Medical Records System Adoption in European Hospitals

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Abstract: Health Care system has had an ongoing focus on improving access to and quality of care, and more recently on cost reduction. The primary mean to achieve these goals has been to change health care policy, as exemplified by the adoption of health information technology in particular the adoption of patient centred information, characterized by the ability to manage comprehensive patience information such as: medical records; appointments scheduling; theatre management and ward reporting. Different terms are used to refer to these systems including the most common: electronic patient record; electronic medical record; computer based patient record and medical records system (MRS). Despite the importance of these systems in health care, little is known about the adoption. This study addresses the existent research gap by analyzing the adoption of MRS in European hospitals. Study data source is the e-Business W@tch 2006 decision maker survey, covering 448 hospitals in the European Union. Additional information related to country wealth indicators, was extracted from the EU official statistics and opinion polls website. Variable choice is based on a derivation from the recently introduced framework know as Human, Organization and Technology fit (HOT-fit) and Technology, Organization and Environment (TOE) framework. Adding the environmental context into the HOT-fit framework, the Human, Organization, Technology and Environment (HOTE) framework is derivate. HOTE framework identifies four contexts that influence information and communication technologies (ICT) adoption: Technology characteristics including equipment but also processes; Organizational context as size, localization and even managerial structure; Human context relating to 'User Involvement'; and Environmental context that incorporate the cultural environment of the country and regulatory influence. In order to reduce the number of variables available, a factor analysis (FA) is performed, using the principal component technique with varimax rotation. Three eigen-value, greater than one are extracted, explaining 69.68% of the variance contained in the data. The three contexts found are: country wealth, competition and technology readiness. To determine the correlation between HOTE framework characteristics and MRS adoption a Logit model is used. For that were used variables obtained from the FA and other variables such as hospital size, education level and research level, gathered directly from the e-business watch survey. MRS adoption is significantly associated with Education Level, Technology Readiness and Country Wealth. Since MRS adoption may be an organization survival strategy for hospitals to improve quality and efficiency while reducing costs, hospitals that are at risk of missing the wave of implementation should be offered incentives that enable them to implement and maintain patient centred information systems.

Keywords: ICT adoption; e-Business, HOTE framework, Hospitals, Factor Analysis, Logit model.

1. Introduction

Healthcare is a sector that is experiencing a significant number of internal, but also external pressures. Progress in medicine and also in information and communication technologies (ICT), are resulting in new methods and new opportunities to support or even enable new types of health care services. The continuously increase of life expectancy, leading to ageing societies, combined with citizen empowerment, stretch the limits of what countries can afford to offer as national health care systems (Daveri 2001, OECD 2004, United Nations 2007). As a result, governments are confronted by the urgent need to find means to limit the rise of healthcare costs without compromising quality, equity and access. The primary mean to achieve these goals has been to change health policy, as the adoption of health information systems (HIS). European Commission Council for health information, stated that "e-Health is today's tool for substantial productivity gains, while providing tomorrow's instrument for restructured, citizen-centered health care systems and, at the same time, respecting the diversity of Europe's multi-cultural, multi-lingual health care traditions. There are many examples of successful e-Health developments including health information networks, electronic health records, telemedicine services, wearable and portable monitoring systems, and health portals." (European Union 2005).

Health information technologies range from simple systems, such as transaction processing systems, to complex ones, such as clinical decision support systems (Yusof *et al.* 2008). One of the most advocated technologies is patient centered information. Patient centered information systems are

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electronic version of patient's information. Different terms are used to refer to these systems including electronic patient record (EPR), electronic medical record (EMR), computer based patient record (CPR) and medical records system (MRS) (Blobel 2000, Chang *et al.* 2007, Kazley and Ozcan 2007). These systems are characterized by the ability to manage comprehensive patience care information such as medical records, appointments scheduling, theatre management and ward reporting. Electronic medical records are "a system that integrates electronically originated and maintained patient-level clinical information derived from multiple sources, into one point of access," and "replaces the paper medical record as the primary source of patient information"(American Hospital Association 2007). United States of America (USA) federal government called 2004 the year for electronic medical records adoption (Thompson and Brailer 2004).

