The potential role of Maturity Models in an assessment of Hospital I.T. Capability in Ireland

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Declaration

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

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Table of Contents

Index of Figures and Tables

Word Count

Dissertation Section	Words in Section
Declarations and Content Tables	1,388
Dissertation Summary	440
Dissertation	23,265
Appendices and References	3,855
Total Words	28,948

Abbreviations

BOK	Body of Knowledge
CDA	Clinical Data Architecture
CEN	Comité Européen de Normalisation
CMM	Capability Maturity Model
DICOM	Digital Imaging and Communications in Medicine
DMAIC	Define, measure, analyse, improve, control
DOH(C)	Department of Health (and Children)
EA	Enterprise Architecture
ED	Emergency Department
EDP	Electronic Data Processing
eHR	electronic Health Record
EMR	Electronic Medical Record
EMRAM	Electronic Medical Record Adoption Model
ERP	Electronic Resource Planning
HEBE	Health Boards Executive
HIMSS	Healthcare Information and Management Systems Society
HIT	Hospital Information Technology
HITCAP	Hospital Information Technology CAPability (score)
HL7	Health Level 7
HSE	Health Services Executive
I.T.	Information Technology
I.T. - CMF	I.T. Capability Maturity Framework
ICT	Information Communications Technology
IHE	Integrating Health Enterprise
IMM	Interoperability Maturity Model
KPA	Key Process Area
KPI	Key Process Indicator
MML	Medical Markup Language
NEHTA	National E-health Transition Authority
NPfIT	National Programme for Information Technology
PACS	Picture Archiving and Communications System
PAS	Patient Administration System
PM	Project Management
PM3	PMMM
PMI	Project Management Institute
PMMM	Project Management Maturity Model
PPARS	Payroll Personnel and Related Systems
RIM	Reference Information Model
SPI	Software Process Improvement
VFM	Value for Money

1 Summary

Capability Maturity Models (CMM) were developed in the Software Engineering industry to allow the assessment of organisational and process maturity against a best practice framework and to establish a roadmap for ongoing development. This dissertation examines the potential to implement a CMM approach to managing Information Technology (I.T.) in healthcare. In particular this work looks at the development of a measurement instrument to assess I.T. sophistication in Irish acute Hospitals which is purported to vary from hospital to hospital and to be lacking in the use of standards.

1.1 Objectives:

Using a sub-set of an existing survey instrument (Jaana et al, 2009), HIT (Hospital Information Technology) sophistication in a sample of Irish acute hospitals is characterised on eight dimensions and is measured and assessed in the form of a HIT Capability score. The scores calculated are compared with those from a Canadian study and predictive variables previously determined as supporting these scores are analysed. The results are compared with the targets identified in the U.S. 'Meaningful Use' initiative (Blumenthal and Tavenner, 2010). An heuristic assessment of the growth of HIT on a national level is provided in accordance with the Nolan stages of growth model (Gibson and Nolan, 1974) and the development of the Irish Electronic Medical Record is heuristically assessed using the European Medical Record Assessment Model (HiMSSANALYTICS, 2011).

1.2 Main Findings:

The results of the quantitative research conducted support the hypothesis that HIT sophistication in the acute care sector in Ireland is varied. On examination of the spread of scores for the Irish sample, there is a difference of 35% points between the highest and lowest scoring hospitals in the Functional vector category (84% – 49%). The overall HIT capability score achieved for the sample was 49% which is seven percentage points lower when compared to results produced in an equivalent Canadian study. Most importantly the results show comparatively low scores on the Integration vector which by definition would demonstrate a measure of sophistication.

1.3 Conclusions:

Many suitable management tools exist capable of the task of best practice and maturity assessment in Healthcare ranging from those in Project Management to those already proven in the interoperability and HIT management domains. An appropriate survey instrument has been identified, customised and utilised in developing a HIT capability scoring mechanism for the acute hospital sector in Ireland. It has been possible to characterise the extent of HIT capability both in terms of individual participating hospitals and on a national basis using an heuristic approach. It has also been possible to analyse the results against those of a comparative Canadian study and to demonstrate support for the antecedent for HIT innovativeness.

2 Introduction and Background

2.1 Irish Hospital Information Technology Background

The Delloitte and Touche Report (Deloitte&Touche, 2001) identified a fragmented and non-standardised Information Systems infrastructure in the Irish Health Service in 1999. Evaluation of data is consequently fragmented which works against the need to share information. In the Irish Health Information National Strategy report of 2004 (DOHC, 2004), the electronic Health Record (eHR) , the report says, will enable shared-care and through integration will support enterprise-wide resource planning. The importance of the interoperability of systems is highlighted and a national coordinated approach to its implementation is advocated. The report describes a landscape of many different systems, some of which are quite sophisticated while mostly there is a paucity of ICT advancement. The lack of standards makes the sharing of information difficult. There is also a legacy of underinvestment in ICT and the estimates for 2004 were set to double. According to the 2004 strategy, a National Health Information standards framework would be developed with input from health service agencies to include data, technical and quality standards and a Health Services Data Model. Future HIT projects are now to be funded in the national context where there is applicability across a number of hospitals. However, to ensure value for money (VFM), all investment in ICT is to be complemented with change management programmes and supported by a comprehensive business case.

In the same year, a (Health Boards Executive (HeBE), 2004) report says ICT will be an enabler to the achievement of a world class health system. The modernisation and reform programmes of the HSE are acknowledged and the ICT strategic vision will be rooted in the business needs which will come with such reform. However, while annual spend on Health ICT commands less than 1% of the overall health budget (Figure 1) – has the service left itself exposed to taking advantage of ICT, the report asks. The ICT budget for the health system was set to increase by a factor of four to six in the near future. The HeBE report set a target of 2011 for the achievement of a strategic ICT framework, one which would be technology independent. In addition to local applications, ICT services would be delivered at an enterprise level and a

library of application services would exist on a national basis. Local implementation resources would take ownership and accountability of projects. Procurement of systems would be conducted on a national basis and would use structured techniques. Value for money would be achieved through the use of standardised procurement processes. An enterprise architectural project would provide: Logical Data Models; Technology architecture; Enterprise-wide networking architecture and secure standards-based technology infrastructure allowing for true interoperability.

Public Health Expenditure

	2001 €b	2002 €b	2003 €b	2004 €b	2005 €b	2006 €b	2007 €b	2008 €b	2009 €b	2010 €b
Capital	6.8	7.9	8.8	9.6	11.1	12.2	13.7	14.5	15	14.4
Current	.37	.5	.5	.5	.5	.46	.58	.59	.44	.39
Total	7.1	8.4	9.3	10.1	11.6	12.7	14.3	15.1	15.5	14.8

Public Health Expenditure - ICT

	2000 €m	2001 €m	2002 €m	2003 €m	2004 €m	2005 €m	2006 €m	2007 €m	2008 €m	2009 €m	2010 €m
Capital	18.1	26.4	28.6	40	67.4	58.4	24.9	30.2	20.4	12.6	40*
Current										100*	100*
Total										112.6	140

Figure 1 - Public Health Expenditure (DOH, 2010)

*Revised Estimates for Public Services 2010

Five years on, a report for Ireland contributing to a European survey on the implementation of eHR's (Hurl and Kenny, 2009) established a status of HIT for Ireland and reported the implementation of disparate systems many of which are not integrated. They reported that the national procurement process had contracted for the delivery of a basic Patient Administration System (PAS) as the cornerstone to its national eHR objective. This system had been rolled out to 26 of the country's 52 acute hospitals by the HSE with implementation priority given to those hospitals using legacy systems deemed at risk. It suggested that a 'rip and replace' strategy should not be followed for the more mature sites and a 'multiple roads' approach supported by standards and integration should be the strategy of choice in these cases. The report recognised that HIT sophistication levels varied greatly from large teaching

hospitals to smaller district hospitals. Anticipating the publication of a HSE ICT Strategy Document, the advocation of a more integrated approach of ICT and business strategies was expected. The much awaited ICT Strategy would identify priorities for investment and a roadmap to the achievement of a national eHR for all hospitals. The strategy was expected to support the understanding that business needs must drive I.T. investment and business managers must own the delivery process. It was hoped that I.T. capability would grow by harvesting existing solutions to deliver benefits quicker and more economically. It was acknowledged that organisational and cultural factors rather than the development of technology were the limiting factors and that a component-based solution coupled with open architecture and international standards would be the ideal way forward. Achievement of the goals of such a strategy is frustrated by the lack of standards and the availability of suitably qualified resources. The ICT Strategy report, which was expected in June 2008, was not published and in April of 2011 its publication was then expected in the "second quarter of 2011" according to a senior HSE official.

2.2 Comparison with the UK National Program for IT

> *"… integrating healthcare records …, is complex and requires excellent technical solutions and vast degrees of cultural and organisational change. To suggest you can build that and roll it out in the same way that you would roll out a supermarket checkout system displays incredible naivety that would make you seriously concerned about their understanding of the complexity of healthcare." - Frank Burns, BJHC 2002.*

The ability of Enterprise Systems to deal with complex business processes is an important key consideration when analysing the approach taken in the NPfIT. In (Brennan, 2009), the author reflects on the UK National Program for I.T. and asks if it has been successful and looks at alternative approaches. With progress stumbling half way through the programme in 2008, Patient Administration Systems (PAS) each with different levels of sophistication have been implemented in only a dozen or so of the 151 acute Hospital Trusts. As a top-down approach using an unwieldy NHS appears to have failed, the suggestion now is that it may have been better to assign responsibility for

delivery to local authorities. Developing a national eHR is not necessarily the answer to delivering integrated care locally and there was no business case made for the achievement of a national eHR. Local Clinical I.T. systems with decision support and sharing of information locally was seen to be the way to deliver real patient care benefit. A catalogue of interoperable accredited systems might have worked just as well and this question was asked of Sir John Pattison (head of the NHS National Programme for IT). Sir John pointed to the issue of capability, especially in the area of change management, and suggested the scale was too vast to entrust to local abilities. Organisational change skills would be required and the view was that neither the suppliers nor the NHS had these skills. Previous procurement methods took too long and did not deliver on financial economies of scale. On the other hand, the estimated saving on foot of a centralised procurement service was in the region of £3.8 billion- £4.4 billion over the 10 years of the programme. It was not difficult therefore to identify the rationale for a national approach. In a separate review by the Professor Lord Darzi, (Darzi, 2008), it is suggested that local achievements are just as important when one considers the length of time it is taking to implement the NPfIT. Interim initiatives are needed so that patient information is shared between different systems and provided to care-givers in different care situations. Benefits which can be achieved sooner than the delivery timescale set for the national strategic systems are important to patients and care-givers and the pursuit of long-term perfection should not inhibit the realisation of such benefits. There is a renewed emphasis on local action and some are looking to the older delivery action programmes while they wait their turn in the national drive.

2.3 The questions addressed in this work

While investment levels in HIT in Ireland remain at existing levels, it is unlikely that a single system approach to achieving a national eHR is achievable in the near future. In the (Health Boards Executive (HeBE), 2004) report the goal set for HIT as an enabler to a world-class health service was to increase health I.T. spend from 1-6%. However, in the National Development Plan covering 2007 – 2013 the implementation of a National Health Information Strategy was allocated just 0.6% of the annual health revenue budget for the same period. In reply to an open question in the survey attached to this work, one

I.T. Manager remarked when asked to provide a general comment on I.T. in his hospital:

> *"Much more potential to use systems. Very little investment forthcoming".*

Looking at the experiences of other countries (Figure 2), the length of time it has taken them to progress with their individual national HIT efforts and the investment levels necessary to support these efforts, real advancement in HIT in Ireland in terms of achieving a national eHR is set to take quite some time.

In the absence of a nationally coordinated, funded and resourced organisation to manage and control the implementation and change management efforts required for such a sizeable goal, it will remain to local initiatives to bridge this gap. With time on our hands, this dissertation suggests that hospitals should conduct a programme of assessment to establish where we are first and to establish a commencement point on the ladder to eHR maturity. If the current status of HIT Capability in Irish Hospitals is one of disparate systems and varying degrees of sophistication, can this be measured and if so how can the growth of HIT infrastructure be managed in accordance with best practice? If the achievement of an integrated eHR of national proportions rests with the interoperability capabilities of these systems based on international standards, how equipped are we in terms of these capabilities? These are the broad questions addressed in this work.

	U.S.	Australia	Canada	Germany	Norway	U.K.
	ONCHIT	HealthConnect	Health Infoway	Better I.T. for Better Health	More Health for Each bIT	National Programme for IT
Start	2006	2000	1997	1993	1997	2002
Expected Completion	2016	Not defined	50% by 2009	2006	2007	2014
Type	eHR, pHR, Telehealth	eHR, point-to-point messaging	eHR	Smart Health Card	eHR	Integrated Care record Service, Electronic appointments and prescriptions
Investment in $US Dollar	$125m	$97.9m	$1.0b	$1.8b	$52.2m	$11.5b

Figure 2 - Efforts to implement HIT in six countries (Anderson et al., 2006)

2.4 The importance of the questions raised in this work

"You can't control what you can't measure"

- *Tom De Marco, Software Engineer, Pennsylvania, USA*

In (Deutsch et al., 2010) the authors look at the most common problem areas experienced in implementing national eHR's in different countries. Many different areas of difficulty are identified and individual measures to address these are identified, however, in the longer run it would be advisable, the report suggests, implementing a more comprehensive approach to tackle all of these issues in a more holistic way. According to the Gartner Group report (Edwards, 2006)

> *"Setting up of a process of continued monitoring and evaluation"*

was second on the list of lessons learned from project failures. The definition of long term goals and strategies and the existence of agreed standards were also identified as being important.

In Ireland there have been recent examples of projects not delivering on expectations when attempts have been made to implement enterprise-wide systems. Very often when systems fail, the tendency is to point a finger at the technology itself rather than the organisational infrastructure pre-requisite to making the systems successful. Readiness and preparedness to implement software successfully are pre-requisite to ensuring success. In a time of relative inactivity it would prove prudent to measure national readiness to ensure that when expenditure comes available that the Health I.T. sector is ready to optimise that investment. Other industries (e.g. Software Engineering) have developed Capability Maturity Models (CMM) which (i) allow the business to assess itself against a best practise framework and (ii) to establish a roadmap for ongoing development to realising value optimisation (Ahern et al., 2008). Capability Maturity Models can measure the level of preparedness in advance of project implementation and set out the framework required to maintain that preparedness up to, during and after the implementation. Management of the healthcare enterprise, in particular in the area of I.T., would be well served with the adoption of a CMM approach. In addition to the application of industry international standards, the CMM will provide the business maturity and value framework required which will give direction to the ultimate vision of a national EHR.

2.5 Similar work in this area

> *"If you don't know where you are, a map won't help" - (Humphrey, 1989)*

This dissertation argues that the constituent parts of the Irish healthcare industry, each at varying and disparate levels of I.T. maturity, should undertake a programme of assessment to establish a starting point of readiness for a national eHR and to measure existing maturity levels. (Paré and Sicotte, 2001) looks at ways of characterising I.T. for operational purposes as it is suggested that I.T. can contribute to an organisations growth and outputs. A measurement instrument which focuses on I.T. adoption is developed and validated. They declare there to be no such recognised, validated instrument in terms of I.T. sophistication available for healthcare organisations however. Such an instrument would allow an I.T. "sophistication profile" of institutions to be developed along different dimensions which would

allow comparisons between institutions. Using Nolan's "stages of EDP growth" conceptual framework (Gibson and Nolan, 1974) it has been possible to characterise I.T. and to identify the concept of I.T. maturity. Using Nolan as a theoretical foundation others went on to further define the criteria for maturity and sophistication. Nolan classifies maturity as the last stage in evolution where "information resources are fully developed and computer based systems are fully integrated". Paré himself went on to identify a multi-dimensional concept which included functional, informational, I.T. management practice and support elements. A literature review including (Hatcher, 1998) identified available I.T. sophistication measurement concepts of the time. Leaning on the Nolan concepts of maturity, Paré developed an I.T. Sophistication Framework in Hospitals based on a revised construct which included:

> *"… diversity of technological devices and software applications used to support patient management and patient care, clinical support and administrative activities … and the extent to which computer-based applications are integrated (electronic and automatic transfer of information)".*

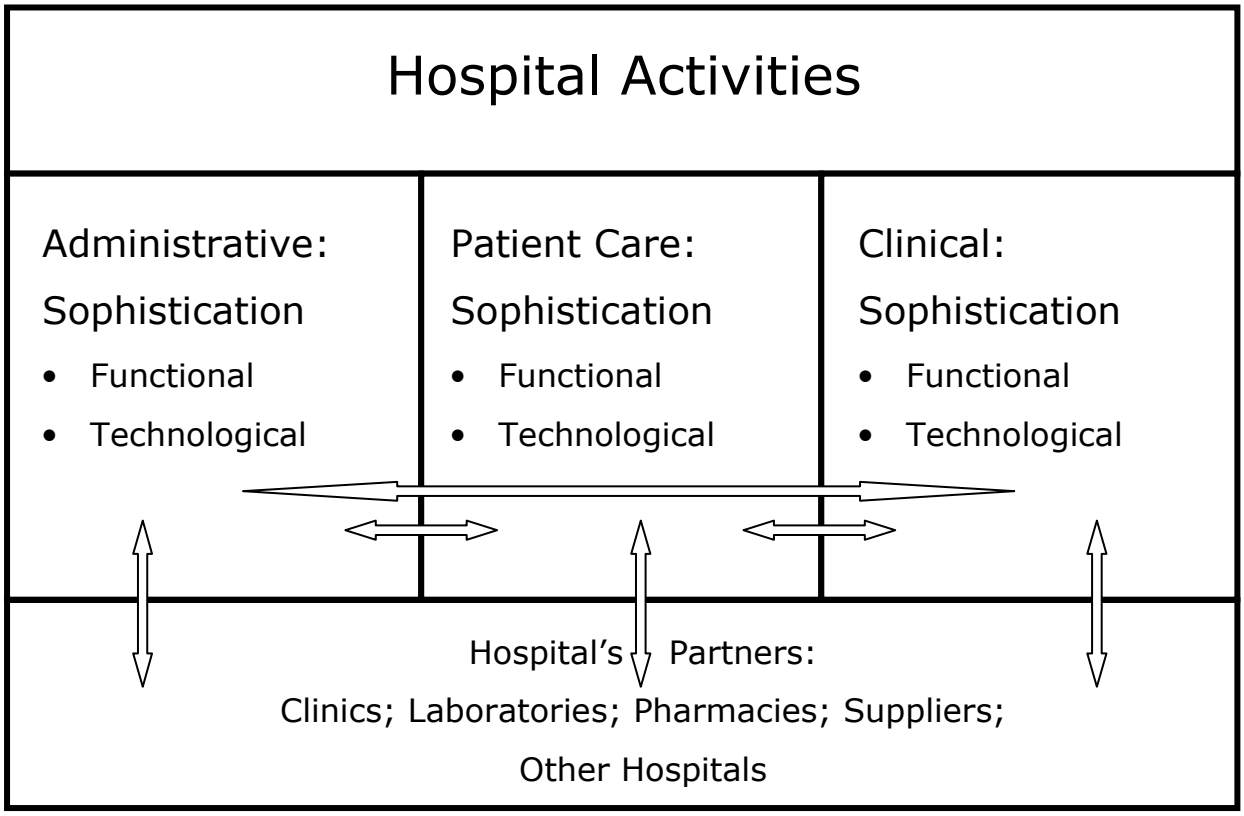


Figure 3 - I.T. Sophistication Framework (Paré and Sicotte, 2001)

In (Jaana et al., 2009) the author reflects on the varying levels of I.T. sophistication across the healthcare spectrum in Canada and the difficulty posed in measuring this maturity. In 2007 they researched the literature and identified previous studies which examined the application of information technology sophistication measurement instruments in Healthcare. Taking the Paré construct, the author developed a revised measurement instrument which allowed the calculation of an I.T. capability score in eight healthcare I.T. dimensions namely: Patient Management; Clinical Systems; Clinical Support; Administration Systems; Internal Integration – Administration Systems; Internal Integration – Clinical Systems; External Integration and Technology and allowed each of the domains be further measured on four vectors, namely: (i) Functional; (ii) Technological (iii) Integration and (iv) Overall.

2.6 Areas which require additional work

While the tool developed by Jaana in 2009 was later applied in a number of additional studies, the authors nonetheless declared a number of areas for further development including: increasing the number of integration factors and the extension of generalisation to countries outside of Canada. The Jaana measurement instrument has not been applied in the Irish context and doing so would address the generalisation issue. By their own admission, the authors also suggest that a larger number of integration factors in the instrument may have led to a better concurrent validity reading in the integration category. There are no measures included in the instrument which attempt to gauge the degree of success of the I.T. capabilities.

2.7 Research Objectives and approach

The objectives of this work are to:

Objective 1	By way of a literature review, research the answers to the questions on HIT management best practice and the applicability of a Capability Maturity Model approach in Healthcare I.T.
Objective 2	By way of a literature review, identify an existing validated HIT Capability survey instrument. Based on this instrument and with industry thought-leader participation, develop a customised version of the tool for use in the Irish acute hospital sector.
Objective 3	Using the instrument developed, measure the level of HIT Capability in an agreed sample of acute care hospitals in Ireland and establish a generic catalogue of applications, technology, standards and management and information models in use.
Objective 4	Analyse the findings through descriptive and comparative analysis with other studies and test the correlation of the measures established with known antecedents.
Objective 5	Triangulate the findings by conducting heuristic evaluations of Irish HIT Capability using other industry models such as EMRAM (Electronic Medical Record Adoption Model)
Objective 6	Outline limitations in the study and identify further work which needs to be undertaken to complete the research in this area.

Figure 4 - Research Objectives

3 Maturity Models – Literature Review

The literature review which follows examines the development of the 'stages of growth' model concept and covers the application of the maturity model with specific reference to the Healthcare domain. The research carried out with this work has identified the more popular disciplines within the domain using the maturity model concept and will focus on these.

3.1 Stages of Growth Models

In (Galliers and Sutherland, 2003) the authors examine the original 'stages of growth' model identified by Richard Nolan, who established a relationship between the growth phase of an EDP (Electronic Data Processing) department and the proportion of money spent on Data Processing. The original models, (Gibson and Nolan, 1974) and (Nolan R L, 1979), noticed that organisations involved in the adoption of Information Technology (I.T.) go through similar stages of organisational growth. Their research looked at I.T. expenditure and noticed it followed a common 'S' shape which had three identifiable change points which in turn allowed them identify four different stages of growth in the life of I.T. introduction.

> *"EDP … is so complex that controlling it or even understanding it is almost too difficult for words".*

It was necessary to characterise this growth in some way to make it more understood to all concerned. The Nolan Stages of growth model initially identified four different stages;

1. Initiation (often referred to as the 'ad-hocracy' stage)
2. Contagion (later expressed as expansion)
3. Control (later expressed as formalisation)
4. Maturity

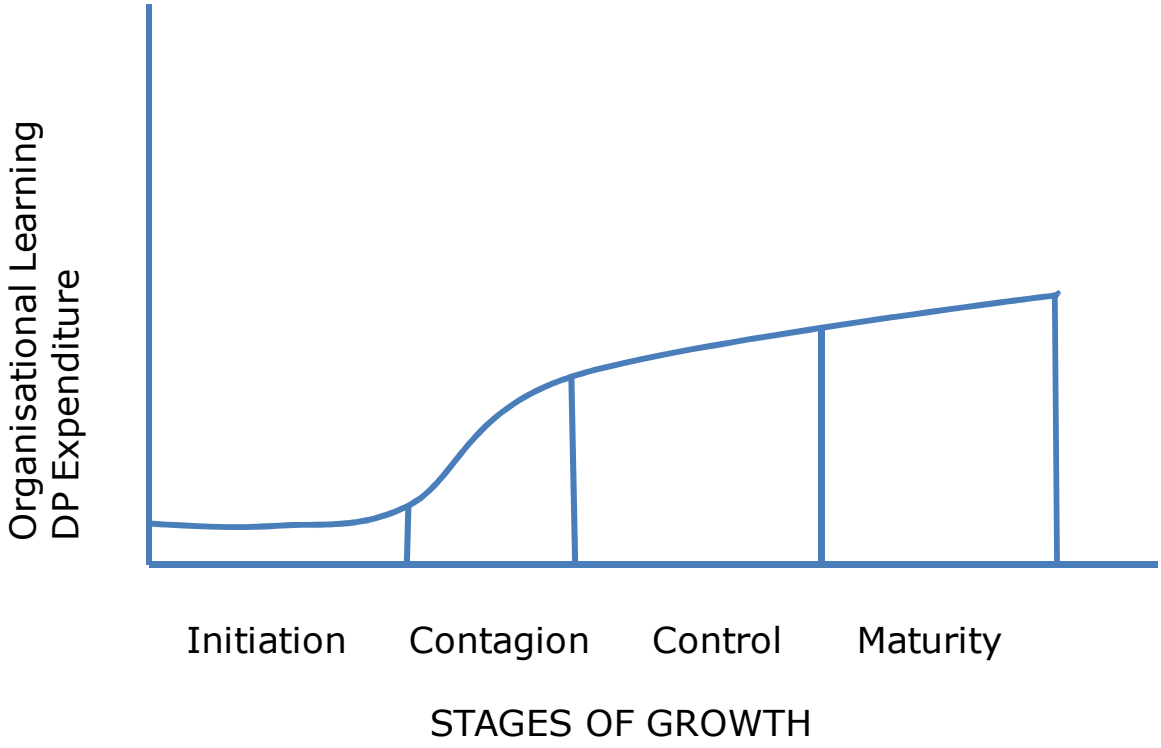


Figure 5 - Four Stages of DP Growth (Galliers and Sutherland, 2003)

In (Galliers and Sutherland, 2003) Nolan's initial model is enhanced to include two additional stages; Integration and Data Administration, and the revised model characteristics were re-expressed as follows:

- **Initiation** (introduction of IT) - this is the initiation phase often described as the 'adhocracy' phase during which there is little control and I.T. issues are not that well understood.
- **Contagion** (proliferation of IT) – during this phase there is expansion of I.T. systems to meet an increasing demand. There is a lack of business involvement in I.T. during this phase.
- **Control** (a need to contain costs) – as the cost of I.T. spirals and a perceived unsatisfactory service from the I.T. Department, formalisation is introduced with an increase of central control and an increased scrutiny of I.T. from management.
- **Integration** – this phase is characterised by an increase in co-operation and discussion where lessons are learned and the I.T. and business functions come closer together.
- **Data Administration** – this phase examines entrepreneurial opportunity which can add value to the business through effective use of I.T.

- **Maturity** (the mature phase) – this phase is described as an integrated harmonious phase where lessons are learned and there is an emphasis on integrating internal and external data and bringing I.T. into the mainstream of the organisation.

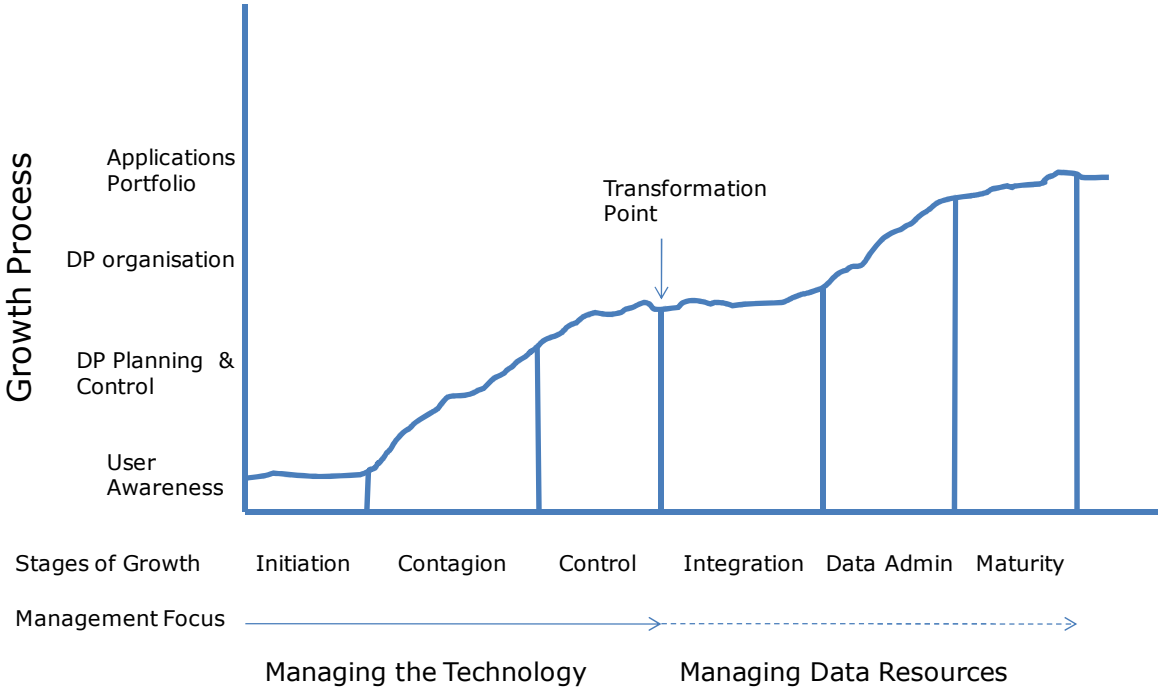


Figure 6 - Nolan's 6 stage growth model (Galliers and Sutherland, 2003) (amended from Nolan, 1979)

Later models by other authors, Earl Model 1986; Bhabuta's Model; Hirscheim Model 1988; each try to address the deficiencies identified in the original Nolan model i.e. the lack of organisational or management focus. In an effort to bridge this gap the authors look at each of the six stages of I.T. growth in terms of the parallel organisational elements as outlined in the 7 S's model of Pascale which examines: Strategy; Structure; Systems; Staff; Style; Skills and Super-ordinate goals (Super-ordinate goals may be described as the shared values or culture of the organisation). The revised Sutherland & Galliers Stages of growth model is included in Appendix (1) and identifies areas in an organisation at different levels of maturity to others. The elements contributing to the shortfall allow these to be the focus for improvement. The model emphasises the importance of addressing the maturity of a particular element in one stage before progressing to the same element in a later stage. The maturity gained at one level is carried forward to subsequent stages.

Consolidation at one stage in all elements is recommended before choosing the most appropriate elements of the next phase on which to focus.

3.2 Capability Maturity Models – definition

In their work co-funded by the European Commission, (Kohlegger et al., 2009) conducted a structured content analysis of 16 different representative maturity models. The work identified the existence of Maturity Models in many different domains with roots firmly set in software engineering. The work analysed the meaning of the term 'maturing' and looked at what elements mature; how a maturity model is used and supported and its main features.

> *"A maturity model conceptually represents phases of increasing quantitative or qualitative capability changes of a maturing element in order to assess its advances with respect to defined focus areas."*

The types of maturity model researched were categorised into maturing of persons; maturing of objects and maturing of social systems and ranked in terms of their approximated diversification as follows:

PSP	Personal Software Process	[Humphrey, et al. 2005]
PCMM	People Capability	[Curtis, et al. 1995]
SFIA	Skills Framework for the Information Age	[SFIA 2007]
Dreyfus Model	Skills Acquisition	[Dreyfus, et al. 1988]
Cross Model	Informal Learning: Innovation and Performance	[Cross 2007]

Figure 7 - Person Maturity Models (Kohlegger et al, 2009)

SPICE	Software Process Improvement Capability dEtermination	[Coletta 1995]
UMM	Usability	[Earthy 1999]
EMM	E-Learning	[Marshall, et al. 2004]
SMMM	Software Maintenance	[April, et al. 2005]
bIMM	Business Intelligence	[Chamoni, et al. 2004]

Figure 8 - Object Maturity Models (Kohlegger et al, 2009)

CMM	Capability	[Paulk, et al. 1993]
CObIT	Control Objectives	[ITGI 2007]
Nolan Model	Stages of Growth	[Nolan 1979]
TMM	Testing	[Burnstein, et al. 1998]
CM3	Corrective Maintenance	[Kajko-Mattsson 2002]
OIMM	Organisational Interoperability	[Clark, et al. 2001

Figure 9 - Social System Maturity Models (Kohlegger et al, 2009)

Assessment of maturity is executed using indicators of maturity such as; individual capabilities, processes and systems. A maturity model assembles and combines the development steps of the maturing element into a number of stages sequentially laid out where each stage is separated from the next by a trigger condition which marks the progression of the element from one stage of maturity to the next.

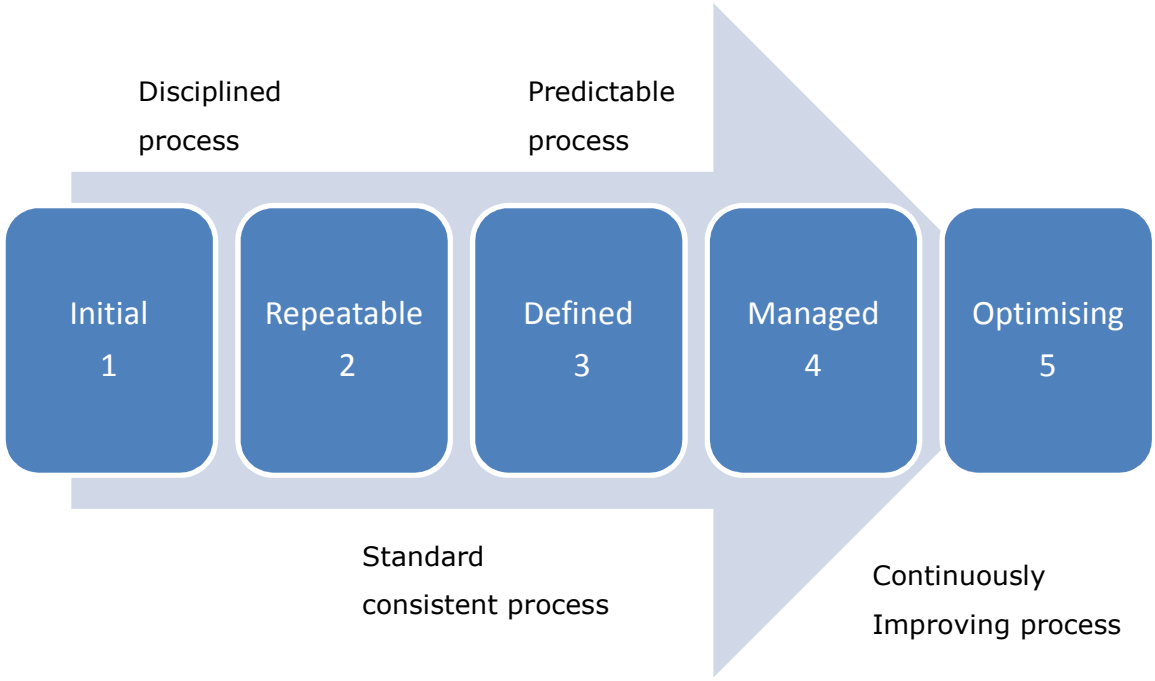
3.3 Capability Maturity Models - history

In 1991 the first version of the CMM was developed by Paulk (Paulk et al., 1993) adding to the work undertaken originally by Watts Humphrey in 1987. The intention of the framework was to help organisations improve their software process and to provide a process by which the capability of software contractors engaged by the government could be assessed. The CMM is described as a method of performing software process assessment or software capability evaluation. The ethos of the maturity model approach is to avoid the longer term success of new projects being dependent upon the heroics of a handful of individuals. Rather the emphasis should be on set of standard processes easily followed by any set of competent individuals. A mature

organisation will have an organisation-wide software process management capability.

