CENTERIS 2014 - Conference on ENTERprise Information Systems / ProjMAN 2014 - International Conference on Project MANagement / HCIST 2014 - International Conference on Health and Social Care Information Systems and Technologies

Exploring the determinants of PAS, EDMS, and PACS adoption in European Hospitals

Elsa Fontainha[a]*, Jorge Tiago Martins[b], Ana Cristina Vasconcelos[b]

[a]*ISEG Department of Economics, Universidade de Lisboa University of Lisbon, Rua Miguel Lupi, 20 - Office n. 514, 1249-078 Lisboa, Portugal*
[b]*Information School, The University of Sheffield, Regent Court – 211 Portobelo Street, Sheffield S1 4DP, United Kingdom*

Abstract

Using data available in two microdatabases - the e-Business Watch survey 2006 and the European Hospital Survey (2012-2013) – the study reported in this paper explores the determinants that lead to the adoption of three of the most commonly used Health Information Systems (HIS) in European Hospitals: Patient Administration Systems (PAS), Electronic Documents Management Systems (EDMS), and Picture Archiving and Communication Systems (PACS). For statistical analysis and modeling purposes, the original variables in the two surveys were transformed into binary variables. In order to explore the determinants of system adoption, Probit models were built taking into consideration the following explanatory variables or predictors: public ownership; hospital size; and human resources allocated to Research and Development. It has been found that being a public hospital, particularly in recent years, has a negative impact on HIS adoption. Hospital size is one of the main positive predictors of HIS adoption. The impact of human resources allocated to R&D is also a determinant of HIS adoption, but less so in recent years.

Keywords: Health Information Systems; Hospitals; Adoption; Determinants; Europe; Patient Administration Systems; Electronic Documents Management Systems; Picture Archiving and Communication Systems

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* Corresponding author. Tel.: +351 213 925 993; fax: +351 213 922 808
 E-mail address: elmano@iseg.ulisboa.pt

1. Introduction

Being critical components of modern societies [1], health systems - whether public, mixed, or distributed among private participants - are under growing pressure to adopt Health Information Systems (HIS) that can help fulfill a variety of performance indicators such as clinical quality, cost awareness, service reach and access, and service efficiency [2-6].

Also at the core of these concerns is the concept of patient-centred healthcare delivery, understood as care which:

> "*a)* explores the patients' main reason for the visit, concerns, and need for information; *(b)* seeks an integrated understanding of the patients' world—that is, their whole person, emotional needs, and life issues; *(c)* finds common ground on what the problem is and mutually agrees on management; *(d)* enhances prevention and health promotion; and *(e)* enhances the continuing relationship between the patient and the doctor" [7].

Keeping to these principles implies that healthcare providers must ensure the availability of reliable patient information [8] and the deployment of effective Information Systems and Information Technology [9] that capture, store, retrieve and transmit information related to patients.

This endeavor can be challenging in rapidly changing hospital environments, and requires a careful alignment of Information Systems and Information Technology with hospitals' business strategies, goals and objectives [10-12].

Focusing specifically on the context of European hospitals, this paper aims at exploring the determinants that lead to the adoption of three of the most common HIS: Patient Administration Systems (PAS), Electronic Documents Management Systems (EDMS), and Picture Archiving and Communication Systems (PACS). These systems are also representative of an evolutionary perspective concerning the development of technological solutions that facilitate the systematic processing of data, information and knowledge in health care.

To avoid terminology ambiguity, PAS are systems that manage and record "patient identification, admissions, bookings and discharge" [13]. PAS typically provide a "master index of patient demographics (name, date of birth, sex, address, PAS number, NHS number)" [14] and hold information concerning patients' location and responsible consultants during specific clinical episodes. Furthermore, PAS usually shape the platform upon which EDMS are developed. EDMS are systems that "that enable patients' clinical paper notes to be scanned onto an electronic document allowing access by an authorised user on a hospital computer" [15]. Finally, PACS are "workflow-integrated imaging system[s] designed to streamline operations throughout the entire patient-care delivery process" [16]. PACS are used to digitally acquire medical images (e.g. X-ray, magnetic resonance imaging, ultrasound, etc.) that are subsequently stored in central data repositories to enable processing, analysis and interpretation by clinicians.

The European Commission decisions and recommendations on health policy stress the role of ehealth tools [17-19] and consider that the technology and information management are drivers of the pace of change in redesigning health in Europe for 2020[17].