This study addresses the existent research gap by analyzing the adoption of MRS in European hospitals, determining the factors that are associated to MRS adoption. Furthermore this study's implications can guide policy and practice through the identification of specific barriers to hospital MRS use.

2. Theoretical Background

Introduction of health information systems can radically affect health care organizations and health care delivery. However, information technology change has been more rapid outside than within the healthcare industry (Chang *et al.* 2007). Other industries faced the similar transformations and developed theories and methods that are being applied to healthcare (Pfeffer and Salancik 1978, Dasputa *et al.* 1999, Ammenwerth *et al.* 2006).

Several evaluation studies on health information technology adoption highlighted that a large number of adoption problems were attributed to the lack of fit between technology, human and organizational context (Davis 1993, Dishaw and Strong 1999, Goodhue *et al.* 2000, Tsiknakis and Kouroubali 2009). Yusof *et al.* (2008) presented an overview of evaluation models in health information's systems, using human, organizational and technology measures. He developed a new framework based on human, organization and technology-fit (HOT-fit) after having conducted a critical appraisal of the findings of existing HIS evaluation studies (right side of Figure 1). Nevertheless, there are also a number of studies in all industries that point out the importance of the environmental context, upon the adoption of information technology (Chang *et al.* 2007, Oliveira *et al.* 2008). Kazley and Ozcan (2007) explored the environment factors as determinant to EMR adoption.

A review of the literature suggests that the technology, organization, and environment (TOE) framework (Tornatsky and Fleischer 1990) may provide a useful starting point for studying adoption of innovation (Lin and Lin 2008, Zhu and Kraemer 2005). The TOE framework identifies three features of a firm's context that may influence adoption of technological innovation: (1) the technological context describes both the existing technologies in use and new technologies relevant to the firm; (2) the Organizational context refers to characteristics of the organization such as scope and size; (3) the Environmental context is the arena in which a firm conducts its business, referring to its industry, competitors, and dealings with the government. The TOE framework explains adoption of innovation, as can be seen in the left side of Figure 1. The TOE framework has been examined in a number of empirical studies on various information system (IS) domains. It was used to explain electronic data interchange (EDI) adoption (Kuan and Chau 2001). Thong (1999) explained IS adoption and use. Pan and Jang (2008) explained enterprise resource planning (ERP) adoption. This framework was also used to explain e-business adoption (Zhu *et al.* 2003, Zhu and Kraemer 2005, Oliveira and Martins 2010) and use (Lin and Lin 2008, Zhu and Kraemer 2005, Zhu *et al.* 2006). Empirical findings from these studies confirmed that the TOE methodology is a valuable framework in which to understand the adoption of IT innovation.

In order to study the adoption of MRS in European Countries, a derivation from the recently introduced framework know as HOT-fit is applied (Yusof *et al.* 2007). We propose to add the environmental factor into the HOT-fit framework, Human, Organization, Technology and Environment (HOTE) framework was derivate. HOTE framework is a junction of HOT-fit framework (Yusof *et al.* 2008) and TOE framework (Tornatsky and Fleischer, 1990). The proposed framework identifies four aspects that influence ICT adoption: Technology context including equipment but also processes; Organizational context as size, localization and even managerial structure; Human context relating to

'User Involvement'; and Environmental context that incorporate country cultural environment and regulatory influence.