> *"Process maturity is the extent to which a specific process is explicitly defined, managed, measured, controlled and effective" [Paulk]*

Traits associated with the mature state are: the potential to grow in capability; consistency; quality and productivity improvement; readiness; standards; verification; predictability and risk management. Identifying that problems exist is important, identifying those that require fixing as a priority requires an evolutionary mechanism – a roadmap enabling the improvement of a process on a continuous basis, a staged growth set of instructions. Each maturity level contains a set of processes each with corresponding goals. Process capability increases when the goals of a specific maturity level have been achieved.



Initial	Success depends on individual effort
Repeatable	Basic Project Management processes are in place to track cost, schedule, functionality and the experience gained on previous projects.
Defined	There is an approved, standard, documented process which is tailored for all projects
Managed	Quantitative measures are introduced for process and product
Optimised	Feedback allows for continuous process improvement through innovation and new technology

Figure 10 - The Five Levels of Software Process Capability (Paulk et al, 1993)

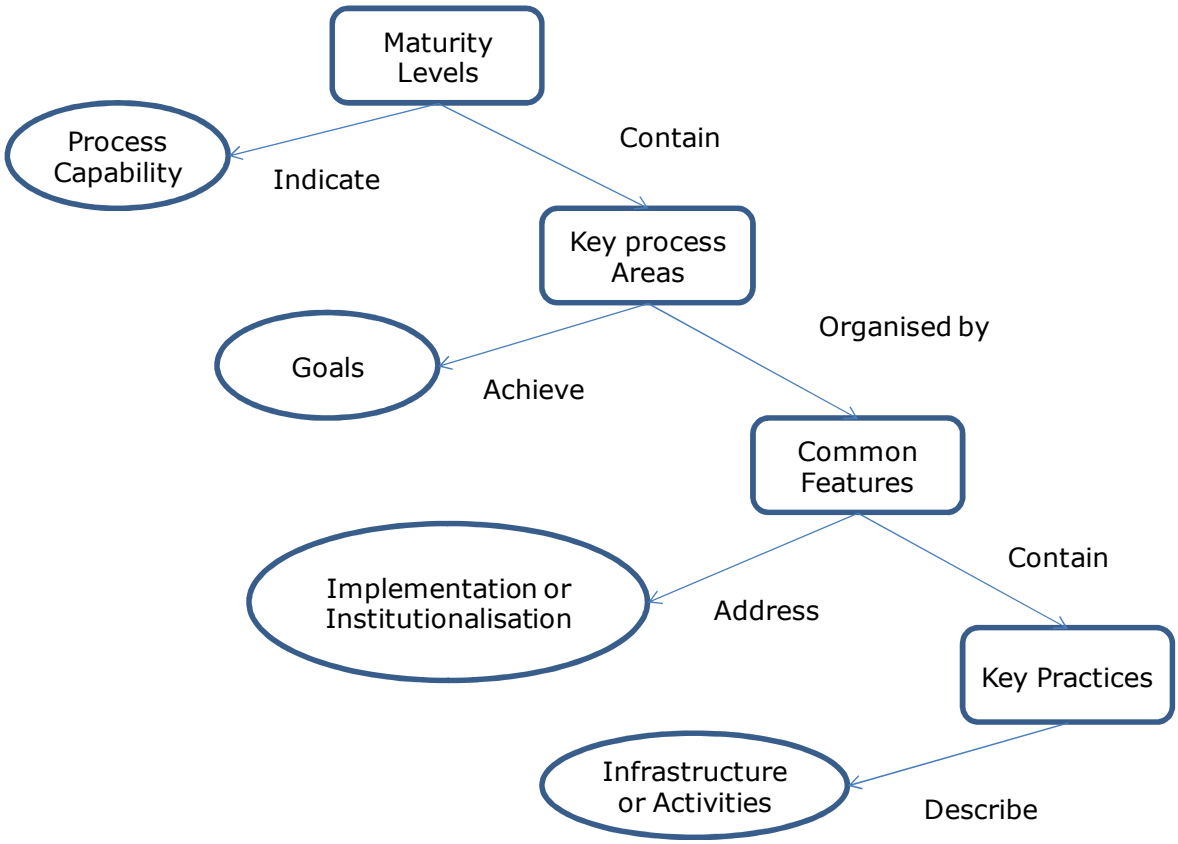


Figure 11 - The CMM structure (Paulk et al , 1993)

Paulk acknowledges that gains in process maturity will take many years as evidenced in the automotive industry. The application of the assessment process requires suitably trained staff and these are difficult to recruit and to keep motivated. In the short term however, the CMM could be tailored for

smaller projects and for smaller organisations. In the long term there is room for improvement to levels 4/5 of the CMM as few have achieved these levels and as little is known of them. The CMM needs to become multi-dimensional to include technology and human resource dimensions and the need to establish an international standard CMM for individual domains is highlighted. A research briefing from the Sloan School of Management (Curley, 2006) and (Curley, 2004) outline a four-strategy Capability Maturity Framework to enable I.T. Directors to focus on a maturity roadmap to lever value from IT. Developed originally to transform the I.T. capability in the Intel Corporation, it has since been further developed by industry led workshops and academic research has tested its applicability in different industries including Healthcare.

3.4 Capability Maturity Models – Electronic Medical Record

In (Wainwright and Waring, 2000), the authors point to advances in technology and healthcare reform in the UK and suggest that organizations in the NHS "have been unable to implement the strategic goals set by the policy makers". The ICT strategy of 1995 emphasises the need for integrated data across the enterprise and at the point of care to multi-disciplinary teams. They find that NHS hospitals are not very mature in terms of adoption and usage and there is a struggle to identify systems that provide adequate integration at a data and cultural level. The Wainright and Waring paper looks at the application of maturity models in the context of I.T. in the NHS. Using the Nolan stages of growth model (Gibson and Nolan, 1974) and (Nolan R L, 1979) the four stages of growth are examined in terms of the characteristics evident throughout each stage. A review and analysis of the previous 10 years efforts to implement ICT in health are reviewed using maturity models as an heuristic to measure levels of I.T. adoption and use (Appendix 2). The authors note that across the full spectrum of the NHS, organisations struggle under the weight of the national strategy each with its own issues, problems and levels of capability. The heuristic exercise allowed progress over the last 10 years to be explored. It helped establish the phase of development the NHS had reached and to compare this with what the Information Technology and Management strategy expected of them at that point. An Integration level of maturity has been assumed to underpin the 1995 strategy and ambitious goals have been set, however, the author suggests that the Integration level has not been achieved.

3.5 Capability Maturity Models – PACS

Maturity in PACS (Picture Archiving and Communications Systems) can be measured on a number of dimensions including inter alia Multimedia technology, Communications protocols and Integrated workflow. In (van de Wetering and Batenburg, 2009) the authors question if PACS has already matured and what the clinical impact has been. PACS and a filmless hospital have many benefits but may also be costly to achieve. It is seen therefore that alignment at an organisational level and successful implementation are prerequisites to maturity. An analysis of the literature identified 34 suitable papers which formed the basis of the analysis for the PACS maturity model. Hospitals use the model to perform an individual maturity assessment but it is not a roadmap to maturity – further work is needed for this. The PACS Maturity Model is included in Appendix 3. In (Whittick and Gill, 2006) it is suggested that a seven level maturity model to a fully Digital Image integrated EHR exists for PACS with progression from Department to Organisational, Regional and finally full EHR integration within Jurisdictional Diagnostic Imaging. (van de Wetering and Batenburg, 2010) looked at the unanticipated costs of PACS especially moving from one maturity level to another and the likely impact this has on budgeting. Blame is put on vendors giving misleading expectations and the failure of hospitals to implement an integrated planning approach. In order to sustain budgeting for PACS it is important to plan strategically and using the maturity model helps with this.

3.6 Capability Maturity Models – Enterprise Resource Planning

Following a study of 25 U.S. and European organisations (Holland and Light, 2001) identified a three stage maturity model associated with the implementation of an Enterprise Resource Planning (ERP) System. These were:

Stage 1	This stage is representative of organisations managing legacy systems and commencing the implementation planning of the ERP
Stage 2	The ERP is complete and the functionality is being exploited across the enterprise. There is an impact on organisational processes
Stage 3	The ERP is normalised into the organisation and strategic value is now being extracted in the form of knowledge management and Customer Relationship Management (CRM)

Figure 12 - ERP Maturity Model (Holland and Light, 2001)

The ERP Maturity Model provides a roadmap in understanding the evolution of the system within the organisation. This in turn provides assistance in understanding the implementation process required to achieving the full strategic value of the system. In terms of research there is now a framework upon which to base further questions regarding other areas which require scrutiny such as: technology diffusion; competitive advantage and the implementation process. The study used a questionnaire and senior managers were interviewed to determine the stage of maturity of each of 25 organisations in terms of implementation. The research framework consisted of 5 theoretical constructs (conceptual model): how I.T. is used strategically; the sophistication of the organisation; the level of adoption of the ERP; Vision; Drivers and learning process. A scoring mechanism was applied to each of the questions in each of the constructs and a maturity score was calculated for each of the organisations to provide a comparative analysis of maturity.

3.7 Capability Maturity Models – Interoperability

The provision of Healthcare involves many different players including, technical, informational and organisational and the ability of these players to interoperate will impact on the delivery of safe and reliable healthcare (NEHTA, 2007). With continually evolving technology and changes to clinical work practice, it is important to be in a position to assess ones capability to take advantage of these developments at any particular point in time. The National E-health Transition Authority of Australia (NEHTA) has devised an Interoperability Maturity Model (IMM). The NEHTA IMM consists of 3 components:

1. The CMMI (Capability Maturity Model Integration) five level maturity model
2. A set of interoperability goals
3. An assessment framework with a national perspective

Maturity Levels of the IMM are classified and characterised as in Figure 13 and address the organisational, informational and technical dimensions in the local, enterprise and national problem domains. Interoperability goals of Re-use; Evolution; Standards basis; Scope; Scalability; Configurability and Explicitness are shared amongst all three dimensions. Specific goals of Business Focus; Governance and Overhead to Change are set for the Organisational dimension. Information goals are classified as: Data Format and Semantics; Meta-data; Ownership and Rights; Common building blocks. Technical goals are classified as: Interface Specification; Functional Decomposition; Communication Protocol; N-tier architecture and Technical policy separation.

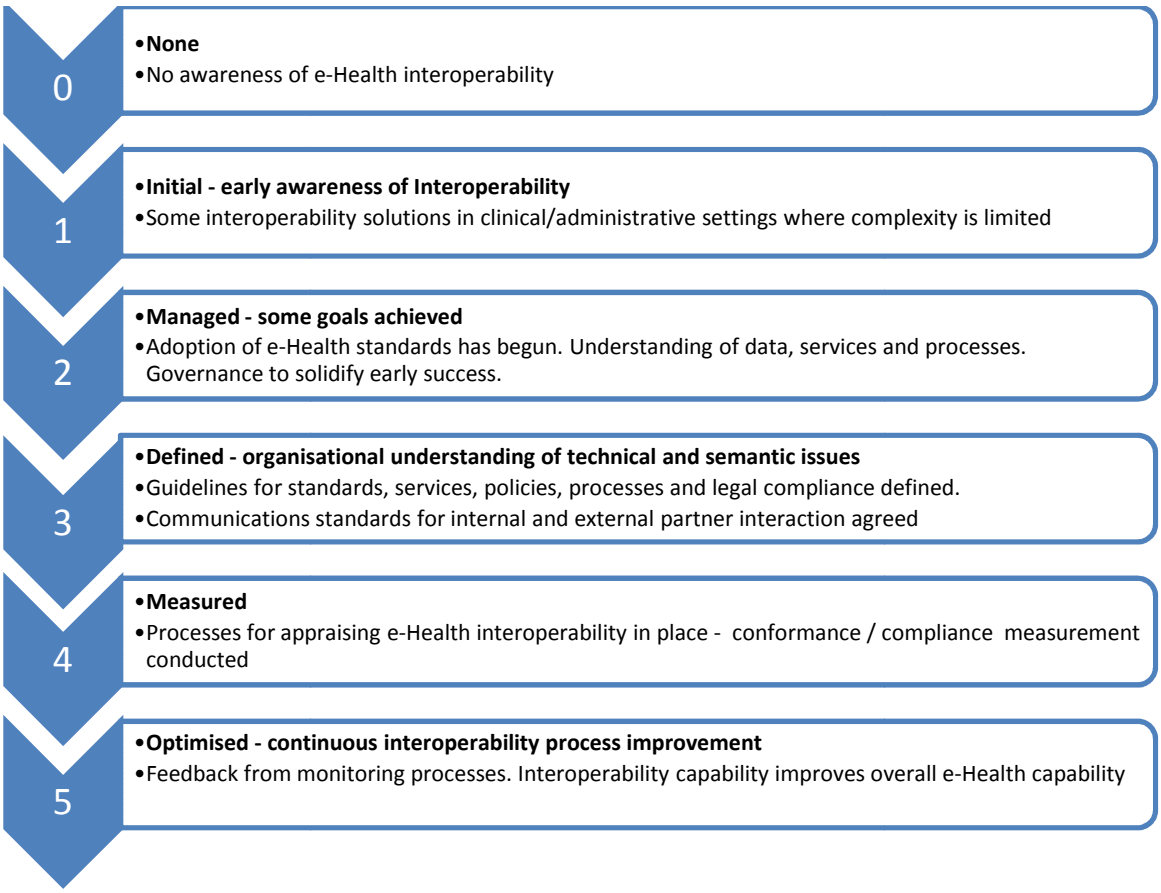


Figure 13 - NEHTA Interoperability Maturity Levels (NEHTA, 2007)

3.8 Capability Maturity Models – Project Management

(Brookes and Clark, 2009) look at the role of Project Management Maturity Models (PMMM). Those available often differ in terms of: scope; depiction of maturity and the project management knowledge area covered. Knowledge areas differ in number between: 9 as in the Project Management Institute's Body Of Knowledge; (Cooke-Davies and Arzymanow, 2003) looks at 10 domains; and (Andersen and Jessen, 2003) use 12 areas – 4 in each of 3 top level areas; Attitude, Knowledge and Action. Future work will attempt to provide a link between PMMM and project success and the development of universally accepted PMMM protocols and procedures.

Stages of maturity are examined:

Performed	The project management process is largely reactive in nature with no control mechanisms and as such are unpredictable
Managed	The PM process has defined structure but again is largely reactive
Defined	The PM process is well defined and is proactively engaged
Quantitatively Managed	The defined process is proactively engaged and there are measurement techniques applied to establish effectiveness giving control
Optimising	The entire PM process is fully engaged and integrated with the business strategy and process improvement of the organisation.

Figure 14 - Stages of Project Management Maturity (Paulk et al., 1993)

Project Management maturity has also been explored in the Berkeley PM Process Maturity Model (Kwak and Ibbs, 2002) where nine knowledge areas and five project processes define a maturity model for project management.

Scope can focus on project management but may also take a broader organisational view as organisational factors will often influence the success or failure of an individual project. (Lee and Andersen, 2006) identified a number of organisational factors which may impact on project performance and argues they should have a place in any Project Management maturity model. These included: a clearly defined organisational strategy with which the Project Team are aligned and the role of the Project Manager is separated from that of line managers; project portfolio management and management support. In (Hillson, 2003) Project Management is seen as a core competence and examines what is best practice for PM. Four levels of increasing PM capability corresponding to the recognised stages of adult/organisation learning were identified:

Naïve	The organisation can't see the value of Project Management in delivering business benefit and previous processes are repeated without learning from the lessons of the past.
Novice	There is PM experimentation with no formal structure processes in place
Normalised	PM is implemented across all aspects of the business. Generic PM processes are formalised and benefits are understood.
Natural	A project based culture predominates the business to gain competitive advantage)

Figure 15 - PM Capability Model (Hillson, 2003)

(Cooke-Davies, 2004) examines the characteristics of a mature project-based organisation, the definition of success and the existence of measures which can adequately size maturity and identify the likely benefits of such maturity. Unlike conventional Capability Maturity Models, Project Management Maturity Models measure the same things at all levels of maturity. In seeking to determine if the definition for success is consistent across all industries and for all types of projects, it is noted that the Petrochemical and Defence industries show as being the more mature as against I.T. and Finance. The Project Management Institute would suggest that there is a common core of practises to suit all industries but after this it is up to local initiative to tailor in accordance with local environmental requirements. Research needs to broaden its vision to understand different aspects of maturity in different industries. If further analysis of the definition of maturity is to be of value, then organisations will have to view maturity as an asset. PM maturity benefits include an organisation-wide ability to manage projects; well defined roles and responsibilities; the retention of detail from previous projects for comparative purposes and support for the strategic goals of the organisation. The success of PM may be measured in terms of time, cost and quality while the measure of project success may need wider parameters (business benefits). Just as there is an absence of global standards for PM so too is there a lack of standards for Maturity Models, an absence which may well inhibit their value.

3.9 Capability Maturity Models – Programme and Portfolio Management

Where there is no organisation-wide project infrastructure, project success will depend mostly on the ability of individuals. In order to develop a project supporting infrastructure which is individual independent and repeatable, companies must stop and ask themselves questions such as: where have we got to and what more needs to be done? In answer to such questions a company must assess itself against an industry standard model to measure how far they have progressed; to identify strengths and weaknesses and to define a roadmap to higher levels of maturity. (Murray, 2006) looks at Portfolio, Programme and Project Management Maturity Models (P3M3). The model incorporates a hierarchy of Key Process Areas (KPA) at project and organisational level. An assessment using these KPA's provides a roadmap to improvement and identifies those KPA's which require attention first. The Office of Government Commerce, a UK government department, developed Projects in a Controlled Environment (PRINCE, PRINCE2) a process-based methodology for controlling projects; Managing Successful Programmes (MSP); Management of Risk (MOR) and ITIL (Information Technology Infrastructure Library) to help public bodies:

- Improve efficiency
- Leverage improved value for money from the procurement of IT services
- Ensure improved success rates for projects and programmes

In 2006 the OGC launched the Portfolio, Programme and Project Management Maturity Model (P3M3) incorporating elements from the CMMI.

Figure 16 - Portfolio, Programme and Project Management Maturity Model (Murray, 2006)

Lean Thinking and Six Sigma are two popular systematic approaches to incremental process innovation. Lean Thinking goes back to the automotive industry in the USA and Japan while Six Sigma is associated with the improvement in the quality programme in Motorola. While originally established in industry, they have been adapted more recently in administration and service areas. In (de Koning et al., 2006) looking at the use of Six Sigma in Healthcare, the authors note that while the rising cost of technology and the aging population may be elements outside of our control, the management of rising costs linked with inefficient processes are items within our control. The authors examine the application of an integrated approach of both models in a Dutch Hospital. Lean is a total system approach with a focus on the customer. Six Sigma is also a customer focused approach with emphasis on decision making based on quantitative analysis. The organisation's strategy is examined and improvement projects are identified as operational goals. Six Sigma has 5 distinct phases of: Define; measure;

analyse; improve; control (DMAIC) and presents as a more complex programme than Lean.

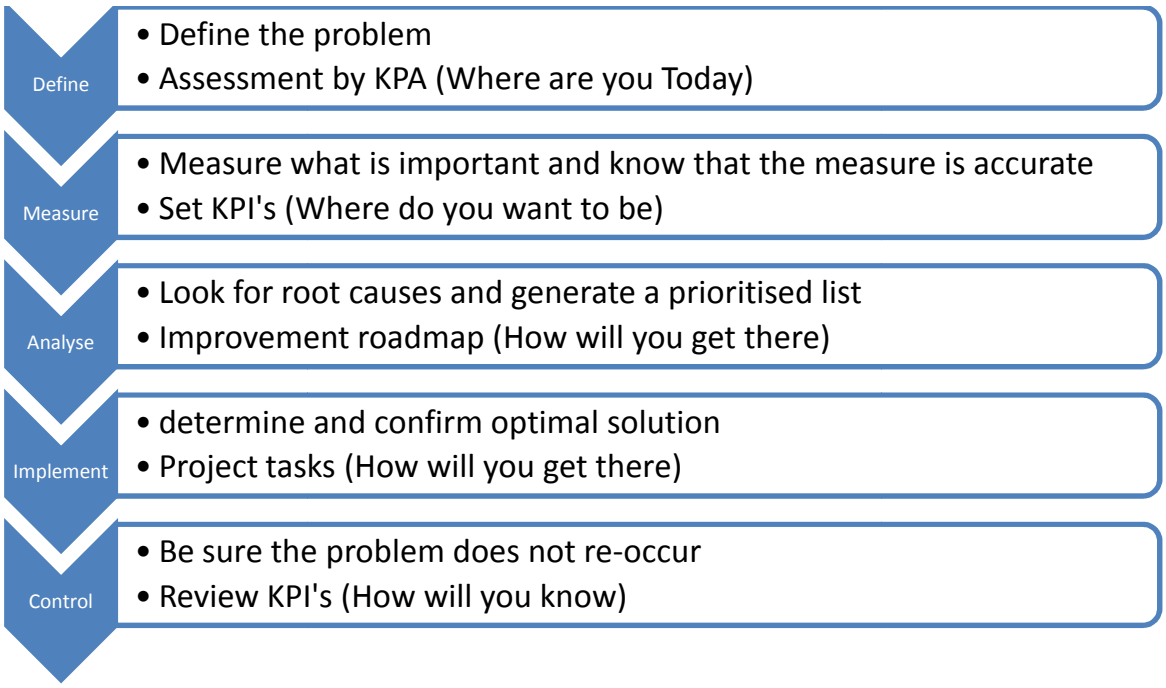


Figure 17 - Six Sigma Process Improvement mapped to the Maturity Model (de Koning et al, 2006)

The Red Cross Hospital in Beverwijk in Holland was chosen where Projects were not aligned strategically with hospital business goals and projects seldom had the backing of a business case. Many projects were incomplete and there was no standard method for project management and control. Some examples of projects tackled successfully using the combined Lean and Six Sigma approach included:

- Shortening Length of Stay for patients with Chronic Obstructive Pulmonary Disease
- Reducing errors in invoices received from temporary agencies
- Reducing numbers of patients requiring intravenous antibiotics
- Reducing Operating Theatre starting times
- Reducing the number of 'open' maintenance calls

Estimates are that approx 68% of corporate I.T. projects fail in that they don't deliver on time, budget or the originally stated business goals (Jeffery and Leliveld, 2004). It proves challenging to choose projects which are in keeping

with organisational strategy when there are many in train across a number of different business units. A bigger challenge is how to maximise business value from I.T. investment. While 60% of companies will test the ROI (Return on Investment) before taking an I.T. project on, only 25% measure the ROI on completion. According to Jeffery, I.T. Portfolio Management (ITPM), akin to a financial assets portfolio and managing them to achieve a balance between risk and return and improving performance, may provide the answer. The management approach focuses on processes used to assess and increase return on I.T. investment while reducing risk. Best practice in this area is now represented by the ITPM Maturity Model and the characteristics defined in four distinct stages. Matching its situation with the characteristics defined for the different stages allows an organisation to place itself along the continuum of maturity. An example of the ITPM Maturity Model is included in Appendix 4.

3.10 Capability Maturity Models – HIT Use and Management

ICT is a strategic part of the health enterprise and the management and use of I.T. is considered a core competency at an organisational and a human level. (Mordue and Seeley, 1997) examine 'Checkpoint', a self assessment tool for managers developed in the NHS in collaboration with the Institute of Health and Care Development, to determine the strengths and weaknesses of their use and management of health informatics. Checkpoint is positioned as a stepping stone to a more formal qualification or accreditation. The assessment tool is in the form of a questionnaire which seeks to establish the applicant's attitude towards computers, their perceived usefulness and organisational and cultural factors important in the alignment of corporate and individual attitudes. Results are fed back and matched to a Checkpoint Action Plan identifying what needs to be addressed to cater for gaps in knowledge and compares results with other managers who also completed Checkpoint. Poor communication between management and ICT professionals often features as a barrier to the adoption of ICT. Checkpoint bridges that gap by opening up dialogue, creating more awareness and interest in ICT, leveraging existing skills and competence and promoting informatics in a business sense. Project success will depend on the ability of the IS professional to forge partnerships. (Wu et al., 2009) look at Healthcare Technology Management competency in IS professionals working in Healthcare. Four domains are examined to arrive at a conceptual model of capability which could prove important to those

responsible in skills development and training of IS professionals and for profiling of individuals to be used in short-listing for vacancies. A questionnaire in each of the categories was developed and validated to establish competency capability in Health Technology Management. The four areas covered include: Healthcare organisation overview; External knowledge networking; Management and interpersonal and Healthcare technology integration.

3.11 Capability Maturity Models – Enterprise Architecture

Enterprise Architecture (EA) is a methodology designed to plan and manage system complexity and to correct poor business alignment of Information Technology. In a culture where the cost of I.T. is rising, EA has been introduced to manage complexity in order to deliver I.T. value. (Bradley, 2008) set out to determine the maturity of enterprise architecture in a survey of 246 senior management and I.T. executives representing 168 U.S. hospitals identified in the HIMSS Analytics Database of 2006. The survey found that 37% had an Enterprise Architecture Unit (EAU) in the organisation. There were two aspects to the survey: (1) targeted the CEO and looked at strategic initiatives in I.T. and performance enabled through the use of IT; (2) targeted the I.T. Manager and was focused on (a) integration and how modular the hospitals I.T. infrastructure was and (b) the business knowledge of I.T. personnel and knowledge of the health sector. The study finds that corporate culture and maturity in certain dimensions of Information Technology Architecture (ITA) are instrumental in determining the level of I.T. infrastructure flexibility and strategic alignment. There are strong relationships established between I.T. infrastructure flexibility and the ability of I.T. to: manage external relationships; enable market responsiveness; lower costs of business operations; reduce clinical errors and improve financial and operational performance. In terms of Enterprise I.T. Architecture the study found that more organisations were planning for I.T. platforms based on a set of established standards followed by platforms to support infrastructure sharing. In terms of the current perceived stage of I.T. Capability, more of those surveyed felt that their respective organisations were currently in Stage 2 of ITA maturity according to the following scale:

- Stage 4 - Creates a library of standardised, reusable business applications and process modules
- Stage 3 - Supports standardisation of processes and provide standardised data where needed
- Stage 2 – Reflects the efficiencies of standardised technical platforms and shared infrastructure services
- Stage 1 - Focus is on the individual needs of local business units

3.12 Capability Maturity Models – Quality Management

> *"A good information system, perceived by its users as a poor system, is a poor system" (Ribiere et al., 1999)*

Quality systems and standards exist in Health Care such as those offered by the Joint Commission on Accreditation of Health Organisations and Cooperation for Transparency and Quality in Health Care (KTQ) but focus mostly on specific quality aspects. ISO standards exist for system ergonomics but not for both computer and paper-based tools. Most ignore the affect of Hospital Information Systems on working processes. In (Ammenwerth et al., 2007) the authors point to the importance of systematic monitoring of quality of information processing systems. HIS-Monitor, a quantitative evaluation tool consisting of 107 questions looking at the efficiency of administrative and clinical tasks in systems versus a list of quality criteria, was developed and validated using 102 participants in Germany and Austria which will identify the strengths and weaknesses of a HIS in terms of quality parameters such as data quality, reliability and usability.

> *"The right information, at the right time and place, in the right format and for the right person"*

underpins the definition of information quality according to Ammenwerth and should be reflected in the monitoring apparatus. The authors also feel that end-users are the only arbiters capable of assessing quality and that the best approach to screening HIS quality is with a questionnaire to many different users. The quality assessment framework consists of a list of questions developed by cross-matching a number of common HIS support activities with quality criteria such as: availability; correctness and completeness; readability and clarity; usability; fulfilment of legal obligations and time needed for

processing. The profiles can be launched on a web page where hospitals can assess themselves anonymously against other hospitals.

3.13 Capability Assessment Instruments

The NHS developed a National Infrastructure Maturity Model (NIMM) (NHS, 2011), which enables NHS I.T. organisations and trusts to:

- Conduct an objective self assessment to establish a point in time specific infrastructure capability maturity
- Identify improvement projects

Before choosing an area for I.T. assessment, an organisation is urged to review all projects and their business drivers. This exercise will identify those capabilities which should have immediate attention. Key performance indicators (KPI) are identified and the assessment technique scores the organisation's performance against KPI's for a specific category. The projects which are supported by the assessment are those which should commence. When the project is complete, the assessment is re-run and the maturity achieved is re-scored. The assessment model consists of a number of Technical and Business categories with a total of seventy four capabilities assigned to each category.

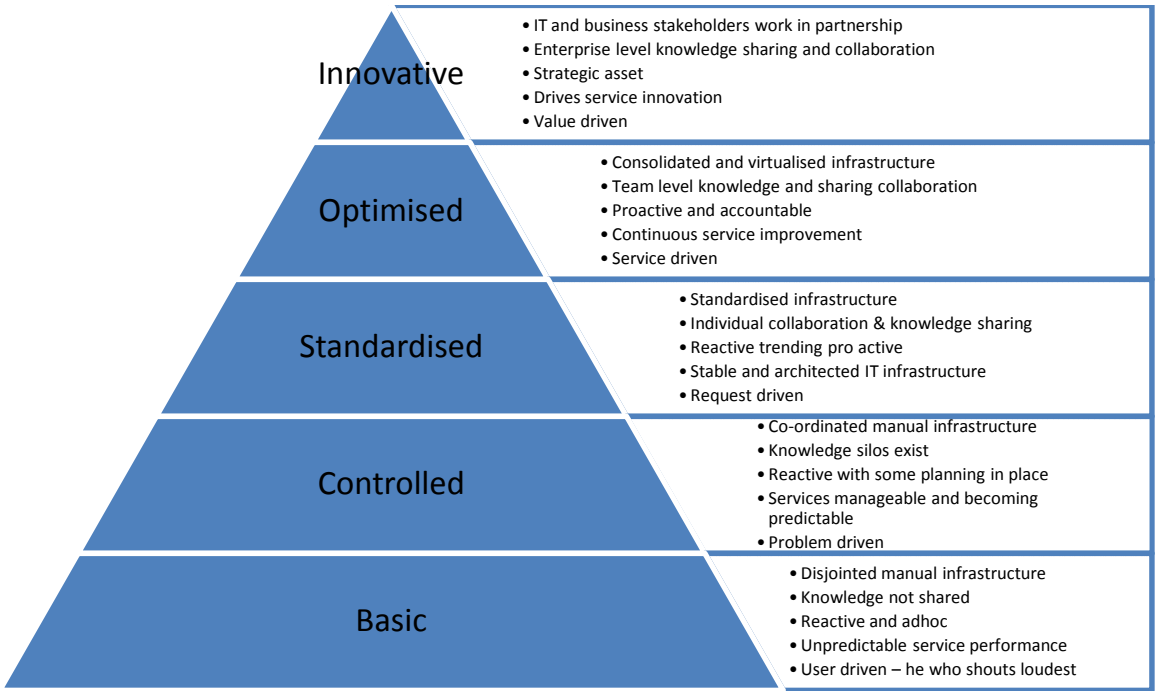


Figure 18 - NHS National Infrastructure Maturity Model (NHS, 2011)

The Intel Corporation has developed the I.T. Capability Maturity Framework (IT-CMF) (Innovation Value Institute, 2011) to help I.T. and business managers align I.T. and business strategy to realise value. To further the development and dissemination of the framework it has been launched on an educational and research platform at the Innovation Value Institute at the National University of Ireland, Maynooth. The framework has been developed with the intention of providing managers in both the private and public sectors with the capability of:

- Measuring and managing the business value of investments in I.T.
- Prioritising I.T. projects
- Ensuring I.T. capability compares favourably with that of competitors

Inspired by the Software Engineering Institute's CMM for software development, there are five levels of maturity identified for each of the main strategies.

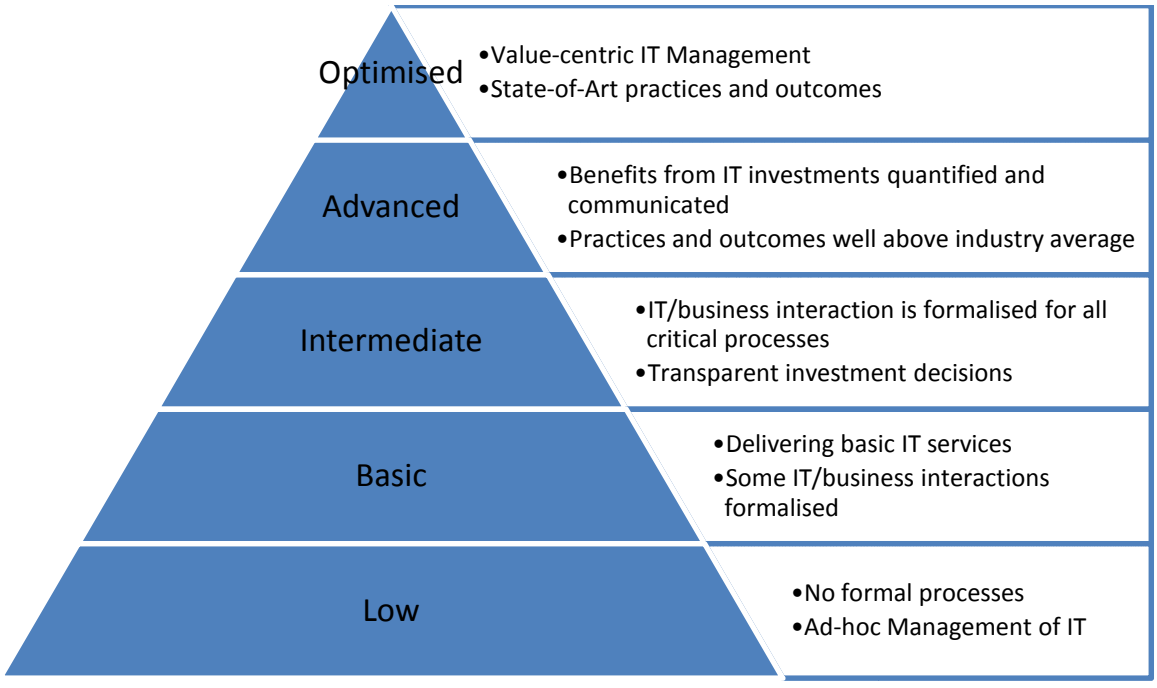


Figure 19 - IT-CMF Organisational Maturity Profile (Innovation Value Institute, 2011)

There are four main strategies in the framework aligned to the business strategies of the organisation; Manage I.T. like a business; Manage the I.T.

Budget; Realise and assess business value; Manage I.T. Capability. Capability Assessment and Management enables CEO's:

- To ensure a standard way of selecting areas for I.T. capability improvement
- Ensure improvement goals are selected based on agreed priorities and that they maximise the impact on I.T. capability improvement
- Creation of credible benchmarks that can be used to verify improvements

The end product of the assessment is the development of a road map to close the gap between the current state of capability and the target capability.

3.14 Barriers to the adoption of CMMI

Software Process Improvement (SPI) models such as CMMI (Capability Maturity Model Integration) used by software development organisations to improve efficiency and better quality software were examined in (Staples et al., 2007). Other examples of this type of framework such as SPICE (Software Process Improvement and Capability Determination), each contain processes and practices which are defined and measurable by way of an appraisal. The relevance and applicability of CMMI has been questioned in the case of smaller organisations. The study examines why organisations decide not to use CMMI and looks at cost, applicability and time to benefit as influencing factors in arriving at the return on investment. The study also examines other factors such as size and type of organisation and resource constraints in smaller organisations. The chart which follows sets out the number of organisations analysed showing reasons for non-adoption:

Reason	Frequency	%
Small organisation	17	43
Too costly	14	35
No time	10	25
Using other SPI	8	20
No clear benefit	4	10
Benefits not wanted	3	8
No customer demands	2	5
Not applicable	2	5
Already known gaps	2	5
Risk of poor certification	1	3

Figure 20 - Top Barriers to the adoption of a CMMI approach (Staples et al, 2007)

The study concludes that smaller organisations may never benefit from CMM as they determine it an infeasible approach for them. CMM is most often offered as a commercial engagement and as such can be costly. CMM needs to be tailored for smaller organisations but commercial suppliers of the assessment process are often reluctant to do this.

