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ADOPTION OF ELECTRONIC HEALTH RECORDS

SYSTEM: DIFFERENTIATING MAIN ASSOCIATIONS

Completed Research

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Abstract

Health organizations are implementing health information technologies such as electronic health records (EHR), information systems (IS), and health information exchange (HIE) networks to improve decision-making. However, over the years, the healthcare environment has demonstrated numerous unsuccessful implementations of such technologies. One of the reasons is that physicians tend not to make use of these technologies in the healthcare environment. The various explanations put forward typically refer to patient, physician, and/or work environment-related factors.

This study evaluated the factors associated with the EHR use among physicians in the complex environment of emergency departments.

We used log-files retrieved from an integrative and interoperable EHR that serves Israeli hospitals. We found that EHR was primarily consulted for patients presenting with internal diagnoses, patients of older age, and it was used more by internists than by surgical specialists. Furthermore, EHR usage was larger for admitted patients than for those discharged.

The findings show factors associated with EHR use and suggest that it is mostly related to case-specific features and to physician specialty. The findings strongly suggest that when planning assimilation projects for EHR systems and HIE networks, attention should be paid to those factors associated with system usage. Specifically, in order to increase the efficiency of the system, and enhance its use in the ED environment, physicians' preferences and practice-related needs need to be taken into account. Furthermore, well-thought IT design and implementation are necessary to generate an increase in meaningful use of HIT, which can serve both physicians' and patients' needs.

Keywords: IS Use, Medical Informatics, Electronic Health Record, Health Information Exchange, Interoperability.

1 Introduction

Healthcare information technologies (HIT) have drawn a lot of attention as the healthcare sector invested heavily in HIT in recent years (Goldschmidt 2005) to improve medical decision-making and increase its efficiency through better medical processes via integration of patients' data within healthcare organizations and interoperability between them. Blumenthal (2009) argued that HIT — computers, software, Internet connection, telemedicine — is not an end in itself but a means of improving the quality of health care, the health of populations, and the efficiency of health care systems. This technology is also aimed at curbing the growth of healthcare costs (Jha et al, 2009a).

Despite numerous claims that HIT has the potential to improve the efficiency and effectiveness of health care providers (Goldman et al, 2006; Jha et al, 2009a; Blumenthal & Tavenner, 2010; Ben-Assuli et al, 2013), heavy investments in health information technology (HIT) in recent years (Goldschmidt, 2005) have documented both successful (Lejbkowicz et al, 2004; The NYT, 2009; Ben-Assuli et al, 2012) and unsuccessful implementations (rejections) of medical IS worldwide (Anderson et al, 2006; Øvretveit et al, 2007). Once unsuccessful and poorly designed, the EHR might lead to time consuming tasks, redundancy of documentation, reduced collaboration etc. (Eliza et al, 2012). This ongoing controversy highlights the importance of holistically studying the factors involved in increasing the usage of HIT in points of care. Bhattacherjee and Hikmet (2007) illustrated the importance of incorporating user resistance in technology usage studies in general and HIT usage studies in particular in order to understand and overcome the obstacles of EHR adoption.

This study is aimed at understanding the factors that influence HIT use. Specifically, we explored which factors affect physicians' decisions to look at patient historical medical data provided by EHR and Health Information Exchange (HIE) network in the high-stress, challenging environment of the emergency department (ED).

The most widespread model that accounts for usability is the technology acceptance model (TAM) (Davis, 1989), which was followed by many extensions (such as DeLone & McLean, 1992, 2003; Venkatesh et al, 2003; Yi et al, 2006). TAM posits that the individual's choice to use an IS is determined by behavioral intention, which depends on two beliefs: perceived usefulness and perceived ease of use. Both these beliefs are also highly relevant to physicians in the challenging environment of the ED. In a similar vein, Spil et al, (2004) developed a 'USE IT' model that characterizes four dimensions of HIT use including: (1) user resistance to the system, (2) relevance of the system to the user's needs, (3) the extent to which the system meets the user's needs, and (4) the availability of resources for designing, operating, and maintaining the system.

