DETERMINANTS OF IT ADOPTION IN HOSPITALS
IT Maturity Surveyed in an European Context

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Abstract: Following the increase of investments in Information Technology (IT) in organizations and companies during the past decade, hospitals are expected to increase their IT maturity as well. But what drives hospitals to invest in IT, in particular integrative and enterprise-wide IT? In the present study we make an attempt to identify key elements of IT adoption for the hospital enterprise, and formulate a model in order to assess their level of IT adoption and maturity. Driven by this model and based on survey data from an European research conducted on 18 countries, statistical analysis is performed. It indicates that IT adoption in hospitals is strongly related to size, i.e. the number of employees and the number of beds of a hospital. Additionally, it is revealed that there are significant differences in adoption levels between general and specialized health care hospitals. Finally, a cross-country analysis shows striking differences between the 18 EU countries in the IT maturity of hospitals as well, from which pioneering as well as the straggling clusters of countries can be classified.

1 INTRODUCTION

Investments in Information Technology (IT) have increased dramatically over the past decade in organizations and companies. At the same time, organizations and their managers struggle on gaining a financial as well as a competitive advantage from their IT investments (Venkatesh et al, 2003). According to some estimations, since the 1980`s approximately 50 percent of capital investment has been spent on IT systems (Westland and Clark, 2000). Several empirical studies have indicated that investments in IT, after some time, positively affect the overall performance of organizations (Raymond et. Al., 1995; Chan et al., 1997). Others claim that IT can likewise take firms down, with greater expenditures rarely translating into superior financial results (Carr, 2003). Many agree that the same controversy also applies for organizations of the healthcare sector. Most organizations within the health care sector represent the area of primary care (e.g. general practitioners, dentists, pharmacists). To specifically explore the resemblance between private and public organizations in their IT investments and IT maturity however, this study will focus on what is called 'the Hospital Enterprise' (Lorenzi & Riley, 1995; Hatcher, 1998; Paré & Sicotte 2001).

Even though hospitals seems to be delayed in deploying IT systems because of their 'legacy burden', one of the most important drivers for them to invest in (Health) Information Technology is the need to minimize operating costs. It is estimated that up to $81-162 billion can be saved annually for both inpatient and outpatient care and approximately 200.000 potentially fatal adverse drug events can be eliminated each year (Taylor et al., 2005; RAND 2005) cutting costs by an additional $1 billion. The largest percentage of savings occurs from the reduced hospital stays, the need for fewer nursing staff and more efficient drug utilization. Furthermore by adopting Health Information Technology (HIT) age-adjusted mortality could be lowered by 18 percent and days taken off work due to sickness could be reduced by 40 million annually (Taylor et al., 2005). In addition, there is a need for a safer system with less human errors which is emphasized in a 2000 report which estimates that as many as 98,000 patients die each year from preventable medical errors (Kohn et al., 2000). Furthermore, in the last years there is a tendency to shift from a institution (supply) centered healthcare system to a more patient (demand) oriented one. This has forced hospitals to apply IS/IT that is patient and process oriented rather than administrative oriented. This

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shift occurs from the need to standardize operations and to create a more safe and flexible health care system (Bates & Gawande, 2003). Because of the specific complexity of the hospital sector, the shift towards a patient-oriented model proves to be very difficult. Unlike other industries, IS/IT in health cannot enable "mass customization". While mass customization refers to the efficient, reliable production of services and goods based on the personalized requirements of the customer (Bates & Gawande, 2003), 'health' is highly sensitive and intangible good that does not comply with the standard economic model of production and consumption. It might be for this reason, that most of the expenditure in IT within hospitals is aimed at administrative tasks such as accounting and logistics, (Haux et al., 2002; Brynjolfsson & Hitt, 2000). At a slow pace, investments shift from IT that support the execution of daily tasks to more hospital-wide and integrative IS/IT.

