise. International Conference on Information Technology: Coding and Computing (ITCC'05), 2005.
HOUGHTON, D. 1996. The Role of Analogical Reasoning in Novel Foreign-Policy Situations. *British Journal of Political Science,* 26**,** 523-552.
HSI, I. Measuring the conceptual fitness of an application in a computing ecosystem. WISER '04 - ACM workshop on Interdisciplinary software engineering research 2004. 27-36.
HSU, T. 2006. The effects of metaphors on novice and expert learners' performance and mental-model development *Interacting with Computers,* 18**,** 770-792.
IANSITI, M. & RICHARDS, G. 2006. The information technology ecosystem: Structure, health, and performance. *Antitrust Bulletin,* 51**,** 77-110.
IVEROTH, E., FRYK, P. & RAPP, B. 2013. Information technology strategy and alignment issues in health care organizations. *Health Care Manage Rev,* 38**,** 188-200.
JAMES, C., HANSON, K., MCPAKE, B., BALABANOVA, D., GWATKIN, D., HOPWOOD, I., KIRUNGA, C., KNIPPENBERG, R., MEESSEN, B., MORRIS, S., PREKER, A., SOUTEYRAND, Y., TIBOUTI, A., VILLENEUVE, P. & XU, K. 2006. To retain or remove user fees?: reflections on the current debate in low- and middle-income countries. *Appl Health Econ Health Policy,* 5**,** 137-53.
JERGENSEN, C., SARMA, A. & WAGSTROM, P. The Onion Patch: Migration in Open Source Ecosystems. ESEC/FSE'11, 2011 Szeged, Hungary.
JOHNSTON, J., LEUNG, G., SAING, H., KWOK, K., HO, L., WONG, I. & TIN, K. 2006. Non-attendance and effective equity of access at four public specialist outpatient centers in Hong Kong. *Soc Sci Med,* 62**,** 2551-64.
JOSSI, F. 2006. Disaster waiting to happen. The national healthcare system has much work to do before the next catastrophe strikes. *Healthc Inform,* 23**,** 26.
KALUCY, R., THOMAS, L. & KING, D. 2005. Changing demand for mental health services in the emergency department of a public hospital. *ANZ Journal of Psychiatry,* 39**,** 74-80.
KAPLAN, B. & DUCHON, D. 1988. Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study. *MIS Quarterly,* 12**,** 571 – 586.
KAPLAN, B. & HARRIS-SALAMONE, K. 2009. Health IT Success and Failure: Recommendations from Literature and an AMIA Workshop. *Journal of the American Medical Informatics Association* 16**,** 291-299.
KARHU, K., BOTERO, A., VIHAVAINEN, S., TANG, T. & HÄMÄLÄINEN, M. A Digital Ecosystem for Boosting User-Driven Service Business. MEDES 2009 2009 Lyon, France.
KETIKIDIS, P., DIMITROVSKI, T., LAZURAS, L. & BATH, P. 2012. Acceptance of health information technology in health professionals: an application of the revised technology acceptance model. *Health Informatics J.,* 18**,** 124-34.
KIM, H., LEE, J. & HAN, J. 2010. The Role of IT in Business Ecosystems. *Communications of the ACM,* 53.
KINNEY, K. 2007. A systems approach to purchasing and implementing new technology. *Nurs Adm Q,* 31**,** 27-32.
KIRKHAM, T., WOOD, S., WINFIELD, S., COOLIN, K. & SMALLWOOD, A. An ecosystem for user centric learning – revolution or evolution? MEDES 2009, October 27-30 2009 Lyon, France.