3.15 HIT Interoperability and International Standards

The Introduction to this dissertation pointed to a number of reports each of which advised on standards and the interoperability of diverse systems as the solution of choice in supporting enterprise-wide resource planning and integrated care. Interoperability may be defined as the ability of systems or sub-systems developed in different technologies to exchange data such that the syntax (format and structure) of the data is understood by both parties. Semantic interoperability goes a step further in that in addition to syntactic interoperability, the data meaning is also understood and this is more readily achieved where both parties engage the same information exchange reference model. Semantic interoperability is seen as a pre-requisite to providing for meaningful clinical decision support and care planning in a shared-care environment.

CEN/ISO 13606 – eHR Communications Standard (EHRcom):

The European norm standard for achieving semantic interoperability in the Electronic Health Record sphere is the CEN/ISO 13606 standard (en13606, 2011). The standard is primarily a communications standard allowing for the sharing of electronic health records (eHR) or extracts of an eHR while preserving the original meaning of the data and the confidentiality intended. In 2002 CEN revised the 13606 pre-standard to incorporate the Dual Model Architecture or 'archetype methodology' approach of openEHR which incorporates:

1. A Reference Model of eHR basic information entities
2. An Archetype of formal clinical concepts composed of constrained combinations of entities from the Reference Model providing semantic meaning to those entities.

Archetypes are typically defined by health care professionals and form a Detailed Clinical Model. Shared-care has become a more common phenomenon in worldwide healthcare practice. In (Schloeffel et al., 2006), the authors review a recent report by the National E-health Transition Authority (NEHTA) of Australia, recommending national interoperability standards for shared Electronic Health Records. The important aspects of interoperability are highlighted as:

- The ability of health care professionals to share aspects of a patient's EHR (electronic health record) to support multi-disciplinary care
- The ability of organisations within an enterprise to share data or to share data at a regional or national level or outside national boundaries
- To enable software and databases developed on different technology platforms to interact

The authors reviewed a number of current standards including:

GEHR /openEHR:

A European Union initiative, the Good European Health Report, initiated the openEHR standard as an open dual-model architecture standard which

incorporates a full eHR specification (creation, storage, maintenance and query), a communications standard and an implementation standard. It incorporates EN13606 as a subset and has had real-world implementation application (openEHR, 2011).

HL7 Reference Information Model (RIM) and Functional Model (FM)

Health Level Seven (HL7) is an ANSI accredited Standards Developing Organisation (SDO) which creates standards for the exchange, management and integratioin of electronic healthcare records.

HL7v2.x (HL7 version 2 and all of its subversions) is a messaging standard which is not based on any underlying reference model (no domain concepts or data type definitions). This standard is used extensively around the world to support links between clinical systems, GP practice systems and eHR's but is not designed with eHR architecture methodology in mind. Vocabularies are defined for specified items but it is not a specifiable information framework. In the longer term systems supporting such message exchange will be replaced with XML web based messaging.

HL7v3, contains a messaging framework for clinical statements, incorporates a reference information model (RIM) and was designed specifically for message exchange. The RIM holds basic classes of health data and the connections with the data held in the HL7 messages. It has ANSI standard data types and a vocabulary defined for the information model. It does not currently incorporate a full eHR architecture specification.

HL7 Clinical Document Architecture (CDA):

The Schloeffel report identifies HL7CDA as a sub-set of EN13606. HL7CDA is an individual-document exchange message standard. The standard which is XML based, is the current HL7 standard for eHR interoperability but it is not a full eHR specification. The standard defines the structure and semantics of clinical documents. CDA uses the HL7 Reference Information Model (RIM) for meaning and the HL7V3 Data Types (part of RIM).

The authors point to the NEHTA report which recommended the development of an Australian standard, based on openEHR, for a shared-eHR system

architecture. (Sanromà et al., 2004) examines various existing standards in a survey conducted in 2004.

Integrating the healthcare enterprise (IHE)

At the instigation of the Radiological Society of North America (RSNA) and the Healthcare Information and Management Systems Society (HIMSS), the IHE organisation was designed to encourage the use of appropriate standards such as HL7, ASTM, and DICOM etc and as such is not a standard in itself. Two specific Integration Profiles for which a recommended set of standards exist are: IHE Retrieve Information for Display (RID) and IHE Cross Enterprise Document Sharing (XDS).

DICOM (Digital Imaging and Communications in Medicine)

The DICOM standard was developed by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA). The standard facilitates the sharing of digital images between software systems and medical imaging equipment. Web Access to DICOM Persistent Objects (WADO) is part of the DICOM standard and "defines a web based service for accessing and presenting DICOM images and reports". DICOM Structured Reports (SR) is an extension to the DICOM standard which covers the encoding of medical reports in a structured manner. Extensive use of the DICOM SR standard is currently more evident in the fields of Radiology and Cardiology.

Medical Markup Language (MML)

The Japanese Ministry of Health and Welfare, uses the HL7 XML based CDA Release 1.0 with a local header extension to cater for the exchange of clinical documents and clinical information. CDA is used as a standardised container within the MML structure and much duplication exists between CDA and the local MML header extension. With the emergence of CDA as a more robust standard, MML has not been implemented commercially outside of Japan.

4 Research

4.1 Approach

The disparate types of computerised systems in the Irish health service and their varying capability have been previously alluded to. The problems posed as a result and the rationale for the need to characterise the overall levels of I.T. capability have also been discussed. The conceptual definition of capability, for the purposes of this dissertation, will be taken to be the existence of a plan to implement or the level of usage determined for a range of computerised systems, services and standards throughout the hospital.

This primary research, therefore, has adopted a quantitative method approach. Using a statistical survey, empirical data on the use of specific computer systems, standards and I.T. management tools in a sample of acute care hospitals in Ireland was gathered. Hospital and staff profiles were also established and using descriptive statistics techniques, the data is summarised and comparative analyses is conducted to investigate relationships between the measure of systems implemented and the profile data of the hospital and I.T. management in the hospital.

4.2 Other Studies in this area

In (Jaana et al., 2009) the authors recognise the importance of Health Information Technology (HIT) in supporting the key objectives of : improved patient safety and quality of care, the improvement of clinical processes and efficiency and the interoperability of systems instrumental in delivering an integrated Health record across the spectrum of care. In recognising the importance and relevance of the interoperability factor, the author pronounces that:

> *"The level of I.T. capacities remains variable across healthcare settings and challenging to gauge".*

Mechanisms to measure I.T. capability exist and are documented in previous studies; however, many fall short in the type of measurement characteristics and the tools used. The Jaana study sets out to address these shortfalls and unifies the work in this area by reviewing the approach in contemporary

studies. A comprehensive literature review is conducted and six studies in particular are singled out for further examination which were: (Amarasingham et al., 2006), (Brown et al., 2003), (Burke and Menachemi, 2004), (Burke et al., 2002), (Goldberger and Kremsdorf, 2001) and (Haruki et al., 1999). Although they each provided a measurement mechanism worthy of consideration, the author identified a consistent set of issues which rendered them less than ideal. Many studies used different terminologies, were variable in scope and examined capability on just one and at most on two dimensions. Other issues included: the absence of a conceptual framework on which the instrument was designed, the random categorisation of measures, a uni-dimensional focus, the crude nature of measures (counts in some cases), the measuring tool had not been validated and it had not been applied in research outside of Canada. The conceptual framework described in the instrument developed by (Paré and Sicotte, 2001) which establishes an I.T. capabilities assessment tool measuring sophistication on three vectors: functional, technological and integration, was chosen as the basis upon which a new I.T. capability measurement instrument would be developed. The Paré tool which had proven psychometric properties provides measurement in eight dimensions including four functional, three integrational and one technological. The tool was validated in both the United States and Canada and was used again in (Jaana et al., 2005) and in four other studies including: (Culler et al., 2006), (Culler et al., 2007), (Jaana et al., 2006) and (Ward et al., 2006). The final instrument incorporates (34) functional applications: (13) technological categories and (11) categories of integration – a total of (58) measures.

Dimension	Functional Vector	Technological Vector	Integration Vector	Total Number of measures
1 - Clinical	14			14
2 - Administrative	9			9
3 - Patient Management	7			7
4 - Clinical Support	4			4
5 - Technology		13		13
6 - Integration - External			9	9
7 - Integration – Admin			1	1
8 - Integration - Clinical			1	1
Total	34	13	11	58

Figure 21 – IT Capability Survey construct (Jaana et al, 2009)

The revised instrument was validated by 221 I.T. Directors/Administrators in the Quebec and Ontario provinces in 2007. Hospitals can use the tool to benchmark activities and as a method of self-assessment.

4.3 Study Constraints

In arriving at the final customised version of the questionnaire for this dissertation, there were a number of constraints:

- the need to preserve the integrity of the original instrument (in order to lean on the previously determined psychometric validity and reliability properties; and to allow meaningful comparison with the results of the instrument as applied in previous studies)
- the need to customise the instrument to better suit the intended sample and to elicit additional information to provide data in support of a more complete catalogue of HIT functionality in use in Ireland
- improvement of the instrument in support of the objective to establish the use of best practice management tools and international standards

- the need not to over-complicate the instrument and to present a comprehensive (not overpowering) and concise set of questions which the respondents could reasonably be expected to complete

4.4 Reason for this approach

Although techniques exist whereby healthcare organisations can establish a maturity level for an electronic medical record (HiMSSANALYTICS, 2011), the facility is proprietary to the HiMSS Analytics organisation and is available for individual hospitals via a registration process directly with that organisation. The use of the EMRAM (Electronic Medical Record Adoption Model) in this case was excluded for the following reasons:

- This work sets out to establish a wider measurement of capability than that offered by EMRAM
- This paper aims to establish capability on a number of different dimensions and includes usage and planning measurement not included in the EMRAM model.
- It would not have been practical to organise an EMRAM evaluation for the number of hospitals in the chosen sample (nor was it deemed necessary to do so)
- The existence of a previously validated instrument was important to substantiate any findings, to avoid the extra burden of validation with an entirely new instrument and to provide a platform for meaningful comparison with results from previous studies which used the original instrument.

4.5 Aims likely to be achieved

The study aimed to establish an online survey response from a sample of acute hospitals in Ireland in respect of their plans to use or the actual usage of a number of specific computerised systems, standards and management models. All questions in the survey had to be optional and presented in as user-friendly a manner as possible in order to elicit the maximum response rate. Leaning on industry thought-leader input, all questions were reviewed to ensure they were clear, concise and easily understandable (Appendix 5). It was anticipated that the survey would provide sufficient data to enable a HIT

Capability score to be calculated for each participant hospital in accordance with the weightings set out in the original survey. It was also anticipated that suitable analyses of the data would be possible to attempt comparison with the results of other surveys which used the instrument and to investigate any links between the scores of I.T. capability established and any organisational criterion gathered.

5 Method

With consent from the original author, this dissertation takes the existing I.T. capability measurement instrument as outlined in (Paré and Sicotte, 2001) and further in (Jaana et al., 2009), and by way of participatory design has customised it making it more applicable in the Irish context. The instrument has been customised on the Functional axis to accommodate applications appropriate in an Irish setting, on the Technological axis to reflect state of art developments and finally, extended on the Integration axis to reflect international thinking in terms of interoperability standards and information exchange (NIST, 2007). With reference to the limitations identified in the original study and the constraints already identified for this research, the existing survey construct was reviewed and analysed with input from two senior industry experts. A revised survey structure was drafted and reviewed on three occasions resulting in the final version included in Appendix (9). The instrument was customised and revised in terms of the measures included as follows:

Dimension	Functional Vector	Technological Vector	Integration Vector	Total Number of measures
1 - Clinical	14			14
2 - Administrative	9			9
3 - Patient Management	15			15
4 - Clinical Support	4			4
5 - Technology		16		16
6 - Integration-External			11	11
7 - Integration - Admin			1	1
8 - Integration - Clinical			1	1
Total	42	16	13	71

Figure 22 - Revised IT Capability construct measures

The revised survey instrument was also updated with twelve additional measures on the use of Management Models and twenty additional measures

on the use of Standards and Terminologies. These new dimensions are additional to the original instrument.

In consultation with the industry experts, it was decided to target the Irish acute hospitals for the survey – Appendices (6 and 7). Twenty five of the acute hospitals are classed as Public Voluntary and while they are funded by the Health Service Executive (HSE) they are not run by the HSE. The other twenty five are both funded and run by the HSE. Each of the Public Voluntary hospitals has an established I.T. Manager responsible for all I.T. matters in the hospital while I.T. for the HSE run hospitals is organised on a regional basis and these hospitals do not have an individual I.T. manager as such.

The author created a personalised mail-merge to each of the I.T. Managers of the Public Voluntary hospitals. The mail-merge included a signed letter of introduction to the survey along with two attachments (1) the Information Sheet for the project and (2) the Survey Consent Form seeking informed consent from the targeted participants in the survey. The Consent Form incorporated the respondents known e-mail address and the targeted respondent was asked to agree to receive the survey via an e-mail link. The letter package was sent by post to each of the targeted respondents and included a stamped addressed envelope for receipt of the returned signed Consent Form. In total 16 responses were received from the Public Voluntary Hospitals (64%). One additional Consent form was received but the respondent never replied to reminders to complete the survey. Due to revised HSE organisational structures and the assignment of I.T. responsibilities on a regional basis, securing responses for the HSE run hospitals proved problematic. The HSE regional manager was contacted on several occasions in efforts to secure responses on behalf of the 25 HSE hospitals. When this failed, the HSE expert himself provided some input on behalf of four of the HSE hospitals in question (16%). An overall response rate of 40% was achieved.

5.1 Data Collection Technique

The final version of the survey was constructed using Survey Monkey, an online survey software facility. Survey questions were posed in terms of one form for each of eight dimensions as in the original survey. An explanation

page preceded each form where necessary. Individual questions were expanded to include examples by way of further explanation. Respondents were advised that all questions were optional, that responses would remain anonymous and that they could withdraw from the survey at any time. Using the e-mail management feature in the software an e-mail was automatically sent to each of the consenting participants which included an SSL (Secure Sockets Layer) encrypted URL link to the survey. The survey remained open for 20 weeks approximately and it took respondents 30 minutes on average to complete.

5.2 Variables and Measures

The original survey used a seven point semantic differential scale to determine the degree of 'usage' in the case of applications implemented where the terms 'barely' and 'extensively' were used to indicate the extremities of the scale. On academic advice that such scales should have 'individual' labels on each of the seven points, the author felt that applying this advice would serve to achieve a separate goal set for the survey. This goal was to correlate 'usage' of applications with the US Meaningful Use initiative which set incentives for care institutions who could declare usage of applications in percentage terms mostly in the 80%+ bracket. The author therefore set about applying a 'percentage usage' scale to the seven points and presented it to the industry experts for agreement. On review it was decided that the resulting scale may be too confusing for respondents and might actually pose a problem in attempting to categorise 'usage' in very discrete percentage terms. A compromise was agreed where the semantic labels for the scale (the start label and the end label) were expanded to indicate a 10% usage for the 'barely' point and an 80%+ usage for the 'extensively' point. Points in between were left indicated by number only but with no additional labelling. It was possible in Survey Monkey to allocate a rating value to the seven point scale for each question in the survey and this was applied where relevant in accordance with the weightings used in the original Canadian Survey (Figure 23).

Apart from this slight modification in presentation, the revised survey used the conceptual framework of the original study which asked for answers to each measure in each of seven dimensions to be categorised as follows: "No Plan",

"Planning", "Implementation started" and "Implementation complete" followed by an indication as to the extent of usage on the seven point scale. In terms of the eight dimension, External Integration, respondents were asked to indicate the level of sharing of electronic information with external agencies on a 1-7 scale commencing with 'None' and extending to 'Extensive'. Respondents were also invited to answer questions in relation to the profile of the hospital in which they worked and in terms of their own personal profile. The intention here was to indicate the statistical likelihood that certain profile values could serve as predictors (or antecedents) of HIT capability on each of the survey dimensions and vectors as described.

The data responses to the online survey questions were logged in the Survey Monkey database and downloaded to a local Excel spreadsheet for analysis.

5.3 Scoring Approach

While additional dimensions and measures were added into the revised survey for this dissertation, these were added to provide additional information only and the calculation of HIT Capability for this dissertation is not contingent on these additional measures. The number of measures and the weightings applied to the measures in the customised instrument were retained as in the original instrument.

Measurement Dimension	No Plan	Plan	Imp Begun	Implemented						
				1	2	3	4	5	6	7
1 – Clinical	0	1	3	4	4	4	4	5	5	5
2 - Admin Systems	0	1	3	4	4	4	4	5	5	5
3 - Patient Management	0	1	3	4	4	4	4	5	5	5
4 - Clinical Support	0	1	3	4	4	4	4	5	5	5
5 – Technology	0	1	3	4	4	4	4	5	5	5
6 - Internal Integration – Admin	0	1	3	4	4	4	5			
7 - Internal Integration – Clinical	0	1	3	4	4	4	4	5	5	5
8 - External Integration				0	1	1	3	4	4	5

Figure 23 - Instrument Weightings (Jaana et al, 2009)

6 Analysis

The customised survey including a results summary is included in Appendix 9.

6.1 Method

The Irish survey data was downloaded from Survey Monkey and gathered into an Excel spreadsheet. It was possible to download the rating values applied in the seven point usage scale of the survey for each question and this is the option the author chose (See Appendix 8). In addition to calculating a HITCAP (HIT capability) score for each hospital individually, the survey analysis also sets out to measure the correlation between the vector and overall scores calculated for the entire sample (n=20) and the different organisational and personal profile parameters gathered. In keeping with the original study, a Student's t-Test (1 tail, two-sample unequal variance) was used in the case of comparison with numerical variables. For comparison with variables of a categorical ordinate nature, the sample scores in each vector were first divided into those hospitals whose HITCAP score fell in the top third of hospitals in the sample and those which fell in the bottom third, and a frequency table split into two column categories was established. The 'Expected' results template was then calculated from the frequency table and the Chi square test was used to establish the degree of correlation. Correlation for the sample results was calculated as follows:

Number of Beds in the hospital	Student's t-Test (p) - as calculated by the TTEST function in EXCEL
Number of Permanent I.T. staff in the hospital	As above
Number of years in IT	As above
Number of years in the hospital	As above
Number of years in the job	As above
The hospital is a university hospital	CHI square test as calculated by the CHITEST function in EXCEL
The hospital has a steering committee	As above
The hospital is an Urban hospital	As above
Hospital I.T. spend >1% of total hospital budget	As above

Figure 24 - Calculation of HIT Capability Correlation

The author analysed responses in the Excel spreadsheet in terms of the data required to calculate a Hospital I.T. Capability Score in accordance with the weightings of the original survey. As the customised survey included additional measures which would not be integral to the calculation of the HITCAP score, these fields were masked from the next step in the process.

6.2 Data Organisation

As each reply to the survey was identifiable to a specific IP address, each response was individually filed to a new Excel spreadsheet line uniquely identified by the IP address. Each IP address was unique to the respondent and as such unique to the hospital on whose behalf the response was made.

6.3 HITCAP Score Calculation

The original study presented a HITCAP score on three vectors and an overall score for the hospital. Vector (1) was classified as the Functional vector and this consisted of aggregated scores for the four functional dimensions namely: Patient Systems; Clinical Systems; Clinical Support Systems and Administrative Systems. Vector (2) was classified as the Technology vector and consisted of the values calculated for the Technology dimension. Vector (3) was classified as the Integration vector and comprised of scores established for Administrative Systems – Internal Integration; Clinical Systems – Internal Integration and the External Integration dimensions. The author introduced algebraic formulae into the spreadsheet which enabled the following calculations for each line (corresponding to each hospital) in the spreadsheet:

1. A total for the Patients Systems dimension was calculated by aggregating the rating scores logged for each relevant question (7) for that dimension.
2. A total for the Clinical Systems dimension was calculated by aggregating the rating scores logged for each relevant question (14) for that dimension.
3. A total for the Clinical Support Systems dimension was calculated by aggregating the rating scores logged for each relevant question (4) for that dimension.

4. A total for the Administrative Systems dimension was calculated by aggregating the rating scores logged for each relevant question (9) for that dimension.
5. A total for the Emerging Technologies dimension was calculated by aggregating the rating scores logged for each relevant question (13) for that dimension.
6. A total for the Administration Systems – Internal Integration dimension was calculated by establishing the rating scores logged for the single question for that dimension.
7. A total for the Clinical Systems – Internal Integration Domain was calculated by establishing the rating scores logged for the single question for that dimension.
8. A total for the External Integration dimension was calculated by aggregating the rating scores logged for each relevant question (9) for that dimension.

The HITCAP scores for each hospital were arrived at as follows:

- First calculate the score for each of 8 dimensions (1-8):

  100 x aggregated totals for the dimension / number of measures in that dimension x Maximum score for each measure

- Next calculate the vector scores by aggregating the individual dimension scores for the vector and dividing by the number of dimensions in the vector.
- Finally calculate the overall hospital score by aggregating the individual dimension scores (1-8) and dividing by the total number of dimensions (8).

An overall HITCAP Score for the sample (n=20) was calculated by first calculating the individual dimension scores for the sample (as per outlined above for hospitals), adding the individual scores for all eight dimensions of the sample and dividing this total by eight.

6.4 Results Analysis and Evaluation

6.4.1 Sample Descriptive Analysis

The average number of beds in the hospitals surveyed was 315. The majority of hospitals (60%) were either university teaching hospitals or those affiliated to one and (75%) were categorised as either urban or regional hospitals. In terms of financial resources no hospital held an I.T. budget in excess of 3% of the operating budget for the hospital while only 10% held an I.T. budget greater than 2%. 40% of hospitals held an IT budget of less than 1% and the majority (50%) held a budget of between 1 and 2%. The number of permanent I.T. staff assigned to the I.T. department ranged from 1-32 with an average of 9 per hospital. In terms of leadership capacity 20% of I.T. Managers surveyed held a Masters Degree (or more) while a slightly higher percentage (25%) held a qualification beyond a primary degree. There were no academic qualification details available for 40% of participants. The average number of years spent by I.T. Managers in I.T. was 19-20 years, an average of 12 years was spent in the hospital and an average of 10 years was spent in the hospital I.T. Managers job. Half of the hospitals surveyed said they had an I.T. Steering committee.

Hospital:	**Yes**	**No**
University Hospitals (or affiliated)	60.00%	40.00%
Presence of an I.T. Steering Committee	50%	50%
Non-rural hospital	75.00%	25.00%
The hospital spend on I.T. is >2% of total hospital budget	10%	90%
IT Manager holds a Masters Degree	20.00%	80.00%

	Min	**Max**	**Average**	**Std. Dev.**
Hospital:				
Number of Beds	65	920	315	272
Number of permanent I.T. Staff	1	32	9	9.3
IT Manager:				
Number of years in IT	3	35	19.7	10.5
Number of years in the hospital	7	19	12	3.2
Number of years in the job	2	19	10	4.3

Figure 25 - Profile of the surveyed hospitals (n=20)

HITCAP (or HIT capability) scores were computed for each hospital and for the survey sample in total along each of eight dimensions, four vectors and overall. The tables which follow summarise the profiles of the HITCAP scores computed in those categories for the survey sample (n=20).

Vector	Dimension	Minimum HITCAP	Maximum HITCAP	Mean HITCAP	Standard Deviation
Functional	Admin Systems	0	88.8	**58.7**	23.1
	Patient Systems	48.5	100	**77.7**	13.7
	Clinical Support	50	100	**76.2**	18.5
	Clinical Systems	24.2	84.2	**49.0**	17.1
	Vector Values	49.3	83.9	**65.4**	11.4
Technological	**Technology**	0	61.5	**32.6**	16.5
Integration	Internal - Admin	0	100	**29**	40.7
	Internal – Clinical	0	100	**40**	37.8
	External	0	64.4	**26**	14.9
	Vector Values	0	76.3	**31.6**	21.4
Sample Values		26.1	74.9	**48.6**	11.8

Figure 26 - HITCAP Scores Summary Descriptive Analysis (n=20)

This dissertation set out with the premise that HIT sophistication in the acute care sector in Ireland was varied and set the task of finding a way to measure it. The findings of the quantitative research conducted supports the hypothesis and a detailed examination of the individual hospital findings are presented in the table which follows.

Application / Hospital	Patient	Clinical	Clinical Support	Admin	Functional Vector	Technology Vector	Internal Integration Admin	Internal Integration Clinical	External Integration	Integration Vector	Overall HITCAP Score	Rank
Hospital_1	94.29	42.86	95.00	57.78	72.48	32.31	0.00	100.00	37.78	45.93	57.50	4
Hospital_2	80.00	70.00	95.00	48.89	73.47	56.92	0.00	0.00	13.33	4.44	45.52	11
Hospital_3	74.29	24.29	100.00	31.11	57.42	15.38	80.00	20.00	24.44	41.48	46.19	9
Hospital_4	71.43	50.00	55.00	44.44	55.22	20.00	0.00	20.00	17.78	12.59	34.83	15
Hospital_5	85.71	47.14	100.00	60.00	73.21	36.92	0.00	20.00	15.56	11.85	45.67	10
Hospital_6	62.86	25.71	80.00	80.00	62.14	43.08	0.00	0.00	26.67	8.89	39.79	13
Hospital_7	71.43	24.29	55.00	46.67	49.35	13.85	80.00	80.00	17.78	59.26	48.63	8
Hospital_8	57.14	41.43	80.00	22.22	50.20	12.31	0.00	80.00	20.00	33.33	39.14	14
Hospital_9	85.71	48.57	75.00	0.00	52.32	0.00	0.00	0.00	0.00	0.00	26.16	17
Hospital_10	88.57	75.71	80.00	88.89	83.29	61.54	0.00	100.00	64.44	54.81	69.89	2
Hospital_11	85.71	71.43	75.00	71.11	75.81	53.85	0.00	20.00	15.56	11.85	49.08	6
Hospital_12	88.57	30.00	95.00	42.22	63.95	20.00	0.00	80.00	6.67	28.89	45.31	12
Hospital_13	48.57	35.71	75.00	55.56	53.71	13.85	0.00	0.00	28.89	9.63	32.20	16
Hospital_14	97.14	57.14	95.00	86.67	83.99	35.38	0.00	100.00	42.22	47.41	64.19	3
Hospital_15	100.00	84.29	50.00	88.89	80.79	47.69	100.00	80.00	48.89	76.30	74.97	1
Hospital_16	88.57	64.29	100.00	66.67	79.88	35.38	0.00	20.00	15.56	11.85	48.81	7
Hospital_17	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42	5
Hospital_18	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42	5
Hospital_19	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42	5
Hospital_20	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42	5

Figure 27 - Irish Hospital HITCAP Scores Detail

On examination of the spread of scores for the Irish sample, there is a difference of 35% points between the highest and lowest scoring hospitals in the Functional vector category (84% – 49%). The sample average for the category is 65% which is moderate to high. The spread in terms of scores on the Technology vector was 12% - 62% and the average for the sample in this category was low at 33%. Hospital nine was excluded from this comparison on the grounds that the survey submission was incomplete in this category. The highest score in the Integration vector was 76% and the lowest was 4.4% with an average sample score of 32% which is also low. Hospital nine was excluded from this comparison on the grounds that the survey submission was incomplete in this category. The spread of the overall HIT capability scores achieved was 75% at the high end to 32% at the low end again excluding hospital nine from the comparison. The overall sample HIT capability score achieved for the sample was 49% which is relatively low.

6.4.2 Functional Vector Analysis

The Functional Vector is comprised of the Administration; Patient; Clinical and Clinical Support application dimensions. The hospital HITCAP scores for the Functional vector range from 49% up to a high of 84%. The average HITCAP score for this vector is 65%.

Functional HITCAP Scores	
Mean	65.45337302
Standard Error	2.550259634
Median	61.29960317
Mode	60.45634921
Standard Deviation	11.4051078
Sample Variance	130.076484
Kurtosis	-1.286049257
Skewness	0.290032475
Range	34.64285714
Minimum	49.3452381
Maximum	83.98809524
Sum	1309.06746
Count	20
Largest(1)	83.98809524
Smallest(1)	49.3452381
Confidence Level(95.0%)	5.337754747

The table above was produced using the Descriptive Statistics Analysis tool provided in Excel and is repeated throughout this section for HITCAP scores in each of the eight instrument dimensions and their corresponding vectors.

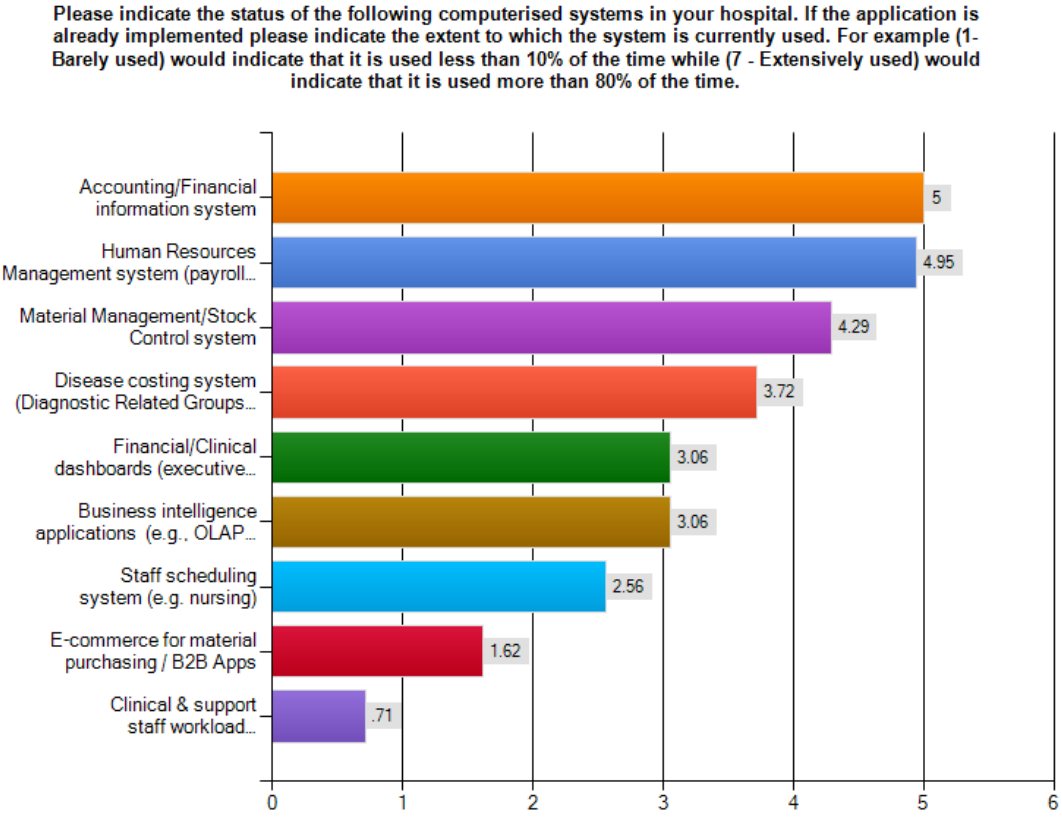
6.4.2.1 Functional Vector Analysis – Administrative Systems

The hospital HITCAP scores for the Administrative Applications dimension range from 22% to 89% (n=19 as one hospital submission was incomplete). The average HITCAP score for this vector is 62% which is moderate.

D4 - Administrative Applications	
Mean	61.87134503
Standard Error	4.366645778
Median	66.66666667
Mode	71.11111111
Standard Deviation	19.03376767
Sample Variance	362.2843116
Kurtosis	-0.451046704
Skewness	-0.411009973
Range	66.66666667
Minimum	22.22222222
Maximum	88.88888889
Sum	1175.555556
Count	19
Largest(1)	88.88888889
Smallest(1)	22.22222222
Confidence Level(95.0%)	9.173982341

The rating values (weightings) assigned to relevant questions in the Functional dimension were as per Figure 23. The Survey Result diagrams which follow were downloaded from the survey instrument software and values to the right of each entry represent an average rating value for that entry for the entire sample.

6.4.2.1.1 Administrative Systems - Survey Results



Of the Administrative Systems, Human Resource Management, Accounting and Materials Management Systems demonstrate high adoption rates while Workload management systems, E-commerce for materials purchasing and Staff Scheduling Systems are least popular. Business Intelligence applications and Staff Scheduling systems rank highest in terms of those which hospitals are planning to implement.

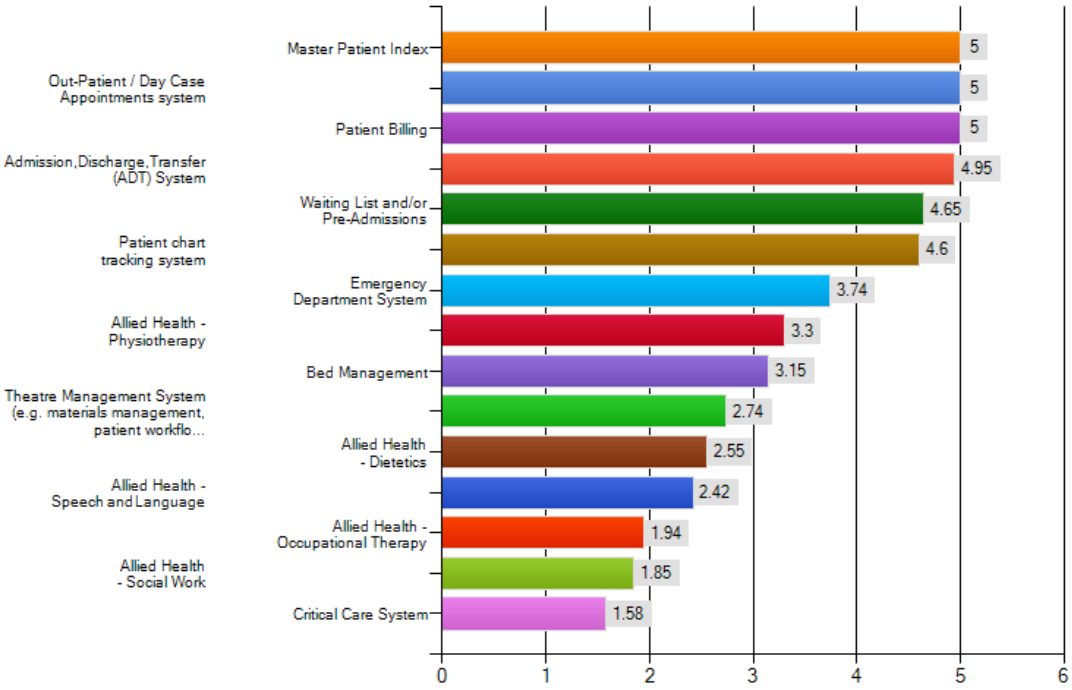
6.4.2.2 Functional Vector Analysis – Patient Systems

The hospital HITCAP scores for the Patient Applications dimension range from 49% to 100%. The average HITCAP score for this dimension is 78% which is high.

D1 - Patient Applications	
Mean	77.71428571
Standard Error	3.085602894
Median	77.14285714
Mode	68.57142857
Standard Deviation	13.79923565
Sample Variance	190.4189044
Kurtosis	-0.552961863
Skewness	-0.266848872
Range	51.42857143
Minimum	48.57142857
Maximum	100
Sum	1554.285714
Count	20
Largest(1)	100
Smallest(1)	48.57142857
Confidence Level(95.0%)	6.458241066

6.4.2.2.1 Patient Management Systems – Survey Results

Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1- Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.