The adoption and maturity of IS/IT in hospitals has been hardly analyzed in an empirical way, i.e. measured, let alone monitored and evaluated for its potential value to improve quality and cut costs. Based on existing measurement methods, and driven by an unique data sample of European hospitals, we explore a measurement for IS/IT adoption and maturity by hospitals. We also construct a conceptual model in order to determine and evaluate the level at which hospitals make effective use of these systems. Besides this theoretical contribution, we claim that such an conceptual model makes it easier to create an adoption plateau for hospitals in order to plan deployment phases for IT systems. In another practical sense, it can also provide useful information about the outcomes of each level of adoption. It is for this reason that this paper aims to theoretically develop an IT maturity model for hospitals, and empirically apply and validate this on a large-scale dataset.

1.1 Structure

This paper is structured as follows. In the next section, a literature overview is presented on the most relevant and recent work on IS/IT adoption in hospitals. Section 3 introduces a conceptual model developed to measure IT maturity and IT adoption in hospitals. Section 4 presents the sample that is used for empirical validation of the model, as well as the basic statistical analysis and methods applied. In section 5, the determinants are tested that are expected to have an influence on the IT adoption level of hospitals, i.e. their size, type and home country. Finally section 6 includes the conclusions which are drawn about the results and a discussion about how this research can be extended or continued.

2 RELATED WORK

In order to study the adoption level of IS/IT in the hospital sector, many researchers have started by classifying the different systems that are used and to create a scale that represents the maturity of these systems. In their study Heinzl & Guttler propose a five stage model of hospital IT reconfiguration based on Venkatramans model of maturity (Heinzl & Guttler, 2000). Venkatraman's model became particularly known since it describes stages of how a business can be reconfigured in order to make use of available IT systems and gain a competitive advantage (Venkatraman, 1991). In their study, Heinzl & Guttler focus on the strategies, IT characteristics and organizational variables and their association with the five levels of maturity of the Venkatraman model. The study of Pare & Sicote also focuses on measuring the level of IT maturity in the hospital sector, influenced by the EDP growth model of Nolan. The authors distinguish between technological sophistication – which include the different hardware devices – and functional sophistication – which represent the diversity of activities or processes (Pare & Sicote, 2001). Based on this two-dimensional distinction the authors present a framework in which hospital activities are divided into three parts, the administrative activities, patient management and patient care activities and finally clinical support activities. For each of these the technological and functional sophistication is measured. Also, the framework takes into account the external partners of hospitals such as clinics, laboratories etc.

Source: Pare´ G., & Sicotte C. (2001) Information technology sophistication in health care: an instrument validation study among Canadian hospitals. *International Journal of Medical Informatics, 63,* 205-223.

A recent study by the Healthcare Information and Management Systems Society (HIMSS) specifies the adoption rate of Electronic Medical Records (EMR) by presenting an eight stage model. It starts from stage '0' where no major ancillary department systems for laboratory, pharmacy and radiology are implemented, to stage 7 where medical records are fully electronic. The HIMSS model represents the necessary steps that are required so all patient

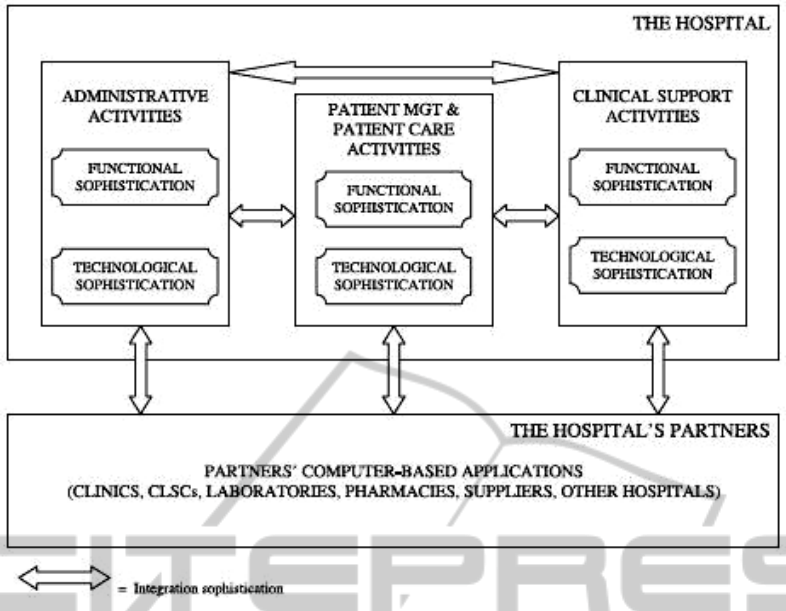

Figure 1: IT Sophistication framework in hospitals.

related functions are completed electronically. Although this model provides a planning tool for adopting EMR systems, it does not apply for other IS/IT used by hospitals.