LEBELLEGO, G., NOURY, N., VIRONE, G., MOUSSEAU, M. & DEMONGEOT, J. 2006. A model for the measurement of patient activity in a hospital suite. *IEEE Trans Inf Technol Biomed,* 10**,** 92-9.
LI, K., NAGANAWA, S., WANG, K., LI, P., KATO, K., LI, X., ZHANG, J. & YAMAUCHI, K. 2012. Study of the cost-benefit analysis of electronic medical record systems in general hospital in China. *J Med Syst,* 36**,** 3283-91.
LIN S & LIN F. Towards an Ecological Perspective on the Evolution of Online Communities of Practice. 39th Hawaii International Conference on System Sciences, 2006 Hawaii.
LOEKITO, E., BAILEY, J., BELLOMO, R., HART, G., HEGARTY, C., DAVEY, P., BAIN, C., PILCHER, D. & SCHNEIDER, H. 2013. Common laboratory tests predict imminent death in ward patients. *Resuscitation,* 84**,** 280-5.
LORENZI, N., NOVAK, L., WEIS, J., GADD, C. & UNERTL, K. 2008. Crossing the Implementation Chasm: A Proposal for Bold Action. *J Am Med Inform Assoc,* 15**,** 290-6.
MEKHJIAN, H., BENTLEY, T., AHMAD, A. & MARSH, G. 2004. Development of a Web-based event reporting system in an academic environment. *J Am Med Inform Assoc,* 11**,** 11-18.
MILLAR, T., SANDILYA, R., TORDOFF, J. & FERGUSON, R. 2008. Documenting pharmacist's clinical interventions in New Zealand hospitals. *Pharm World Sci,* 30**,** 99-106.
MILLARD, P. 2006. *Nosokinetics Group* [Online]. Available: http://users.wmin.ac.uk/coiec/nosokinetics.htm#_Conferences_and_Talks [Accessed 22/6 2006].
MILLET, S. & HONTON, E. 1991. *A Manager's Guide to Technology Forecasting and Strategy Analysis Methods,* Columbus, Ohio, Battelle Press.
MITRA, R., SINGH, V. & JOHRI, A. Cyber-learning Ecosystem – Tools, Technology and Users. iConference 2011, February 8-11 2011 Seattle, WA, USA.
MIWA, M., KAWAGUCHI, H., ARIMA, H. & KAWAHARA, K. 2006. The effect of the development of an emergency transfer system on the travel time to tertiary care centres in Japan. *Int J Health Geogr,* 5**,** 25.
MORRISON, L., VERBEEK, P., MCDONALD, A. & AL, E. 2000. Mortality and prehospital thrombolysis for acute myocardial infarction. A meta-analysis. *JAMA,* 283**,** 2686–92.
MULDUR, S. 2003. Computer-aided planned maintenance system for medical equipments. *J Med Syst,* 27**,** 393-8.
MYERS, M. 1997. *Qualitative Research in Information Systems* [Online]. Available: http://www.qual.auckland.ac.nz/ [Accessed 28 Sep 2014].
NAKAGAWA, Y., YOSHIHARA, H. & NAKAGAWA, H. 2011. New Indicators Based on Personnel Cost for Management Efficiency in a Hospital. *J Med Syst* 35**,** 625–637.
NEUMAN, Y. & NAVE, O. 2009. Metaphor-based meaning excavation. *Information Sciences,* 179**,** 2719-2728.
NGWENYAMA, O. K. & LEE, A. S. 1997. Communication Richness in Electronic Mail: Critical Social Theory and the Contexuality of Meaning. *MIS quarterly,* 21**,** 145-167.
NICHOLSON, E., MACE, G., ARMSWORTH, P. & ATKINSON, G. 2009. Priority research areas for ecosystems services in a changing world. *Journal of Applied Ecology,* 46**,** 1139-1144.
OATES, B. J. 2006. *Researching Information Systems and Computing* SAGE.
OLIVA, J., LOBO, F., MOLINA, B. & MONEREO, S. 2004. Direct health care costs of diabetic patients in Spain. *Diabetes Care,* 27**,** 2616-21.