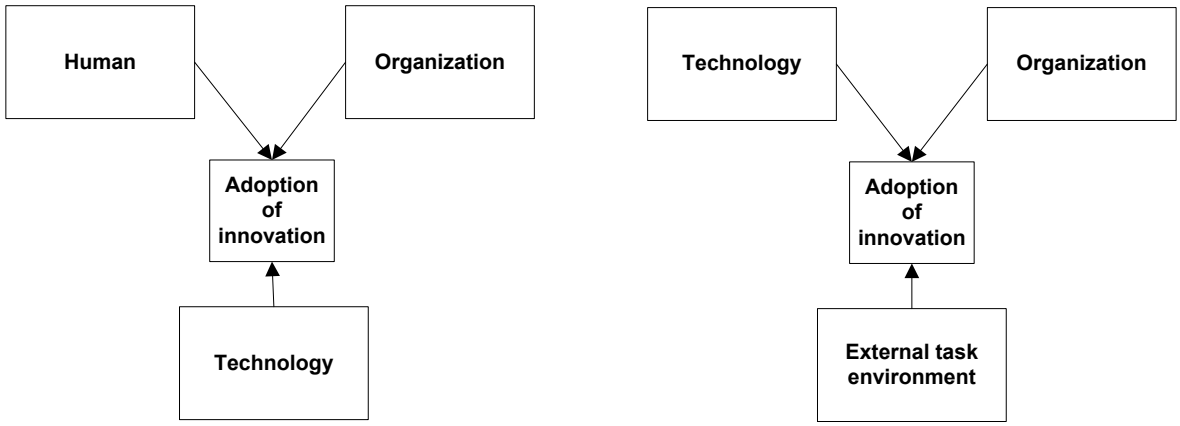

Figure 1: Hot-fit framework (Yusof *et al.*, 2008) and TOE framework (Tornatzky and Fleischer, 1990)

3. Conceptual model and hypotheses

Factors of ICT adoption have largely been discussed in the literature (Ammenwerth *et al.* 2006, Yusof *et al.* 2008, Kazley and Ozcan 2007, Tsiknakis and Kouroubali 2009). In order to study MRS adoption, we introduce a new framework HOTE. HOTE framework identifies four aspects that influence MRS adoption: Technology context; Organizational context; Human and Environmental contexts. According to HOTE framework a conceptual framework for MRS is depicted on Figure 2.

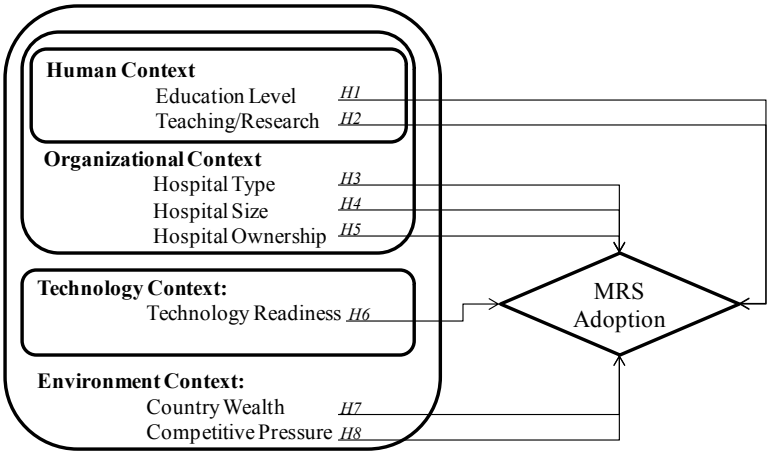

Figure 2: Conceptual Framework for MRS adoption

3.1 Human

Introduction of MRS systems can radically affect health care delivery. Professionals need to adapt themselves to the use of this new technology adoption. This can found many obstacles, depending on individual level attributes as IT Knowledge and training, motivation and openness to new ways of working (Ammenwerth *et al.* 2006). Overall capacity to evaluate technologies opportunities depend primarily on human capital and organization knowledge (Cohen and Levinthal 1989). MRS implementation requires employees with higher education level (Martins and Oliveira 2008).