3 A CONCEPTUAL MODEL FOR IT ADOPTION BY HOSPITALS

Following the work of the scholar's referred to in the above section, we develop our conceptual model for IT maturity in hospitals by first identifying the elements of IS/IT adoption in the hospital enterprise. The common attributes of the frameworks presented in the previous section are used to define the 'pillars' of measuring hospital IT adoption. Commencing from the work of Tornatzky & Fleischer (1990), who in their framework study the adoption of E-Business in a wide range of enterprises, we identify six different pillars or key elements of IT adoption.

- As in all industries including the hospital sector, *IT infrastructure* must be present in order to support all necessary activities either within the hospital or between business partners. This need for IT infrastructure is also pinpointed in the study of Pare and Sicote who name it technological sophistication and place it in all four variables of their framework.
- Next to infrastructure, Tornatzky & Fleischer allocate a central position in their framework to IT expertise, referring to the knowledge and skills of the people involved in the use of IT systems. This *IT expertise or e-skills* is a variable used in many frameworks of IT adoption which underlines its importance (Tornatzky & Fleischer, 1990; Zhu et al, 2002).
- Another important part of the Tornatzky & Fleischer Technology – Organization – Environment framework is the *Industry Specific Know-how with regard to IS/IT*. This variable addresses both the IT knowledge of the (top) management, as well as the organizational knowledge of the IT managers and consultants (cf. Luftman, 2000, 2007). Basically, this is about business/IT alignment (Chan & Reich, 2007), in this context expressed as the expertise to understand healthcare specific IT.
- To model IT maturity from an integrative, i.e. cross-functional and external perspective, we propose that IT maturity should also address the concept of *online sales & marketing*. The rise of client or customer orientation mentioned earlier, has radically redesigned processes within numerous organizations, including hospitals. The introduction of the Electronic patient Record illustrates this, but also the cooperation between hospitals and health insurance organizations that are the main financial customers of hospitals in many countries.
- In line with the previous element, *online*

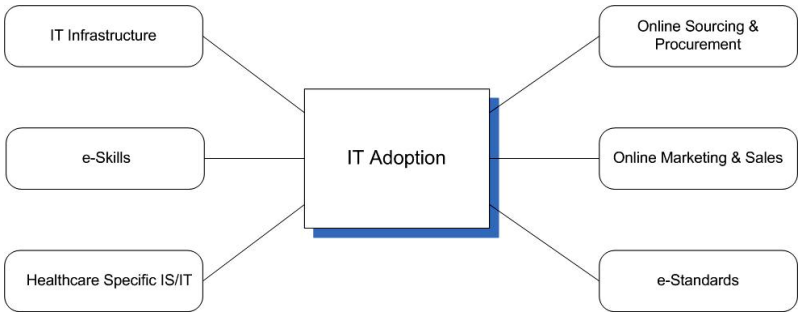

Figure 2: Classification of six hospital IT adoption elements.

sourcing & procurement can be considered a business function that has been significantly digitized, which is described by many authors (Beukers et al., 2006; Kiang et al., 1999). Another aspect that has an influence on the adoption of IT systems is the *readiness of trading partners* which is also included in the framework of Tornatzky & Fleischer. In their study they regard the lack of trading partners as an inhibitor for the adoption of E-Business systems, and with the same rationale we make the assumption that the more ready trading partners there are, the more likely a hospital will be to adopt IT systems. This fact is also denoted in the work of Pare & Sicotte, where the hospitals external partners are included in their framework and are considered an important factor in IT sophistication for the hospital sector.

- Finally one last factor that is becoming increasingly important due to the large number of interacting IT systems is that of *e-Standards*. A number of authors refer to the increasing concern in the use of e-Standards, including Chen, who underlines the importance of integrating different IT systems with other external partners as well as internally (Chen, 2002).