Individual physicians face a number of other obstacles even in the context of an up- and- running HIT system. Boonstra & Broekhuis (2010) reviewed the literature concerning the acceptance of EHR by physicians, and defined eight main types of obstacles: Financial barriers (whether the physician can afford and profit from such implementation), technical barriers (mostly lack of computer skills), time-related barriers (time needed to learn the system, enter data and convert existing records), psychological barriers (especially loss of professional autonomy), social barriers (the collective decision of physicians in the practice to adopt or reject the system), organizational barriers and barriers related to the change process (attitudes towards change may lead to resistance to the new tools).

Practice theories (Orlikowski, 2000; Barnes, 2001; Reckwitz, 2002; Østerlund & Carlile, 2005) take a more direct view of how IT behaves (Oborn et al, 2011), and draw attention to the interaction of IT with differences in physicians' routines as a function of specialty. Poor integration of HIT with the clinical workflow, as well as incompatibility of the IS design with the user's actual workflow may lead to the workarounds, can increase doctors' cognitive load, add unnecessary additional non-medical tasks, and also reduce collaboration within the organization (Mazlan & Bath, 2012). Hanseth et al. (2006) argue that local work practices and patient information do not always go hand in hand with the basic requirement in IS of a shared, consistent, and non-redundant information dataset. In fact, one of the key

issues discussed in national and international-level debates over EHR implementation approaches is that organizations want systems that are better tailored to their specific organizational needs (Robertson et al, 2010). In a cross sectional study, Pynoo et al (2012) found that the main motivation for physicians to start using EHR is watching other physicians using the EHR. In line with such arguments, we included an additional factor that clearly affects IT usage; namely, the physician speciality.

2 Literature Survey

The implications of using HIT at points of care have been studied from various perspectives. Research has shown that IT can help achieve the goals of safer, more effective, patient-centered, timely, efficient, and equitable health care. Whilst improving quality of care, HIT can also decrease costs of health care services and contribute to substantial annual savings for organizations (Kaushal et al, 2005). Ben-Assuli and Leshno (2013) demonstrated how using EHR in a simulated scenario of patients displaying symptoms of acute myocardial infraction led to substantial cost effectiveness results. Shield et al. (2010) found that physician-patient relationship was not harmed by the use of EHR, the information availability increased work flow efficiency and physicians were predisposed to share more with patients. It has already been established that medical EHRs have an impact on medical decisions. Goldman et al. (2006) showed, for instance, that children with abdominal pain receive more effective medical care when physicians review their medical history.

Nevertheless, there has been less research documenting the clinical and economic implications of HIT use (Basu and Meltzer 2007; Claxton et al, 2002, 2004). The productivity paradox (Brynjolfsson and Hitt 1996) may be one of the main traditional reasons why the adoption of HIT is progressing slowly (Gans et al, 2005). In the case of actual exploitation of information, physicians retrieve only a limited amount of relevant information even without time constraints (Hersh and Hickam 1998). Furthermore, the use of HIT objectively poses new challenges to the medical staff, and intersects with other professional routines (Novak et al, 2012). Therefore, the issue of barriers and enablers of proper implementation of HIT has become an important one to study. Esquivel et al. (2012) noted that medical IT showed a poor technological fit to the hospital environment and proposed that flexibility in the referral process is necessary for effective system use by staff. There has been some research regarding what may facilitate or prevent the implementation of HIT. Miller and Sim (2004) surveyed the use of HIT in an attempt to map the barriers of using such systems. They concluded that apart from organizational barriers of concern to policy-makers (e.g. high financial costs), physicians refrained from using the system due to high time costs, difficulties with technologies, lack of use-incentives, and their own attitudes. Lin et al. (2012) pointed out that many physicians may feel threatened by the implementation of HIT, seeing it as a potential source of extra workload. Nevertheless, the adoption of HIT in one unit of care or service can lead to a 'network effect' that increases the likelihood of other units to follow suit (Ayers et al, 2009).