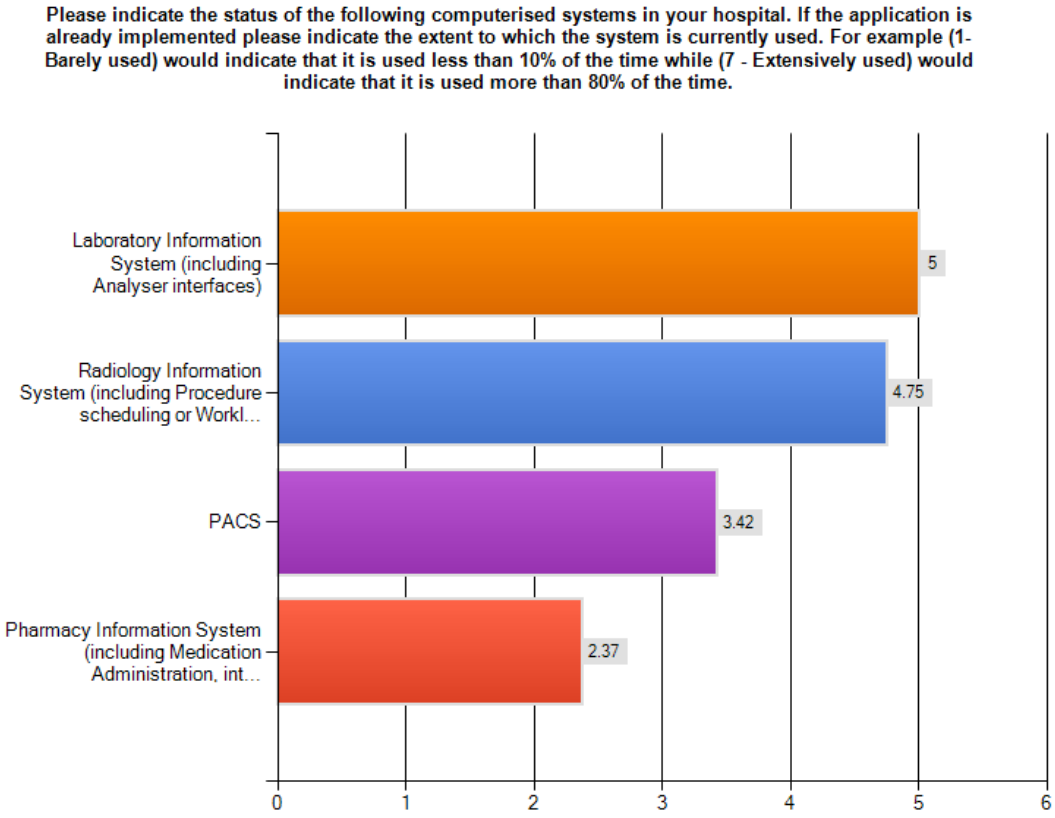
Patient Management Systems are highly utilised in the Admissions, Billing and Ambulatory Care categories. Adoption tails off in the case of Emergency Department Systems (N.B. not all hospitals surveyed have an ED), Bed Management and Theatre Management Systems. Critical Care and some Allied Health areas are least popular. Those highest on the planning list include: Physiotherapy, Social Work, Speech and Language, Theatre Management and Bed Management systems.

6.4.2.3 Functional Vector Analysis – Clinical Support Systems

The hospital HITCAP scores for the Clinical Support Applications dimension range from 50% to 100%. The average HITCAP score for this dimension is 76% which is high.

D3 - Clinical Support Applications	
Mean	76.25
Standard Error	4.149746346
Median	77.5
Mode	55
Standard Deviation	18.55822984
Sample Variance	344.4078947
Kurtosis	-1.622191947
Skewness	-0.081916029
Range	50
Minimum	50
Maximum	100
Sum	1525
Count	20
Largest(1)	100
Smallest(1)	50
Confidence Level(95.0%)	8.685518903

6.4.2.3.1 Clinical Support Applications - Survey Results



In the Clinical Support category, Laboratory Systems enjoy a 100% utilisation rate closely followed by Radiology and PACS systems with rates of 4.75 and 3.42 respectively. Of the Clinical Support Systems, Pharmacy is the least implemented and used with a rate of 2.37. Of the hospitals surveyed 32% have plans to implement a PACS system and 16% have plans to implement a Pharmacy Information System.

PACS achieved a rating score of 3.42 indicating high levels of implementation and/or plans to implement. 32% of respondents indicated they had plans to implement PACS. This result is indicative of the plan in train to implement PACS nationwide in accordance with a national procurement policy. 92% of respondents indicated that PACS would feature in their plans to complete the implementation of the EMR. In addition, of those PACS systems implemented, 100% reported the use of the internationally recognised DICOM standard with a small number also reporting the use of DICOM SR (Structured Reports) and WADO (Web access to DICOM Objects). The latter standards usage indicates measures to cater for machine-readable interpretation of data and more open

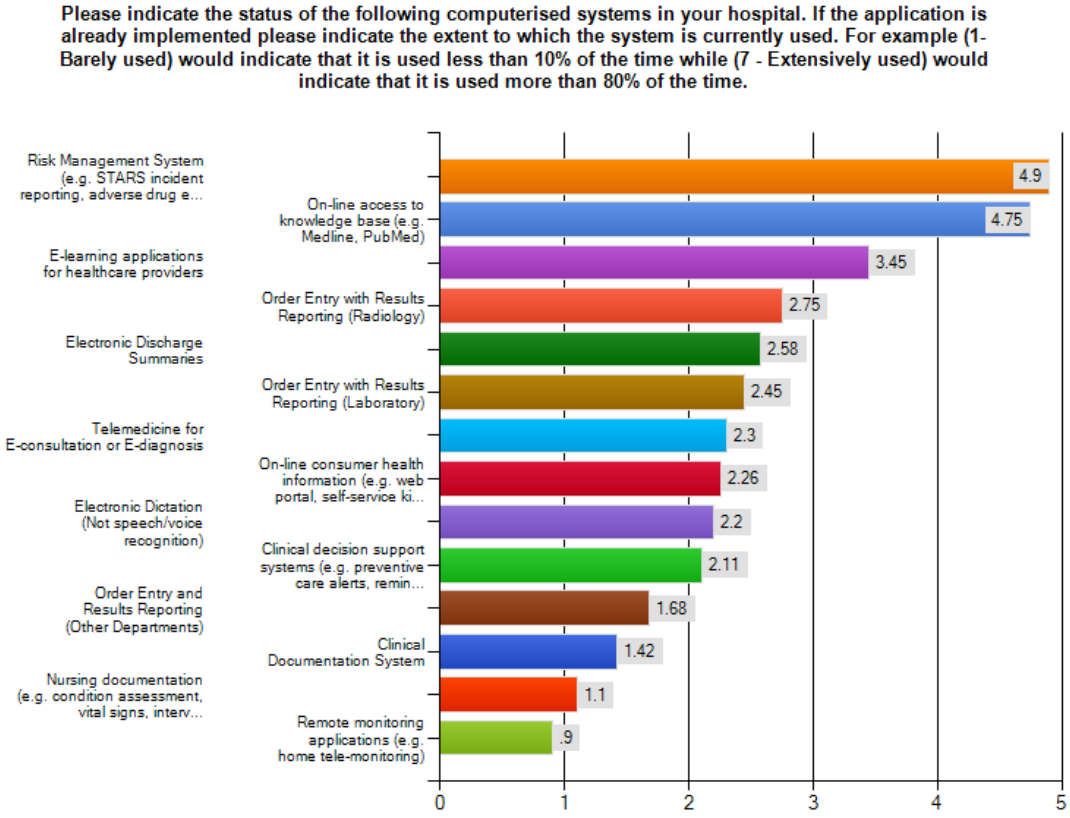
access to images. It is also important to note the parallel deployment of Tele-medicine and e-Diagnosis Clinical Applications reported in this study which have achieved a usage rating of 2.33 coupled with the high usage rating (4.75) attributed to the deployment of Radiology Systems. There are indications here of the general maturity of PACS reaching clinical process capability (level 4), see Appendix 3 - PACS Maturity Model, and efforts to optimise maturity with the introduction of internationally recognised standards. Fully optimised maturity will only be achieved with a fully integrated EMR.

6.4.2.4 Functional Vector Analysis – Clinical Systems

The hospital HITCAP scores for the Clinical Applications dimension range from 24% to 84% which represents a spread of 60%. The average HITCAP score for this dimension is 49% which is low.

D2 - Clinical Applications	
Mean	49.07142857
Standard Error	3.844835559
Median	47.14285714
Mode	47.14285714
Standard Deviation	17.19462734
Sample Variance	295.6552095
Kurtosis	-0.429678573
Skewness	0.388028398
Range	60
Minimum	24.28571429
Maximum	84.28571429
Sum	981.4285714
Count	20
Largest(1)	84.28571429
Smallest(1)	24.28571429
Confidence Level(95.0%)	8.047333292

6.4.2.4.1 Clinical Applications – Survey Results



Closer examination of this category shows that the use of Risk Management Systems and access to on-line Knowledge Databases are the most popular followed by E-learning Applications and Order Entry for Radiology. Clinician based Order Entry for Radiology has a higher adoption rate than Order Entry for Laboratory. Electronic Dictation, Order Entry for Laboratory and Electronic Discharge Summaries rate the highest systems in terms of planning.

6.4.2.5 Functional Vector Analysis – Summary

While the overall HITCAP score for the sample (n=20) is low to moderate at 49%, the average score on the functional vector is moderate at 65%. This may be explained in part by the public nature of the Irish healthcare system which places an emphasis on the exchange of information between providers and government agencies in support of the control process. The overall Administrative Systems dimension score is moderate at 62% and the most widely adopted administrative applications are indicative of those early adopters as outlined in Nolan's stages of growth model (see Figure 6 – Nolan's 6 stage growth model). There is only moderate evidence that Administrative systems adoption has matured into the Contagion and Control stages of maturity portrayed by the widespread implementation of scheduling

applications and the maturity of external integration as would be demonstrated by the implementation of e-commerce applications.

Both the Patient Management (78%) and Clinical Support (76%) scores are at the high end of the scale. These scores are supported by the knowledge that general Patient Administration Systems (PAS) have been the focus of efforts in HIT over the last two decades (foundation systems) and continue to enjoy this focus with the recent national policy to replace legacy systems which have reached end of life. Clinical Support Systems such as Radiology, Laboratory and Pharmacy are at the business end of the majority of activity in the health service and tend to benefit from the advantages of computerisation. The adoption of fully integrated Pharmacy Systems offering e-prescribing, medication administration and clinical decision support at the point of care appear to lag behind the adoption of the diagnostic departments. Open access to an industry standard drugs classification database may be the issue here and warrants independent investigation. On the other hand the score for Clinical Systems is on average less than moderate (49%) and highlights the continued lack of progress in the implementation of systems which potentially benefit the patient more and reduce clinical errors such as Order Communications, Nursing and Clinical documentation and Clinical Decision Support. The figures on clinical systems suggest that 41% have plans to implement Order Entry Systems; 20% plan to implement either Nursing or Clinical Documentation Systems and 16% plan to implement some kind of Clinical Decision Support. The adoption of Systems in this category will characterise hospitals reaching fuller maturity as they overcome not just the technical requirements of integration (sometimes between standalone departmental systems such as Pharmacy and the Order Communications facility of a separate EMR) but the workflow and organisational requirements of integration where multi-disciplinary care and inter-departmental cooperation is required. This level of maturity in the Irish acute care sector has not been evident to any great extent in this study.

6.4.3 Emerging Technology Vector Analysis

The Emerging Technology vector score (34%) is low, however, the figures show that of those with plans to implement more technology, 42% of these

will concentrate on Voice/Speech recognition, 32% on Single Sign-on technology and 37% on Radio-frequency Identification and sending reminders to patients via Text messaging. Clinical Data Warehousing (44%) and Bedside Terminals (67%) feature highest in those technologies for which hospitals have no plans at all.

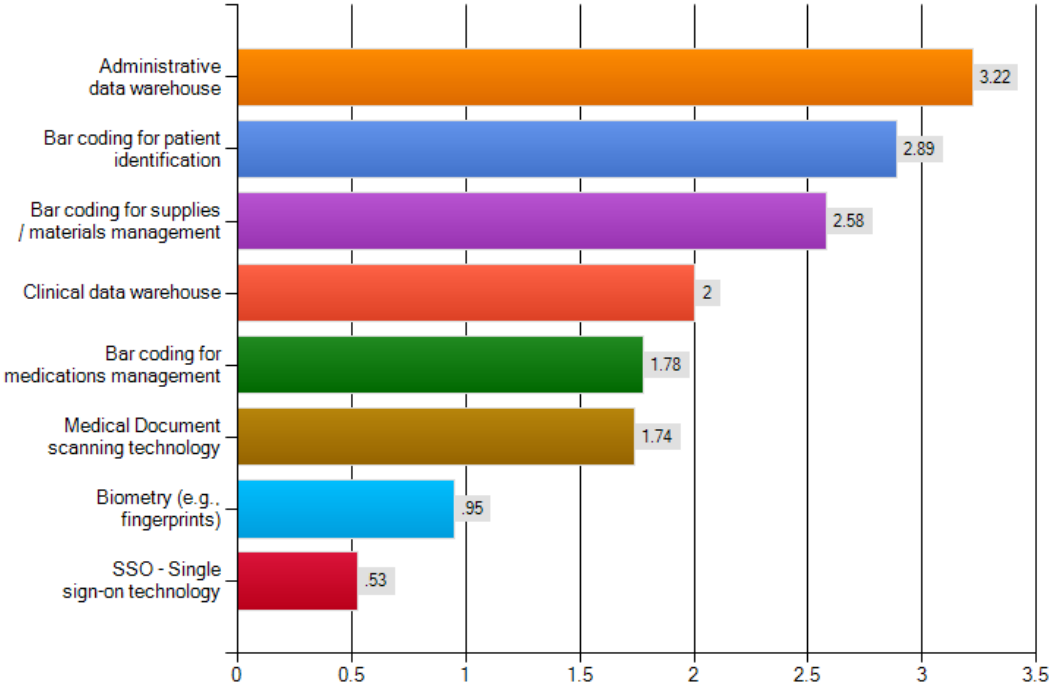
6.4.3.1 Emerging Technology Vector Analysis – Technology Systems

The hospital HITCAP scores for the Emerging technology vector range from 12% to 62% (n=19 as one hospital submission was incomplete). The average HITCAP score for this vector is 34% which is low.

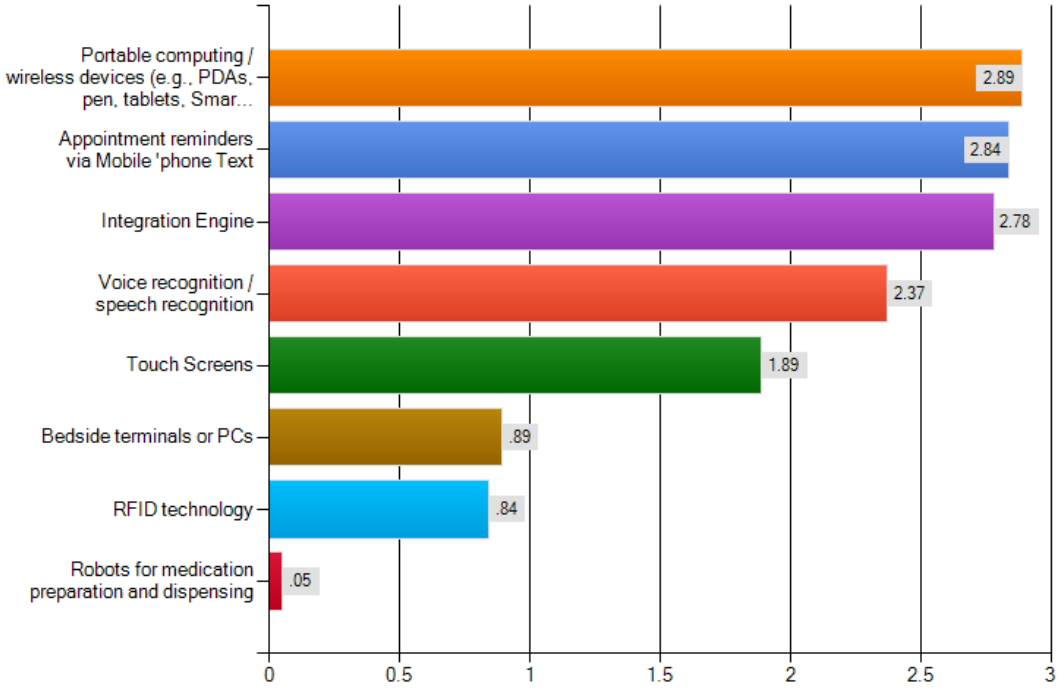
Technology HITCAP Scores	
Mean	34.33198381
Standard Error	3.446240262
Median	36.92307692
Mode	38.46153846
Standard Deviation	15.02181304
Sample Variance	225.654867
Kurtosis	-0.84041713
Skewness	0.03439164
Range	49.23076923
Minimum	12.30769231
Maximum	61.53846154
Sum	652.3076923
Count	19
Largest(1)	61.53846154
Smallest(1)	12.30769231
Confidence Level(95.0%)	7.240282111

6.4.3.1.1 Emerging Technology - Survey Results

Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1- Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.



Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1- Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.



Data-warehousing (administrative data), Portable computing, Bar-coding for patient identification and supplies, Appointment text reminders and Integration engines proved to be the most widely adopted technologies while Single-sign on, Radio-frequency Identification and Bedside computers were amongst the least utilised. Technological innovation, which is synonymous with maturing organisations, is evident only to a minor degree in the Irish study.

6.4.4 Integration Vector Analysis

The Integration Vector is comprised of the Internal Integration – Administration, Internal Integration – Clinical and the External Integration dimensions. The hospital HITCAP scores for the overall Integration vector range from 0% to 76%. The average HITCAP score for this vector is 32% which is low.

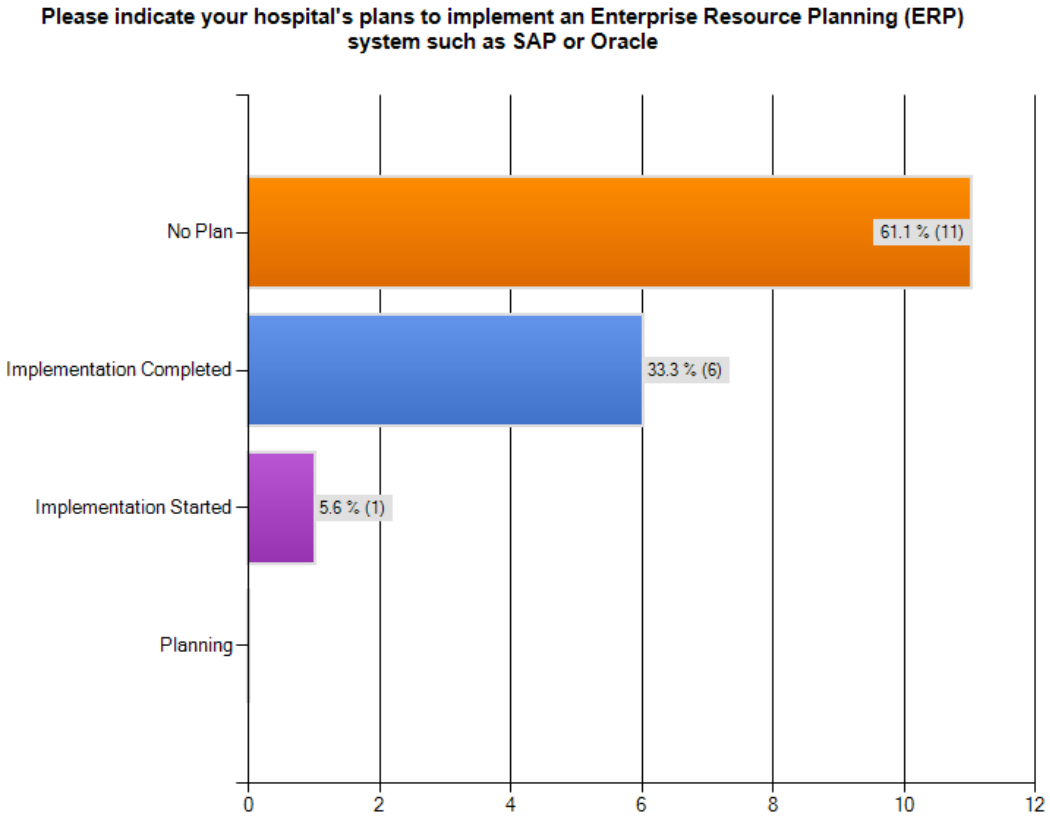
Integration HITCAP Scores	
Mean	31.66666667
Standard Error	4.789368958
Median	37.40740741
Mode	43.7037037
Standard Deviation	21.41870912
Sample Variance	458.7611003
Kurtosis	-0.901506621
Skewness	0.192129602
Range	76.2962963
Minimum	0
Maximum	76.2962963
Sum	633.3333333
Count	20
Largest(1)	76.2962963
Smallest(1)	0
Confidence Level(95.0%)	10.02426441

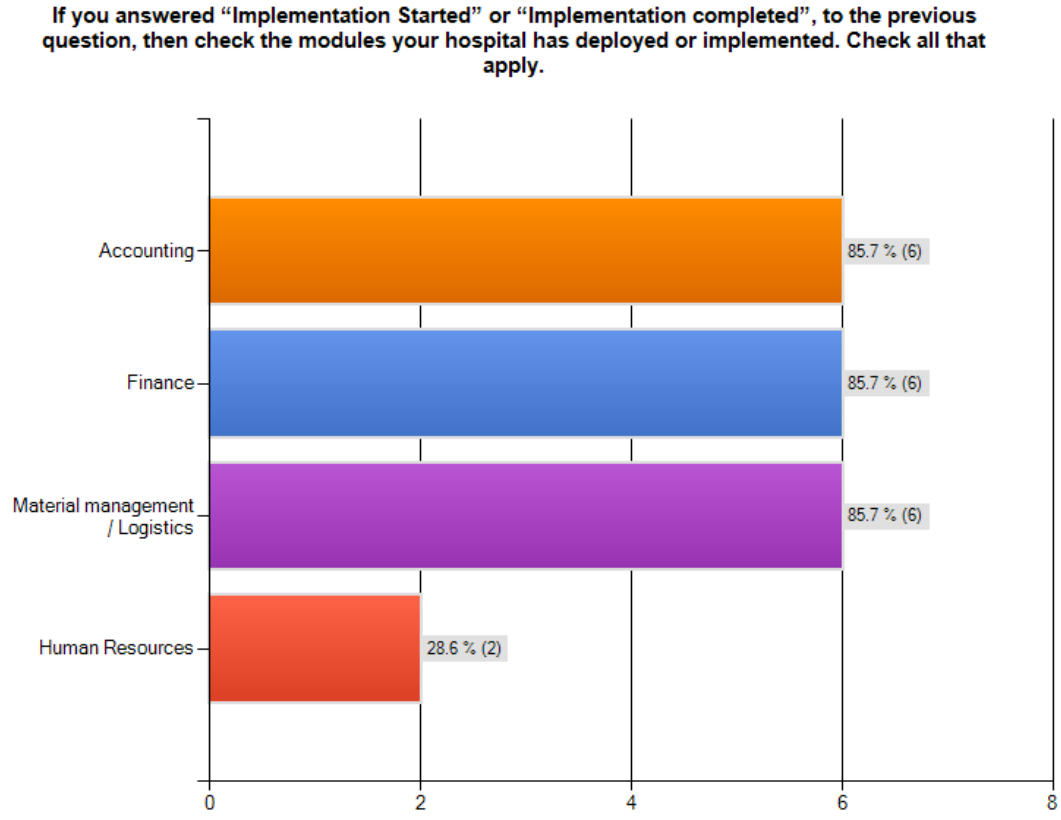
6.4.4.1 Integration Vector Analysis – Internal Administration

Scores on each of the internal dimensions of the Integration vector are low at 29% and 40% respectively and at 26% the external integration dimension is lowest of all. The hospital HITCAP scores for the Internal Integration - Administration dimension range from 0% to 100%.

D6 - Internal Integration - Administration	
Mean	29
Standard Error	9.116208815
Median	0
Mode	0
Standard Deviation	40.76892521
Sample Variance	1662.105263
Kurtosis	-1.572865576
Skewness	0.722132704
Range	100
Minimum	0
Maximum	100
Sum	580
Count	20
Largest(1)	100
Smallest(1)	0
Confidence Level(95.0%)	19.08044429

6.4.4.1.1 Internal Integration – Admin Systems Survey Results





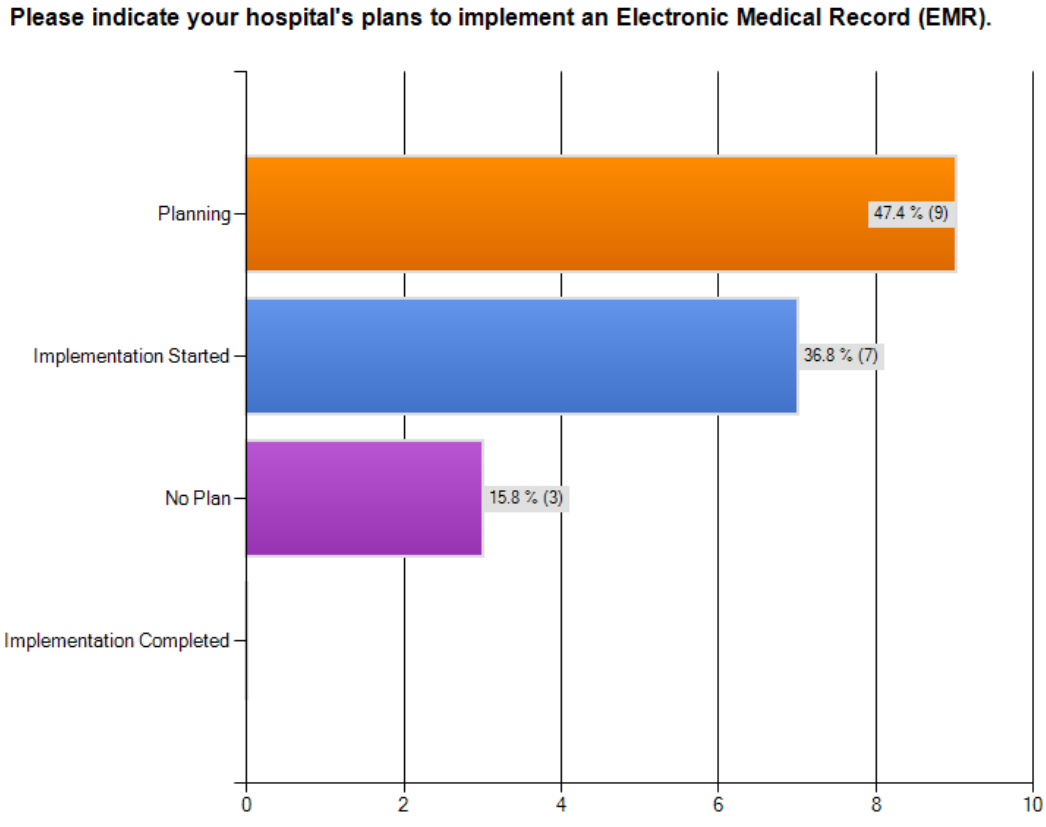
Only one third of hospitals surveyed have completed the implementation of an ERP system while 61% have no plans to do so. It is important to point out here that only 16% of Public Voluntary hospitals completed the survey and that the thrust of ERP implementations nationally focused on those particular hospitals. The national PPARS project set out to implement a national ERP System in the HSE acute sector. The implementation stalled and only some of the initial pilot sites were fully implemented. As set out in (Holland and Light, 2001), maturity assessment would be feasible by closer examination of the different aspects of the implementation including: strategic use, organisational sophistication, penetration of the ERP in the organisation, the corporate vision for the system and especially the lessons to be learned from the initial failure to deploy the system on a national basis.

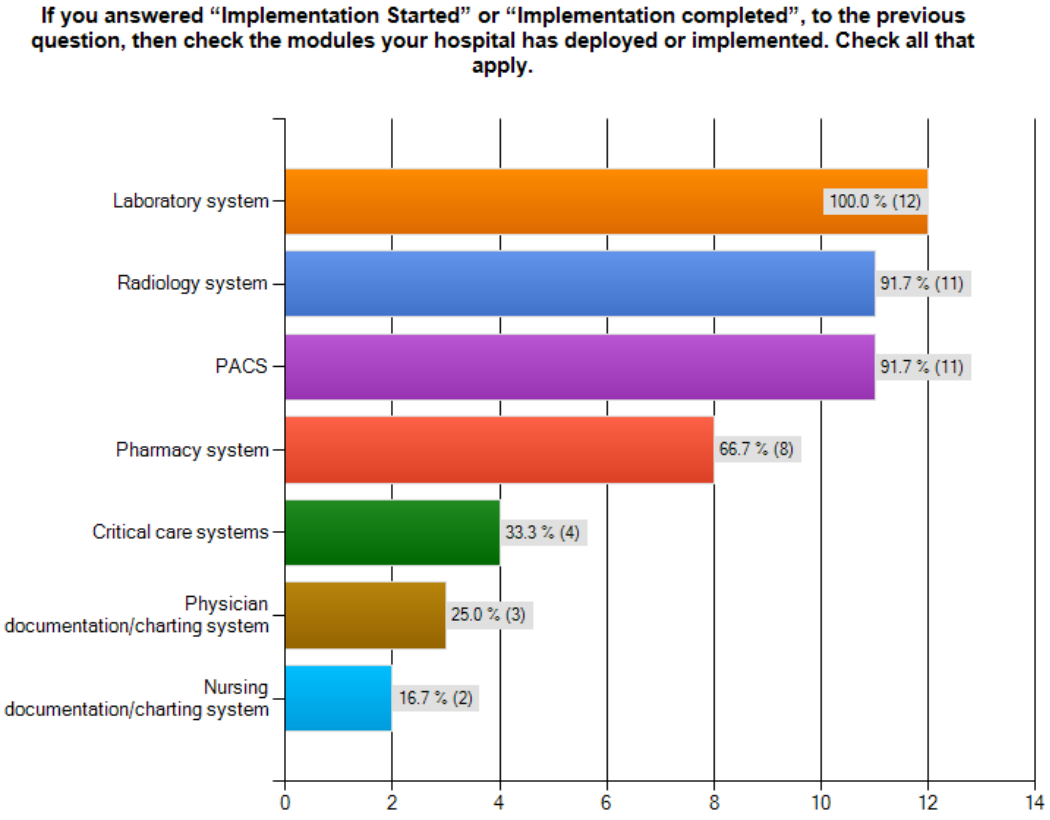
6.4.4.2 Integration Vector Analysis – Internal Clinical

The hospital HITCAP scores for the Internal Integration - Clinical dimension range from 0% to 100%. The average HITCAP score for this dimension is 40% which is low.

D7 - Internal Integration - Clinical	
Mean	40
Standard Error	8.46043423
Median	20
Mode	20
Standard Deviation	37.83621212
Sample Variance	1431.578947
Kurtosis	-1.396092001
Skewness	0.621875459
Range	100
Minimum	0
Maximum	100
Sum	800
Count	20
Largest(1)	100
Smallest(1)	0
Confidence Level(95.0%)	17.70789232

6.4.4.2.1 Internal Integration – Clinical Systems Survey Results





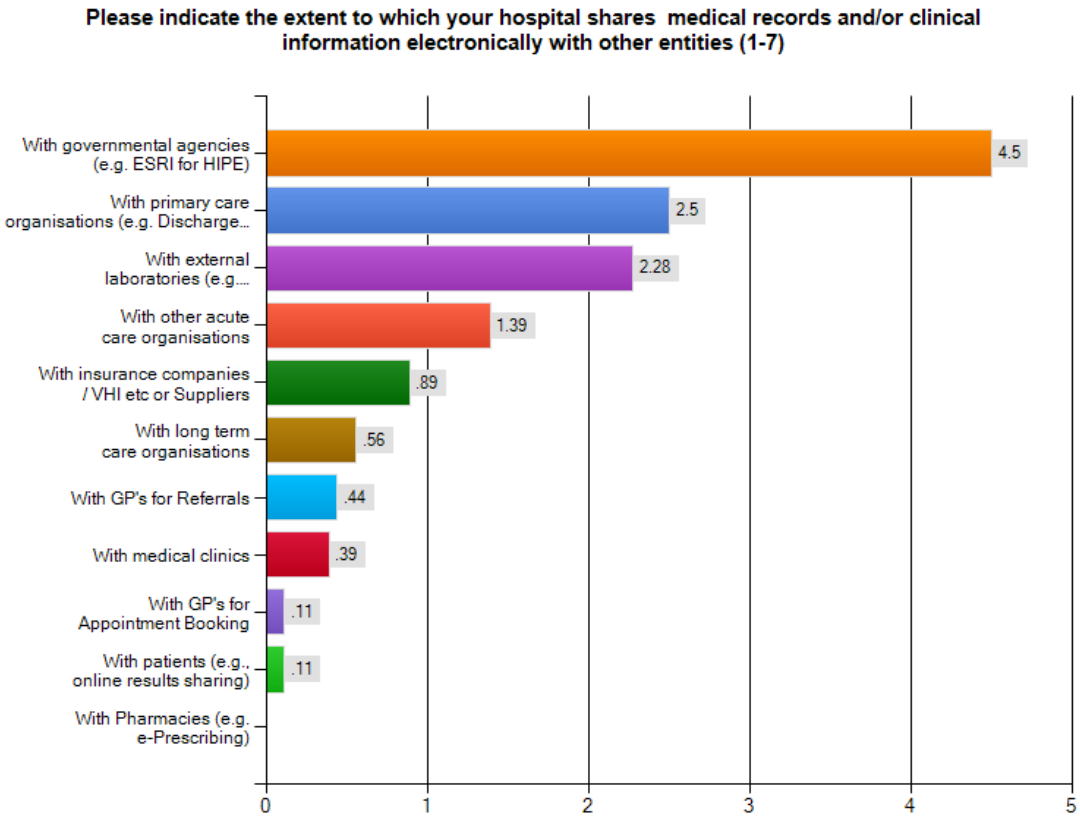
47% of hospitals are planning to introduce an EMR while no hospital has succeeded in completing one. Of those hospitals which have commenced an EMR implementation, Laboratory, Radiology and PACS systems feature highest of those considered for inclusion while Clinician and Nursing documentation Systems feature least.

6.4.4.3 Integration Vector Analysis – External

The hospital HITCAP scores for the External Integration dimension range from 0% to 64%. The average HITCAP score for this dimension is 26% which is low.

D8 - External Integration	
Mean	26
Standard Error	3.335671694
Median	25.55555556
Mode	31.11111111
Standard Deviation	14.91757732
Sample Variance	222.5341131
Kurtosis	1.1561369
Skewness	0.769620672
Range	64.44444444
Minimum	0
Maximum	64.44444444
Sum	520
Count	20
Largest(1)	64.44444444
Smallest(1)	0
Confidence Level(95.0%)	6.981641079

6.4.4.3.1 External Integration – Survey Results



Apart from integration with government agencies for HIPE, average rating valuation for all other categories in this dimension are individually low with integration for Patients and Pharmacies scoring lowest of all.