The six elements described above comprise the first part of our conceptual model. The second part of the model consists of a scale that measures each of the 6 elements in terms of actual adoption and maturity level of IT in hospitals. This maturity classification can be considered as the second dimension of our conceptual model that is combined with the first dimension, being the six elements of IT adoption as described above. We measure the maturity of each element on a scale from a situation where no IT or related processes exist within a hospital, to the highest level of IT adoption in which the full potential of IT is leveraged to shape and transform business operations both internally and externally. The graph below shows the two dimensions of our conceptual model and how this stretches the IT maturity field. The dots and line depict an example of a hospitals score using this model. The shape and position of the line indicate both the level and balance of IT maturity.

3.1 Hypotheses

Having constructed the model of IT adoption in hospitals in the previous section, it is possible to make a number of assumptions based on prior research before analyzing the datasets. IT adoption levels within hospitals will be benchmarked over three aspects; the size of the hospital (number of employees and/or beds), the type and ownership of the hospital, and the country in which it operates.

According to earlier studies on adoption by cf. Rogers, it can be expected that large organizations have an inclination to being more innovative when considering IT solutions (Rogers, 1983). For e-business adoption, this is empirically confirmed by e.g. Batenburg & Constantiou (2008) and Teo, Lin and Lai (2009). Consequently, we expect the same for the hospital enterprise.

- *H1. Larger hospitals can be expected to be more innovative, thus having a higher level of IT adoption.*

From past research it can be expected that the various strategies of hospitals types differ (cf. Liedtka, 1992), resulting in different IT adoption levels as is found to apply in organizations of various sectors.

- *H2. Significant differences in IT adoption can be expected between the individual types of hospitals.*

Many country differences within Europe in IT adoption can be found on studies conducted on a range of systems and business domains, consequently we can expect the same to apply for

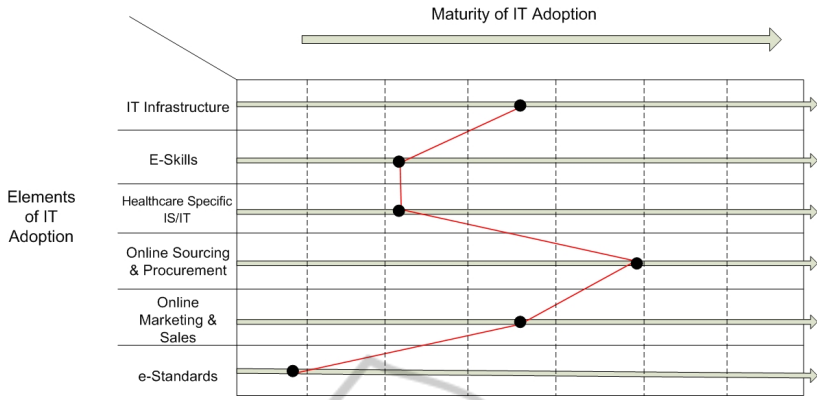

Figure 3: A conceptual model for IT hospital maturity.

hospitals (cf. Selhofer et al., 2008),

- *H3. Significant variations can be expected between countries mean levels of IT adoption.*

4 DATA AND MEASUREMENTS

4.1 Dataset

The survey data used for this paper to empirically validate the conceptual model were collected through the e-Business W@tch project in 2006. This EU-funded project has the aim of studying the impact that e-Business and IT have on a range of business sectors. The data collection was performed through a Computer-assisted telephone interview (CATI) based on a questionnaire which was completed by 834 hospital respondents in 18 European countries. For each hospital one respondent responsible for decisions in the IT field (Head of IT department, Senior in IT department or Manager for smaller hospitals) was asked to answer the survey questions consisting of ten modules as well as some questions about the background of the hospital. The hospitals that are present in the dataset include general health care hospitals as well as specialized health care hospitals.