H1: Hospitals with higher education levels are more likely to adopt MRS;

Teaching hospitals provide a great deal of charity care and medical research, as well as provide the training and educations of many of the nation's health care workforce. According to Retchin and Wenzel (1999), academic health centers can easily adapt to the use of MRS because they "have the expertise to resolve the remaining software issues, the components necessary for the integrated delivery, a culture for innovation in clinical practice, and a generation of future providers that can be acclimated to the requisites for computerized records."

H2: Teaching hospitals are more likely to adopt MRS;

3.2 Organization

In the organizational context, general health care hospitals face a higher degree of competitiveness (Kazley and Ozcan 2007). General hospitals often report higher occupancy rates and more financial and social pressures. A specialized hospital is only option for a specific target, thus not requiring the hospital to compete with others in the environment. Also the amount of inter-departmental information should be much lower comparing to a general hospital were the different services act as isolated islands. For these reasons, is expected that a general hospital would be more likely to take actions, such as MRS adoption to attract patients.

H3: General health care hospitals are more likely to adopt MRS;

Hospital ownership may also guide organizational strategy, based on hospital mission and values. Since MRS adoption is expressed in e-health 2005, as a European priority (European Union 2005), hospitals dependent of public funds may anticipated MRS adoption.

H4: Public hospitals are more likely to adopt MRS;

Organizational size is one of the most studied ICT adoption factors, since size is associated with more financial capability but also adequate human resources (Zinn *et al.* 1997, Kazley and Ozcan 2007). Larger hospitals achieve easily economies of scale and mainly information and resources needed across the organization. Several studies show positive relationship between ICT adoption and organization size (Zhu *et al.* 2003, Pan and Jang 2008). It is expected that larger hospitals tend to adopt MRS.

H5: Larger hospitals are more likely to adopt MRS;

3.3 Technology

Technology readiness (TR) can be defined as hospital technology profile or even hospital technology appetite. Apart from MRS adoption, Hospitals may already use other distinct systems, many times departmental “islands of automation”, that support specific daily activities. MRS integrates electronically originated and maintained patient-level clinical information derived from multiple sources. Literature suggests that integrated technologies tend to enhance performance (Hong and Zhu 2006). Burke *et al.* (2002) reported that hospitals with a higher level of overall IT adoption exhibit a very different profile, especially concerning strategic IT applications. On the other hand, Healthcare industry is a data sensitive industry, and despite all the existing standards and frameworks such as Health Level 7 (HL7), information security is frequented reported as an obstacle to ICT adoption (Gomes and Lapão 2008, ISO/IEC 27001 2005). “Security protection” should be an important influence upon MRS adoption. Therefore, in general is expected that hospitals with greater TR are more likely to adopt MRS.

H6: Hospitals with higher technology readiness are more likely to adopt MRS;

3.4 Environment

Empirical evidence suggests that competitive pressure is a powerful driver of ICT adoption and diffusion (Gibbs and Kramer 2004, Kazley and Ozcan 2007), therefore is expected that the adoption of MRS is influenced by the proportion of surrounding MRS adopters. Under a competitive market, hospitals may be pressured to secure their market share of patients. Under a variety of offers, patients may elect where to go for health care and will likely choose a hospital that offers new or better services such as MRS.

H7: An environment competition increases the likelihood of hospital MRS adoption;

Several studies (American Hospital Association 2007, Kazley and Ozcan 2007) point the cost of implementation as the greatest barrier to ICT adoption. This factor is particular relevant for e-health adoption since, health care industry in Europe is still very dependent of public funds (Forum e-health 2008). Hospitals in areas where the amount of financial resources are more abundant are more likely to have the support for high cost services and technology such as MRS. Balotsky (2005) reported that ‘markets with greater per capita income supported higher hospital cost’.