ORACLE THINKQUEST EDUCATION FOUNDATION. 2006. *ThinkQuest.org.* [Online]. Available: http://library.thinkquest.org/11353/ecosystems.htm [Accessed 22/6/2006.
PALVIA, P., MAO, E., SALAM, A. & SOLIMAN, K. 2003. Management Information Systems Research: What's There in a Methodology? *Communications of the Association for Information Systems,* 11**,** 289-309.
PALVIA, P., MIDHA, V. & PINJANI, P. 2006. Research models in Information Systems. *Communications of the Association for Information Systems,* 17**,** 1042-1063.
PANT, S. & HSU, C. 1995. Strategic Information Systems Planning: A Review. *1995 Information Resources Management Association International Conference.* Atlanta, Georgia.
PARE, G. 2004. Investigating Information Systems with Positivist Case Research. *Communications of the Association for Information Systems,* 13**,** 233-264.
PARIKH, M. 2002. Knowledge Acquisition Through Case Study Development: A Student Researcher Perspective. *Communications of the Association for Information Systems,* 8**,** 360-379.
PELLETIER, D., DUFFIELD, C. & DONOGHUE, J. 2005. Documentation and the transfer of clinical information in two aged care settings. *Aust J Adv Nurs,* 22**,** 40-5.
PORTER, A., ROPER, A., MASON, T., ROSSINI, F. A. & BANKS, J. 1991. *Forecasting and Management of Technology,* New York, NY, Wiley-Interscience,.
PREMKUMAR, G. & KING, W. 1994. Organizational Characteristics and Information Systems Planning: An Empirical Study. *Information Systems Research* 5**,** 75-109.
QUAADGRAS A. Who joins the platform? The case of the RFID Business Ecosystem. 38th Hawaii International Conference on System Sciences. , 2005 Hawaii.
REDDY, A. S., LOH, S. & KANE, R. A. 2006. Budget variance analysis of a department wide implementation of a PACS at a major academic medical center. *J Digit Imaging,* 19 Suppl 1**,** 66-71.
REICH, D., KAHN, R., WAX, D., PALVIA, T., GALATI, M. & KROL, M. 2006. Development of a module for point-of-care charge capture and submission using an anesthesia information management system. *Anesthesiology,* 105**,** 179-86; quiz 231-2.
REID, W. & MOONEY, H. 2005. Ecosystems and Human Well-Being (Synthesis): A Report of the Millennium Ecosystem Assessment Millennium Ecosystem Assessment.
REINA-TOSINA, J., ROA, L., CACERES, J. & GOMEZ-CIA, T. 2002. New approaches toward the fully digital integrated management of a burn unit. *IEEE Trans Biomed Eng,* 49**,** 1470-6.
REUILLE, R. 2004. Bed control report: a computer-based system to track patient admissions delayed or rescheduled due to a bed shortage. *J Nurs Adm,* 34**,** 539-42.
RICCIARDI, A., LARGERON, N., GIORGI-ROSSI, P., RAFFAELE, M., COHET, C., FEDERICI, A. & PALAZZO, F. 2009. Incidence of invasive cervical cancer and direct costs associated with its management in Italy. *Tumori,* 95**,** 146-152.
ROSE P. 1997. *Mutualistic Biodiversity Networks: the relationship between soil biodiversity and mutualism, and their importance to ecosystem function and structural organization.* [Online]. Available: http://www.angelfire.com/sk/monkeypuzzle/mbiooverviewmain.html
ROSENKOPF, L. & NERKAR, A. 1999. *On the Complexity of Technological Evolution: Exploring Coevolution Within and Across Hierarchical Levels in Optical Disk Technology,* Thousand Oaks, California, Sage Publications.