4.2 Measurements

We measure the six elements of IT adoption in hospitals as described in the conceptual model. In order to measure the maturity level of these elements, a number of questions were selected from the e-Business W@tch questionnaire. Below all elements of the IT adoption model are described by the original survey questions. All questions were coded in the same binary manner for consistency, where one point is assigned to each question answered as *Yes* and no points are assigned in the case where the answer is either *No* or *Don`t Know.*

4.3 Variable Construction

For each element, the maturity score ranges from a minimum of zero points (all answers "*No*" or "*Don`t Know*") to a maximum that depends on the numbers of questions (all answers "Yes").The cumulative score of each element is divided by the total number of questions so that the scale is standardized between 0 (none of the questions is positively answered) and 1 (all of the questions are positively answered). In order to estimate the overall IT adoption level for each hospital, the un-weighted average of all six dimensions is accounted. In all variable constructions we assume that all questions per element, and likewise all elements in accumulation, are of equal importance.

5 ANALYSIS AND RESULTS

The e-Business W@tch dataset contains a vast amount of information to explore the determinants of IT adoption in the hospital enterprise. In this section, the IT adoption and maturity of hospitals is first described based on our conceptual model. Then the variation in IT maturity is analyzed by correlating it with three 'independent' variables, (1) the size of hospitals (i.e. the number of employees and number of beds), (2) their home country and (3) the type of hospital (general health care or specialized health care, and public, non-profit or private). Not only will the overall IT maturity level serve as the dependent variable, also each element of the IT adoption concept will be examined separately,

IT Infrastructure
Q: In what way does your hospital enable remote access? Does it enable remote access via: (1) Fixed line connections, (2) Wireless-Local-Area-Networks or W-LANs, (3) Mobile communication networks, for example by using mobile devices, (4) Virtual private Network (VPN)
Q: I am going to read you a list of network applications. For each, please tell me if your hospital uses this application or not. Does your hospital use:(1) Local Area Network (LAN), (2) Wireless LAN, (3) Voice-over-IP
e-Skills
Q: Does your hospital use e-learning application that is for instance learning material for employees available on an Intranet or on the Internet?
Q: Does your hospital regularly send employees to ICT training programmes?
Healthcare Specific IS/IT
Q: Does your hospital use the following departmental systems: (1) Patient Administration System, (2) Radiology Information System (RIS), (3) Picture Archiving Systems (PACS) and medical image transmission, (4) Pharmacy Management System, (5) Electronic Transmission of Prescriptions, (6) Computerised Physician Order Entry (CPOE)
Online Sourcing & Procurement
Q: Does your hospital use the internet or other computer-mediated networks to place order for goods or services online?
Q: Does your hospital currently support the selection of suppliers or procurement processes by using specific IT solutions?
Q: Which of the following sourcing or procurement related processes does your hospital support by specific IT solutions? Do you use IT solutions for: (1) Finding suppliers in the market, (2) Inviting suppliers to quote prices or submit proposals, (3) Ordering goods or services, (4) Running online auctions
Online Marketing & Sales
Q: Does your hospital have its own website on the internet?
Q: Does your hospital use a CRM system that is specific software for customer relationship management?
Q: Does your hospital allow customers to order goods or book services online from the website or through other computer-mediated networks?
Q: Does your hospital support marketing or sales processes by using specific IT solutions
Q: Which of the following marketing or sales related processes does your hospital support by specific IT solutions? Do you use IT solutions for: (1) Receiving orders from customers, 92) Enabling customers to pay online for ordered products or services
e-Standards
Q: Does your hospital take into account industry specific standards when making decisions on what technology and data standards to use?

Figure 4: The e-business w@tch questions used for measuring for IT hospital maturity.

in relation to the three independent variables. Hence a larger number of correlation analyses can be applied to check stability of results.

By performing a descriptive analysis on the six elements used in the IT adoption model we present *Table 1* below. The first observation is that hospitals have a higher level of IT adoption of *Healthcare Specific IS/IT* in comparison with the other five elements. On average, hospitals tend to have 44% of these applications adopted. In contrast, hospitals have lower adoption rates with regard to *Online Marketing & Sales* and *Online Sourcing & Procurement*. On average only 18% of the questions of this element are positively answered. This shows that most hospitals did not set the step towards external IS/IT application, i.e. the e-business type of investments

5.1 Size and IT Adoption

When exploring hospital size into account as a potential determinant of IT maturity, we examine two elements, (1) the number of employees, as well as (2) the total number of beds that the hospital accommodates. Entries where the respondent did not provide information on the number of employees or beds were excluded. Because of this, the total number of hospitals dropped to 773 with regard to

Table 1: IT Adoption Descriptive Statistics.