6.4.4.4 Integration Vector Analysis – Summary

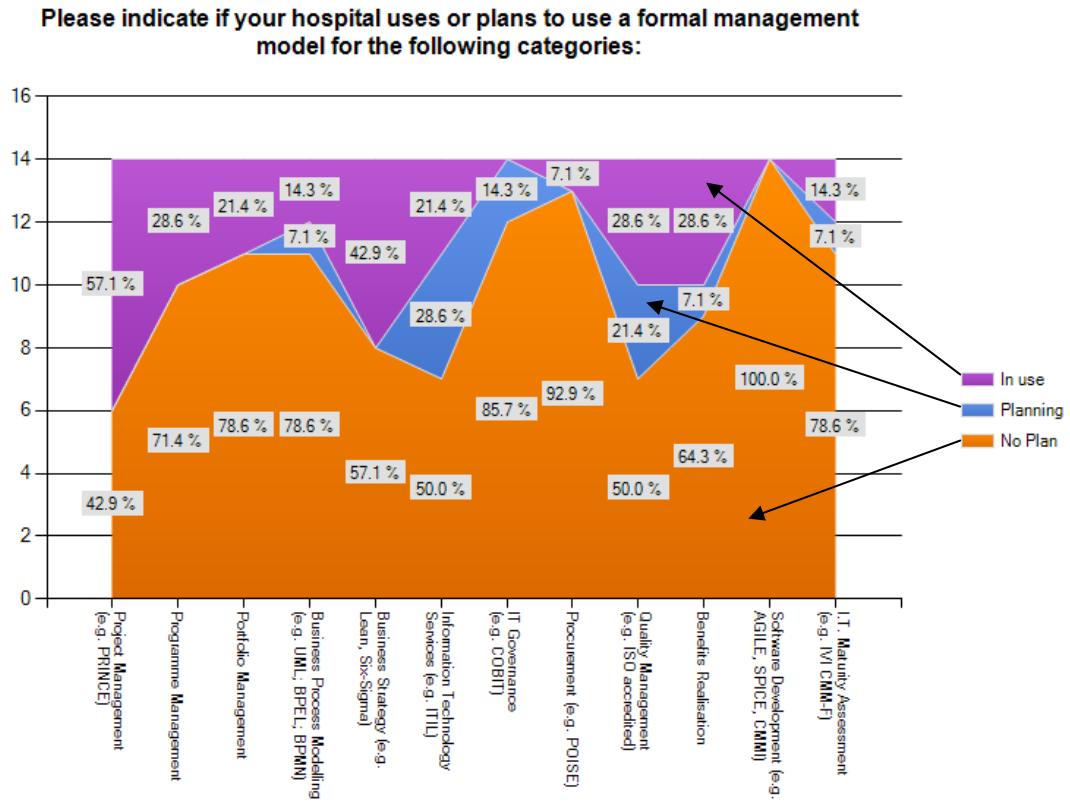
Referring to the revised Nolan Stages of Growth model (see Figures 5,6), the ultimate stage of maturity is characterised by extensive internal and external integration of systems and data and the recognition that I.T. is an integral part of the organisation. External integration efforts will afford the organisation opportunities of innovation where the true potential of the enterprise may be realised. While HIT systems in general in the Irish situation would appear to have progressed beyond the initiation and contagion stages of maturity, there is occasional evidence that some are now in the more mature stages of integration and data administration (e.g. PACS deployment) but for the most part, hospitals in the acute sector linger in the mid-mature control stage with increasing levels of government involvement. The true measure of this general lack of maturity is evidenced by the quite low internal and external integration

scores achieved. If as stated in more than one report on the future of Irish HIT in recent times, that integration and interoperability of systems was the way forward, then there is still much to achieve.

6.4.5 Management and Maturity Models Analysis

Respondents were asked to indicate their usage of (or plans to use) a number of different I.T. management models. The highest percentage (57%), use a Project Management tool such as PRINCE followed by 43% who use a Business Strategy model such as Lean or Six-Sigma. The highest scoring in the planning category (29%) were those looking at management models for Information Technology Services such as ITIL while 86% had no plans to introduce an I.T. Governance model, and 79% had no plans to introduce a Portfolio management model, a Business Process modelling tool or an I.T. Capability Assessment tool.

6.4.5.1 Management Tools - Survey Results



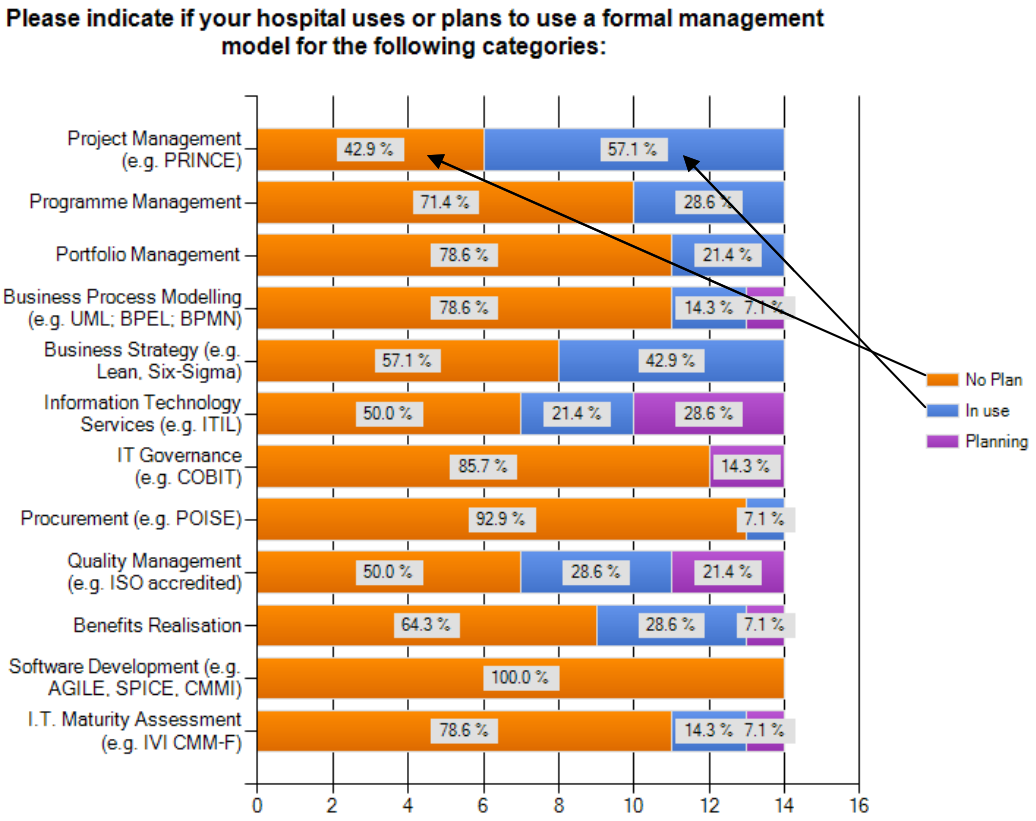
With only 14% of respondents using a Business Process Modelling tool, and 79% with no plans to do so, it would appear that the means by which the integration of HIT and business processes may be managed according to best practise is being overlooked by the majority of hospitals. Moreover, it would

seem that those systems closest to the clinical process such as Nursing and Clinical notes are set to suffer and feature least in the plans for inclusion in the EMR. Worthy of note here is the need to involve clinicians and the workflow implications of introducing such systems. The partnership building core competency identified in (Wu et al., 2009) which examines the integration of healthcare technology and the IS function is key to this problem. Further analysis of this area is warranted.

6.4.5.2 Project Management

Traditionally, the early implementations of HIT in Ireland left the Project Management role to the supplier whose objective it was to bring the project to conclusion, on schedule and within budget and to quickly move on to the next revenue earning opportunity. Unless tied by a performance clause in the contract, the supplier PM was not really interested in staying around to measure benefits. Neither was the supplier PM familiar with the organisations in question or appreciative of its strategic direction. The need for a site PM evolved whereby the business and strategic requirements of the organisation were represented. To ensure that the goals and objectives of the project fit into the I.T. architectural and business goals of the hospital, the PM needs to be trained in the use of a professionally recognised PM programme - see Figure 14 – Stages of PM Maturity (Paulk et al., 1993).

6.4.5.2.1 Project Management Systems - Survey results

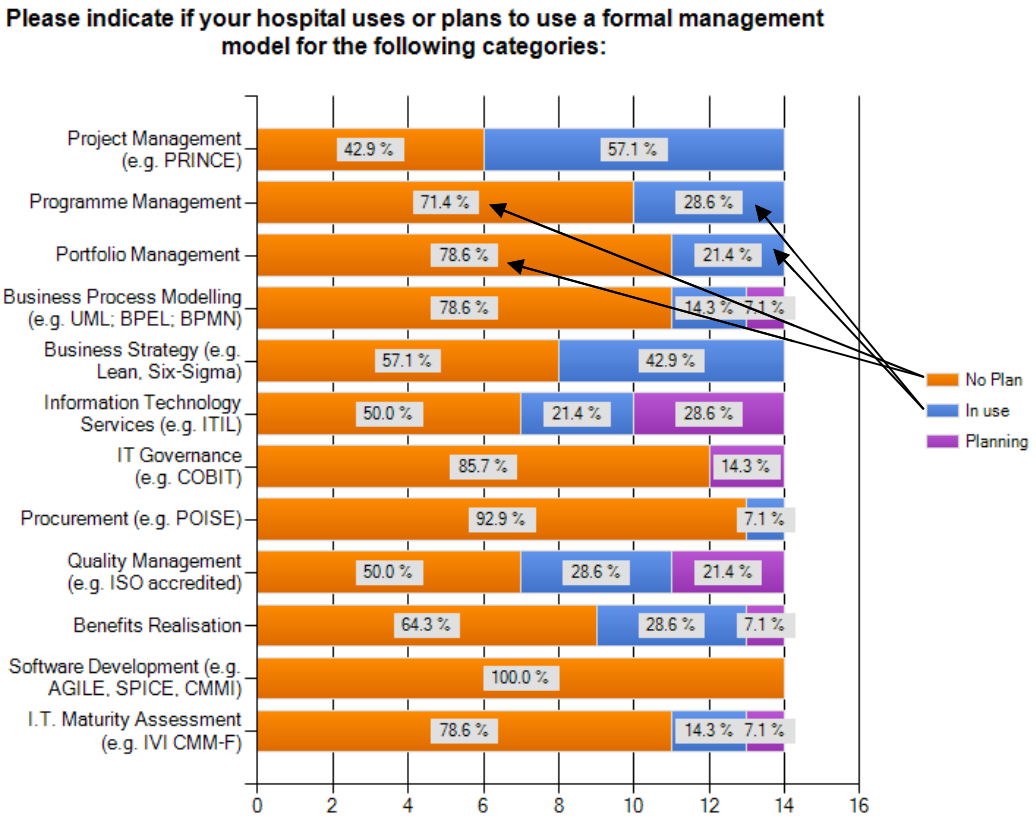


While the majority (57%) of hospitals are actively engaging in the use of an industry recognised Project Management Tool, the remainder have no plans to do so. This trend may be indicative of the recent implementation approach whereby corporate project management resource is assigned to local projects which have been procured nationally. While this approach may overcome the local shortage of such skills in the short term, there is the danger that local strategic business objectives may lose representation.

6.4.5.3 Programme and Portfolio Management

With an increasing number of projects in the proliferation phase of maturity, it becomes more and more important to manage them consistently to ensure an acceptable level of success. The HSE in Ireland have looked to regional or hand-picked industry experts to push the implementation of national solutions locally. It is important however, that local resources remain involved to maintain the local interest and direction. Portfolio management is required to prioritise and choose those projects which will deliver best value and return and local resource are best placed to identify this. In the case of having to support or replace legacy systems, this level of local vision is all important.

6.4.5.3.1 Programme and Portfolio Management - Survey results



The evidence of the Irish survey would suggest that only the minority of hospitals use either a Programme Management tool (29%) or a Portfolio Management tool (22%) and the remainder in each case have no plans to introduce one. The use of Business alignment management tools such as Lean and Six Sigma in individual hospitals is encouraging at 43%. If the trend, however, is that the implementation of systems locally is to be planned at a corporate level, the expectation is that this type of management tool is being used at a corporate level to manage the ongoing introduction of HIT into the acute sector – see Appendix 4 ITPM Maturity Model. Further analysis is required in this area.

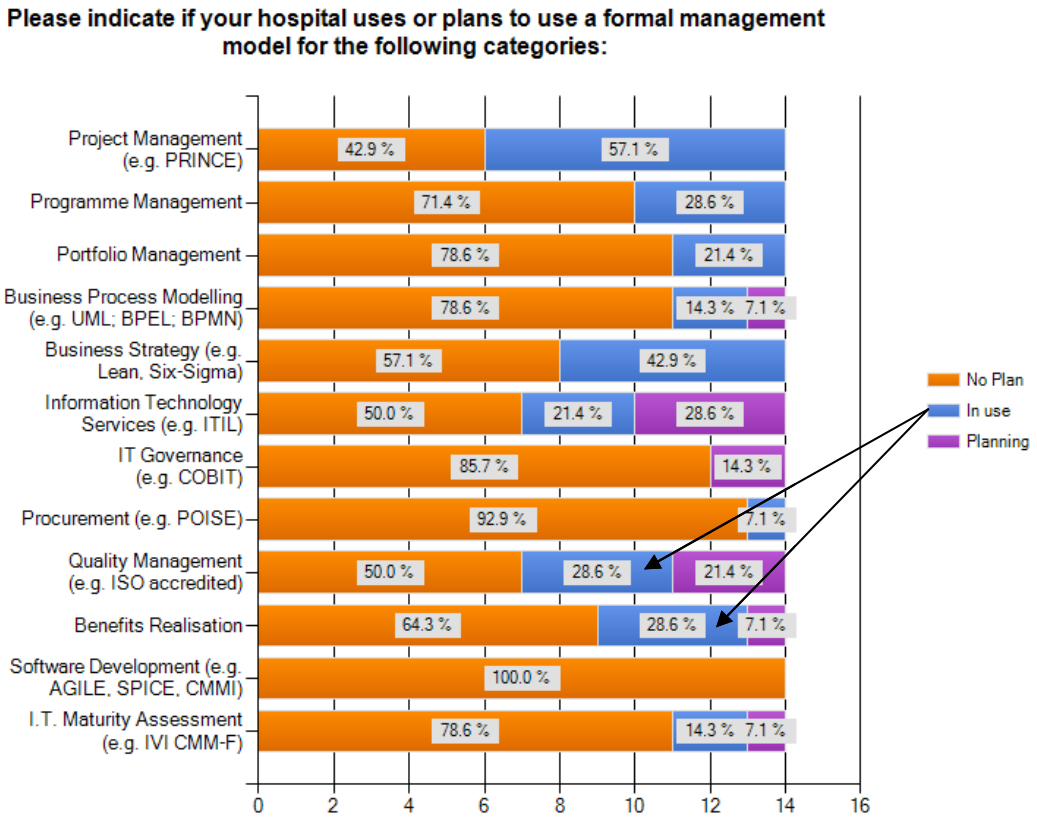
6.4.5.4 Health Information Technology Use and Management

The survey connected with this study did not assess the characteristics of the use or management of I.T. by managers within the Health sector. Section 3.11 of this dissertation, Capability Maturity Models – HIT Use and Management, points to 'Checkpoint' as outlined in (Mordue and Seeley, 1997) which allows for such an assessment. Such a programme of assessment would be advocated to ensure the resources in management positions are appropriately trained and accredited. The launch of such a programme for local resources would in the opinion of this author, better serve HIT in Ireland than the recruitment of resources from outside of the industry often lacking in the domain skills and knowledge already in the possession of existing staff.

6.4.5.5 Quality Management Systems Analysis

Quality was an issue raised in the critique of existing systems by (Hurl and Kenny, 2009). This research did not attempt to measure the quality of systems implemented and further work in this area would be advocated. The use of quality maturity models such as those set out in HIS-Monitor in (Ammenwerth et al., 2007) would serve to identify quality measures such as data quality, data reliability and usability.

6.4.5.5.1 Quality Management Models - Survey results



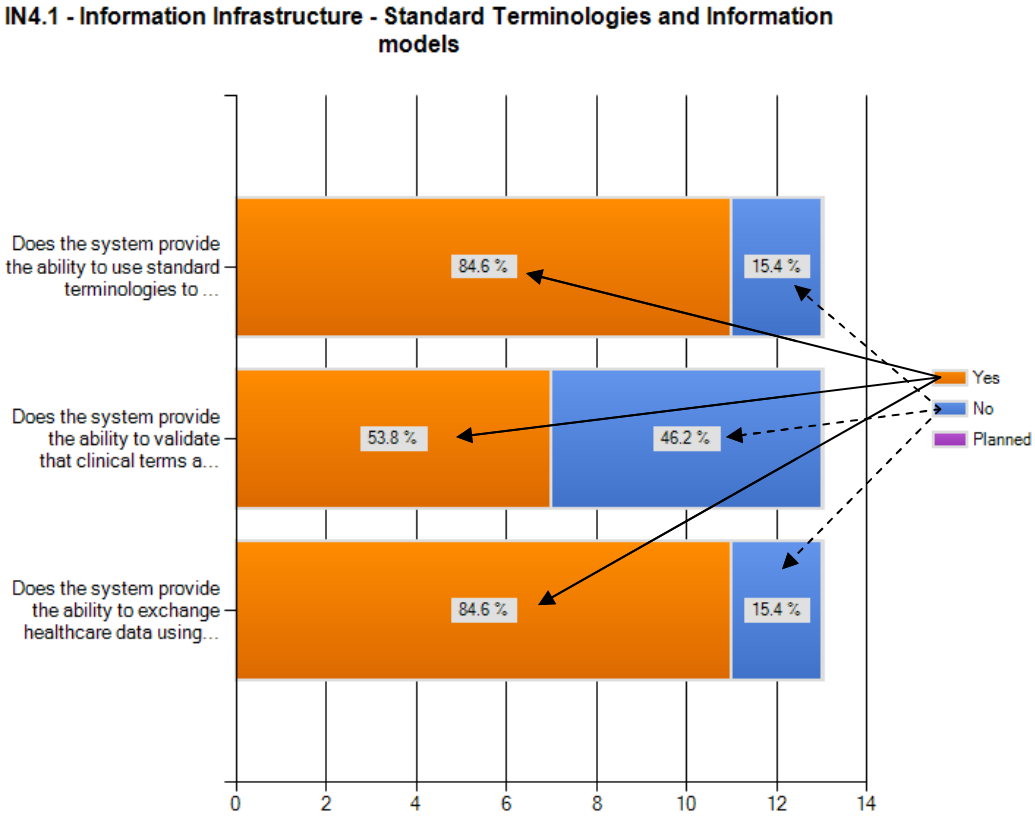
Our survey response showed that 29% of respondents are actively using a Quality Management system and 29% use a Benefits Realisation Programme.

6.4.6 Information Infrastructure Analysis

6.4.6.1 Standard terminologies and Information Models:

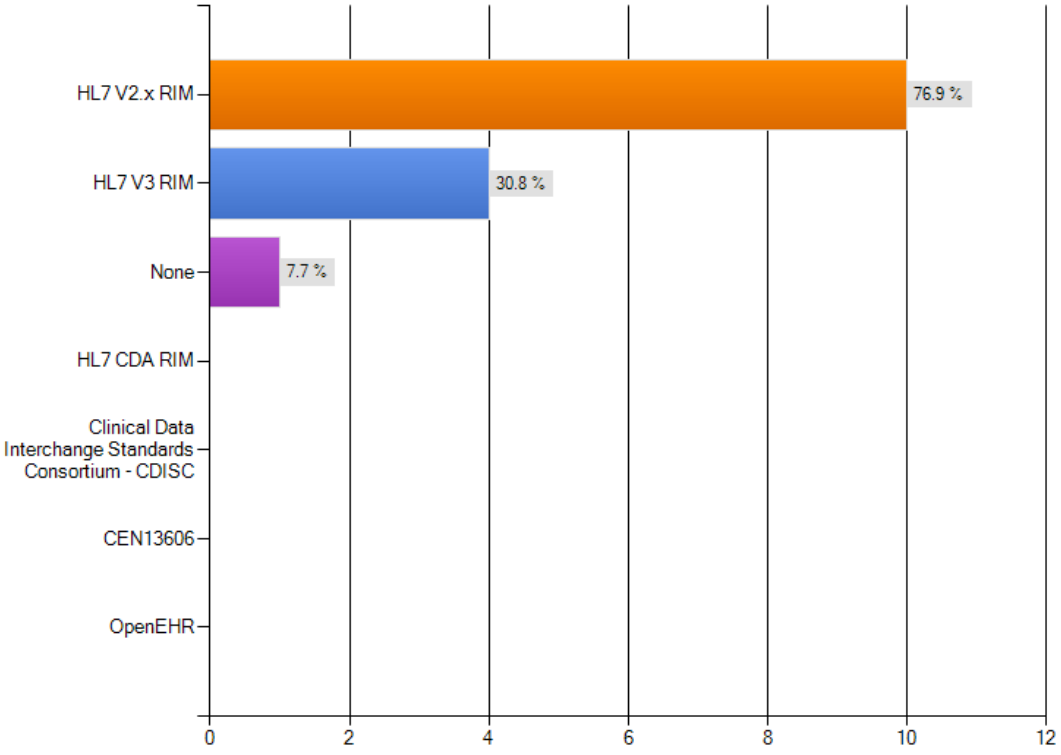
The HL7 Reference Information Model (RIM) was used to formulate questions in the survey on the interoperability characteristics of systems already installed. The full responses to this section of the survey are available in Appendix 9, page 125.

6.4.6.1.1 Terminologies and Information Models – Survey results



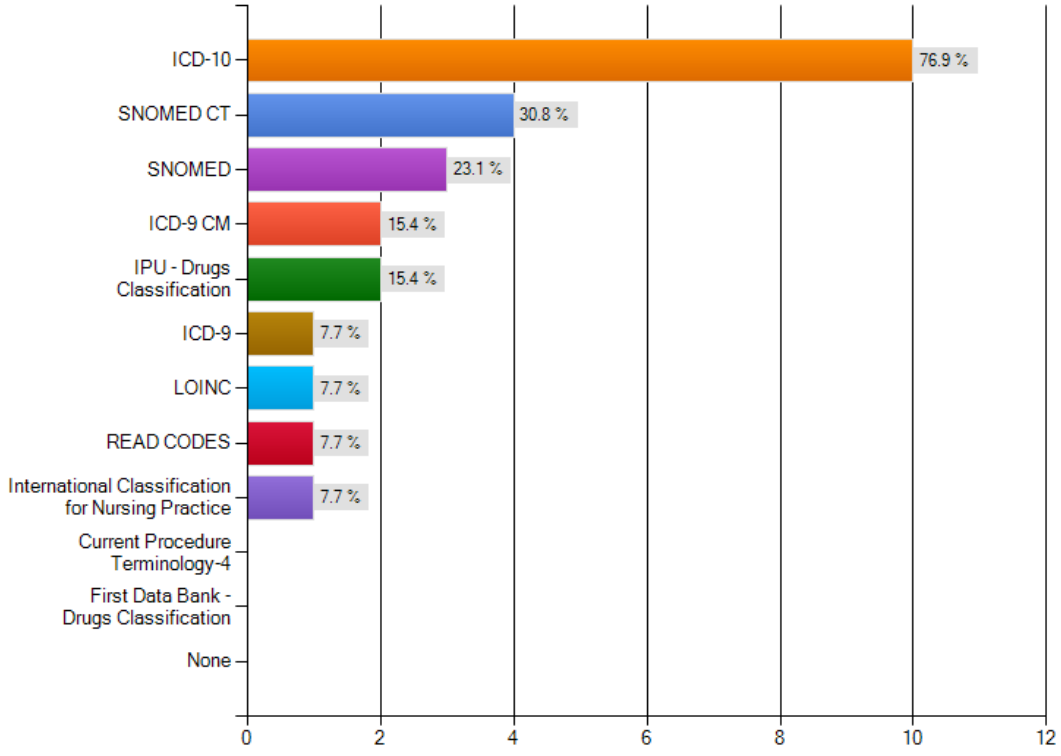
In terms of the use of standard terminologies and information models, results showed (n=13) that 85% of systems implemented compared favourably with the definition in the HL7 RIM for this category.

Please indicate the Standard Information Model in Use:

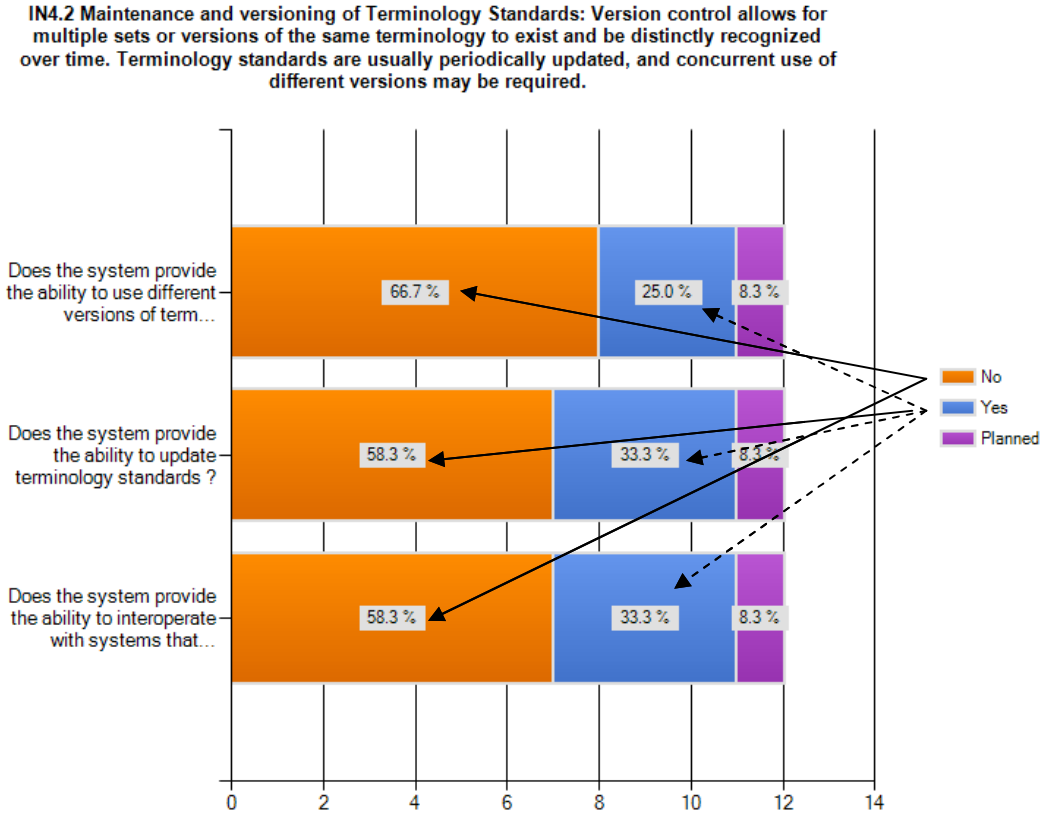


77% of respondents use the HL7 V2.x standard while 31% use HL7 V3.

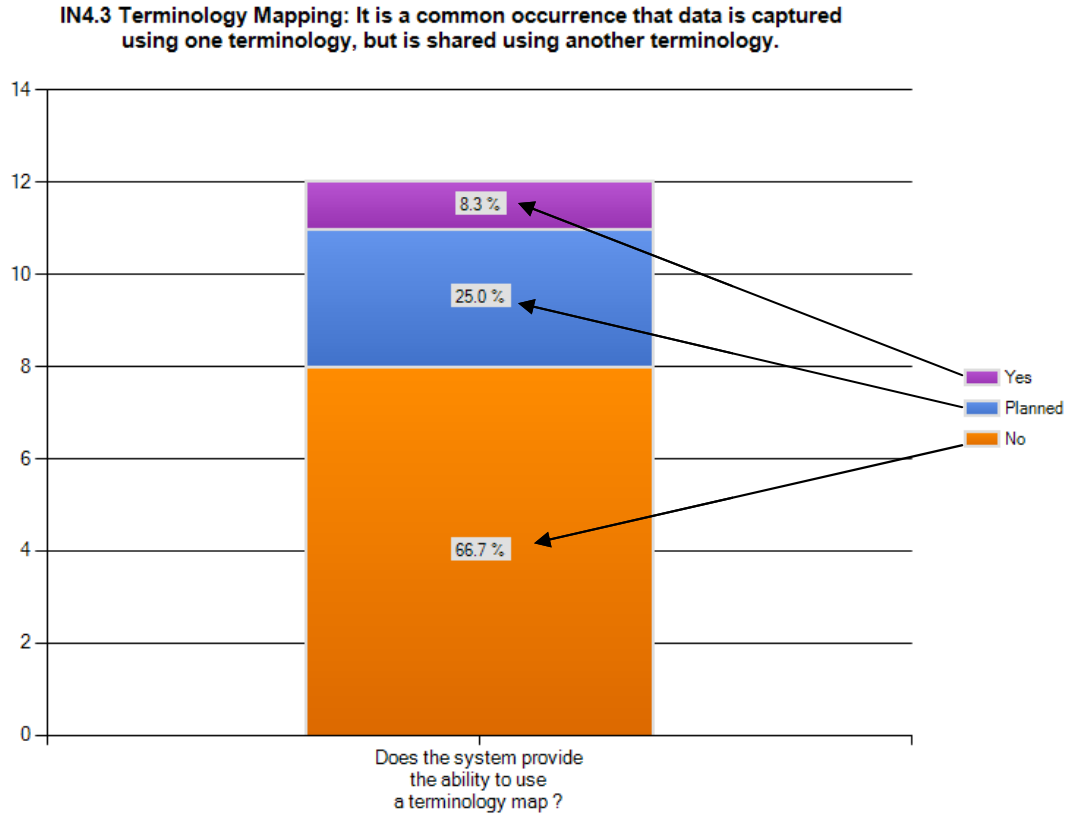
Please indicate which Standard Terminologies are currently in use:



77% of respondents use the ICD-10 Diagnosis Classification terminology and one respondent acknowledged using both ICD-9 and ICD-10.



With 12 respondents to the question regarding the ability of systems to support the use of more than one terminology standard version, 67% of systems were unable to operate as described by the definition in the HL7 RIM.

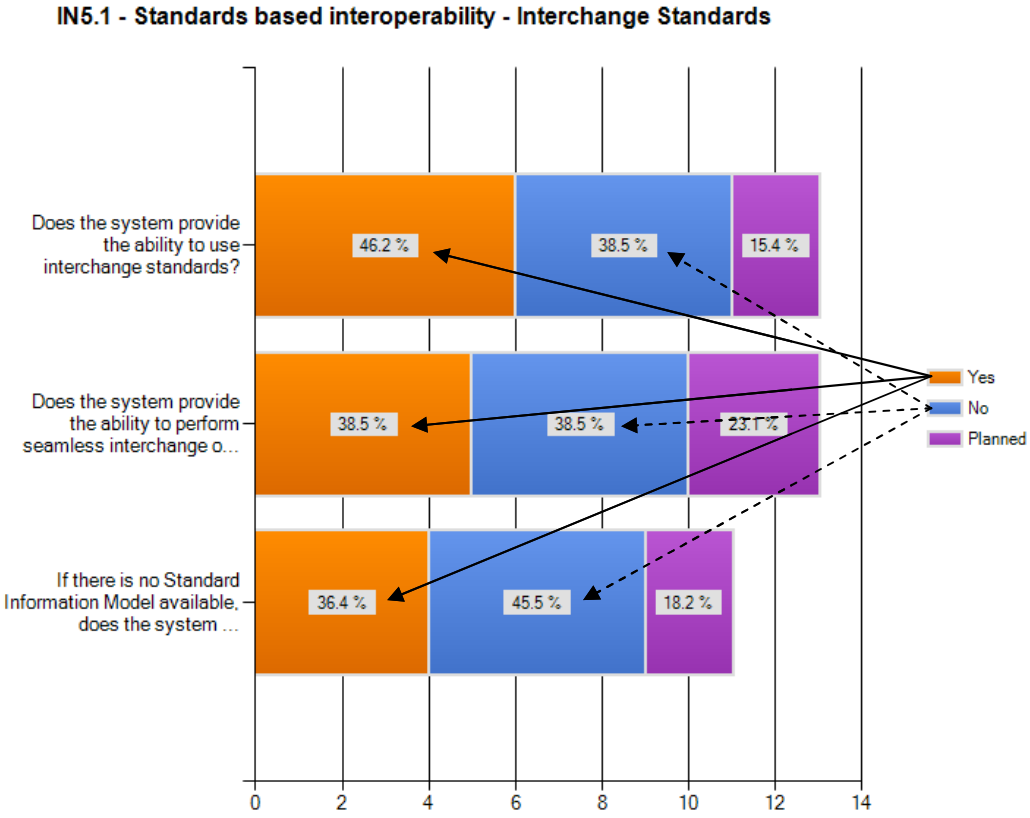


6.4.7 Standards and Interoperability Analysis

The introduction to this dissertation identified interoperability and adherence to standards as the direction of choice in terms of the pursuit of a national EHR in Ireland. Our national readiness to follow such a path however, would indicate a shortfall in the tools required at a technical level. Using the NEHTA Interoperability Maturity Model in Figure 13 would suggest we are currently at level 2 ('Managed, some goals achieved') of a five point maturity scale. The adoption of e-Health standards has begun but there is no evidence of uniform implementation of a nationally agreed set of standards incorporating services, policies and legal compliance. If the NEHTA model were to be followed, interoperability would be planned on a broader scale and would incorporate not just the technical dimension of interoperability, but the informational and organisational dimensions also. Interoperability would be assessed in terms of problems at a community, enterprise and local level and a starting point of maturity established in the growth process. Enterprise Architecture units would devise a modular approach providing for re-usable elements, evolution, and the use of open standards, scalability and configurability which are all necessary interoperability goals. At an organisational level business focus

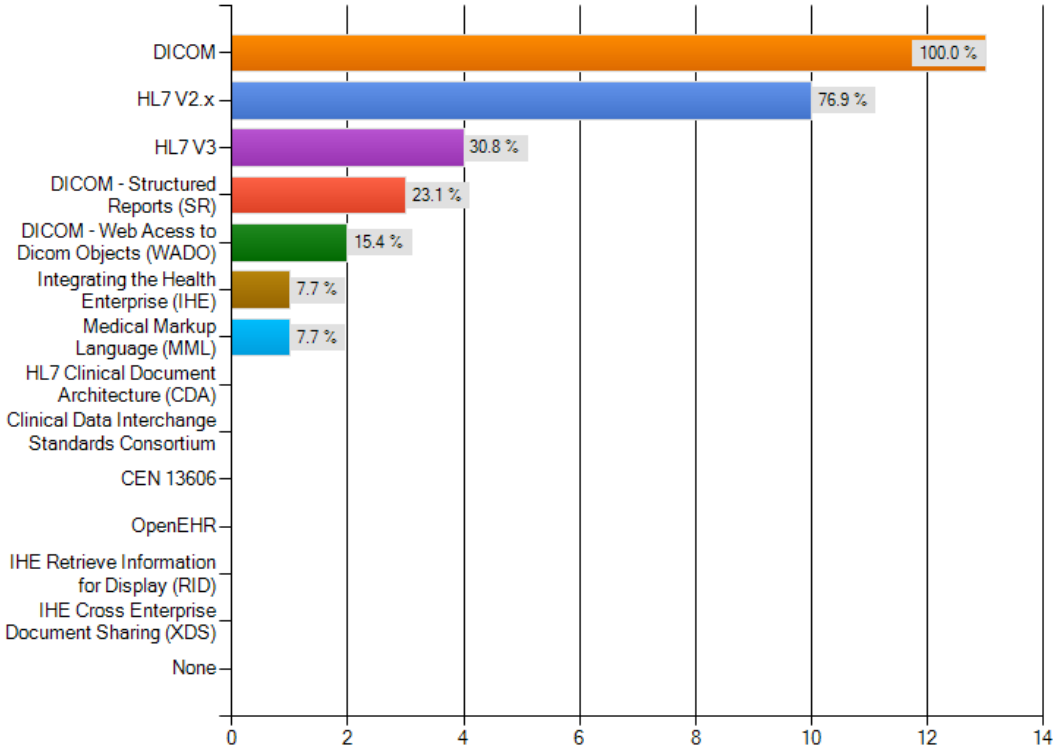
would be all important and at an informational level clear lines of distinction between syntactical and semantic data models would be drawn. In (Bernstein et al., 2005) integration of EHR systems is part of the Danish I.T. strategy for 2003-2007. Pilot projects were initiated at a national level to introduce a common EHR information model considered key in order to achieve semantic interoperability. A survey of four different model approaches is conducted: (1) in Aarhus County where a generic model comprising a common EHR for all hospitals in the county is planned; (2) in Copenhagen where systems are being integrated using the DHE (Distributed Healthcare Environment) middleware's data model; (3) in Vejle and Viborg where a communication model – a shared record project, is planned and (4) a semantic model (National Health Board) – basic EHR information model. The major pilot projects in Aarhus and Copenhagen are vetted by an EHR Observatory group. The vetting process includes both a clinical and technical assessment including: change readiness; clinical functionality assessment; workflow analyses and usability analyses using criteria such as: conformity with use-case scenarios; conformity with business rules; conformity with the information model and conformity with communications standards. The Aarhus approach is being looked at with interest while there are issues keeping archetypes updated and coherent. There is wide commitment to the National data model and the creation of archetypes adds granularity easily and effectively without the need for clinicians to take on the bigger task of a health-wide model.