H8: Hospitals from richer countries are more likely to adopt MRS;

4. Data and methodology

Study data source is the e-Business W@tch 2006, developed by the European Commission, Enterprise & Industry Directorate General to study the impact of ICT and e-business on enterprises, industries and on the economy in general. In spring 2006 e-business watch (http://www.ebusiness-watch.org) conducted the latest decision maker survey that coved 834 hospitals from the 13 000 existent in European Union (EU), using computer-aided telephone interview (CATI) technology. The survey considered only hospitals that used computers and the sample drawn was a random sample of the hospitals in each country.

According to Eurostat recommendations, upon "did not answer" or "does not know" as answer to a specific question, should not imply its imputation, based on operator's answer and consequently final sample include 448 hospitals from 16 European countries: France; Germany; Italy; Poland; Spain; UK; Belgium; Czech Republic; Finland; Greece; Hungary; Latvia; Lithuania; Netherlands; Portugal and Sweden, where 79% of the data collected from Owner, managing director, Head or IT senior member, suggesting high quality of the data source.

In order to consider the environment context present in the adopted framework, additional information from EU official statistics and opinion polls website was used (http://europa.eu/documentation/statistics-polls/index_en.htm). Statistics as percentage of Households with internet access, gross domestic product (GDP) per inhabitant and total spending in research and development (R&D) as percentage of GDP, allowed building what we designate as country wealth indicator. Because Turkey and Norway are not European Union members the above statistics were not available. Consequently these countries were excluded from the analysis.

In order to reduce the number of variables available, a factor analysis (FA) is performed, using the principal component technique with varimax rotation (for further details see Sharma (1996)).

To test the adopted conceptual framework, since the dependent variable is binary (to adopt or not), a logit model is developed. Literature evidences the use of logit model to study the following adoptions: computer-mediated communication technologies (Premkumar 2003), internet (Martins and Oliveira 2008), web site (Oliveira and Martins 2008), e-commerce (Martins and Oliveira 2009) and e-business (Pan and Jang, 2008, Zhu *et al.* 2003). Logit model pretends to estimate the following conditional probability

$$P(y = 1| x) = \Lambda (x\beta) \quad (1)$$

Where y=1 if hospital decided to adopt MRS and zero otherwise; x is the vector of explanatory variables, β the vector of estimated parameters and Λ (.) is the standard logistic cumulate distribution.

5. Results

To reduce the number of variables available (variables used in the analysis are described in Appendix), a FA is performed, using principal component technique with varimax rotation. The variables used in the analysis are described in Table 1.

Three eigen-value, greater than one are extracted, explaining 69.68% of the variance contained in the data. The three factors found are: country wealth, competitor and technology readiness (Table 2). Kaiser-Meyer-Olkin (KMO) that measures sample adequacy is 0.79, which can be considered good (Sharma 1996). Individual KMO is also adequate, since all factors have a loading greater than 0.50. The analysis employs a well-explained factor structure.

When items are positively, but imperfectly correlated, a scale enjoys a substantial improvement in reliability over a single item. Reliability is the consistency of a set of items that make up a scale. All three factors have a composite reliability over the cut-off of 0.70, as suggested by Straub (Straub 1989).

Table 1: Description of item used in FA

Indicator	Description
Country Wealth Indicator	
GDP	Gross Domestic Product per inhabitant (in PPS)
% Household net access	% of households connected to the internet
RDP	Total spending on R&D as a percentage of GDP
Competition	
	Why did you hospital decide to engage in e-business activities? (0 = not at all; 1= not important; 2= important)
Competitors	Because your competitor also engage in
Health Insurance Funds	Because your health insurance funds expected
Get edge over	Because your hospital believes that e-business will help to get an edge over your competitors
Technology Readiness	
	Sum of the following applications :
Nº Online Applic	Does your hopsital use online applications other then e-mail: share documents; track working hours;
Nº Support Applic	Does your hospital have: Intranet; Own website; Online services and orders; Radio Frequency Identification (RFID);
Nº Network Applic	Does your hospital use the following network applications: Local area network (LAN); Wireless LAN; Voice-over-IP
Nº Depart Systems	Does your hospital use the following departmental systems: Patient Administration System; Radiology Information Systems; Medical Image Transmission; Pharmacy mgt system; Electronic transmission of prescriptions; Computerized Physician Order Entry
Nº Sec Applic	Does your hospital have: HL7 standards; secure server technology; firewall
	Sum of the following (0= do not know what this is; 1= no; 2= yes)
ICT Training	Does your hospital regulary send employees to ICT training? Does your hospital use e-learning applications?