ROSSER, M. 2006. Advancing health system integration through supply chain improvement. *Healthc Q,* 9**,** 62-6, 4.
SANTIBANEZ, C. 2010. Metaphors and argumentation: The case of Chilean parliamentarian media participation. *Journal of Pragmatics,* 42**,** 973-989.
SCRIVENS, E. 1995. *Accreditation: Protecting the Professional or the Consumer?*, Buckingham, UK, Open University Press.
SEGARS, A. & GROVER, V. 1999. Profiles of Strategic Information Systems Planning *Information Systems Research,* 10**,** 199-232.
SHARMA, R. & YETTON, P. 2007. The Contingent Effects of Training, Technical Complexity, and Task Interdependence on Successful Information Systems Implementation. *MIS Quarterly,* 31**,** 219-238.
SHEKELLE, P. G., MORTON, S. C. & KEELER, E. B. 2006. Costs and benefits of health information technology. *Evid Rep Technol Assess (Full Rep)***,** 1-71.
TENGILIMOGLU, D., CELIK, Y. & ULGU, M. 2006. Comparison of computing capability and information system abilities of state hospitals owned by Ministry of Labor and Social Security and Ministry of Health. *J Med Syst,* 30**,** 269-75.
TEUBNER, R. A. 2007. Strategic information systems planning: A case study from the financial services industry. *Journal of Strategic Information Systems,* 16**,** 105–125.
THOMAS, C., CADWALLADER, H. & RILEY, T. 2004. Surgical-site infections after orthopaedic surgery: statewide surveillance using linked administrative databases. *J Hosp Infect,* 57**,** 25-30.
THOMPSON, K. 2006. *Biological ecosystems, what businesses must learn* [Online]. Available: http://www.bioteams.com/2006/03/10/biological_ecosystems_what.html [Accessed 27/6 2006].
TIWANA, A., KONSYNSKI, B. & BUSH, A. 2010. Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. *Information Systems Research,* 21**,** 675–687.
TOWNSEND, M. Managing a Security Program in a Cloud Computing Environment. InfoSecCD '09, September 25-26 2009 Kennesaw, GA, USA.
TRINGALI, M. & DE LUSIGNAN, S. 2005. Foundations of a healthcare knowledge management application system. *AMIA Annu Symp Proc.*
TRYPUC, J., MACLEOD, H. & HUDSON, A. 2006. Developing a culture to sustain Ontario's Wait Time Strategy. *Healthc Pap,* 7**,** 8-24.
TURNER, K., MEYER, B. & STEWART, M. 2004. "Mercy meds" boosts safety. An initiative at a St. Louis-based system reduces the danger of medication errors. *Health Prog,* 85**,** 37-9, 62.
TUTTLE, D., HOLLOWAY, R., BAIRD, T., SHEEHAN, B. & SKELTON, W. K. 2004. Electronic reporting to improve patient safety. *Qual Saf Health Care,* 13**,** 281-6.
UNDERWOOD, H. 2012. PartoPen: Enhancing the Partograph with Digital Pen Technology. *CHI 2012.* Austin, Texas, USA.
UNKNOWN 2007. Data trends. Declining capacity in acute care hospitals may indicate problems. *Healthc Financ Manage,* 61**,** 114-5.
UNKNOWN 2012. Under the gun to act, hospitals in Washington state put their hopes on seven "best practices" to curb non-emergent use of their EDs by Medicaid patients. *ED Manag,* 24**,** 85-8.
UNKNOWN. 2013a. *Biodiversity Indicators Partnership* [Online]. Available: http://www.bipindicators.net/indicators/ecosystemintegrityservices/incidenceofhumaninducedecosystemfailure/2010 [Accessed 30/7 2013].
UNKNOWN. 2013b. *CDM Net Home Page* [Online]. Precendence Healthcare. Available: http://precedencehealthcare.com/cdmnet/ [Accessed 20/10 2013].