6.4.7.1 Interchange Standards - Survey results



46% of respondents (n=13) indicated that their systems provided the ability to use interchange standards with the majority (77%) using HL7V2.x. Further analysis of this area is warranted given the low levels of both internal integration (Administrative Systems = 29% and Clinical Systems = 40%) and external integration (26%) achieved as outlined previously. The figures might suggest that while some systems have an in-built ability to provide standards-based interchange, these facilities are not utilised to maximum benefit.

Please indicate which of the following communications interchange standards are in use:



Of particular note is the 100% usage of the DICOM standard across all hospitals who responded (n=13) reflecting the national project in train to introduce PACS into all acute hospitals. Also of note is evidence (8%) of the use of the IHE standard approach advocated in the national PACS procurement process.

7 Discussion

7.1 Comparative Analysis – Canadian Study

In this section, a comparative analysis of the HITCAP scores from the Irish study against those established in the original Canadian study is conducted. First, the hospital high, low and sample average scores calculated for the Irish study are identified.

	Functional vector	**Technological vector**	**Integration vector**	**Overall Score**
Sample Low	54%	14%	10%	32%
Sample High	81%	48%	76%	75%
Sample Average	65%	33%	32%	49%

Figure 28 - Irish Sample HIT Capability High/Low/Average Scores

The Canadian study HITCAP scores were identified from [Paré et al, 2010] which were:

	Dimension	**Dimension HITCAP**	**Vector HITCAP**	**Overall HITCAP**
Functional vector	Admin Systems	65%	66%	
	Patient Systems	64%		
	Clinical Support	84%		
	Clinical Systems	52%		
Technological Vector	Emerging Technologies	30%	30%	
Integration vector	Internal - Admin	74%	51%	
	Internal - Clinical	45%		
	External	34%		
Overall HITCAP				**56%**

Figure 29 - HIT Innovativeness scores in hospitals (Paré, Jaana and Sicotte, 2010)

The HITCAP score for the Irish Study (n=20) was calculated and is as follows:

	Dimension	Dimension HITCAP	Vector HITCAP	Overall HITCAP
Functional vector	Admin Systems	58.78%	65.45%	
	Patient Systems	77.71%		
	Clinical Support	76.25%		
	Clinical Systems	49.07%		
Technological Vector	Emerging Technologies	32.62%	32.62%	
Integration vector	Internal - Admin	29.00%	31.66%	
	Internal – Clinical	40.00%		
	External	26.00%		
Overall HITCAP				**48.68%**

Figure 30 - HIT Capability scores for Irish Hospital sample (n=20)

In comparison with the corresponding figures from the Canadian study, the overall score for the Irish sample was seven points less than that achieved in Canada. While the Irish sample size (n=20) was considerably smaller than that of the Canadian study (n=106), a sizeable increase in the Irish sample size would not in the opinion of the author affect the overall Irish score in a positive way. On the contrary, the understanding is that if the sample size were to be increased substantially with the addition of further Public HSE hospitals, the overall score may well prove to be lower than that achieved. The functional vector scores were very similar in both studies (the Irish score is just one point short of the equivalent Canadian score) showing that overall efforts to install, implement and use systems across the patient, administrative and clinical divides, is about the same in both countries. When one looks a bit deeper however into the dimension breakup of the functional vector scores, the use of administrative systems in Ireland lags behind that of Canada by six points approximately. Apart from Financial, Payroll and Personnel systems, the administrative dimension includes applications for Business Intelligence, Executive Information and Clinical Workload management. The Irish score for the Patient Systems dimension is a significant fourteen points ahead of the Canadian score but lags the corresponding Canadian scores for Clinical Support and Clinical systems by eight points and three points respectively. The technological vector scores for

the Irish study is three points more than its Canadian counterparty 33-30%. Perhaps the difference in the overall scores can be explained best by an examination of the scores for the Integration dimensions. At 32% the Irish vector score lags the Canadian score by a significant nineteen points and with deeper analysis the most significant difference is found in the Internal integration – Administration systems dimension where the difference is forty five points. This dimension examines the use (or plans to implement) Enterprise Resource Planning systems such as SAP or Oracle incorporating Accounting, Financial, Payroll/Personnel and Materials Management systems into a single database platform. Important to note at this juncture, and mooted here as a reasonable explanation for the significant comparative difference for figures in this category, is the stalled implementation in Ireland of the PPARS (Personnel, Payroll and Related Systems) national project which would have seen the implementation of ERP in all HSE hospitals, quite a number of which it was not possible to have included in this study. There is a more moderate difference in the Internal integration – Clinical systems category of five points and this gap widens to eight points when comparing the scores for the sharing of electronic data with external agencies.

> *If as previously expounded by Nolan, Paré and others that domain maturity is characterised by the level of integration achieved, then maturity is an ideal yet to be realised as supported by this study of Healthcare Information Technology capability in a sample of Irish acute hospitals.*

Each of the comparative scores were graphed in Excel using a Radar 4-dimensional presentation of the four scores using one axis for the Application vector; one axis for the Technology vector; one axis for the Integration vector and finally one axis for the Overall HITCAP score. The Figure which follows contains the Irish study scores (high, low and sample average scores) alongside the Canadian scores for comparison. Hospitals participating in the Irish study will receive this diagram with the scores for their individual hospital incorporated on request.

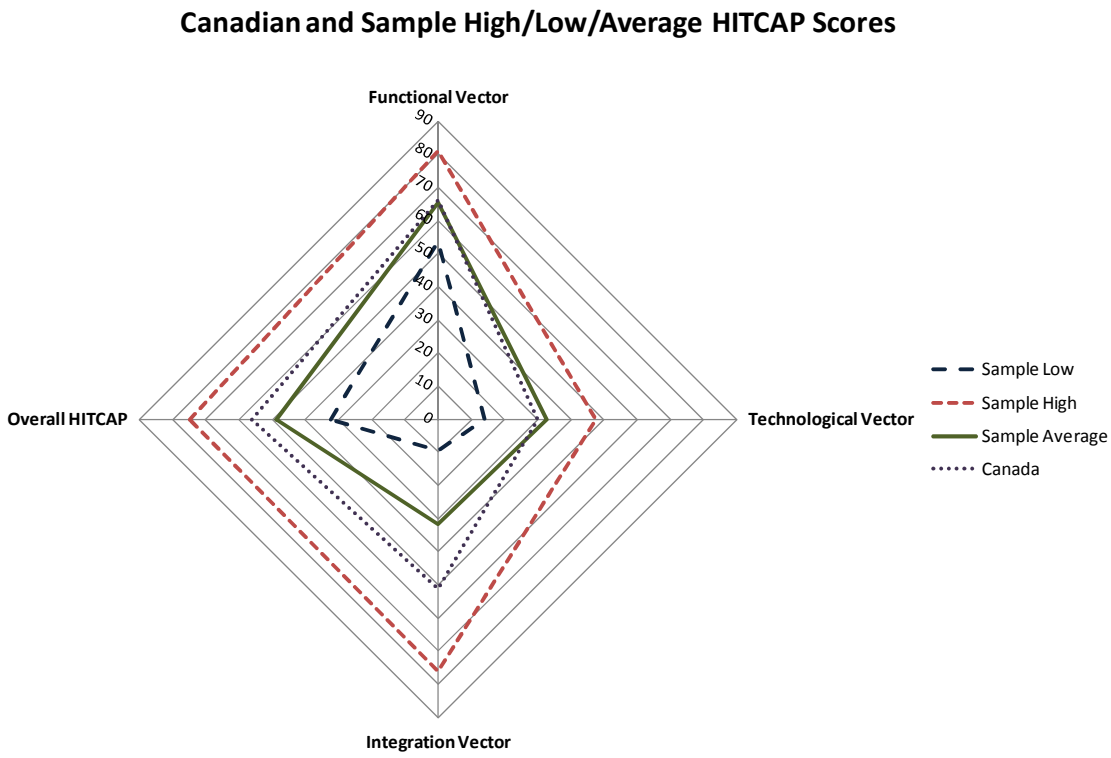


Figure 31 - Irish Sample HIT Capability Radar Plot

7.2 Comparative Analysis - Innovativeness factors

In a survey of Chief Information Officers in two Canadian provinces (Paré et al., 2010), the authors set out to identify the level of innovativeness in Canadian hospitals (n=106) and to test its association with the structural profiles of the hospitals and the I.T. Managers themselves. HIT capability is defined as the level to which Administrative and Clinical systems are deployed, used and integrated in hospitals and the question asked is: "what organisational factors are most likely to affect HIT capability in public hospitals"? Nine different hypotheses are tested as outlined in the table which follows for the Canadian study:

	Hypothesis	**Proven/Not proven**
H1	Larger hospitals will have higher HIT capability	Proven to be significant for the overall score but not significant on the integration vector
H2	University hospitals will have higher HIT capability	Not supported significantly against the overall score. Was supported in terms of the Technology vector
H3	*Hospitals with larger Operating budgets will have higher HIT capability*	*Supported significantly*
H4	Hospitals with larger I.T. budgets will have higher HIT capability	Supported significantly
H5	Hospitals with an I.T. steering committee will have higher HIT capability	Proven for the Functional and Integration vectors Not proven on the Technology vector
H6	Length of time I.T. Manager working in I.T. will have a positive association with higher HIT capability	Proven
H7	*Being a member of a multi-hospital network will have a positive association on HIT capability*	*Not proven*
H8	Urban hospitals will have a positive association on HIT capability	Proven overall and for Functional innovativeness but not on the Technology or Integration vectors
H9	A greater number of I.T. resources will have a positive effect on HIT capability	Proven

Figure 32 - HIT Innovativeness Antecedent Hypotheses (Paré et al, 2010)

This paper conducted a similar analysis on a sample of Irish acute care hospitals (n=20) and apart from H3 (see below for explanation) and H7 (which was not proven in the Canadian study and on this basis was excluded from the Irish study) set out to test the same hypotheses using a combination of the Student t-Test and the Chi-square test working examples of which can be found in Appendix 13. The results are presented in the table which follows.

Structural Capacity Comparison:

The Canadian study identifies hospital size as one of the strongest predictors of HIT capability, particularly on the functional and overall vectors, however, found no significant correlation (NS) on the integration vector and only moderate correlation (**) on the technology vector. Innovative hospitals in Canada will have more than twice the number of beds compared with less innovative hospitals. In the Irish study strong correlation (***) was found on all vectors and the more innovative hospitals will have more than 3 times the number of beds on average on all vectors except for the integration vector where the number falls to just over twice as much on average. The Canadian study found no significant correlation between innovativeness and the hospital being a university (or affiliate) teaching hospital except for on the functional vector where the correlation was minor (*). The Irish study found no significant correlation on any vector for this parameter.

Financial Capacity Comparison:

The Canadian study showed financial capacity as a strong antecedent for overall HIT capability. The correlation was moderate to strong (** - ***) on all vector fronts in terms of overall hospital operating budget but ranged from not significant to minor, moderate and strong in terms of percentage budget allocated to IT. The Irish study suffered somewhat from the unavailability of hospital operating budget figures and had to depend on an indication of percentage allocation to I.T. as a source of financial capacity. This limited the correlation of figures in this area and no significant correlation was evident on any of the vectors measured. The data available in this area should be targeted for improvement in any future attempts to re-run the study in Ireland.

Independent Variable		Functional vector				Technological vector				Integration vector				Overall HITCAP			
		Low	*High*	*IRL*	*CAN*	*Low*	*High*	*IRL*	*CAN*	*Low*	*High*	*IRL*	*CAN*	*Low*	*High*	*IRL*	*CAN*
Structural Capacity	Number of Beds	153	537	***	***	153	498	***	**	237	598	***	NS	174	612	***	***
	University Hospital Y/N	67%	83%	NS	NS	67%	67%	NS	*	67%	67%	NS	NS	67%	67%	NS	NS
Financial Capacity	% budget allocated to IT > 1%	2.0%	2.0%	NS	*	2.0%	2.0%	NS	**	2.0%	2.0%	NS	*	1.8%	1.7%	NS	***
Leadership Capacity	IT tenure years	21.5	18	***	*	20	14.25	*	NS	22.25	17.25	*	NS	23.75	22	***	*
	Hospital tenure years	11	12.75	***		10.75	12.75	***		11.75	13.5	**		10.75	15	***	
	Position tenure years	11	8.5	***		10.25	8.5	***		11.75	8.75	**		9	10.75	***	
	IT Steering Committee Y/N	50%	67%	NS	*	50%	67%	NS	*	33%	67%	NS	NS	67%	67%	NS	*
Knowledge Sharing	Urban Hospitals Y/N	67%	67%	NS	**	84%	67%	NS	NS	66%	33%	NS	NS	67%	33%	NS	*
	Permanent IT resources	2.6	16.1	***	***	2.6	13.8	***	***	5.6	15.5	***	***	3.8	15.3	***	***

Figure 33 - Antecedents of HIT Innovativeness (Irish Sample n=11)

Key:

		p value
Not significant	NS	equal or > .05
Low significance	*	<.05
Moderate significance	**	<.005
High significance	***	<.001

Leadership Capacity Comparison:

The Canadian study showed that I.T. Managers in hospitals with high HITCAP scores have on average from .6 to 5.6 (depending on the vector) more experience in terms of years in I.T. than those managers in hospitals with lower HITCAP scores. No significant correlation to I.T. tenure years was demonstrated in the Canadian study on either of the technology or integration vectors and only minor correlation on the functional and overall vectors. This correlation profile is not upheld in the Irish study where there is significant correlation on the functional vector and overall and minor correlation on the technological and integration vectors. The variance in terms of years ranges from 1.75 years to 5.75 years (depending on the vector) in this category in the Irish study – interestingly showing the IT Manager tenure in years to be lower in those hospitals with higher HITCAP scores.

Unlike the Canadian study, the Irish study conducted comparisons between levels of innovativeness and year's tenure in the hospital and the job currently held. The same correlation as for years I.T. tenure was demonstrated in the Functional and overall categories while there was an increase in significance from low to high in the technological vector and an increase from low to moderate in the integration vector. It should be pointed out that the sample size for this correlation exercise dropped from n=20 to n=11 in the Irish study due to the fact that many HSE acute hospitals do not have an I.T. manager as such and are managed at a regional level by a regional I.T. director. Input on behalf of these regional directors was not forthcoming in the Irish study and is an area for attention in any future studies. The Irish study identified no significant correlation to levels of innovativeness when it comes to the presence of an I.T. Steering committee in the hospital. The Canadian study found minor correlation only in the functional, technology and overall vectors.

Knowledge Sharing:

The average number of staff in highly innovative hospitals in the Canadian study range from 19 to 30 more on average (depending on the vector) compared to staffing levels in less innovative hospitals. As in the Canadian study, strong correlation exists in this category in the Irish study where the average in terms of additional staff ranges from 9.9 to 13.5 (depending on the

vector). There was no correlation evident for those hospitals in the urban category, unlike the Canadian study where moderate correlation was demonstrated in the functional category and only minor correlation overall.

7.3 Comparative Analysis – EMR Adoption Model

EMRAM, the European EMR Adoption Model (HiMSSANALYTICS, 2011), which is based on the U.S. equivalent, has been re-expressed to take account of input from HIT experts in Europe. As the model incorporates its own scoring algorithms which allow for different combinations of applications especially in the area of Clinical Data Repositories, Controlled Medical Vocabularies and different levels of Clinical Decision Support, it is beyond the scope of this paper to attempt a definitive scoring for the Irish hospital sample against this model. The latest version of the model, modified to accommodate the European changes, is included for reference below. Using an heuristic evaluation of how the Irish survey sample matches up against this model, and allowing for mandatory applications only, Level 1 is achieved by 45% (n=9) of the hospitals surveyed. All hospitals surveyed have a Laboratory system (usage rating of 5) and 95% have a Radiology System with a usage rating average of 4.75. 45% of hospitals have a full Pharmacy System and the usage rating average is 2. Of that 45% (assuming cumulative capability is required to progress to the next level):

- Only one hospital has a Clinical Data Warehouse installed while only 22% (n=2) have plans to implement one
- None have an EMR implemented while 33% (n=3) have plans to and 44% have started. 23% have no plans to implement an EMR.
- 33% are using a controlled medical vocabulary i.e. SNOMED
- 22% have Clinical Decision Support capabilities
- 33% have Clinical Document Imaging

On this basis, only one of the hospitals included in the Irish survey with this research would win accreditation to Level 2 of the European EMRAM. Many of the hospitals within the sample however, would be credited with the credentials outlined for other higher levels within the framework (but not necessarily having the cumulative capabilities of lower levels) as follows:

- 40% of all hospitals surveyed use CPOE for Laboratory (usage rating average of 2.45) and 50% have plans to implement this facility
- 45% of all hospitals surveyed use CPOE for Radiology (usage rating average of 2.75) and 35% have plans to implement this facility
- Only 20% use Nursing Documentation Systems and 25% use Clinical Documentation systems with usage ratings of 1.1 and 1.42 respectively.
- All hospitals have access to Knowledge Bases with a usage rating average of 4.75 while 55% use Telemedicine facilities with a usage rating average of 2.3.
- 45% of hospitals have Clinical Decision Support capabilities with a usage rating average of 2.11
- 60% of hospitals surveyed have PACS with a usage rating of 3.42.
- 35% of hospitals have Clinical Document scanning facilities and Bar-coding for medications with usage ratings of 1.74 and 1.78 respectively and 55% of hospitals have Patient bar-coding facilities with a usage rating average of 2.89.

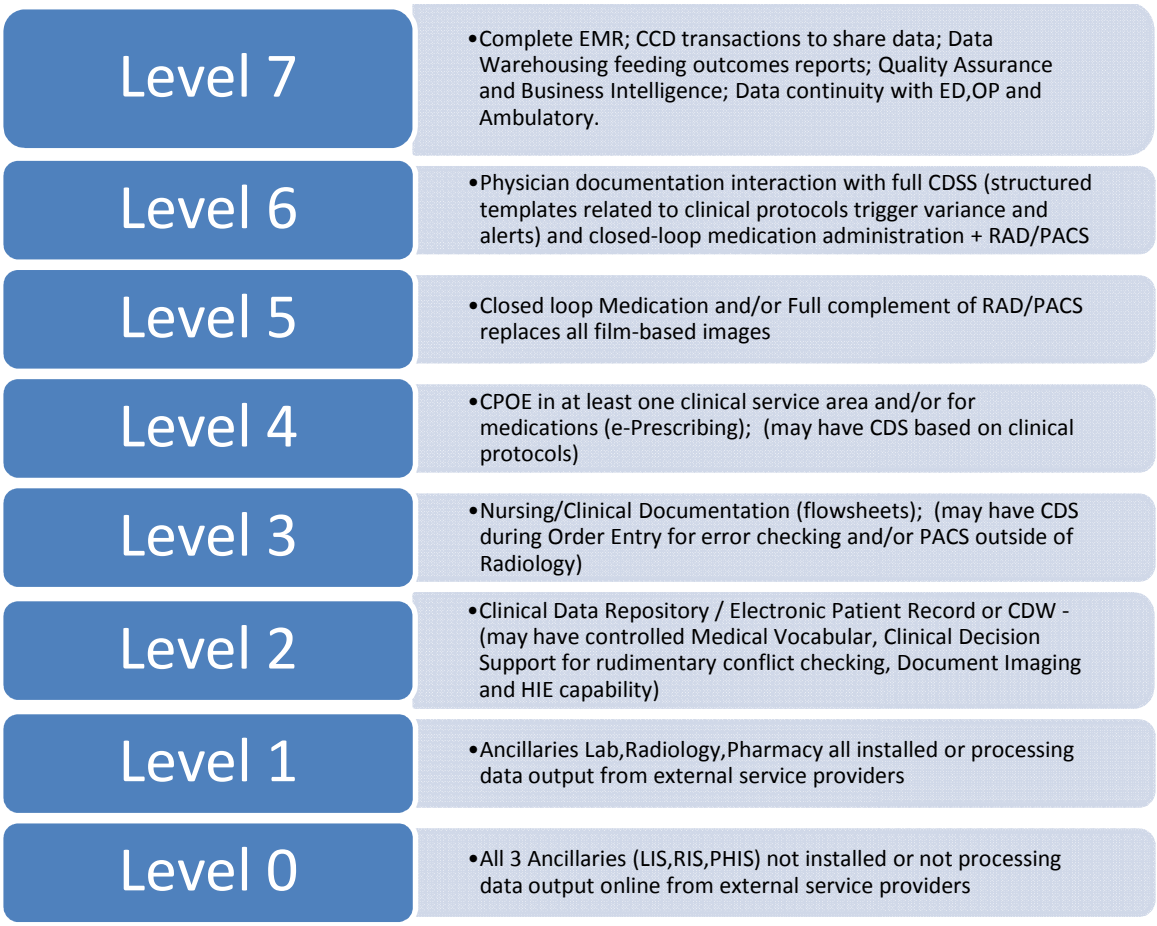


Figure 34 - European EMR Adoption Model (HiMSSANALYTICS, 2011)

7.4 Comparative Analysis - Meaningful Use

In order for professionals and hospitals in the U.S. to be eligible to receive payments under the Recovery Act incentive programs, they must be able to demonstrate 'meaningful use' of EHR systems which have been certified (Blumenthal and Tavenner, 2010). A definition of "meaningful use" of EHR technology was issued by the Medicare and Medicaid organisations (Beaudoin, 2009). The survey instrument accompanying the research with this paper has been adapted to reflect the metrics of the recent U.S. "Meaningful Use Regulations" and participants in this survey were asked to indicate how far systems/technologies have been implemented to reflect these metrics. Two rules (11, 23), were omitted on the grounds that they don't easily apply to the Irish situation. The remaining twenty one rules are mapped to their survey equivalent questions in Appendix 11.

The responses to the corresponding survey questions were examined and a response profile was developed for each participant in the survey. Each hospital was assessed and marked out of a possible twenty one points and then given an equivalent percentage score. The highest scoring hospital achieved a score of 76% and the lowest ranking score was 24%. The average score for the group (n=20) was 54%.

	Q'aire	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20
MU5	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MU6	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MU8	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MU13	b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU19	a	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MU4	SQ4-1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
MU2	SQ4-1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
MU1	SQ3-1,2,3	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0
MU7	SQ3-9	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
MU12	SQ3-12*	0	1	0	1	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1
MU15	SQ3-5*	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MU16	SQ3-5*	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MU18	SQ3-9 or 10	1	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
MU10	SQ14-1*	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1
MU9	SQ9-1*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU14	SQ10-8	0	0	0	1	1	0	1	0	1	0	0	0	0	1	0	1	1	1	1	1
MU17	SQ10-3	0	1	0	1	1	1	0	0	1	0	0	0	1	1	0	1	1	1	1	1
MU20	SQ10-10	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1
MU21	SQ10-9	1	1	0	1	1	1	0	1	1	0	0	0	1	1	1	1	1	1	1	1
MU22	SQ10-10*	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1
MU3	SQ14-1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1
		16	15	11	14	13	11	8	11	16	5	11	8	10	14	12	12	12	12	12	12
		76.19%	71.42%	42.86%	66.66%	61.90%	57.14%	38.09%	52.38%	76.19%	23.80%	52.38%	38.09%	47.61%	66.66%	57.14%	57.14%	57.14%	57.14%	57.14%	57.14%

Figure 35 - Meaningful Use Comparison (Irish Sample n=20)

7.5 Comparative Analysis – Nolan's stages of growth

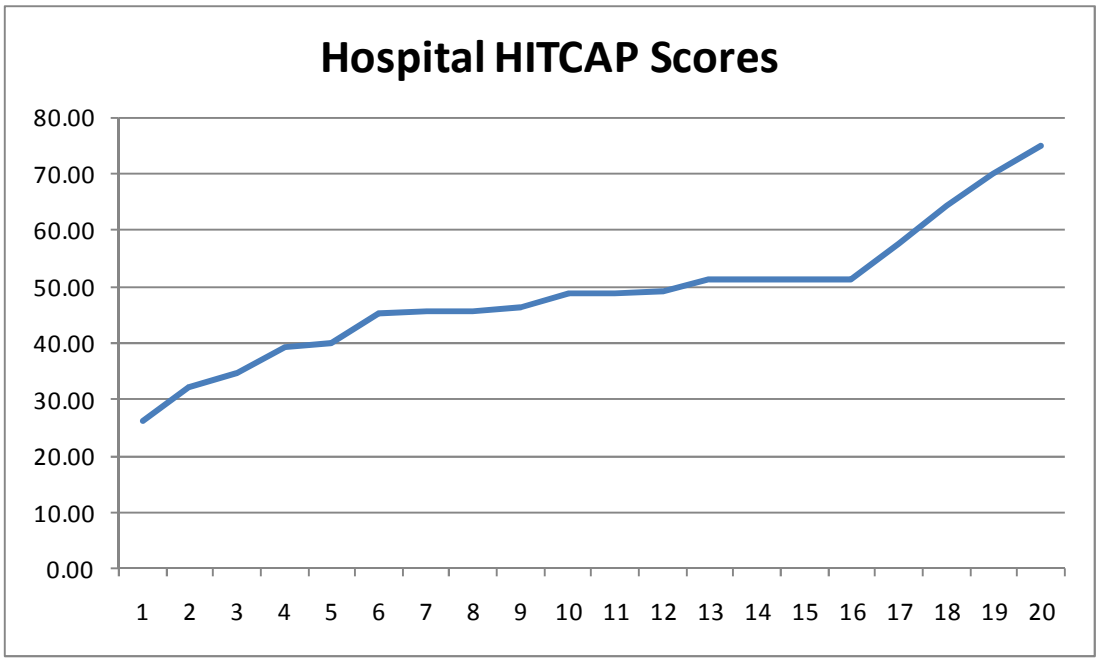


Figure 36 - Hospital HITCAP Ranked Scores (Irish Sample n=20)

When the sample hospital HITCAP scores are ranked and graphed, the resulting curve emulates the Nolan 'S' curve discussed earlier. Although there is no obvious clustering of data to clearly indicate the growth staging process, further analysis should indicate that hospitals (1-6) in the early stages of maturity are representative of those still coming to terms with the management of legacy systems, perhaps systems that are earmarked for replacement and as such no appreciative development or diffusion of the system is possible. The second phase of maturity would be characterised by hospitals 7-15 who have secured the implementation of foundation systems and progressed into more advanced developments catered for by a good foundation and enabled diffusion of those systems beyond pilot areas in the organisations. The last phase of maturity is identified in hospitals 16-20 who have successfully scaled the maturity barriers of stages 1 and 2 of growth and managed to exploit the benefits of internal and external integration to a certain extent. This analysis would be consistent with the Nolan definition of maturity in stage 3.

It is evident that generally HIT in Ireland is stuck rigidly in the Control phase as outlined in the Nolan 6 stage growth model in Figure 6, (also described as the 'Centralised Dictatorship' stage). As Figure 37 which follows depicts, we

have chased through the Initiation stage in the 1980's into the Contagion stage up to the 2000's and now with a proliferation of systems, some of which deliver to expectations, some which do not or have failed, further efforts are now controlled centrally in an attempt to exercise some level of strategic management. The national maturity of HIT clearly awaits the introduction of Data Administration, Integration and internationally recognised standards to lift it from Control into the latter stages of maturity. For now, the perceived failure of the national PPARS system in 2000, the resulting publication of the Value For Money Report in 2001 and the introduction of a national Shared Services Function in 2004 has placed the future development of HIT clearly in the control of centralised functions aimed at nationally procured systems, from a national priority projects list, from a budget under the control of the Department of Finance and overseen by the Health Information and Quality Authority.

Stages of Growth	Information Technology initiatives in the Irish Health Service 1980-2010
Initiation: Introduction of I.T. systems	Single systems approach for PAS with McAuto and Gerber Alley; Financial Accounting and Management Budgeting: Patient costing analysis via Manpower analysis and cost of consumables.
Contagion: Witnessed by a rapid proliferation of systems, increase in technology and supporting infrastructure; technological progress, opportunity, political decisions and increased consumer demand.	Other foundation systems suppliers emerge: SMS; CHL; hospitals no longer tied to the national solution to guarantee DOH funding; Focus on Departmental systems for Radiology, ED and Laboratory; HISS, is undertaken by most hospitals, with patient, clinician and management requirements built into the equation often with mixed success. HIPE - ICD and DRG coding forming the basis for Casemix analysis and budget allocation DOH Management Activity and KPI Reporting
Control: Spending on I.T. escalates and Return on Investment is negligible. There may be 1 or 2 disasters, control is taken back, budgets are cut and it is made more difficult to purchase and develop systems and ICT is put under the control of the Finance Director. Business cases and financial justification is demanded for all investment and value for money initiatives are drawn up with centralised purchasing to lever from bulk buying and CRM agreements.	The perceived failure of the national PPARS system (1998-2005) The publication of the VFM Report 2001 The introduction of a Health Shared Services Function 2004 The introduction of a national priority projects list by the HSE The management of I.T. budget allocation directly by the Dept of Finance The introduction of nationally procured systems (PPARS; PACS; iSOFT; LIMS) The implementation of a national standards and quality authority – HIQA 2007 Waiting List Management portal - HealthStat dashboards (2009)
Interfacing	Many hospitals implement point-to-point interfaces in efforts to achieve a level of integration between disparate systems but often without the use of a common set of standards.
Integration: The organisation addresses its difficulties becoming more comfortable with IT. Systems are organisation-wide, seamlessly integrated and there is sharing of common data bases and minimal duplication of data.	Best of breed systems emerge taking the place of single supplier offerings based on Integration Engine approach Enterprise Systems approach initiated coupled with the use of industry standards GP hospital links via HealthLinks using early industry standards such as HL7 V2.x
Maturity (Not yet achieved)	Integrated Electronic Patient Record /Electronic Health Record across Primary and Acute Care

Figure 37 - Heuristic - Irish HIT Stages of Growth 1980-2010

7.6 Study Limitations

Further attempts to launch the instrument used in this study in Ireland would benefit from health service support to ensure completion by a greater number of hospitals. The study was limited by the unavailability of HSE hospital resources to complete the survey (64% response from non-HSE hospitals; 16% response from HSE hospitals) due to work commitments. When reviewing the content of the survey attached to this work with the industry experts, concerns were raised regarding whether chosen respondents would complete the questionnaire or not. Reasons given by the experts for not responding included: "suspicion; paranoia; time constraints; lack of interest; danger of looking bad; ability; understanding; availability of right persons". The availability of accurate data such as that on actual Operating Budget allocation per hospital and actual I.T. Budget allocation per hospital would have served to allow a more accurate comparative analysis with the corresponding Canadian study in identifying likely predictors of capability. Data on I.T. Manager Academic and industry qualifications was also limited. The customised measurement instrument was constrained to the extent that it was necessary to maintain consistency with the original survey in order to provide meaningful comparative analysis. Future work in this area would include additional elements and apply additional weightings to them to create an even more comprehensive HITCAP score for Ireland.

8 Conclusions

This research supports the hypothesis that HIT capability in the Irish acute sector is varied and that there is still much to do in terms of maturing this capability. This proves especially true on the Clinical Applications and Technological fronts and in terms of achieving more internal and external integration. (Simon et al., 2009) points to the general increase in the adoption of HIT systems. Apart from functions with e-prescribing capabilities, however, the types of functions used by practitioners which have been available for some time, have not changed appreciably. This dissertation has already alluded to the scarce use of systems with decision support capabilities (rating average of just 2.11) and the possibility that efforts to undertake workflow design might encourage more use of clinical applications. Accreditation (e.g. CCHIT) of systems to ensure minimum functional requirements are met may ensure the availability of more CDS-type functionality and the meaningful use initiatives providing financial incentives for systems use is a significant development in the U.S. While there is evidence in the results of our survey that some hospitals have plans to continue extending the use of HIT, our research has paradoxically identified constraints in terms of funding for this effort and a national approach to systems implementation and funding endangers individual hospital initiatives. Notwithstanding the financial constraints, this work points to efforts which will serve to prepare our hospitals in terms of HIT adoption in the interim. A programme of assessment using best practice techniques will help establish where we are in all aspects of I.T. capability. Whether funding is available or not, this approach is important in order to prioritise what is to be done and to identify a good starting point for future efforts. The use of appropriate assessment tools in this regard is highly recommended and this paper has shown that Maturity Models do exist for many of the different domains of HIT.

This research demonstrated that 79% of those who responded to the question said they were not planning to implement a programme of maturity assessment and only 14% were already undertaking such a programme. In a telephone interview with the I.T. Director of one of the major Voluntary acute hospitals in the survey sample, this author learned that the assessment model fast becoming the one of choice was the IT-CMF (Capability Maturity

Framework). Unlike the language used in CobiT (Control Objectives for Information and related Technology) and ITIL (Information Technology Infrastructure Library), that used in the IT-CMF was seen as less technical and more easily understood by senior management. The model was being implemented with a view to bringing I.T. strategy more in line with the business strategy of the hospital by introducing quality of care metrics and KPI's which reflected national health directives. This author also learned that there were plans to engage other interested Irish acute hospitals in the experiences of the major acute hospital in question. Those who have implemented maturity models in different industries have identified the importance of lessons learned and the opportunity for late comers to avoid the mishaps of those who have gone before them. It is important therefore that those hospitals who have already embarked on programmes of self assessment share their experiences with others who have not yet done so. When the Jaana study was run in the U.S. the results identified hospitals that were part of a network as a positive predictor for high HIT capability. The same correlation was not evident in the Canadian study and the authors explained this by highlighting the different funding models for health in the two countries. In the US, where resources were shared from a central pool for networked hospitals, it was customary to seek assistance from sister organisations in many areas of HIT. In Canada on the other hand, this was less likely to happen where funding for an individual hospital was the defining factor in whether HIT initiatives were undertaken or not. Although it is set to change with the mooted Trust-like re-organisation of hospitals, the current funding model for health (and health IT) in Ireland compares more with the Canadian than the US model.