Table 2: Factor and Validity Analysis

Item Measured	Factor			Composite reliability
	1	2	3	
Country Wealth Indicator				**0,93**
GDP	-0,05	**0,81**	0,23	
% Household net access	0,08	**0,80**	0,09	
RDP	0,00	**0,96**	0,15	
Competition				**0,95**
Competitors	**0,92**	0,00	0,09	
Health Insurance Funds	**0,88**	0,05	0,09	
Get edge over	**0,88**	0,00	0,16	
Technology Readiness				**0,77**
Nº Online Applic	0,14	0,18	**0,54**	
Nº Support Applic	0,21	0,25	**0,50**	
Nº Network Applic	-0,01	0,05	**0,55**	
Nº Depart Systems	-0,02	-0,02	**0,75**	
Nº Sec Applic	0,17	0,21	**0,57**	
ICT Training	0,06	0,06	**0,50**	
Eigen Value	**3,77**	**2,46**	**1,77**	
% Variance Explained	**31,44**	**20,52**	**17,72**	

Table 3 resumes explanatory variables used to determine the probability of hospital's MRS adoption, through a logit model.

Table 3: Explanatory variables description

Variable	Description
Human	
Education Level	% of employees with university degree
R&D	Number of employees conducted research and development
Organizational	
Hospital Type	Categorical variable, indicating hospital type (0= specialized 1= general)
Nº beds	Hospital capacity/dimension measured by number of beds
Ownership	Categorical Variable concerning hospital ownership (0= refuse 1=private 2= public/non-profit)
Technological	
Technological Readiness	FA index built upon hospital technological appetite
Environmental	
Country Wealth Indicator	FA index built upon country economic variables such as GDP, R&D, %Internet Access
Competition	FA index built upon hospital engage ICT drivers

Logit model results are summarized on Table 4. Due to the existence of missing values only 448 observations were used. Estimation results show that, at 5% significance level only Education Level, TR and Country Wealth are positively associated with MRS adoption. Goodness of fit is measured in two ways: first through the log likelihood test that reveals global significance and finally the discriminate power of the model is assessed, by the area under the curve that is equal to 76%, revealing a good discrimination. There is evidence to accept the significance of the model.

Table 4: Logit model for MRS adoption

Variable	Coefficients		Standard Error	P-value
Human				
Education Level	0,010	**	0,000	0,030
R&D	0,020		0,010	0,139
Organizational				
Hospital Type	-0,187		0,240	0,436
Nº beds	0,000		0,000	0,550
Ownership	0,178		0,250	0,484
Technological				
Technological Readiness	0,946	**	0,160	<0,0001
Environmental				
Country Wealth Indicator	0,303	**	0,130	0,016
Competition	-0,013		0,120	0,912
Likelihood Ratio	**93,28**			**<0,000**
Area Under the curve (AUC)			**0,7557**	
Sample Size			**448**	

** Significant at 5%

Figure 3 resumes the influence of each of the significant variables into MRS adoption probability. Making each of the significant variables range from minimum to maximum observed value and keeping the other variables at the average value, it is possible to estimate the influence of each significant variable on MRS adoption probability. The slope of each of the curves obtained, show the influence on MRS adoption probability. From Figure 3 we can conclude that Technology Readiness has the strongest impact on hospital MRS adoption.