UNKNOWN. 2014. *Aged and Community Care - Models of Care* [Online]. WA Department of Health. Available: http://www.agedcare.health.wa.gov.au/home/moc.cfm [Accessed January 31 2014].
VAN ANGEREN, J., BLIJLEVEN, V. & JANSEN, S. Relationship Intimacy in Software Ecosystems: A Survey of the Dutch Software Industry. MEDES'11 November 21-24 2011 San Francisco, USA.
VAN DER MEIJDEN, M., TANGE, H., TROOST, J. & HASMAN, A. 2003. Determinants of success of inpatient clinical information systems: a literature review. *J Am Med Inform Assoc,* 10**,** 235-43.
VARIOUS 1997. Information Systems and Qualitative Research. *In:* LEE, A. L., J; DEGROSS, JI. (ed.). Springer.
VARIOUS 2005. Research in Information Systems: A Handbook for Research Supervisors and their Students. *In:* AVISON, D., PRIES-HEJE, J. (ed.). Oxford, UK: Elsevier.
VENKATESH, V. 2013. *Unified Theory of Acceptance and Use of Technology* [Online]. Walton College of Business, US. Available: http://www.vvenkatesh.com/organizations/Theoretical_Models.asp [Accessed 16/10 2013].
VENKATESH, V., MORRIS, M., DAVIS, G. & DAVIS, F. 2003. User Acceptance of Information Technology: Toward a Unified View *MIS Quarterly,* 27**,** 425-478.
VEST, J., YOON, J. & BOSSAK, B. 2013. Changes to the electronic health records market in light of health information technology certification and meaningful use. *J Am Med Inform Assoc,* 20**,** 227-232.
VICEDO, B. & CONDE, C. 2007. The application of new technologies to hospital pharmacy in Spain. *FARM HOSP,* 31**,** 17-22.
VUORI, E. 2006. Intellectual capital in a business ecosystem. *International ProACT Conference.* Tampere, Finland.
WALSHAM, G. 1995. The Emergence of Interpretivism in IS Research. *Information Systems Research,* 6**,** 376-394.
WANG, D., CARR, E., GROSS, L. & BERRY, M. 2005. Toward ecosystem modeling on computing grids. *Computing in Science and Engineering,* 7**,** 44-52.
WATSON, R. T. & STRAUB, D. W. 2007. Future IS Research in Net-enabled Organizations. *The DATA BASE for Advances in Information Systems,* 38**,** 8-19.
WEBER, R. 2004. The Rhetoric of Positivism Versus Interpretivism: A Personal View. *MIS Quarterly,* 28**,** iii-xii.
WHALEY, B. & HOLLOWAY, R. 1997. Rebuttal Analogy in Political Communication: Argument and Attack in Sound Bite. *Political Communication,* 4.
WHITTEN, P., MYLOD, D., GAVRAN, G. & SYPHER, H. 2008. "Most Wired Hospitals" Rate Patient Satisfaction: Considering the role of IT as a variable in health care institution quality assessment. *Communications of the ACM,* 51.
WIDEMAN, C. & GALLET, J. 2006. Analog to digital workflow improvement: a quantitative study. *J Digit Imaging,* 19 Suppl 1**,** 29-34.
WIMAN, B. 1995. Metaphors, analogies, and models in communicating climate-change uncertainties and economics to policy: a note on a pre-UNCED U.S. case. *Ecological Economics,* 15**,** 21-28.
WINTER, A., BRIGL, B., FUNKAT, G., HABER, A., HELLER, O. & WENDT, T. 2007. 3LGM2-modeling to support management of health information systems. *Int J Med Inform,* 76**,** 145-50.
WYATT, J., BATLEY, R. & KEEN, J. 2010. GP preferences for information systems: conjoint analysis of speed, reliability, access and users. *Journal of Evaluation in Clinical Practice,* 16**,** 911–915.

XAVIER, A. Measuring the efficiency of Portuguese hospitals with DEA: an approach using the General Algebraic Modeling System. 5th WSEAS Congress on Applied Computing conference, 2012. 62-67.

XUE, Y. & LIANG, H. 2007. Understanding PACS development in context: the case of China. *IEEE Trans Inf Technol Biomed,* 11**,** 14-6.

YU, L. 2011. Coevolution of Information Ecosystems: A Study of the Statistical Relations among the Growth Rates of Hardware, System Software, and Application Software. *ACM SIGSOFT Software Engineering Notes* [Online], 36.

ZAHEDI, F. 1987. Reliability of information systems based on the critical success factors - formulation. *MIS Quarterly,* 11**,** 187-203

ZHANG, D. & SHI, Z. The Application of Multi-agent Technologies in Distributed Ecosystem Process Simulation System GLOPEM-CEVSA GCIS '09. WRI Global Congress on Intelligent Systems, 2009. 109 - 112

ZOHAR, D., LIVNE, Y., TENNE-GAZIT, O., ADMI, H. & DONCHIN, Y. 2007. Healthcare climate: a framework for measuring and improving patient safety. *Crit Care Med,* 35**,** 1312-7.

APPENDICES

Appendix 1- Arid Zone Analogy

Some of the potential analogies that can be drawn between the arid zone (or desert) ecosystem and the hospital management technology ecosystem (HOME) are as follows:

Arid Zone Ecosystem Descriptor	***Comparison with Forest Ecosystem (Clinical/Scientific Domain in Hospitals)***	***HOME Equivalent***
highly specialised plants and animals/highly adapted	Diversity of life forms Complex/layered environment Multiple levels of forest	Only certain staff that survive in competitive environment (few positions- top of pyramid)
Little water - diversion into forest	Plentiful rain and nutrients	Little investment (versus clinical technologies) (rain and nutrients)
High temperature	More temperate- less extremes of temperature	Internal and external political pressure and exposure
Competition for scarce resources	More resources available	Highly competitive/cut throat environment (squeaky wheel gets the oil in relation to resourcing)
Sporadic rain – life forms adapted for opportunistic use/storage	Regular, rather than sporadic, rainfall	Intermittent funding (versus continuous flow of money into clinical environment)