2. PAS, EDMS and PACS adoption in European Hospitals

2.1. Databases and samples

The results of the empirical study reported in this paper are based on data available in two micro databases: the e-Business Watch survey 2006 (e-BW) [20] and the European Hospital Survey (2012-2013) (EHS) [21]. The e-Business Watch supported the work of the European Commission's Enterprise and Industry Directorate General in the field of ICT and contain a sub-set of questions that address specifically the activities of hospitals.

The total samples are: 834 hospitals in the e-Business Watch survey and 1753 hospitals in the European Hospital Survey. Both databases have significant missing information (e.g. hospital size measures such as the number of employees or the number of beds). As a consequence, some calculations will not include all of the hospitals that have been surveyed. Only medium-size and large hospitals - respectively employing between 50-249 employees and 250

or more employees - are analised. Also as a result of missing information for some explanatory variables, the application of the probit models is based on smaller samples.

The two questionnaires have different content. e-BW 2006 was originally applied to several sectors of activity and generally aimed at collecting information on ICT infrastructure, e-skills development and outsourcing, ICT expenditure and investments, internal and external e-collaboration, online sourcing and procurement, online marketing and sales, ICT impacts, drivers and inhibitors, and innovation activity of the hospital or company. EHS 2012-2013 focuses mainly on aspects of ehealth, with a comparatively higher level of detail. However, questions of general scope such as hospital growth, financial position or strategic direction are missing in the latter.

The specific questions focusing on the use of PAS, EDMS and PACS in the two surveys are presented in Table 1. For statistical analysis and modeling purposes, the original variables were transformed into binary variables: value 1 represents the adoption of a given HIS, and value 0 represents the non-adoption of such HIS.

Table 1. Survey Questions, e-BW 2006 and EHS 2012-2013

e-BW 2006	EHS 2012-2013
PAS: "Does your hospital use the following departmental systems? Do you use Patient Administration system?" Alternative answers: "yes; no; do not know."	*PAS*: "How are you currently managing the following services? Recording and storage of patient's medical digital data or other clinical data". Alternative answers: "Not chosen; Currently managed in-house; Question skipped"
EDMS: "Does your hospital use any of the following systems or applications for managing information in the hospital? Do you use a Medical Records Management system? Alternative answers: "yes; no; do not know."	*EDMS*: "Which type of Electronic Medical Records (EMRs)/ Electronic Health Records (EHRs)/ Electronic Patient Records (EPRs) does your hospital mainly use?" Alternative answers: "Hospital-wide EMR/EHR/EPR shared by all clinical services; Multiple loc/dept EMR/EHR/EPR, which share information; Multiple loc/dept EMR/EHR/EPR, not sharing information; No EMR/EHR/EPR systems used in the hospital; Don't know; Question skipped.
PACS: "Does your hospital use the following departmental systems? Do you use Picture Archiving Systems (PACS) and medical image transmission?" Alternative answers: yes; no; do not know.	*PACS*: "Does the hospital use a Picture Archiving and Communication System (PACS)?" Alternative answers: "Yes; No; Don't know; Question skipped"

Source: e-BW 2006 and EHS 2012-2013 Questionnaires.

2.2. Frequency of adoption of PAS, EDMS and PACS

Tables 2 and 3 reveal that PAS are adopted by a large share of hospitals (87% in 2006 and 91% in 2013). However, in 2006 less than one third of the hospitals (29%) combined the use of three HIS (PAS, EDMS and PACS). The percentage of combined use of the three types of HIS doubles in 2012-2013 (60%).

Table 2. Europe: PAS, EDMS and PACS adoption (Frequency %) , 2006 (source: e-BW)

	N. of Hospitals (valid answers)	Frequency of Adoption
PAS	471	87 %
EDMS	469	70 %
PACS	467	36 %
PAS & EDMS & PACS	467	29 %

Table 3. EU27+3: PAS, EDMS and PACS adoption (Frequency %), 2012-2013 (source: EHS)

	N. of Hospitals (valid answers)	Frequency of Adoption
PAS	1276	91 %
EDMS	1243	85 %
PACS	1266	71 %
PAS & EDMS & PACS	1243	60 %