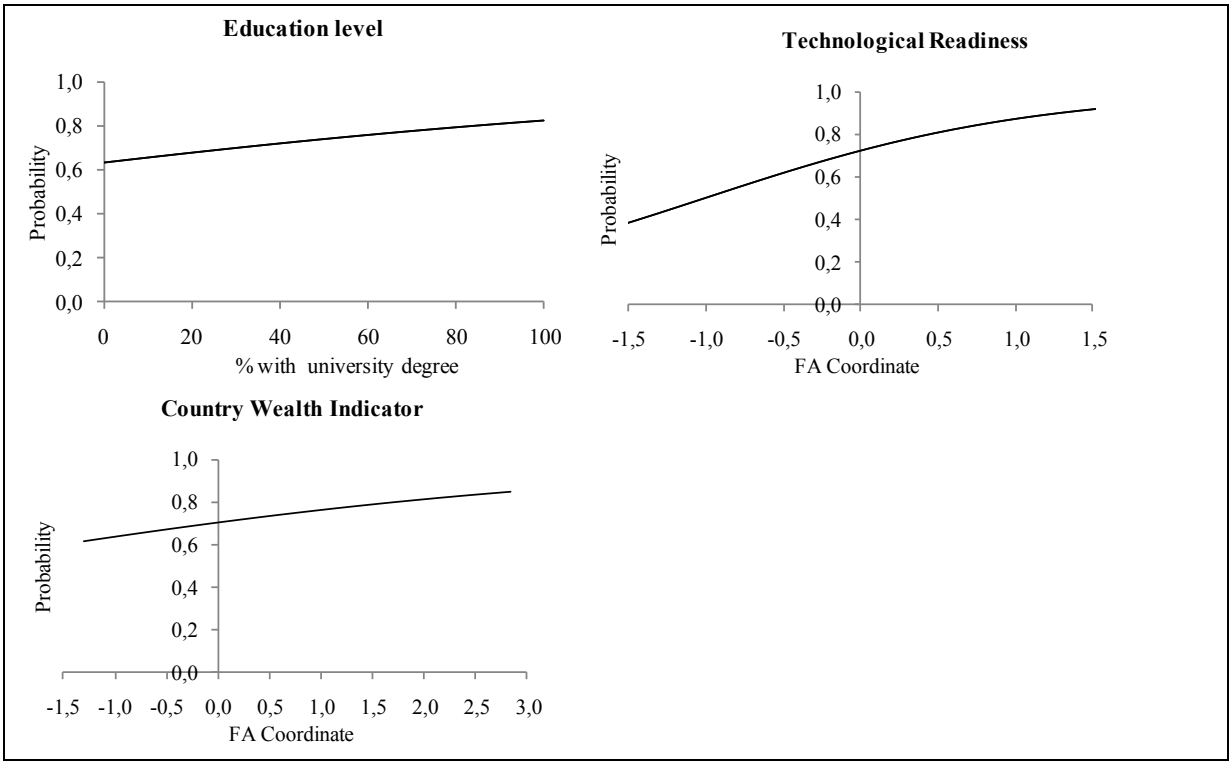

Figure 3: Influence of each of the significant variables on MRS adoption probability

6. Discussion

Finding 1: Organizational context do not influence MRS adoption;

The research framework confirms some findings from previous studies in identifying critical factors affecting a hospital ICT adoption. From the four contexts identified (Human; Organizational; Technology and Environment), this study disagrees on the Organizational context, concluding that MRS adoption is significant associated with Human, Technological and Environmental contexts.

Finding 2: Hospitals with higher TR are more likely to adopt MRS;

This finding is based on the estimated logit model. TR proven to be the most significant variable. TR can be defined as hospital's technological appetite, since this indicator includes other existing systems, networks, security and also ICT training. This finding is consistent with the literature (Burke *et al.* 2002, Chang *et al.* 2007, Martins and Oliveira 2008). The possible reason is that MRS integrates electronically originated and maintained patient-level clinical information derived from multiple sources. Also the existence of different applications across the organization, make the acceptance of a new system much easier. Furthermore a hospital with TR equal to 1.5 (maximum value for study samples) has 90% probability of MRS adoption.