The Irish Health ICT Strategy expected in 2008 was never published. An updated strategy report is now due but the importance of a properly resourced implementation plan both in terms of the finance required to bring it to fruition and the properly trained human resource required to deliver it, cannot be over emphasised. Having identified the positive predictors of high HIT capability, it is important to protect them so that they do not become barriers to future progress.

8.1 Objectives Revisited

In terms of identifying best practice and maturity assessment mechanisms the literature review accompanying this work has identified extensive evidence of suitable management tools to undertake this task ranging from those for best practice in Project Management to those already proven in the interoperability and HIT management domains. An appropriate survey instrument has been identified in that proposed and developed by Jaana and it has been possible to customise the instrument and apply it in an Irish setting while maintaining its validity and integrity. The instrument has been utilised in developing a HIT capability scoring mechanism for the acute hospital sector and it has been possible to characterise the extent of HIT capability both in terms of individual participating hospitals and on a national basis using an heuristic approach. The boundaries of the existing survey instrument were extended in this study with; the inclusion of a section on management models; the inclusion of a section on the use of standards and the inclusion of a section on interoperability capabilities. The scores calculated have been compared with equivalent scores calculated in a parallel Canadian study and predictive variables previously determined as supporting these scores have been analysed and in several cases supported. The scores show low levels of HIT maturity on average. These measures have been triangulated first with an heuristic assessment of the growth of Irish HIT on a national level in accordance with the Nolan stages of growth model and secondly with an assessment of the development of the Irish Electronic Medical Record using the European Medical Record Assessment Model. The research responses have also been used to map the level of adoption of HIT identified in the survey to those identified in the U.S. which would qualify for incentivised funding under the 'Meaningful Use' initiative. In addition, the research has examined the use of standards and terminologies in the Irish HIT sector to determine the basis on which future interoperability of systems may be achieved. In particular the research has identified a number of management and maturity models which provide the platform on which continuous assessment of management capability may be performed and has analysed the existing and planned adoption of these models in the Irish acute hospital sector. It has also been possible throughout this process to identify shortcomings in the current approach and to suggest areas for further improvement.

8.2 Contribution made by this work

This work has extended the generalisation of the original HIT capability measuring tool outside of Canada and provides strong support for the research model. The hypotheses of the original study were upheld in many respects by the results of the Irish study proving the reliability and validity of the survey instrument and the accuracy of the predictors of innovativeness. The deployment of the measurement instrument also provided an opportunity to extend the instrument in the integration vector and to fill some of the gaps that existed in the instrument identified by the authors.

In the Irish context, the study establishes a context for the understanding that HIT capabilities in the acute sector were mixed and allows for the characterisation of HIT capability in real terms. The assessment tool provides a mechanism by which hospitals may compare themselves with like institutions in Ireland and it also provides a sound comparative analysis tool to the outside world.

8.3 The focus of further work

- The new instrument did elicit additional information, which although it was relevant to establishing a catalogue of systems for the acute care sector in Ireland, these were not material to the calculation of the current HITCAP score. Future work in this area would include the additional elements and apply additional weightings to them to create an even more comprehensive HITCAP score for Ireland.

- The latest approaches to CMM frameworks establish a best-practice roadmap in many different areas of I.T. Further developments may establish additional online assessment instruments which would focus on these aspects of HIT capability; provide an offline comparative analysis with the results of other institutions with similar characteristics and provide a regional/national I.T. Capability profiling service.

Facilities using such frameworks could be provided so that organisations may continue to assess themselves independently, to establish a starting point for

further efforts, to determine which aspects of I.T. require attention first and to provide a means of continuous assessment. Continuous assessment is important as an organisation makes changes, as new aspects and standards are introduced into the measurement process/tool and as a means of determining that the organisation has not taken a step backwards from previously attained maturity levels for any reason.

8.4 Instrument extension

The instruments could be deployed in the private hospitals sector to provide additional comparative material. In addition, the instruments should be extended to incorporate specific measures for:

- Systems features assessment a lá the meaningful use definitions or the HL7 functional model definitions
- Systems quality assessment incorporating data quality; usability and reliability
- Systems success evaluation as outlined in (DELONE and MCLEAN, 2003) using measures of systems quality (technical success); informational quality (semantic success) and organisational impacts (effectiveness success)
- Organisational integration factors such as factors affecting healthcare technology and IS function cooperation outlined in (Wu et al., 2009)
- Adoption and diffusion as outlined in the McFarlan / McKenney diffusion model in (Raho et al., 1987). The model presents a procedural process set out in four distinct phases in understanding and managing the diffusion process and bridging the gap between the individual learning process and organisational change.
- Corporate planning, Enterprise Architecture and business process modelling

There would be a requirement to re-validate the instrument if additional dimensions and measures are to be included.

In addition to having the instrument issued by way of an online questionnaire, the author has developed a software prototype of the instrument in Visual

Basic 10 which will calculate the HITCAP score as the user proceeds through the instrument questions (See Appendix 12 for details). The software version could be launched as a web page where individual hospitals could conduct an online assessment independently. The web page could be extended as an open national service allowing for the assessment of capability in the many different areas of HIT, identifying areas needing attention and providing gap analysis and comparative analysis feedback. The assessment could also advise on recommended standards thus providing an impetus for those unsure as to how to proceed in this area. Run nationally, the assessment tool would serve to provide a HIT capability profile of our hospital service and more importantly provide to identify areas for attention in individual hospitals. The tool can also be seen as the beginning of a national register / catalogue of systems and a list of the standards in use. Such facilities should be offered as open-source offering a self-assessment technique in the first instance. A national service of assessment leading to accreditation could follow.

> *"We find no sense in talking about something unless we specify how we measure it; a definition by the method of measuring a quantity is the one sure way of avoiding talking nonsense..."*
>
> *— Sir Hermann Bondi in Relativity and Common Sense (1964)*

9 Appendices

9.1 Appendix 1 – Stages of Growth Model

ELEMENT	1 Ad hocracy	2 Foundations	3 Centralised	4 Cooperation	5 Entrepreneurial	6 Harmonious
Strategy	Acquisition of hardware, software etc	IT audit; find out and meet user needs (reactive)	Top-down IS planning	Integration coordination and control	Environmental scanning and opportunity seeking	Maintain comparative strategic advantage; monitor futures; interactive planning
Structure	None	IS often subordinate to accounting or finance	DP department; centralised DP shop; end-users running free at Stage 1	Information centres; library records etc. in same unit; Information services	SBU coalition(s) – many but separate	Centrally coordinated; coalitions (corporate and SBU views concurrently)
Systems	Ad hoc; unconnected ; operational; manual and computerise d IS; uncoordinate d; concentratio n in financial systems; little maintenance	Many applications; many gaps; overlapping systems; centralised; Operational; mainly financial systems; many areas unsatisfied; large backlog; heavy maintenance overload	Still mostly centralised; uncontrolled end-user computing; most major business activities covered; database systems	Decentralised approach with some controls; mostly lack of coordination; some DSS – ad hoc; integrated office technology systems	Decentralised systems with central control and coordination; added value systems; more DDS-internal, less ad hoc; some strategic systems (using external data); lack of internal and external data integration of communications technologies with computing	Inter-organisational systems (supplier, customer, government links); new IS based products; External-internal data integration
Staff	Programmer s / contractors	Systems Analysts / DP Managers	IS planners; Is Manager; DB Administrator; Data Administrator; Data Analysts	Business Analysts; Information Resource Manager (CIO)	Corporate/busines s/IS planners (one role)	IS Director/mem ber of board of directors
Style	Unaware	Don't bother me (I'm too busy)	Abrogation/dele gation	Democratic dialectic	Individualistic (product champions)	Business team
Skills	Technical (very low level); individual expertise	Systems development methodology	IS believes it knows what the business needs Project Management	Organisationa l integration; IS knows how the business works; Users know how IS works (in their area); business management (for IS staff)	IS Mgr (member of snr executive team); knowledgeable users in some IS areas; entrepreneurial marketing skills	All senior management understand IS and its potential
Superordina te goals	Obfuscation	Confusion	Snr management concerned; DP defensive	Cooperation	Opportunistic Entrepreneurial Intrapreneurial	Interactive Planning

Stages of Growth Model (Sutherland & Galliers, 1989, p32, reproduced in Galliers, 1991, pp 61-62)

9.2 Appendix 2 – UK National IT&M ambition levels v feasibility and progress

Stages of Growth	**Information Management and Technology initiatives in the NHS 1990-2000**
Initiation: Introduction of I.T. systems	FIP (Financial Information Project), Management Budgeting: Patient costing analysis via Manpower analysis and cost of consumables and equipment.
Contagion: Witnessed by a rapid proliferation of systems, increase in technology and supporting infrastructure; technological progress, opportunity, political decisions and increased consumer demand.	Koerner, Resource Management Initiative, HI Support Systems pilots. Focus on Departmental systems and a common Patient Identifier to track the cost of the patient across the departments. Specialty costing was introduced but failed as clinicians got nothing back by way of information which would help them in the care delivery process. Individual hospitals and departments are now encouraged to implement departmental systems across the hospital in efforts to secure the information required. HISS is seen as ambitious with only 3 pilots implemented in the UK, with patient, clinician and management requirements built into the equation.
Control: Spending on I.T. escalates and Return on Investment is negligible. There may be 1 or 2 disasters, control is taken back, budgets are cut and it is made more difficult to purchase and develop systems and ICT is put under the control of the Finance Director. Business cases and financial justification is demanded for all investment and value for money initiatives are drawn up with centralised purchasing to lever from bulk buying and CRM agreements.	NAO 1996 HISS report, introduction of POISE (Procurement of Information Systems Effectively) and PRINCE (Projects in Controlled Environments) and NHS wide clearing system
Integration: The organisation addresses its difficulties becoming more comfortable with IT. Systems are organisation-wide, seamlessly integrated and there is sharing of common data bases and minimal duplication of data.	GP hospital links, NHSnet, hospital Order Communications.
Data Administration	EPR level 4+
Maturity (Not yet achieved)	Integrated Electronic Patient Record /Electronic Health Record across Primary and Acute Care

UK National IT&M ambition levels v feasibility and progress (Wainright and Waring,2000)

9.3 Appendix 3 – PACS Maturity Model

Optimised PACS	System integration; web based technology; image distribution via web based ePR , Optimisation of the patient care process.	➢ Continuous clinical PACS integration ➢ PACS process innovation	➢ Full enterprise PACS chain integration	➢ Full integration with patient centred ePR
Integrated managed innovation	Initial integration of PACS into the ePR and cross-enterprise exchange of digital images and documentation; Computer Aided Radiology; Computer Aided Diagnosis; Clinical Decision Support Systems; intelligent data mining;	➢ Quantitative statistical control mechanism ➢ Clinical diagnosis and decision support	➢ Technological adoption; CAD; Image Assisted Surgery System, Full Field Digital Mammography, bone age assessment	➢ Cross enterprise PACS exchange ➢ Initiation of PACS integration with ePR ➢ Intelligent data mining ➢ Clinical collaboration
Clinical process capability	Handles workflow and patient management, hospital wide PACS distribution, often outside the hospital	➢ Hospital wide PACS (web) distribution and communication ➢ Control/Status management ➢ consultation and e-learning	➢ Patient folder management ➢ Image based clinical action	➢ PACS/HIS/RIS integration ➢ Workflow and patient (folder) management ➢ Teleconferencing
PACS process	Effective process redesign, 2nd generation PACS, focus on medical images but no patient workflow management. Integration of HIS and RIS with the various PACS modalities	➢ PACS process redesign ➢ Quality and transparency	➢ Optimising manual PACS process ➢ Initiation of system integration	➢ Qualitative measurements
PACS Infrastructure	Unstructured implementation and usage; technical and organisational problems arise such as with interfacing because of the lack of standards	➢ Image acquisition Storage	➢ Basic image distribution	➢ Basic Display process

PACS Maturity Model - Re-created from van de Wettering and Batenberg, 2009

9.4 Appendix 4 – ITPM Maturity Model

	Defined	Managed	Synchronised
Advanced Valuation			Monitoring of projects earned value in deployment and choosing based on option value – future opportunities
Feedback Mechanism			Score card evaluation of projects giving feedback of I.T. alignment
Benefits Measurement			Measurement of I.T. value
Active Portfolio Management			Weighting of portfolio in terms of Risk and Return
Strategic Alignment		Annual business and I.T. meetings to align I.T. with business strategy	More regular business and I.T. meetings to align I.T. with business strategy
Financial Metrics		Use of Financial metrics to prioritise: NPV; ROI; IRR	
Demand Management		Well defined scheme for prioritising projects and ranking projects for investment	
Centralisation			Use of portfolio software
Standardisation	Applications and infrastructure well defined and documented	IT portfolio segmented by asset class	

ITPM Maturity Model (Jeffery and Leliveld, 2004)

9.5 Appendix 5 - Expert input to Questionnaire Design

1. Are the sections included adequate in representing an accurate measure of I.T. Capability in Irish Hospitals? i.e. are there any excluded which should be included/excluded? (e.g. Communications Infrastructure; Meaningful Use; HL7 FM; Project Management; Portfolio Management)
2. Are the questions in each section fully representative of the features which ought to be measured?
3. Are the questions easily understood?
4. Is the questionnaire presented in a clear and concise manner?
5. Are there any sensitive questions which it might be better to exclude?
6. Will the questionnaire answer the objectives of the study?
7. Who should be chosen to pre-test the questionnaire
8. Is it reasonable to expect that respondents will take the time to complete the questionnaire
9. Should the author consider an incentive for participants to complete the questionnaire
10. How long should it take to complete it – ideally?
11. Should a time limit be set for its completion
12. When is the best time to issue it – month/day of week
13. Decide on participants
14. Contact details for participants
15. Is there any contemporary Irish or international study I should reference
16. Survey Monkey sample survey availability

9.6 Appendix 6 – Voluntary Acute Hospitals

	Voluntary Acute Hospitals
1	Adelaide and Meath Hospital
2	Beaumont Hospital
3	Cappagh National Orthopaedic Hospital
4	Coombe Women's Hospital
5	Cork University Hospital
6	Mater Misericordiae University Hospital
7	Mayo General Hospital
8	Mercy University Hospital
9	Merlin Park University Hospital
10	Mid Western Regional Hospital
11	Naas General Hospital
12	National Maternity Hospital
13	Our Lady's Children's Hospital Crumlin
14	Portiuncula Hospital, Ballinasloe
15	Roscommon County Hospital
16	Rotunda Hospital
17	Royal Victoria Eye and Ear Hospital
18	South Infirmary - Victoria University Hospital
19	St. James's Hospital
20	St. John's Hospital
21	St. Luke's Hospital
22	St. Michael's Hospital
23	St. Vincent's University Hospital
24	Temple Street Children's University Hospital
25	University Hospital Galway

9.7 Appendix 7 – Public Acute Hospitals

	HSE Public Acute Hospitals
1	Bantry General
2	Cavan General
3	Connolly Hospital
4	Kerry General
5	Letterkenny General
6	Lourdes Orthopaedic Hospital, Kilcreene,
7	Louth County Hospital
8	Mallow General Hospital
9	Mid Western Regional Ennis
10	Mid Western Regional Hospital Nenagh
11	Mid Western Regional Maternity, Limerick
12	Mid Western Regional Orthopaedic Hospital Croome
13	Midland Regional Mullingar
14	Midland Regional Tullamore
15	Monaghan General Hospital
16	Our Lady of Lourdes Hospital, Drogheda
17	Our Lady's Hospital Navan
18	Portlaoise Midland Regional
19	Sligo General
20	South Tipperary General
21	St. Columcilles Hospital Loughlinstown
22	St. Lukes General Hospital Kilkenny
23	Tralee General Hospital
24	Waterford Regional
25	Wexford General Hospital

9.8 Appendix 8 – Survey Data Download Extract

RespondentID	CollectorID	StartDate	EndDate	Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the												
				Master Pa	Patient cha	Waiting Lis	Bed Mana	Admissior	Out-Patien	Emergenc	Patient Bill	Theatre M	Critical Ca	Allied Hea	Allied Hea	Allied Hea
1430899843	18355334	05/23/2011	05/23/2011	5	5	5	5	5	5	5	5	4	4	4	4	4
1427022776	18355334	05/19/2011	05/19/2011	5	5	4	4	4	5	0	5	4	5	4	4	
1377091291	18355334	04/06/2011	04/06/2011	5	1	5	1	5	5	5	5	5	0	1	1	1
1375667887	18425645	04/05/2011	04/05/2011	5	5	5	5	5	5	0	5	5	0	5	0	5
1374128994	18355334	04/04/2011	04/04/2011	5	5	4	5	5	5	5	5	5	0	5	0	5
1374104438	18355334	04/04/2011	04/04/2011	5	5	5	0	5	5	1	5	1	0	4	0	0
1373970655	18425645	04/04/2011	04/04/2011	5	5	5	0	5	5	5	5	0	0	0	0	0
1371016122	18355334	03/31/2011	03/31/2011	5	5	5	0	5	5		5		0	1		
1369432785	18355334	03/30/2011	03/30/2011	5	5	5	0	5	5	5	5	5		1	0	0
1367592171	18355334	03/29/2011	03/29/2011	5	5	5	5	5	5	5	5	5	1	5	5	5
1366487161	18355334	03/28/2011	03/28/2011	5	5	5	5	5	5	4	5	1	5	1	1	1
1366263585	18355334	03/28/2011	03/28/2011	5	5	5	1	5	5	5	5	5	1	4	1	4
1366196628	18355334	03/28/2011	03/28/2011	5	1	0	1	5	5	0	5	1	0	0	0	0
1366090364	18355334	03/28/2011	03/28/2011	5	5	5	5	5	5	5	5	5	4	5	4	4
1366066701	18355334	03/28/2011	03/28/2011	5	5	5	5	5	5	5	5	5	5	5	5	5
1365646045	18355334	03/27/2011	03/27/2011	5	5	5	1	5	5	5	5	1	5	1	1	1
1394984802	18741975	04/21/2011	04/21/2011	5	5	5	5	5	5	4	5	0	0	5	5	0
1394975259	18741975	04/21/2011	04/21/2011	5	5	5	5	5	5	4	5	0	0	5	5	0
1394849385	18741975	04/21/2011	04/21/2011	5	5	5	5	5	5	4	5	0	0	5	5	0
1386763791	18741975	04/14/2011	04/21/2011	5	5	5	5	5	5	4	5	0	0	5	5	0

9.9 Appendix 9 - Customised Survey and Results

I.T. Capability Assessment - HIT CAP_v 1.1

SurveyMonkey

1. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.

	No Plan	Plan	Installed not used	1 Barely used	2	3	4	5	6	7 Extensively used	Rating Average	Response Count
Master Patient Index	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	20.0% (4)	**80.0% (16)**	5.00	20
Patient chart tracking system	0.0% (0)	10.0% (2)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	20.0% (4)	**65.0% (13)**	4.60	20
Waiting List and/or Pre-Admissions	5.0% (1)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	5.0% (1)	0.0% (0)	5.0% (1)	25.0% (5)	**55.0% (11)**	4.65	20
Bed Management	20.0% (4)	20.0% (4)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	5.0% (1)	20.0% (4)	**30.0% (6)**	3.15	20
Admission,Discharge,Transfer (ADT) System	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	0.0% (0)	21.1% (4)	**73.7% (14)**	4.95	19
Out-Patient / Day Case Appointments system	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	20.0% (4)	**75.0% (15)**	5.00	20
Emergency Department System	15.8% (3)	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	21.1% (4)	5.3% (1)	0.0% (0)	0.0% (0)	**52.6% (10)**	3.74	19
Patient Billing	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	25.0% (5)	**70.0% (14)**	5.00	20

Theatre Management System (e.g. materials management, patient workflow, operative reports)	26.3% (5)	21.1% (4)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	5.3% (1)	0.0% (0)	0.0% (0)	**42.1% (8)**	2.74	19
Critical Care System	**57.9% (11)**	10.5% (2)	0.0% (0)	0.0% (0)	0.0% (0)	10.5% (2)	0.0% (0)	5.3% (1)	0.0% (0)	15.8% (3)	1.58	19
Allied Health - Physiotherapy	10.0% (2)	**25.0% (5)**	0.0% (0)	0.0% (0)	5.0% (1)	5.0% (1)	10.0% (2)	20.0% (4)	5.0% (1)	20.0% (4)	3.30	20
Allied Health - Speech and Language	**31.6% (6)**	21.1% (4)	0.0% (0)	0.0% (0)	5.3% (1)	5.3% (1)	5.3% (1)	21.1% (4)	0.0% (0)	10.5% (2)	2.42	19
Allied Health - Occupational Therapy	**44.4% (8)**	16.7% (3)	0.0% (0)	0.0% (0)	0.0% (0)	11.1% (2)	5.6% (1)	0.0% (0)	0.0% (0)	22.2% (4)	1.94	18
Allied Health - Social Work	**40.0% (8)**	25.0% (5)	0.0% (0)	0.0% (0)	5.0% (1)	5.0% (1)	5.0% (1)	5.0% (1)	0.0% (0)	15.0% (3)	1.85	20
Allied Health - Dietetics	**25.0% (5)**	20.0% (4)	0.0% (0)	0.0% (0)	10.0% (2)	5.0% (1)	**25.0% (5)**	0.0% (0)	0.0% (0)	15.0% (3)	2.55	20
										answered question		**20**
										skipped question		**0**

2. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.

	No Plan	Plan	Installed not used	1 Barely used	2	3	4	5	6	7 Extensively used	Rating Average	Response Count
Order Entry with Results Reporting (Laboratory)	15.0% (3)	**45.0% (9)**	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	40.0% (8)	2.45	20
Order Entry with Results Reporting (Radiology)	15.0% (3)	35.0% (7)	5.0% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	0.0% (0)	**40.0% (8)**	2.75	20
Order Entry and Results Reporting (Other Departments)	31.6% (6)	**42.1% (8)**	0.0% (0)	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	21.1% (4)	1.68	19
Telemedicine for E-consultation or E-diagnosis	**40.0% (8)**	5.0% (1)	0.0% (0)	5.0% (1)	10.0% (2)	10.0% (2)	25.0% (5)	0.0% (0)	0.0% (0)	5.0% (1)	2.30	20
Electronic Discharge Summaries	10.5% (2)	**42.1% (8)**	5.3% (1)	0.0% (0)	5.3% (1)	0.0% (0)	5.3% (1)	5.3% (1)	15.8% (3)	10.5% (2)	2.58	19
Electronic Dictation (Not speech/voice recognition)	10.0% (2)	**55.0% (11)**	0.0% (0)	0.0% (0)	0.0% (0)	10.0% (2)	0.0% (0)	15.0% (3)	5.0% (1)	5.0% (1)	2.20	20
On-line consumer health information (e.g. web portal, self-service kiosks)	**47.4% (9)**	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	10.5% (2)	5.3% (1)	0.0% (0)	26.3% (5)	2.26	19
Remote monitoring applications (e.g. home tele-monitoring)	**70.0% (14)**	10.0% (2)	5.0% (1)	0.0% (0)	10.0% (2)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	0.90	20
Nursing documentation (e.g. condition assessment, vital signs,	**60.0% (12)**	20.0% (4)	0.0% (0)	0.0% (0)	10.0% (2)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	10.0% (2)	1.10	20

Clinical Documentation System	**52.6% (10)**	21.1% (4)	0.0% (0)	5.3% (1)	5.3% (1)	0.0% (0)	0.0% (0)	5.3% (1)	0.0% (0)	10.5% (2)	1.42	19
On-line access to knowledge base (e.g. Medline, PubMed)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	5.0% (1)	10.0% (2)	5.0% (1)	10.0% (2)	0.0% (0)	**65.0% (13)**	4.75	20
Clinical decision support systems (e.g. preventive care alerts, reminders, diagnosis support, disease management)	**36.8% (7)**	15.8% (3)	0.0% (0)	21.1% (4)	15.8% (3)	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	2.11	19
E-learning applications for healthcare providers	20.0% (4)	5.0% (1)	0.0% (0)	5.0% (1)	10.0% (2)	15.0% (3)	5.0% (1)	5.0% (1)	**25.0% (5)**	10.0% (2)	3.45	20
Risk Management System (e.g. STARS incident reporting, adverse drug events)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.0% (1)	5.0% (1)	10.0% (2)	0.0% (0)	**80.0% (16)**	4.90	20
										Other (please specify)		1
										answered question		**20**
										skipped question		**0**

3. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.

	No Plan	Plan	Installed not used	1 Barely used	2	3	4	5	6	7 Extensively used	Rating Average	Response Count
Pharmacy Information System (including Medication Administration, interaction checking, drug profile alerts)	**36.8% (7)**	15.8% (3)	0.0% (0)	0.0% (0)	5.3% (1)	5.3% (1)	5.3% (1)	5.3% (1)	0.0% (0)	26.3% (5)	2.37	19
Radiology Information System (including Procedure scheduling or Worklisting, integrated Radiology Reporting)	0.0% (0)	5.0% (1)	0.0% (0)	0.0% (0)	5.0% (1)	0.0% (0)	0.0% (0)	25.0% (5)	0.0% (0)	**65.0% (13)**	4.75	20
PACS	5.3% (1)	31.6% (6)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	**57.9% (11)**	3.42	19
Laboratory Information System (including Analyser interfaces)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	20.0% (4)	**80.0% (16)**	5.00	20
										Other (please specify)		1
										answered question		**20**
										skipped question		**0**

4. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.

	No Plan	Plan	Installed not used	1 Barely used	2	3	4	5	6	7 Extensively used	Rating Average	Response Count
Medical Document scanning technology	**42.1% (8)**	21.1% (4)	0.0% (0)	5.3% (1)	10.5% (2)	15.8% (3)	0.0% (0)	5.3% (1)	0.0% (0)	0.0% (0)	1.74	19
SSO - Single sign-on technology	**63.2% (12)**	31.6% (6)	0.0% (0)	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.53	19
Biometry (e.g., fingerprints)	**73.7% (14)**	5.3% (1)	0.0% (0)	5.3% (1)	5.3% (1)	0.0% (0)	5.3% (1)	5.3% (1)	0.0% (0)	0.0% (0)	0.95	19
Bar coding for medications management	**38.9% (7)**	22.2% (4)	0.0% (0)	0.0% (0)	0.0% (0)	11.1% (2)	27.8% (5)	0.0% (0)	0.0% (0)	0.0% (0)	1.78	18
Bar coding for supplies / materials management	**36.8% (7)**	10.5% (2)	0.0% (0)	5.3% (1)	0.0% (0)	10.5% (2)	0.0% (0)	0.0% (0)	21.1% (4)	15.8% (3)	2.58	19
Bar coding for patient identification	21.1% (4)	21.1% (4)	0.0% (0)	5.3% (1)	0.0% (0)	5.3% (1)	10.5% (2)	5.3% (1)	5.3% (1)	**26.3% (5)**	2.89	19
Administrative data warehouse	**33.3% (6)**	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	11.1% (2)	0.0% (0)	22.2% (4)	5.6% (1)	27.8% (5)	3.22	18
Clinical data warehouse	**44.4% (8)**	16.7% (3)	0.0% (0)	5.6% (1)	0.0% (0)	5.6% (1)	0.0% (0)	22.2% (4)	0.0% (0)	5.6% (1)	2.00	18
										answered question		**19**
										skipped question		**1**

5. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.

	No Plan	Plan	Installed not used	1 Barely used	2	3	4	5	6	7 Extensively used	Rating Average	Response Count
Bedside terminals or PCs	**66.7% (12)**	16.7% (3)	0.0% (0)	0.0% (0)	5.6% (1)	0.0% (0)	5.6% (1)	5.6% (1)	0.0% (0)	0.0% (0)	0.89	18
Portable computing / wireless devices (e.g., PDAs, pen, tablets, Smart phones)	10.5% (2)	**26.3% (5)**	0.0% (0)	10.5% (2)	**26.3% (5)**	10.5% (2)	5.3% (1)	10.5% (2)	0.0% (0)	0.0% (0)	2.89	19
Voice recognition / speech recognition	10.5% (2)	**42.1% (8)**	0.0% (0)	5.3% (1)	5.3% (1)	15.8% (3)	15.8% (3)	5.3% (1)	0.0% (0)	0.0% (0)	2.37	19
Robots for medication preparation and dispensing	**94.7% (18)**	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.05	19
RFID technology	**52.6% (10)**	36.8% (7)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	0.84	19
Touch Screens	**42.1% (8)**	15.8% (3)	0.0% (0)	5.3% (1)	10.5% (2)	5.3% (1)	15.8% (3)	5.3% (1)	0.0% (0)	0.0% (0)	1.89	19
Appointment reminders via Mobile 'phone Text	10.5% (2)	**36.8% (7)**	5.3% (1)	0.0% (0)	0.0% (0)	5.3% (1)	0.0% (0)	10.5% (2)	5.3% (1)	26.3% (5)	2.84	19
Integration Engine	**33.3% (6)**	11.1% (2)	0.0% (0)	0.0% (0)	0.0% (0)	5.6% (1)	5.6% (1)	11.1% (2)	0.0% (0)	**33.3% (6)**	2.78	18
										Other (please specify)		1

answered question	**19**
skipped question	**1**

6. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensively used) would indicate that it is used more than 80% of the time.

	No Plan	Plan	Installed not used	1 Barely used	2	3	4	5	6	7 Extensively used	Rating Average	Response Count
Accounting/Financial information system	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	10.5% (2)	0.0% (0)	**89.5% (17)**	5.00	19
Human Resources Management system (payroll and personnel)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.3% (1)	0.0% (0)	10.5% (2)	0.0% (0)	**84.2% (16)**	4.95	19
Staff scheduling system (e.g. nursing)	**27.8% (5)**	22.2% (4)	0.0% (0)	5.6% (1)	5.6% (1)	0.0% (0)	5.6% (1)	5.6% (1)	0.0% (0)	**27.8% (5)**	2.56	18
Financial/Clinical dashboards (executive information systems)	22.2% (4)	11.1% (2)	0.0% (0)	0.0% (0)	5.6% (1)	5.6% (1)	**27.8% (5)**	11.1% (2)	0.0% (0)	16.7% (3)	3.06	18
Business intelligence applications (e.g., OLAP cubes, data mining tools)	5.9% (1)	29.4% (5)	0.0% (0)	0.0% (0)	5.9% (1)	5.9% (1)	**35.3% (6)**	5.9% (1)	5.9% (1)	5.9% (1)	3.06	17
E-commerce for material purchasing / B2B Apps	**50.0% (8)**	12.5% (2)	0.0% (0)	0.0% (0)	31.3% (5)	6.3% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	1.63	16
Disease costing system (Diagnostic Related Groups and/or Case Mix Groups)	16.7% (3)	5.6% (1)	0.0% (0)	0.0% (0)	0.0% (0)	16.7% (3)	5.6% (1)	11.1% (2)	**22.2% (4)**	**22.2% (4)**	3.72	18

Material Management/Stock Control system	5.9% (1)	5.9% (1)	0.0% (0)	0.0% (0)	5.9% (1)	0.0% (0)	11.8% (2)	5.9% (1)	5.9% (1)	**58.8% (10)**	4.29	17
Clinical & support staff workload management system	**70.6% (12)**	17.6% (3)	0.0% (0)	5.9% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	5.9% (1)	0.71	17
										Other (please specify)		2
										answered question		**19**
										skipped question		**1**

7. Please indicate your hospital's plans to implement an Enterprise Resource Planning (ERP) system such as SAP or Oracle

	Response Percent	Response Count
No Plan	**61.1%**	**11**
Planning	0.0%	0
Implementation Started	5.6%	1
Implementation Completed	33.3%	6
	answered question	**18**
	skipped question	**2**

8. If you answered "Implementation Started" or "Implementation completed", to the previous question, then check the modules your hospital has deployed or implemented. Check all that apply.

	Response Percent	Response Count
Accounting	**85.7%**	**6**
Human Resources	28.6%	2
Finance	**85.7%**	**6**
Material management / Logistics	**85.7%**	**6**
	Other (please specify)	0
	answered question	**7**
	skipped question	**13**

9. Please indicate your hospital's plans to implement an Electronic Medical Record (EMR).

	Response Percent	Response Count
No Plan	15.8%	3
Planning	47.4%	9
Implementation Started	36.8%	7
Implementation Completed	0.0%	0
answered question		19
skipped question		1

10. If you answered "Implementation Started" or "Implementation completed", to the previous question, then check the modules your hospital has deployed or implemented. Check all that apply.

	Response Percent	Response Count
Laboratory system	100.0%	12
Pharmacy system	66.7%	8
Radiology system	91.7%	11
Nursing documentation/charting system	16.7%	2
PACS	91.7%	11
Physician documentation/charting system	25.0%	3
Critical care systems	33.3%	4
Other (please specify)		1
answered question		12
skipped question		8

11. Please indicate the extent to which your hospital shares medical records and/or clinical information electronically with other entities (1-7)

	1 - No sharing	2	3	4	5	6	7 - Extensive	Rating Average	Response Count
With other acute care organisations	**44.4% (8)**	5.6% (1)	22.2% (4)	11.1% (2)	0.0% (0)	5.6% (1)	11.1% (2)	1.39	18
With long term care organisations	**72.2% (13)**	11.1% (2)	5.6% (1)	5.6% (1)	5.6% (1)	0.0% (0)	0.0% (0)	0.56	18
With primary care organisations (e.g. Discharge Summaries via HealthLinks)	**38.9% (7)**	5.6% (1)	0.0% (0)	11.1% (2)	5.6% (1)	5.6% (1)	33.3% (6)	2.50	18
With GP's for Referrals	**72.2% (13)**	11.1% (2)	11.1% (2)	0.0% (0)	5.6% (1)	0.0% (0)	0.0% (0)	0.44	18
With GP's for Appointment Booking	**88.9% (16)**	5.6% (1)	5.6% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.11	18
With medical clinics	**77.8% (14)**	0.0% (0)	16.7% (3)	0.0% (0)	5.6% (1)	0.0% (0)	0.0% (0)	0.39	18
With Pharmacies (e.g. e-Prescribing)	**100.0% (18)**	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.00	18
With insurance companies / VHI etc or Suppliers	**55.6% (10)**	27.8% (5)	5.6% (1)	0.0% (0)	0.0% (0)	0.0% (0)	11.1% (2)	0.89	18
With external laboratories (e.g. NVRL; Private Lab.)	22.2% (4)	11.1% (2)	11.1% (2)	**33.3% (6)**	5.6% (1)	0.0% (0)	16.7% (3)	2.28	18
With governmental agencies (e.g. ESRI for HIPE)	0.0% (0)	0.0% (0)	0.0% (0)	11.1% (2)	22.2% (4)	5.6% (1)	**61.1% (11)**	4.50	18
With patients (e.g., online results sharing)	**88.9% (16)**	11.1% (2)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.11	18
							Other (please specify)		0

answered question	**18**
skipped question	**2**

12. Please indicate the number of permanent IT staff in your hospital:

	Response Count
	15
answered question	**15**
skipped question	**5**

13. Please enter the number of inpatient beds in your hospital:

	Response Count
	19
answered question	**19**
skipped question	**1**

14. What percentage of the hospital's annual budget is devoted to ICT ? - please include all ICT related expenditure including staffing.