2.3. HIS adoption and HIS implementation profile in Portugal (2006 and 2012-2013)

A finer-grained level of analysis reveals that Portugal exhibits a higher level of HIS adoption when compared with the global results for Europe (Table 4 vs. Table 2 and Table 5 vs. Table 3). Additionally, Radiology Information Systems (RIS), Pharmacy Management System (PMS), Electronic Transmission of Prescriptions (ETP) and Computerised Physician Order Entry (CPOE) are adopted in 2006 by half or over half of the Portuguese medium-sized and large hospitals (Table 4). However, in 2010 and 2012, Portugal's HIS implementation profile, according to different indicators, did not differ significantly from EU27+3 [21:188]. Finally, the evolution from 2010 to 2012 reveals a decrease of PACS usage and hospital-wide EMR/EHR/EPR shared by all clinical services in 41 acute hospitals. The acute hospitals are the hospitals where survey respondents consider that "the hospital was an acute or general hospital and in case they did not, whether they reported that the hospital had an emergency department, and at least one of the following: a) routine and/or life-saving surgery operating room; and/or b) an intensive care unit"[21]. Considering all the results obtained from EHS (13 eHealth indicators derived from the specific answers to the questionnaire) the eHealth profile of Portugal is close to the EU27+3 mean, being 'ePrescribing' in Portugal 48% above the mean and 'Broadband > 50Mbps' 30% above the mean [21].

Table 4. Portugal: ehealth tools adoption (Frequency %) , 2006 (source: e-BW)

	N. of Hospitals Medium and Large (valid answers)	Frequency of Adoption
PAS	37	92 %
EDMS	37	62 %
PACS	36	50 %
PAS & EDMS & PACS	36	31 %
RIS	36	50 %
PMS	39	89 %
ETP	37	51 %
CPOE	37	65 %

Table 5. Portugal: PAS, EDMS and PACS adoption (Frequency %), 2012-2013 (source: EHS)

	N. of Hospitals Medium and Large (valid answers)	Frequency of Adoption
PAS	29	97 %
EDMS	28	100 %
PACS	29	79 %
PAS & EDMS & PACS	28	79 %

3. Exploring HIS adoption determinants using two micro databases: e-BW 2006 and EHS 2012-2013

In order to explore the determinants of the PAS, EDMS and PACS adoption Probit models were built taking into consideration the following explanatory variables or predictors: public ownership (*Public*); hospital size measured by two categories: medium (50-249 employees) or large (50 or more employees) (*Size*); and human resources allocated to Research and Development (*R&D HR*). This short list of explanatory variables results from the use of two different data sources with relatively few equivalent/comparable variables.

The ownership of the hospital (public or private) is interesting to study in separate because the current management and investment decisions in a public hospital and a private hospital are taken through different processes, levels of decision, financial restrictions criteria and legal framework. This also explains the inclusion of this specific question in both surveys and the correspondent analysis [20-21]. A debate about public hospital management and organizational performance can be found in [22] and the importance of individual, organizational, and contextual factors on hospital adoption of innovations is stressed in [23].Several studies conclude about the positive relation between the hospital size and the adoption of innovations [23-26].

The results obtained from Probit models show that the hospital size affects positively the adoption of hospital size was found to positively affect in particular the adoption of PACS and the combined adoption of PAS, EDMS and PACS (see the marginal effects and significance levels in the last column in Tables 6 and 7). Being a large hospital increases by 20% the probability of adopting the three HIS together in 2006 and by 36% in 2012-13. Comparing large hospitals with medium-sized hospitals, the probability also increases for PACS implementation from 22% in 2006 to 30% in 2012-2013. In recent years the adoption of EDMS also increases with hospital size (18%).

Being a public hospital has a negative impact on HIS adoption: in 2006 PAS probability decreases by 11%; and in 2012-2013 EDMS decrease by 4%. PACS and simultaneous use of the three HIS decrease by 11%. The positive impact of human resources allocated to R&D is relevant in general and leads to HIS adoption, but less so in recent years.

Table 6. Marginal Effects after Probit, PAS, EDMS and PACS; Europe 2006 (source: e-BW)

	Model PAS	Model EDMS	Model PACS	Model PAS & EDMS & PACS
Public	-.1068862***	-.0175694	-.04068	-.0287429
	(.03536)	(.0482)	(.05318)	(.05049)
Size	.0794957**	.0789379	.2215951***	.1946143***
	(.03695)	(.05021)	(.05313)	(.05012)
R&D HR	.0025744*	.003888**	.0047772***	.0044266***
	(.00147)	(.00167)	(.00158)	(.00143)
Number of observations	376	376	374	367
LR chi2(3)	17.90	12.53	41.23	40.95
Prob > chi2	0.0005	0.0058	0.0000	0.0000
Log likelihood	-151.02678	-228.43428	-213.3179	-188.3375
Pseudo R2	0.0559	0.0267	0.0881	0.0981

Significance levels are: *** (1%), **(5%), * (10%).