Appendix 2- Key Informant Interview Questions

1.Gender

- M
- F

2.Age Bracket

- 19-34
- 35-44
- 45-54
- 55-64
- 65+

3.Industry Sector – Hospital/Government/IT Industry

- Hospital
- Government
- IT Industry
- Other

4.Job Role

- Hospital manager/executive – if so - prime area(s) of responsibility

- IT and Information Ops – if so – which area eg- developer, apps specialist
- IT and Information Management
- Clinician
- Clinician Manager – if so - prime area(s) of responsibility
- Program Leader
- Other……..

5.Total Years experience in stated Industry Sector

- 0-5
- 6-9
- 10-14
- 15-19
- 20-24
- 25+

6.Total Years experience in Healthcare Industry

- 0-5
- 6-9
- 10-14

- 15-19
- 20-24
- 25+

7.What technologies do you think are a key part of a hospital IT environment? (More than one OK)

- Patient administration and workflow technologies eg- PAS, RIS, LIS
- Clinical Systems eg – PACS, electronic ordering , electronic results viewing, EHR , clinical decision support systems
- HR systems
- Finance Systems
- Executive Dashboards
- Management Decision Support Systems including for example, GUI's to data warehouses
- Bed boards or patient flow tracking systems
- Analytic and Predictive Systems e.g. Cap Plan
- Other …….

8.In thinking about these systems – which do you think are essential to managing hospitals (as opposed to managing individual patients' care directly) and why?

9.Do you think that there is one critical technology that is a must in terms of managing hospitals, or that acts as a cornerstone of that management – which do you think it would be? And why?

10.If yes - Do you believe there are any key relationships between that technology and others you have described above? And why do you say that?

11.Do you think these systems you described in question 1 have been successful in that role of assisting the management of hospitals? Say on a 1 to 10 scale where 1 = totally unsuccessful and 10 = completely successful.

12.In your mind, how have you established that relative level of success?
Is it number of users?
Is it routine use in decision making?
Is it the level of investment made in these systems?
Is it perceived product maturity?
Is it their level of integration between technologies?
Is it their effect on hospital performance in access, quality or finance?
Or other measures?

13.Do you think these systems you described in question 1 have changed in recent years in relation to their role in assisting the management of hospitals? Say on a 1 to 5 scale where 1 = very adverse change , 3 = no change , 5 = very positive change.

14.In what ways (good or bad) do you think these systems have changed in recent years? For example:

have they got easier or harder to use ?

have they got easier or harder to integrate?

do they provide more functionality than they previously did, or vice versa

are more hospital staff using them?

are they more readily available in hospitals, and if so why?

Other ways

15.What forces and factors from within hospitals do you think determined the level of change you have indicated in your answer above?

Internal funding availability

Needs around patient access

Needs around quality of care

Financial Imperatives

Changing Models of care – eg a shift to ambulatory or virtual services, the building of a new facility

Management changes and restructures

Other factors

16.What forces and factors from outside of hospitals do you think determined the level of change you have indicated in your answer above?

has their cost come down

are they easier to develop

have standards or available implementation technologies changed them – and how?

funding availability

Other factors

17.What do you think is the relative contribution of those 2 elements (inside versus outside of the hospital forces/factors) above to the change you have observed ?

Eg – 50% internal, 50% external .....or variations

18.Do you think that there has been any interplay between these factors driving change? Can you explain how these factors have interacted in your view? For example – has the level of government funding for standards initiatives supported or limited the evolution of these systems?

19.What are the currently unmet needs of hospital managers (of all types) in relation to IT in your opinion? (this assumes there are some – a valid assumption as in many dimensions we all have ongoing unmet needs, and this is also the base assumption behind the entire PhD) For example

Incorrect information

insufficient information

too much information

insufficient or inadequate functionality

insufficient support for decision making

insufficient support for predicting future events - eg - occupancy crises

Others

20.and why do you say that?