	N	Mean	Std. Deviation	Range	Min	Max
IT Infrastructure	834	0.26	0.19	1	0	1
e-Skills	834	0.34	0.37	1	0	1
Healthcare Specific IS/IT	834	0.44	0.29	1	0	1
Online Sourcing & Procurement	834	0.18	0.24	1	0	1
Online Marketing & Sales	834	0.18	0.15	1	0	1
e-Standards	834	0.29	0.24	1	0	1
Overall Adoption Level	**834**	**0.28**	**0.16**	**0.80**	**0**	**0.80**

Table 2: Correlation Analysis: IT Adoption/Absolute number of employees & number of beds.

	Pearson`s Correlation Coefficient	Significance Level	Pearson`s Correlation Coefficient	Significance Level
	Number of Employees (773)		Number of Beds (670)	
IT Infrastructure	0.286	0.000	0.189	0.000
e-Skills	0.245	0.000	0.168	0.000
Healthcare Specific IS/IT	0.275	0.000	0.347	0.000
Online Sourcing & Procurement	0.125	0.000	0.106	0.003
Online Marketing & Sales	0.080	0.013	0.094	0.008
e-Standards	0.268	0.000	0.168	0.000
Overall Adoption Level	**0.344**	**0.000**	**0.290**	**0.000**

Table 3: Level of IT adoption by type of hospital.

	General Health Care (588)	Specialized Health Care (246)	t-value	Difference	Significantly Different
IT Infrastructure	0.27	0.22	3.35	0.05	Yes
e-Skills	0.39	0.25	5.07	0.14	Yes
Healthcare Specific IS/IT	0.47	0.35	5.74	0.12	Yes
Online Sourcing & Procurement	0.18	0.18	0.29	0.00	No
Online Marketing & Sales	0.17	0.17	-0.50	0.00	No
e-Standards	0.29	0.29	0.86	0.00	No
Overall Adoption Level	**0.30**	**0.24**	**4.55**	**0.06**	**Yes**

the absolute number of employees, and to 670 with regard to the absolute number of beds.

The results of (Pearson) bivariate correlations analyses confirm our expectation, both for the number of employees as well as for the number of beds as indicators of hospital size. The correlation analyses were pretested checked by computing the log of both size measurements to control for skewness of distribution. The results remain the same. We can therefore conclude that size significantly matters for the hospital IT adoption and its maturity elements.

5.2 Type of Hospital and IT Adoption

Another relevant characteristic to be studied is the type of hospitals, basically distinguishing general health care and specialized health hospitals, and public, non-profit and private hospitals. Our sample consists of 834 hospitals of which 588 are general health care hospitals and 246 are specialized health care hospitals. In addition, the ownership of the hospitals can be broken down with a total of 821 hospitals of which 361 are public, 101 non-profit and 359 are private. Table 3 and 4 show the results of split sample analysis and significant test of the between group differences.

Results from the paired sample T-Test in Table 3 indicate that general health care hospitals have significant higher IT adoption rates with regard to the elements of IT infrastructure, e-Skills, and Internal & External e-Collaboration as well as for the Overall adoption Level. It appears that these significant differences are spread over the six different elements, confirming the general hospital broadly and generally invest in IT.

Table 4: Level of IT adoption by type of hospital.

	Public (361)	Non-Profit (101)	Private (359)
IT Infrastructure	0.26	0.27	0.25
e-Skills	0.37	0.34	0.32
Healthcare Specific IS/IT	0.46	0.44	0.41
Online Sourcing & Procurement	0.17	0.22	0.17
Online Marketing & Sales	0.16	0.16	0.19
e-Standards	0.30	0.33	0.27
Overall Adoption Level	**0.29**	**0.29**	**0.27**