(a) Marginal effects are for discrete change of the dummy variable from 0 to 1

Table 7. Marginal Effects after Probit, PAS, EDMS and PACS; EU27+3 2012-2013 (source: EHS)

	Model PAS	Model EDMS	Model PACS	Model PAS & EDMS & PACS
Public	.0065958	-.0364882*	-.1129457***	-.1093229***
	(.01894)	(.02161)	(.02838)	(.03317)
Size	.0211568	.1800637***	.2996143***	.3591767***
	(.01926)	(.0225)	(.03179)	(.03719)
R&D HR	3.60e-10	-5.33e-10	-2.92e-09**	-3.39e-09**
	(.00000)	(.00000)	(.00000)	(.00000)
Number of observations	1249	1216	1239	1208
LR chi2(3)	1.82	64.59	101.01	104.02
Prob > chi2	0.6112	0.0000	0.0000	0.0000
Log likelihood	-376.0118	-482.75943	-698.83741	-764.42368
Pseudo R2	0.0024	0.0627	0.0674	0.0637

Significance levels are: *** (1%), **(5%), * (10%).

(a) Marginal effects are for discrete change of the dummy variable from 0 to 1.

4. Discussion, conclusions and future work

The digital future for healthcare is patient-centred. At the present, health care services supported by HIS respond mostly to recording, retrieving and reporting of information rather than to more advanced clinical purposes (e.g. consultations online). Hospitals face several barriers that hinder the implementation of HIS, ranging from deficiency of interoperability to absence of regulatory framework and human and material resources [18].

There is a need to improve the depth and breadth of knowledge available on the determinants and critical success factors of HIS adoption. Quantitative analysis such as the one reported in this paper contributes a refined evidence-based focus for the further development of qualitative analysis on e-health implementation. A recent literature review [26] identifies the main ehealth domains: management systems; communication systems; information systems; and decision support systems. The results presented in this paper show that some HIS have not yet achieved widespread implementation, particularly in medium-sized hospitals. There is a slow adoption of ehealth in routine care and the potential benefits can increase with higher transparency and accessibility to health records, for example combining personal health records with home monitoring devices and sensors [27]. Patient health status and information needs can act either as stimuli or obstacles of public engagement with ehealth services [28]. Consequently a complete study of ehealth implementation and use must address supply and demand issues.

The empirical analysis reported in this paper reveals that one of the main positive predictors of the use of HIS is hospital size. Size also matters for European firms' adoption of Enterprise Information Systems (EIS) [29]. Being a public hospital, in particular in recent years, has a negative impact on HIS implementation in Europe. Further research should examine if this finding is potentially related to the effects of the financial crisis and austerity in Europe's public health sector [30]. This could be done following a longitudinal approach by country clusters and including contextual variables.

Finally the study reported in this paper is not without limitations. First, the difficulty of comparing results obtained from two databases/questionnaires, one of which lacking data on the human and economic context of ehealth implementation in each hospital. Second, data for 2006 was extracted from a general questionnaire administered to European firms where Hospitals are one of the sectors considered. This was also done previously [31]. Third, whilst EDMS is one of the top HIS addressed in the ehealth literature [32], the data available has not lead to a complete explanation of EDMS adoption determinants. Finally, the scope and size of this paper does not allow to evaluate the level of maturity of information systems and technologies in Portuguese hospitals [33].

References

[1] Calltorp J. How can our health systems be re-engineered to meet the future challenges? The Swedish experience. Social Science & Medicine 2012; 74:677-679

[2] Chiasson M, Reddy M, Kaplan B, Davidson E. Expanding multi- disciplinary approaches to healthcare information technologies: what does information systems offer medical informatics? International Journal of Medical Informatics 2007, 76:S89–S97.

[3] Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E, Morton S, Shekelle P. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. Annals of Internal Medicine 2006; 144:742–752.

[4] Jha A, Doolan D, Grandt D, Scott T, Bates D. The use of health information technology in seven nations. International Journal of Medical Informatics 2008; 77:848–854.

[5] Haux R. Medical informatics: past, present, future. International Journal of Medical Informatics 2010; 79:599–610.

[6] Mullner RM, Chung K. Current issues in health care informatics. Journal of Medical Systems 2006; 30:1–2.

[7] Stewart M. Towards a global definition of patient centred care. British Medical Journal 2001; 322:444–445.

[8] Aarts J, Peel V. Using a descriptive model of change when implementing large scale clinical information systems to identify priorities for further research. International Journal of Medical Informatics 1999; 56: 43-50.

[9] Cunningham SG, Wake DJ, Waller A, Morris, AD. Definitions of eHealth. In: Gaddi A, Capello F, Mancan, M, editors. eHealth, Care and Quality of Life. Berlin: Springer, 2014. p. 15-30.