Currently little is known regarding factors that are related to the use (or lack thereof) of HIT in actual doctor-patient encounters in the medical setting. A great deal of research on this topic has focused on physicians' attitudes, perceptions and beliefs. Cenfetelli and Schwartz (2011) made a pioneering attempt at profiling the rejecters of IT. Their profiling revealed several interesting characteristics of IT-rejecters (e.g. suspicions concerning the security of information, preference for the current system, disbelief in the HIT's contribution to efficiency), but their work was restricted to the rejecters' personal traits and not the actual decision to use IT or not in real time. Many factors impact use, including workflow, time pressure, the physical environment, social environment, organizational policies of use, and personal attributes such as age, language, literacy, personal health, stress, and disabilities (Redish 2010).

The issue of HIT incorporation in health care system and its related factors is a crucial one, which can have a negative impact on the quality and safety of patient care. Hence, this study focuses on the impact of various factors on the usage of EHR systems and HIE networks such as the source of medical history in EDs, rather than on other traditional sources of medical information.

3 The EHR

This study focused on the main health maintenance organization (HMO) in the State of Israel, listed as one of the world's top five largest non-governmental HMOs. This HMO owns general hospitals (all surveyed in this study).

The HMO deployed an EHR and HIE network. The system retrieves data from various healthcare entities that are registered as part of the HIE network. This data retrieval architecture furnishes a comprehensive, integrated and real time virtual patient record available at all distributed points of the HMO. The system gathers historical medical data from the other HIT at the HMO's points of care. The data examined here included patients' demographics, permanent, adverse reactions, detailed lab and imaging results, past diagnoses, etc. However, this EHR provides full integrative information only for patients belonging to the main HMO. Integrated medical information regarding community encounters on patients from other HMOs is not available, and physicians solely have information regarding the patient's previous admissions to the hospital.

4 Objectives

This study was designed to explore the factors and conditions that affect information system usage. Studying the factors associated with the decision of whether or not to use EHR challenging due to the complexity of the natural setting in which such decision processes take place. The physician facing this decision considers the challenges of the ED environment (stress and time-pressure) as well as the patient's condition and her/his own resources and characteristics. To better understand the role of different sources of information, this study examines the use of EHR as a data that is created throughout different points of care that belongs to the HIE network.

5 Research Model

It has been established that the rates of HIT adoption among physicians and service providers varies as a function of patient characteristics (Hing and Burt 2009; Huttner et al, 2008), physician specialty (Burt and Sisk 2005), medical environment (Jha et al, 2009b), and others. We sought to portray the interrelations and impacts of several characteristics and variables that comprise each case on the physician's decision to consult and use the EHR. These correlates were grouped in clusters representing several facets of each referral.

Patient health status and case complexity included age, differential diagnoses, current results of medical tests, and the eventual admission decision – that is, admit or discharge. Patients who are eventually admitted (vs. discharged) represent the more complex and severe portion of cases physicians encounter in the ED (Huttner et al, 2008). These needs are exacerbated as the complexity of cases is increased by complaints of an internal nature (vs. surgical) and an apparent deterioration of the patients' medical status.

HYPOTHESIS 1.1: The likelihood of physicians accessing EHR will be higher for patients who are eventually admitted (in the case of admissions, physicians will tend to use the EHR more than in cases of discharged patients).

HYPOTHESIS 1.2: The likelihood of physicians accessing EHR will be higher for patients having an internal diagnosis (compared to patients having a surgical diagnosis).

Physician specialty refers to the physician having a surgical specialty versus internal specialties. According to the literature, surgical specialists are less likely to use an EHR (Burt and Sisk 2005). Similarly, it was found that across specialties, surgical subspecialties had the lowest rates of meaningful use of a web-enabled imaging decision support system (Ip et al, 2012).