Finding 3: Hospitals from richer countries are more likely to adopt MRS;

Country Wealth is positively associated with MRS adoption (Table 3). More, a hospital from the wealthiest country has 80% change of MRS adoption. MRS have heavy acquisition and implementation costs, but also the maintenance costs are something that hospital's need to considered into their expensive lines. This finding is concordance with literature (Kazley and Ozcan 2007).

Finding 4: Hospitals with higher education levels are more likely to adopt MRS;

According to the estimated model (Table 3), education level is positively associated with MRS adoption. This conclusion is in line with literature (Chang *et al.* 2007, Kazley and Ozcan 2007, Martins and Oliveira 2008). Hospitals are formed by a specific group of professionals with specific training, that not necessary include ICT training and despite the mental image that hospital stands for doctor and nurses, this is not the reality (Lapão 2005). The majority of hospital's employees are medical auxiliary that do not have necessary a university degree.

Finding 5: Teaching hospitals may be more likely to adopt MRS

R&D variable is in the frontier of significance (Table 3), with 13% significance level so we cannot exclude this factor so determinant, especially if we consider that education level is a significant variable. In theoretical terms, hospitals with a higher level of research employees should also present a higher education level and higher technology profile (Retchin and Wenzel 1999).

Finding 6: Hospital size does not influence MRS adoption;

Surprise may arise from hospital size, since is frequently appointed as an important adoption factor (Chang *et al*. 2007, Kazley and Ozcan 2007). Nevertheless, literature revision in other industries points this variable "controversial" predictor for IT adoption. However, larger organizations have multiple levels of bureaucracy and this can impede decision-making processes regarding new ideas and projects (Hitt *et al.* 1990, Whetten 1987). Moreover, e-business adoption often requires close collaboration and coordination that can be easily achieved in smaller organizations. There is also empirical evidence against this positive relationship (Martins and Oliveira 2008, Oliveira 2008, Zhu *et al.* 2006). The advantage of the availability of funds being greater for large firms (Iacovou *et al.* 1995, Rogers 2003) does not prevail, nor does the disadvantage of larger firms having multiple levels of bureaucracy, which can impede decision-making processes regarding new ideas and projects (Hitt *et al.* 1990, Whetten 1987). Martins and Oliveira (2008) concluded that firm size is only relevant for simple technologies adoption, becoming irrelevant upon complex technologies.

7. Conclusions

Within the context of an e-health policy in Europe that advocates the use of ICT in health care industry, this study fills a gap in the literature by analysing adoption factors. Theoretical framework incorporates the factors identified on previous studies, identifying four adoption factors: Human; Organizational; Technological and Environmental. Using a sample from hospitals across EU, estimation results show that MRS adoption is positively associated with Education Level, TR and Country Wealth, excluding the organizational factor. Hospitals are a particular organization where human aspect overlaps the organizational, becoming the factor in MRS adoption.

If hospitals are more likely than other to adopt MRS based on Human, Technological and Environment characteristics, it is possible that these significant variables represent barriers to MRS utilization to some hospitals. According to this study hospitals from poor countries, with poor technology readiness and lower education levels are less likely to adopt MRS. Since MRS is one of the most advocated technologies, for hospital performer booster, improving quality and efficiency, policy makers should take steps to encourage the adoption, by creating specific financial support, or even greater financial reimbursement to hospitals the use MRS. Additional, provide proper programs that aid hospital implementing and also teaching employees to use MRS systems.

This study makes an important theoretical contribution, since it allows excluding Organizational context as an important context to MRS adoption. Nevertheless this conclusion needs to be assed upon other e-health systems. For future research, a theoretical framework based on three contexts: Human, Technology and Environment (HTE) should be applied in order to understand Hospital ICT adoption.

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