	Less than 1%	1 - <2%	2 - <3%	3 - <4%	4+ %	Response Count
% Budget	35.3% (6)	52.9% (9)	11.8% (2)	0.0% (0)	0.0% (0)	17
					answered question	17
					skipped question	3

15. Please categorise your hospital:

		Response Percent	Response Count
Urban		52.6%	10
Rural		26.3%	5
Regional		21.1%	4
		answered question	19
		skipped question	1

16. Is your hospital a university teaching hospital (or affiliated)?

		Response Percent	Response Count
Yes		63.2%	12
No		36.8%	7
		answered question	19
		skipped question	1

17. Is there a formal ICT Steering committee in your hospital?

		Response Percent	Response Count
Yes		47.4%	9
No		52.6%	10
		answered question	19
		skipped question	1

18. Please indicate if your hospital uses or plans to use a formal management model for the following categories:

	No Plan	Planning	In use	Response Count
Project Management (e.g. PRINCE)	42.9% (6)	0.0% (0)	**57.1% (8)**	14
Programme Management	**71.4% (10)**	0.0% (0)	28.6% (4)	14
Portfolio Management	**78.6% (11)**	0.0% (0)	21.4% (3)	14
Business Process Modelling (e.g. UML; BPEL; BPMN)	**78.6% (11)**	7.1% (1)	14.3% (2)	14
Business Strategy (e.g. Lean, Six-Sigma)	**57.1% (8)**	0.0% (0)	42.9% (6)	14
Information Technology Services (e.g. ITIL)	**50.0% (7)**	28.6% (4)	21.4% (3)	14
IT Governance (e.g. COBIT)	**85.7% (12)**	14.3% (2)	0.0% (0)	14
Procurement (e.g. POISE)	**92.9% (13)**	0.0% (0)	7.1% (1)	14
Quality Management (e.g. ISO accredited)	**50.0% (7)**	21.4% (3)	28.6% (4)	14
Benefits Realisation	**64.3% (9)**	7.1% (1)	28.6% (4)	14
Software Development (e.g. AGILE, SPICE, CMMI)	**100.0% (14)**	0.0% (0)	0.0% (0)	14
I.T. Maturity Assessment (e.g. IVI CMM-F)	**78.6% (11)**	7.1% (1)	14.3% (2)	14
			Other (please specify)	0

answered question	**14**
skipped question	**6**

19. IN4.1 - Information Infrastructure - Standard Terminologies and Information models

	Yes	No	Planned	Response Count
Does the system provide the ability to use standard terminologies to communicate with other systems (internal or external to the EHR)?	**84.6% (11)**	15.4% (2)	0.0% (0)	13
Does the system provide the ability to validate that clinical terms and coded clinical data exists in a current standard terminology ?	**53.8% (7)**	46.2% (6)	0.0% (0)	13
Does the system provide the ability to exchange healthcare data using formal standard information models and standard terminologies ?	**84.6% (11)**	15.4% (2)	0.0% (0)	13
			answered question	**13**
			skipped question	**7**

20. Please indicate which Standard Terminologies are currently in use:

	Response Percent	Response Count
ICD-9	7.7%	1
ICD-9 CM	15.4%	2
ICD-10	**76.9%**	**10**
LOINC	7.7%	1
Current Procedure Terminology-4	0.0%	0
READ CODES	7.7%	1
SNOMED	23.1%	3
SNOMED CT	30.8%	4
IPU - Drugs Classification	15.4%	2
First Data Bank - Drugs Classification	0.0%	0
International Classification for Nursing Practice	7.7%	1
None	0.0%	0
	Other (please specify)	2
	answered question	**13**

skipped question	**7**

21. Please indicate the Standard Information Model in Use:

	Response Percent	Response Count
HL7 V2.x RIM	**76.9%**	**10**
HL7 V3 RIM	30.8%	4
HL7 CDA RIM	0.0%	0
Clinical Data Interchange Standards Consortium - CDISC	0.0%	0
CEN13606	0.0%	0
OpenEHR	0.0%	0
None	7.7%	1
	Other (please specify)	0
	answered question	**13**
	skipped question	**7**

22. IN4.2 Maintenance and versioning of Terminology Standards: Version control allows for multiple sets or versions of the same terminology to exist and be distinctly recognized over time. Terminology standards are usually periodically updated, and concurrent use of different versions may be required.

	Yes	No	Planned	Response Count
Does the system provide the ability to use different versions of terminology standards ?	25.0% (3)	**66.7% (8)**	8.3% (1)	12
Does the system provide the ability to update terminology standards ?	33.3% (4)	**58.3% (7)**	8.3% (1)	12
Does the system provide the ability to interoperate with systems that use known different versions of a terminology standard ?	33.3% (4)	**58.3% (7)**	8.3% (1)	12
			answered question	**12**
			skipped question	**8**

23. IN4.3 Terminology Mapping: It is a common occurrence that data is captured using one terminology, but is shared using another terminology.

	Yes	No	Planned	Response Count
Does the system provide the ability to use a terminology map ?	8.3% (1)	**66.7% (8)**	25.0% (3)	12
			answered question	**12**
			skipped question	**8**

24. IN5.1 - Standards based interoperability - Interchange Standards

	Yes	No	Planned	Response Count
Does the system provide the ability to use interchange standards?	**46.2% (6)**	38.5% (5)	15.4% (2)	13
Does the system provide the ability to perform seamless interchange of data with other systems that use recognised interchange standards?	**38.5% (5)**	**38.5% (5)**	23.1% (3)	13
If there is no Standard Information Model available, does the system provide a formal explicit information model in order to support the ability to operate seamlessly with other systems?	36.4% (4)	**45.5% (5)**	18.2% (2)	11
			answered question	**13**
			skipped question	**7**

25. Please indicate which of the following communications interchange standards are in use:

	Response Percent	Response Count
HL7 V2.x	76.9%	10
HL7 V3	30.8%	4
HL7 Clinical Document Architecture (CDA)	0.0%	0
Clinical Data Interchange Standards Consortium	0.0%	0
CEN 13606	0.0%	0
OpenEHR	0.0%	0
Integrating the Health Enterprise (IHE)	7.7%	1
IHE Retrieve Information for Display (RID)	0.0%	0
IHE Cross Enterprise Document Sharing (XDS)	0.0%	0
DICOM	**100.0%**	**13**
DICOM - Structured Reports (SR)	23.1%	3
DICOM - Web Acess to Dicom Objects (WADO)	15.4%	2
Medical Markup Language (MML)	7.7%	1

None	0.0%	0
	Other (please specify)	0
	answered question	13
	skipped question	7

26. IN5.2 Interchange Standards: Versioning and Maintenance

	Yes	No	Planned	Response Count
Does the system provide the ability to use different versions of interchange standards ?	41.7% (5)	**50.0% (6)**	8.3% (1)	12
Does the system provide the ability to reconfigure the way that data is transmitted as an interchange standard evolves over time ?	**41.7% (5)**	**41.7% (5)**	16.7% (2)	12
Does the system provide the ability to make an interchange standard backwards compatible ?	33.3% (4)	**50.0% (6)**	16.7% (2)	12
Does the system provide the ability to interoperate with other systems that use earlier versions of an interoperability standard ?	33.3% (4)	**50.0% (6)**	16.7% (2)	12
			answered question	12
			skipped question	8

27. IN5.3 Standards based Application integration: Desktop visual integration may be achieved via HL7 Clinical Context Object Workgroup (CCOW) standards -workflow functions may be integrated via The Workflow Management Coalition (WfMC) standards - EHR may be integrated in an Enterprise Information System Architecture via Service Oriented Architecture (SOA) standards.

	Yes	No	Planned	Response Count
Does the system provide the ability to support standards-based application integration ?	16.7% (2)	**83.3% (10)**	0.0% (0)	12
			answered question	12
			skipped question	8

28. IN5.4 Interchange Agreements: An EHR can use entity registries to determine the security, addressing, and reliability requirements between partners. An EHR can use this information to define how data will be exchanged between the sender and the receiver.

	Yes	No	Planned	Response Count
Does the system use interchange agreement descriptions when exchanging information with partners ?	20.0% (2)	**80.0% (8)**	0.0% (0)	10
			answered question	10
			skipped question	10

29. Please indicate which of the following application integration standards are in use:			
		Response Percent	Response Count
Integrating the Health Enterprise (IHE)		12.5%	1
HL7 Clinical Context Object Workgroup (CCOW)		37.5%	3
The Workflow Management Coalition (WfMC)		0.0%	0
Enterprise Information System Architecture via Service Oriented Architecture (SOA)		12.5%	1
None		**62.5%**	**5**
		Other (please specify)	0
		answered question	**8**
		skipped question	**12**

30. Please indicate the highest level of academic or professional training you have achieved (Not necessarily IT):	
	Response Count
	12
answered question	**12**
skipped question	**8**

31. Please indicate the number of years experience you have in the use and / or management of ICT:	
	Response Count
	13
answered question	**13**
skipped question	**7**

32. Please indicate the number of years experience you have working in this hospital:	
	Response Count
	13
answered question	**13**
skipped question	**7**

33. Please indicate the number of years experience you have in your current position:

	Response Count
	13
answered question	13
skipped question	7

34. Please add below any comments you may have regarding the extent to which information technologies and computer-based applications are used in your healthcare organisation

	Response Count
	3
answered question	3
skipped question	17

Page 3, Q1. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensivel...

1	Maternity System	Apr 21, 2011 2:37 PM

Page 4, Q1. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensivel...

1	Diabetic Management system / Oncology Management system	Apr 4, 2011 10:06 AM

Page 4, Q1. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensivel...

Page 6, Q1. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensivel...

1	I have indicated a lower rating for technology not rolled out to all departments.	Mar 27, 2011 5:50 PM

Page 7, Q1. Please indicate the status of the following computerised systems in your hospital. If the application is already implemented please indicate the extent to which the system is currently used. For example (1-Barely used) would indicate that it is used less than 10% of the time while (7 - Extensivel...

1	Payroll Outsourced	Apr 5, 2011 11:34 AM
2	If I have not answered, it indicates that I am not aware of these systems but they could be implemented.	Mar 27, 2011 5:52 PM

Page 9, Q2. If you answered "Implementation Started" or "Implementation completed", to the previous question, then check the modules your hospital has deployed or implemented. Check all that apply.

1	Radiotherapy database	Mar 31, 2011 5:33 PM

Page 11, Q1. Please indicate the number of permanent IT staff in your hospital:

1	8	May 23, 2011 1:18 PM
2	5	May 19, 2011 12:35 PM

Page 11, Q1. Please indicate the number of permanent IT staff in your hospital:		
3	5	Apr 21, 2011 2:57 PM
4	3	Apr 6, 2011 10:34 AM
5	2	Apr 5, 2011 11:41 AM
6	7	Apr 4, 2011 10:23 AM
7	3	Apr 4, 2011 10:07 AM
8	1	Apr 4, 2011 3:50 AM
9	4	Mar 31, 2011 5:36 PM
10	32	Mar 29, 2011 9:02 AM
11	13	Mar 28, 2011 4:41 PM
12	8	Mar 28, 2011 2:16 PM
13	5	Mar 28, 2011 1:18 PM
14	22	Mar 28, 2011 9:49 AM
15	25	Mar 28, 2011 8:56 AM

Page 11, Q2. Please enter the number of inpatient beds in your hospital:		
1	243	Jun 18, 2011 1:54 PM
2	>800	May 23, 2011 1:18 PM
3	100	May 19, 2011 12:35 PM
4	65	Apr 21, 2011 4:46 PM

Page 11, Q2. Please enter the number of inpatient beds in your hospital:		
5	226	Apr 21, 2011 4:42 PM
6	172	Apr 21, 2011 4:16 PM
7	340	Apr 21, 2011 2:57 PM
8	150	Apr 6, 2011 10:34 AM
9	160	Apr 5, 2011 11:41 AM
10	194	Apr 4, 2011 10:23 AM
11	208	Apr 4, 2011 10:07 AM
12	85	Apr 4, 2011 3:50 AM
13	120	Mar 31, 2011 5:36 PM
14	920	Mar 29, 2011 9:02 AM
15	520	Mar 28, 2011 4:41 PM
16	155	Mar 28, 2011 2:16 PM
17	220	Mar 28, 2011 1:18 PM
18	540	Mar 28, 2011 9:49 AM
19	900	Mar 28, 2011 8:56 AM

Page 14, Q1. Please indicate which Standard Terminologies are currently in use:		
1	ICD10 AM	Mar 28, 2011 2:23 PM
2	ICD-10 AM	Mar 28, 2011 8:59 AM

Page 20, Q1. Please indicate the highest level of academic or professional training you have achieved (Not necessarily IT):		
1	Third level - Computer Science	May 19, 2011 12:41 PM

Page 20, Q1. Please indicate the highest level of academic or professional training you have achieved (Not necessarily IT):		
2	Bsc Degree	Apr 6, 2011 11:27 AM
3	BComm	Apr 5, 2011 11:51 AM
4	Nat Certificate- Business Studies	Apr 4, 2011 1:11 PM
5	Masters	Apr 4, 2011 10:39 AM
6	BA degree	Apr 4, 2011 10:23 AM
7	M. Sc	Mar 31, 2011 5:43 PM
8	Master Degrees (2) Basic degree (1) Diploma (2) Certificate (1)	Mar 29, 2011 9:08 AM
9	B.Sc (hons)	Mar 28, 2011 4:56 PM
10	MSc	Mar 28, 2011 2:26 PM
11	Pg Dip	Mar 28, 2011 1:22 PM
12	BSC in Computer Science	Mar 28, 2011 9:03 AM

Page 20, Q2. Please indicate the number of years experience you have in the use and / or management of ICT:		
1	30	May 23, 2011 1:22 PM
2	14	May 19, 2011 12:41 PM
3	9	Apr 6, 2011 11:27 AM
4	15	Apr 5, 2011 11:51 AM
5	11	Apr 4, 2011 1:11 PM
6	30	Apr 4, 2011 10:39 AM

Page 20, Q2. Please indicate the number of years experience you have in the use and / or management of ICT:		
7	20	Apr 4, 2011 10:23 AM
8	35	Mar 31, 2011 5:43 PM
9	3	Mar 29, 2011 9:08 AM
10	35	Mar 28, 2011 4:56 PM
11	10	Mar 28, 2011 2:26 PM
12	25	Mar 28, 2011 1:22 PM
13	20	Mar 28, 2011 9:03 AM

Page 20, Q3. Please indicate the number of years experience you have working in this hospital:		
1	19	May 23, 2011 1:22 PM
2	10	May 19, 2011 12:41 PM
3	9	Apr 6, 2011 11:27 AM
4	10	Apr 5, 2011 11:51 AM
5	13	Apr 4, 2011 1:11 PM
6	11	Apr 4, 2011 10:39 AM
7	12	Apr 4, 2011 10:23 AM
8	7	Mar 31, 2011 5:43 PM
9	12	Mar 29, 2011 9:08 AM
10	12	Mar 28, 2011 4:56 PM

Page 20, Q3. Please indicate the number of years experience you have working in this hospital:		
11	15	Mar 28, 2011 2:26 PM
12	14	Mar 28, 2011 1:22 PM
13	17	Mar 28, 2011 9:03 AM

Page 20, Q4. Please indicate the number of years experience you have in your current position:		
1	19	May 23, 2011 1:22 PM
2	10	May 19, 2011 12:41 PM
3	9	Apr 6, 2011 11:27 AM
4	3	Apr 5, 2011 11:51 AM
5	11	Apr 4, 2011 1:11 PM
6	11	Apr 4, 2011 10:39 AM
7	12	Apr 4, 2011 10:23 AM
8	7	Mar 31, 2011 5:43 PM
9	2	Mar 29, 2011 9:08 AM
10	12	Mar 28, 2011 4:56 PM
11	10	Mar 28, 2011 2:26 PM
12	14	Mar 28, 2011 1:22 PM
13	10	Mar 28, 2011 9:03 AM

Page 20, Q5. Please add below any comments you may have regarding the extent to which information technologies and computer-based applications are used in your healthcare organisation		
1	ICT infrasture in RCH is dependant on network links to the regional centres in Galway. Considerable budgetary and hospital size	Apr 4, 2011 1:11 PM

Page 20, Q5. Please add below any comments you may have regarding the extent to which information technologies and computer-based applications are used in your healthcare organisation		
	limitations in place so future developments cannot be confirmed	
2	We have critical dependency on our legacy system and on the 55 critical systems that are tightly integrated with it.	Mar 29, 2011 9:08 AM
3	Much more potential to use systems. Very little investment forthcoming.	Mar 28, 2011 4:56 PM

9.10 Appendix 10 – Irish Hospital HITCAP scores detail

	Dim 1 - Pat Apps	Dim 2 - Clinical Apps	Dim 3 - Clinical Support Apps	Dim 4 - Admin Apps	Functional Vector	Dim 5 - Technology	Dim 6 - Internal Integ - Admin	Dim 7 - Internal Integ - Clin	Dim 8 - External Integration	Integration Vector	Overall Hosp HITCAP
Hospital_1	94.29	42.86	95.00	57.78	72.48	32.31	0.00	100.00	37.78	45.93	57.50
Hospital_2	80.00	70.00	95.00	48.89	73.47	56.92	0.00	0.00	13.33	4.44	45.52
Hospital_3	74.29	24.29	100.00	31.11	57.42	15.38	80.00	20.00	24.44	41.48	46.19
Hospital_4	71.43	50.00	55.00	44.44	55.22	20.00	0.00	20.00	17.78	12.59	34.83
Hospital_5	85.71	47.14	100.00	60.00	73.21	36.92	0.00	20.00	15.56	11.85	45.67
Hospital_6	62.86	25.71	80.00	80.00	62.14	43.08	0.00	0.00	26.67	8.89	39.79
Hospital_7	71.43	24.29	55.00	46.67	49.35	13.85	80.00	80.00	17.78	59.26	48.63
Hospital_8	57.14	41.43	80.00	22.22	50.20	12.31	0.00	80.00	20.00	33.33	39.14
Hospital_9	85.71	48.57	75.00	0.00	52.32	0.00	0.00	0.00	0.00	0.00	26.16
Hospital_10	88.57	75.71	80.00	88.89	83.29	61.54	0.00	100.00	64.44	54.81	69.89
Hospital_11	85.71	71.43	75.00	71.11	75.81	53.85	0.00	20.00	15.56	11.85	49.08
Hospital_12	88.57	30.00	95.00	42.22	63.95	20.00	0.00	80.00	6.67	28.89	45.31
Hospital_13	48.57	35.71	75.00	55.56	53.71	13.85	0.00	0.00	28.89	9.63	32.20
Hospital_14	97.14	57.14	95.00	86.67	83.99	35.38	0.00	100.00	42.22	47.41	64.19
Hospital_15	100.00	84.29	50.00	88.89	80.79	47.69	100.00	80.00	48.89	76.30	74.97
Hospital_16	88.57	64.29	100.00	66.67	79.88	35.38	0.00	20.00	15.56	11.85	48.81
Hospital_17	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42
Hospital_18	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42
Hos[ital_19	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42
Hospital_20	68.57	47.14	55.00	71.11	60.46	38.46	80.00	20.00	31.11	43.70	51.42
Sample Total	1554.29	981.43	1525.00	1175.56		652.31	580.00	800.00	520.00		
Sample HITCAP	77.71	49.07	76.25	58.78	65.45	32.62	29.00	40.00	26.00	31.67	48.68

9.11 Appendix 11 – Meaningful Use

	Q'aire Ref. / Notes
Functional - Patient Systems :	
[MU5] The application allows for the maintenance of an active medication allergy list Y/N.	a
[MU6] The application allows the recording of demographics Y/N.	a
[MU8] The application allows for the Recording of 'smoking status' for patients Y/N	a
[MU13] The application performs an on-line check for insurance eligibility electronically from public and private payers Y/N	b
[MU19] The application incorporates a summary care record for each transition (episode) of care and referral Y/N.	a
Functional - Clinical Support Systems	
[MU4] The application maintains an active medication list Y/N. (Pharmacy)	SQ4-1
[MU2] The System incorporates facilities for drug-drug, drug-allergy, drug- formulary checks which have been enabled Y/N	SQ4-1
Functional - Clinical Systems	
[MU1] The Patient Clinical System allows for the use of CPOE for orders (any type) directly entered by authorizing provider (for example, MD, RN) Y/N - 10%	SQ3-1,2,3
[MU7] The System allows for the recording and charting of changes in vital signs (Temperature; Blood Pressure; Heart Rate; Respiratory rate) Y/N.	SQ3-9
[MU12] Clinical Decision Support facilities have been enabled in the System Y/N (Min of 5)	SQ3-12*
[MU15] The System allows for patients to be provided with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, allergies, discharge summary, and procedures), upon request Y/N	SQ3-5*
[MU16] The System allows for patients to be provided with an electronic copy of their discharge instructions and procedures at time of discharge, upon request Y/N	SQ3-5*
[MU18] The system allows for the recording of medication reconciliation at relevant encounters and each transition of care Y/N	SQ3-9 or 10
Functional - Administration Systems	
[MU10] The System allows for the generation of lists of patients by specific conditions to use for quality improvement, reduction of disparities, research, and outreach Y/N	SQ14-1*
Internal Integration – Electronic Medical Record (Lab is integrated into EMR)	
[MU9] Does your EMR Incorporate clinical lab-test results as structured data Y/N. (50% of results)	SQ9-1*
External Integration	
[MU14] The System allows for the submission of claims electronically to private payers Y/N.	SQ10-8
[MU17] The system has facilities to exchange key clinical information (for example, discharge summary, procedures, problem list, medication list, allergies, diagnostic test results), among providers of care and patient authorized entities electronically Y/N.	SQ10-3
[MU20] The System has facilities to submit electronic data to immunization registries Y/N.	SQ10-10
[MU21] The System has facilities to provide electronic submission of reportable lab results to public health agencies Y/N	SQ10-9
[MU22] The System has facilities to provide electronic syndromic surveillance data to public health agencies Y/N.	SQ10-10*
Standards & Terminologies	
[MU3] The Patient Administration System maintains an up-to-date problem list of current and active diagnoses based on ICD-9-CM or SNOMED CT Y/N	SQ14-1

Notes:
a) - the feature was not included in the survey but is known to exist in all systems in acute care hospitals in Ireland
b) - the feature was not included in the survey but is known to exist (whole or in part) in systems in acute care hospitals in Ireland
KEY:
SQPP-N ==> Survey Question Page - Question Number
SQ3 - 12*: survey did not ask for the specific number of CDS alerts implemented
SQ3 - 5*: taken to be Electronic Discharge Summaries - usually sent direct to the GP in Ireland
SQ14 - 1*: taken if the hospital has implemented a Standard Terminology for Diagnosis, that this report is then feasible
SQ9 - 1*: % of results incorporated not discernable
SQ10 - 10*: taken to be equivalent to the facility of electronic transferral of LAB data to external Laboratories

Where Meaningful Use is measured by % of patients; encounters; referrals; orders etc; the rating value in the survey has been used to establish this measure - e.g. rating value of 2-6 inclusive ==> 10%+, while a rating value of 7 ==> 80% and +

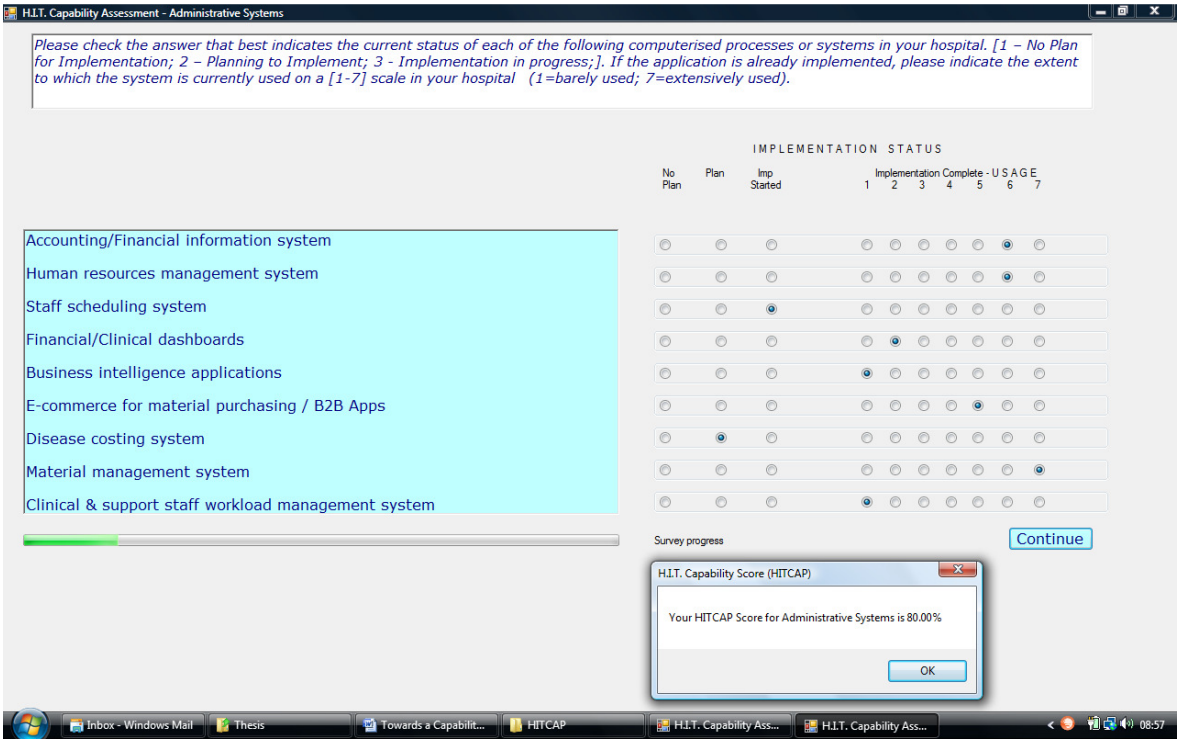
9.12 Appendix 12 – HITCAP Software Screens

The author developed a software application prototype which calculates a HITCAP score using the weightings of the original survey instrument. A freely available version of Microsoft Visual Basic (VB10 Express, downloaded from the Microsoft online download database in December 2010) was used for the development. The author initiated a new project using VB10 and loaded the application with the customised tables of the revised survey instrument. The survey questions were divided into individual forms in accordance with the eight dimensions defined in the original survey. Each form was programmed to present as if the user were being asked to answer the questions of the survey. All questions were programmed to be optionally replied to and where only one response was expected to a particular question, this logic was built into the application. Similarly, where a question might allow a multiple response, this logic was also built into the application. The weightings for the measures used in the original survey instrument were programmed into the application. The application was tested and a sample set of survey responses were calculated manually and then using the new application to validate the application integrity.

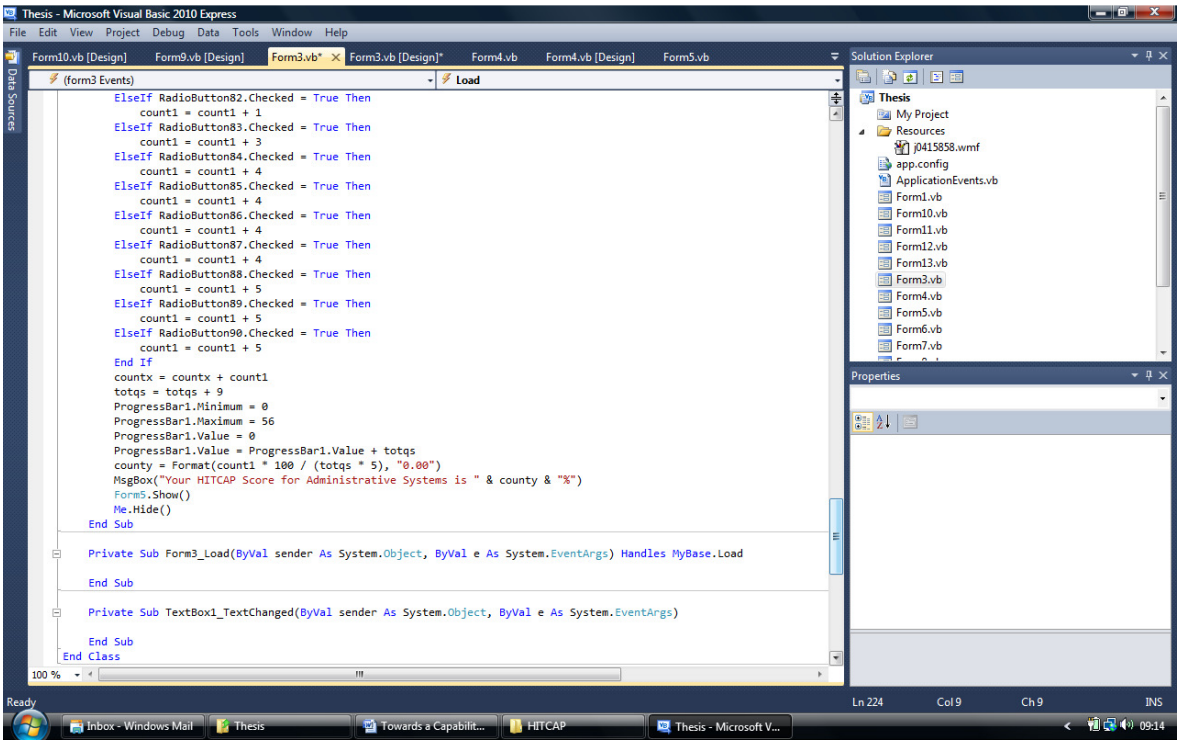
While the application was developed primarily to assist in arriving at the Capability scoring mechanism for this piece of work, the author is of the opinion that the application could easily be published to a Web Site and made freely available to interested parties in the Irish Health Service who would then be in a position to use the HITCAP Scoring Tool whenever they required and as often as they required. The site would require FrontPage extensions installed for it to be deployed in this way. It is also possible to publish the application to distributable media.

The current version of the HITCAP scoring tool calculates dimension scores as the user progresses through the application giving an overall score on completion of the final screen of questions. The application does not currently log replies to a database but with a little customisation this would be possible. The benefit of such a step would be to provide a mechanism for a trusted third party to provide comparative analyses of the HITCAP score for individual institutions with those of other institutions and to provide an option to print a Gap Analysis Report identifying the steps required to increase the score for the

institution in the various functional dimensions. It would also provide a foundation database for those interested to examine the antecedents potentially contributing to the level of maturity of I.T. capability in Irish institutions.



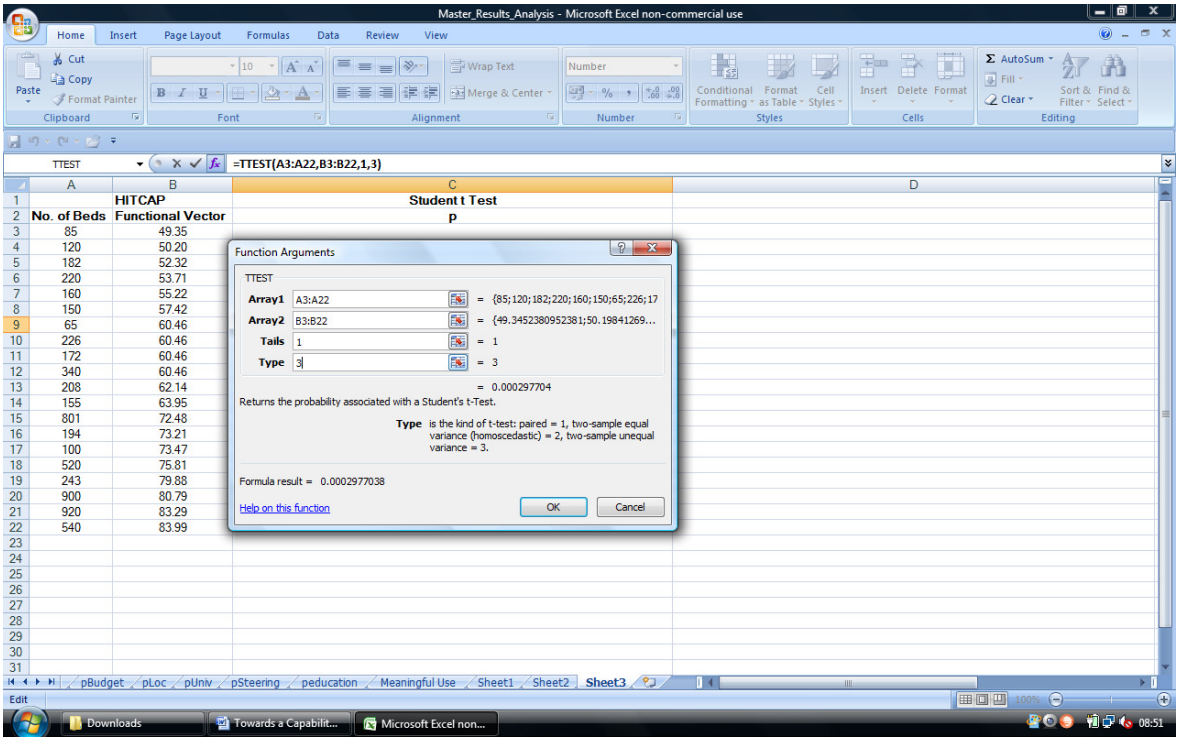
VB10 generated HITCAP software sample Screen



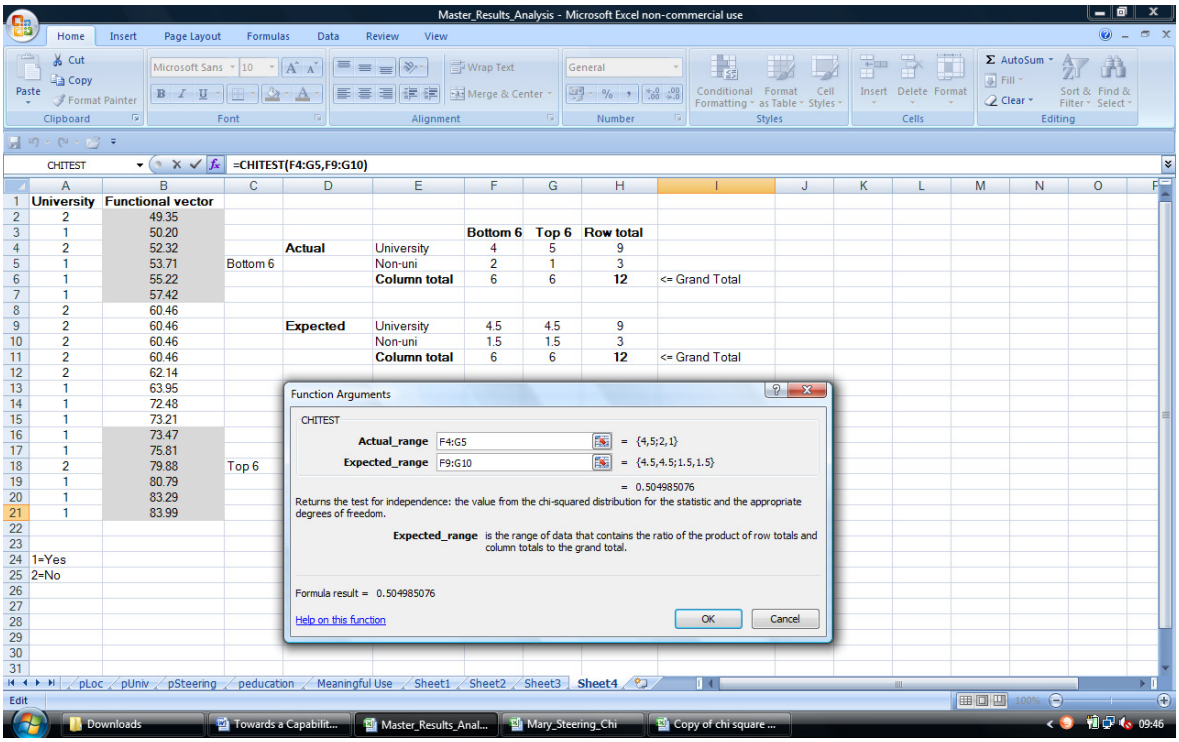
VB10 source code sample

9.13 Appendix 13 – Correlation Calculation Examples

Example Student t Test: 1 tail; 2 sample unequal variance



Example Chi square test



1. Calculate the row totals, column totals, and grand total for the Actual data
2. Calculate Expected value for each cell as (row total * column total / grand total)

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