HYPOTHESIS 2: The likelihood of physicians accessing the EHR will be higher for physicians with a non-surgical specialty.

Each hypothesis was tested twice: (1) for EHR use in general and (2) for external (Interoperability) medical information usage.

Figure 1 shows the initial model along with the hypotheses and variables.



Figure 2. Hypotheses and Research Model

6 Materials and Methods

6.1 Track Log Files Analysis

Log-files were retrieved from the main HMO for ED referrals during four years (after the IS was adopted by all hospitals and the HIE was established). The log-file consists of 340,804 admitted patients and 474,310 non-admitted patients. The log-file came from seven main hospitals owned by the HMO that use an EHR and an interoperable HIE network to share medical information from distributed health suppliers electronically.

6.2 Independent Variables

Admission decisions - Admission decision was coded as a binary variable that described the decision whether or not to admit the patient to the ED (1 for admit decision and 0 for discharge decision), as used in previous studies (Richardson, 1998; Ben-Assuli et al, 2012).

Differential Diagnosis (DD) - The DDs of ED referred patients were entered into the database using the WHO International Classification of Diseases (ICD/10) code. This variable enabled us to evaluate the relationship between using medical history and the type of diagnosis made by the decision-makers; these diagnoses included: chest pain (CP), abdominal pain (AP), gastroenteritis (GE), urinary tract infection (UTI). These frequent diagnoses were chosen – prior to the data-analysis – by a panel of senior physicians in cooperation with the main HMO.

Practice Related Factors - physician specialty was coded as a binary variable that characterized the specialty of the physician (1 for surgeon and 0 for internist).

Age – Measured in years.

6.3 Independent Variables – Confounders

Patient confounders refer to personal characteristics that may impact physicians' decision to use the EHR. In this study we controlled for **gender** and **HMO medical insurance**. Only patients insured by the main HMO have full, integrative information provided on them. Insurance type was chosen to control for major differences in the quality and the amount of medical information between patients insured by different HMOs. In this study, age was regarded as an explanatory factor for EHR use and not as a confounder, since morbidity and disability are clearly more frequent in the years prior to death (Guralnik et al, 1991). For gender, however, we were not able to formulate a conclusive hypothesis and hence – gender was entered as a confounding variable.

Environment confounders included **hospital** and **ED unit** in which the patient was treated. Jha et al. (2009b) found that hospitals that care for poor patients and minority group patients fall behind in the use of HIT. Burt and Sisk (2005) reported that department size substantially affected the probability of using EHR; a larger number of physicians in a department was associated with a higher probability of EHR use. Because different hospitals and ED units experience different rates of crowdedness, vary in terms of the number of physicians, and serve a variety of populations, it was important to control for possible effects of hospital on the level of EHR usage.

6.4 Dependant Variable

EHR Used refers to access to at least one of several medical history components in the focal EHR. This was measured as a dichotomous variable (1=history viewed; 0 if not).

External Information used (Interoperability) - This variable indicates the viewing of historical information created outside the specific hospital and provided online by certain health suppliers connected to the HIE network. External information concerned past and present main HMO insured patients whose local and external types of information were available to a certain extent. This type of information is much more difficult and thus costly to facilitate and to maintain (Hanseth et al, 2006; Lesh et al, 2007), and such operational online access to external information is still only available in a few HMOs and leading medical centers around the globe. The variable was coded 1 if external information was viewed from the EHR and 0 if it was not viewed.

7 Data Analysis and Results

7.1 Descriptive Statistics

Table 1 shows that in only 37.1% of all referrals to hospitals, patients' historical information was viewed via the EHR (43.4% of which resulted in admit decisions). In other words, 62.9% of all referrals did not involve any use of medical history. Additionally, physicians made a rather limited use of external information (81.1% of the cases in which EHR was viewed did not include external information).