[10] Lenz R, Kuhn, KA. Towards a continuous evolution and adaption of information systems in healthcare. International Journal of Medical Informatics 2004; 73:75–89.

[11] Maij LE, Toussaint PJ, Kalkshoven M, Poerschke M, Zwetsloot- Schonk JHM. Use case and DEMO: aligning functional features of ICT-infrastructure to business processes. International Journal of Medical Informatics 2002; 65:179–191.

[12] Bush M, Lederer A, Li X, Palmisano J, Rao S. The alignment of information systems with organizational objectives and strategies in health care. International Journal of Medical Informatics 2009; 78:446–456.

[13] Car J, Black A, Anandan C, Cresswell K, Pagliari C, McKinstry B, Procter R, Majeed A, Sheikh A. The impact of eHealth on the quality and safety of healthcare. A systematic overview and synthesis of the literature. NHS Connecting for Health Evaluation Programme, May 2008. Available from: http://www.ehealthnews.eu/content/ view/1209/62/ (Accessed April 2014).

[14] The Royal College of Radiologists. A practical guide to implementing Ordercomms and electronic remote requesting in radiology. London: The Royal College of Radiologists, 2014.

[15] Kain N, Koshy O. Electronic document management systems: benefits and pitfalls. British Journal of Healthcare Management 2013; 19:173-177.

[16] Huang HK. Some historical remarks on picture archiving and communication systems. Computerized Medical Imaging and Graphics 2003; 27:93–99.

[17] European Union. eHealth Task Force Report –Redesigning health in Europe for 2020 2012; Luxembourg : Publications Office of the European Union.

[18] European Commission. eHealth in the EU: what's the diagnosis?. Press Release 2014; Brussels: 24.3.2014.

[19] European Commission. On effective, accessible and resilient health systems. Communication from the Commission 2014; Brussels: 4.4.2014 COM(2014) 215 final.

[20] European Commission. E-Business Watch. http://ec.europa.eu/enterprise/archives/e-business-watch/about/methodology.htm

[21] Sabes-Figuera, Ramon. European Hospital Survey:Benchmarking Deployment of e-Health Services (2012–2013) 2013; Seville: European Commission Joint Research Centre, Institute for Prospective Technological Studies.

[22] Anderson, Stuart. Public, private, neither, both? Publicness theory and the analysis of healthcare organisations. Social Science & Medicine 2012; 74 (3) : 313-322.

[23] Kimberly, John R., Evanisko, Michael J.. Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations." Academy of Management Journal. 1981; 24 (4): 689-713.

[24] Burke, D. E., Wang, B. B. L., Wan, T. T., Diana, M. L. Exploring hospitals' adoption of information technology. Journal of Medical Systems. 2002; 26(4): 349-355.

[25] Adler-Milstein, Julia, Jordan Everson, Lee, Shoou-Yih D. Sequencing of EHR adoption among US hospitals and the impact of meaningful use.Journal of the American Medical Informatics Association. 2014; amiajnl-2014.

[26] Mair FS, May C, O'Donnell C, Finch T, Sullivan F, Murray E. Factors that promote or inhibit the implementation of e-health systems: an explanatory systematic review. Bulletin of the World Health Organization. 2012;90(5):357-64.

[27] Wicks P, Stamford J, Grootenhuis MA, Haverman L, Ahmed S. Innovations in e-health. Quality of Life Research. 2014;23(1):195.

[28] Hardiker, Nicholas R., and Maria J. Grant. Factors that influence public engagement with eHealth: a literature review. International Journal of Medical Informatics 80.1 (2011): 1-12.

[29] Fontainha, E. The determinants of ERP, SCM and CRM Systems in European Firms. ENTERprise Information Systems. Springer Berlin Heidelberg, 2010; 147-150.

[30] Karanikolos, M., Mladovsky, P., Cylus, M., Thomson, S., Basu, S., Stucler, D., Mackenbach, J.P., and McKee, M. Financial crisis, austerity, and health in Europe. The Lancet

[31] Marques A, Oliveira T, and Martins MO. Medical Records System Adoption in European Hospitals. The Electronic Journal Information Systems Evaluation 2011; 14(1):89-99.

[32] Cheung CSK, Tong ELH, Chan WM, Wang HHX, Kwan MWM, Fan CKM, Liu KQL, and Wong MCS. Factors Associated With Adoption of the Electronic Health Record System Among Primary Care Physicians. JMIR Medical Informatics 2013; 1:1-11.

[33] Rocha, Álvaro. Evolution of information systems and technologies maturity in healthcare. International Journal of Healthcare Information Systems and Informatics (IJHISI) 2011; 6(2): 28-36.