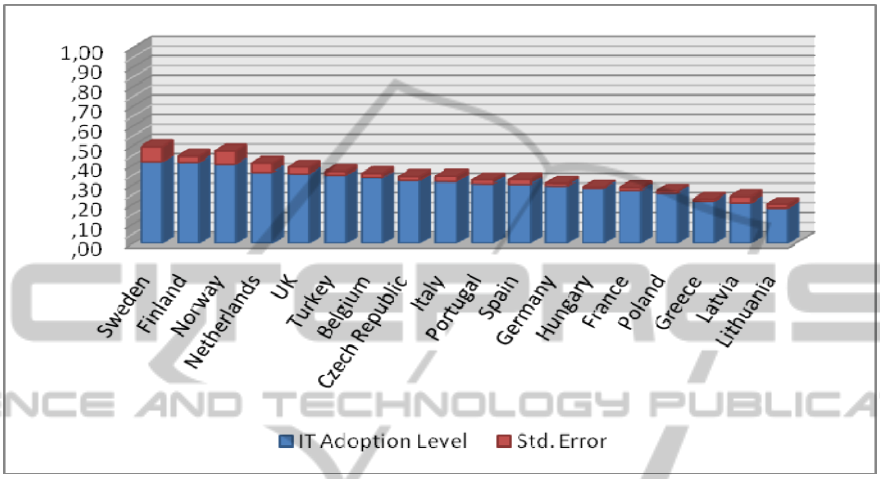

Figure 5: Adoption level of IT in hospitals by country.

Table 4 shows the group averages of the public, non-profit and private hospitals. Results of t-tests on all pairs showed no significant differences in IT adoption level for any group difference. Apparently, the group differences are too small to be significant, indicating that this hospital characteristic is not as important as the distinction between general versus specialized. One interesting observation from Table 4 though, is that private hospitals have lower adoption rates in all elements as well as in overall adoption except for the Online Marketing & Sales element. This might be explained by the need for private hospitals act in a 'competitive' market.

5.3 IT Adoption by Country

Our final analysis concerns the comparison between the IT adoption rates by hospitals for each country. The aim is to identify which countries are front runners of IT adoption in their hospital enterprises, and explore what elements might influence in comparison with other countries. Figure 3 shows the results for the average and overall IT adoption scale, included its standard error by country.

Performing an Analysis of Variance on the dataset, the differences between countries appear to be significant. The highest IT adoption rates are by hospitals from Sweden (0.42), Finland (0.41) and Norway (0.40). The three countries with hospitals that have the lowest IT adoption levels are Lithuania (0.17), Latvia (0.18) and Greece (0.20). The fact that the Scandinavian hospitals are the (relative) frontrunners in IT maturity, complies with a number of studies that indicate their leader position within Europe in terms of 'Networked Readiness Index' (OECD, 2004) as well as in per capita spending in IT (OECD, 2008). However, fully explaining these differences in IT adoption and their underlying reasons is a challenge which a number of scholars have tried to investigate (Batenburg, 2007; Miller et al;. 2006; Van Everdingen & Waarts, 2003).

6 CONCLUSIONS & FURTHER RESEARCH

In this paper we studied the IT adoption of 834 hospitals across 18 European countries and investigated a number of determinants of a hospitals' IT maturity. The study was based on a model we developed for IT adoption in hospitals, consisting of six elements and five maturity levels. The construction of this model was based on both

hospital specific as well as general IT and organizational studies.

Summarizing we conclude that the number of employees of a hospital has a significant positive correlation with the IT adoption level as well as with its elements. Also, hospitals with larger amounts of beds have a significantly higher IT adoption rate, indicating that size strongly matters for IT maturity in the hospital sector.

In addition, the IT adoption levels for different types of hospitals were compared. We found that there is a significant difference between general and specialized health care hospitals with the former having higher overall IT adoption rates. Contrary to our expectation, when comparing between public, non-profit and private hospitals no significant differences were found.

Finally, the cross-country adoption level is analyzed for all 18 countries the responding hospitals are located in. Results indicate that there are large differences between countries, with Scandinavian hospitals having high levels of IT adoption (Sweden, Finland, Norway) compared to hospitals from eastern and south European countries (Lithuania, Latvia, Greece).

Many issues remain to be explored and issued. In particular, the country differences in IT adoption by hospitals are subject for further research. How to identify the reasons that lead this variation of results? How do country differences relate to other factors, both on the country as on the hospital level?

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