21.and in which topic areas:

patient access

financial management

resource management (including HR)

quality management

Others

22.and why do you say that?

23.In light of those unmet needs, in what ways do you think these systems may change in the next 5-10 years?

More or less prevalent

Better or worse integration with other relevant systems

Broader range of information versus information overload

Easier or harder to use

Others

and why do you say that?

24.Ultimately – do you think these current unmet needs will be met in the next 5-10 years in light of the changes you think may occur? Grade your answer from 1 to 5: 1 = very confident they **will not** through to 5 = very confident they **will.** 3 = unsure

25.What intra hospital forces and factors do you think will drive towards your predicted outcome in the next 5-10 years?

Funding - enough or not enough

Patient access needs

The need for financial success

The need to improve quality

More or fewer skilled IT and information professionals

Others

26.What forces and factors external to hospitals do you think will drive towards your predicted outcome in the next 5-10 years?

The development or underdevelopment of standards

Funding – sufficient or insufficient

The complexity of managing hospitals

The further development or insufficient development of suitable technologies

Others

27.In thinking about the sorts of technologies important to the management of hospitals – can you identify things that take any of the following roles?

- **the component role** - "describes technologies when they are used as components in more complex technologies" (eg – the hard disk drive)
- **the product and application role** - "describes technologies when they are built up from a set of components, and are designed to perform a specific set of functions or satisfy a specific set of needs" (eg – an MP3 player)
- **the support and infrastructure role** – "describes technologies when they work in conjunction or collaboration with (or as a peripheral to) other technologies" eg – a printer (Adomavicicus et al , 2006)

28.In thinking about planning in this environment, from the perspective of your role (as a manager or clinician manager, product developer, hospital executive, funder etc) how do you go about it? What frameworks do you use? What drivers do you take account of? What constraints do you have to bear in mind?

29.Finally, in thinking about this interview and the questions you have answered – how would you characterise the hospital IT environment as it pertains to the management of hospitals (as opposed to the management of individual patients)

as a lush forest full of trees, wildlife, birds and plentiful rainfall

as a barren desert with not much water, harsh sun and where not many species of plants and animals can survive

as a coastal environment with seaside plants and creatures, and exposed to the elements and tides

as woodland with trees, much wild life, and beautiful flowers

as a snow scape with much moisture, cold temperatures and specially adapted wildlife and plant life

Or another physical environment you can think of

Please explain your answer

Appendix 3- Site 1 – IM and T Planning Artefact

Project Request Registration – Form B

SELF ASSESSMENT

Priority Ranking for New IM&T Project Requests

Project Name:

	Direct Patient Benefit	Direct Staff Benefit	Management Accountability	Financial Benefits	Governance	Other
Mandatory Support	☐Restores or maintains current level of patient safety in a very substantial way	☐Restores or maintains current level of staff safety in a very substantial way	☐Nil	☐Nil	☐Required to achieve legal compliance	
High Level	☐Enhances current level of patient safety in a very substantial way	☐Enhances current level of staff safety in a very substantial way	☐Retains current ability of manager to improve accountability for patient outcomes when non electronic options are not in place or possible	☐Maintains ability to pay staff or service providers in an accurate and timely manner	☐Required to achieve state policy compliance	
Desirable	☐Improves Patient Care	☐Restores or maintains staff satisfaction/rotation	☐Enhances ability of managers to improve accountability for patient outcomes where non electronic options are in place or possible	☐Has a significant measurable financial benefit that is immediately available for other users eg. Enhance revenue collection	☐Required to achieve Area Policy compliance	
Low Level		☐Enhances staff satisfaction/rotation	☐Enhances ability of managers to improve accountability to NSW Health for non patient matters	☐Has a marginal direct financial benefit but is more efficient	☐Required to achieve local policy compliance	

Instructions: Self Assessment to be completed by Project Manager/Applicant and reviewed by Project Sponsor as part of application. Please click the" cell" in each column that best represents your initiative. Any column left blank will be assumed as 'not applicable', i.e. No benefit. If there are benefits not otherwise listed please include them under 'other' and specify what those benefits are.