Characteristics	Total Study Sample	EHR Was Not Used	EHR Was Used
	n=815,114 (100%)	n=512,987 (62.9%)	n=302,127 (37.1%)
Age (years)	51.8±25.7	49.7±26.3	55.6±24.3
Male (%)	389,330 (47.8%)	243,484 (47.5%)	145,846 (48.3%)
Insurance (main HMO %)	634,097 (77.8%)	392,962 (76.6%)	241,135 (79.8%)
Admissions (%)	340,804 (41.8%)	209,805 (40.9%)	130,999 (43.4%)
Admission Period (days)	4.8±7.3	4.5±7.1	5.3±7.8
Surgical Physicians (%)	114,830 (14.1%)	75,899 (14.8%)	38,931 (12.9%)
External History Viewed (%)	57,061 (7%)	-	57,061 (18.9%)

Data are means (\pm SD) or number of subjects (proportion). All Significance levels of univariate comparisons were lower than 0.001.

Table 1.Characteristics of the Sample and Descriptive Statistics

7.2 The Outcomes of Regression for the use EHR

We ran the logistic regressions using several sets of variables: **Medical condition variables**, **practice variables**, **patient confounders**, **and environment confounders**. The latter confounders of hospital and ED unit are not shown here, but were included in these regressions (in order to avoid overload).

H1.1: Table 2 below reveals that when a patient is admitted, the rate of using the EHR increased by 10% (OR =1.1) compared to discharged patients, after controlling for all the discussed confounders.

H1.2: AP and UTI – both internal DDs – were found to have the highest positive association with using EHR (16.4% and 14% respectively). Out of all the presented DDs, GE, had the only negative association with EHR use (-15.7%). The CP diagnosis was found to have non-significant low positive associations with using EHR.

H2: The likelihood of physicians accessing EHR increased by 31.8% for physicians with a non-surgical specialty (p<0.01, adjusted OR=0.682), which is consistent with earlier findings (Burt & Sisk, 2005; Jensen & Aanestad, 2006; Ip et al, 2012) and confirms our Hypothesis 2 as well.

Both these results (Hypotheses 1 and 2 were confirmed) suggest that the variables normally associated with deteriorated medical conditions, brings about additional use of the EHR, as expected. Type of insurance also played an interesting role. When the insured patients were members of the main HMO, the rate of using the EHR increased by 7.4%. Lastly, we noted that for male patients, the rate of using the EHR was marginally lower than for females.

Variable	EHR Used		
-	B (S.E.)	Odds Ratio –OR	
Admitted	0.095 (0.006)	1.100 ***	
СР	0.013 (0.01)	1.013 ^{n/a}	
AP	0.152 (0.011)	1.164 ***	
GE	-0.171 (0.019)	0.843 ***	
UTI	0.131 (0.02)	1.140 ***	
Age	0.008 (0.000)	1.008 ***	
Surgical- Physician	-0.382 (0.119)	0.682 **	
Insurance	0.071 (0.005)	1.074 ***	
Gender	-0.025 (0.005)	0.975 ***	
Constant	-1.462 (0.119)	0.232	

*** p<0.001, ** p<0.01, *p<0.05, + p<0.1; n/a not applicable (the tables below employ the same conventions).

Table 2.Logistic regression on the decision to use EHR

As for our patient confounders, we found that for male patients, the rate of using the EHR decreased by 2.5% compared to female patients, and that when the insured patients were members of the main HMO, the rate of using the EHR increased by 7.4%. The increased rate of using the EHR for the main HMO members may suggest that the additional patient data (mainly based on interoperability) available exclusively for the main HMO members may increase system use.

7.3 The Outcomes of Regression for use of external information (Interoperability)

Table 3 below shows the results of the regressions for external information usage. It repeats the earlier examination, only this time external information sources were treated separately and thus show the effect of various factors on the interoperability of medical information.

Table 3 shows that when a patient was admitted, the extraction rate of external information through the EHR increased by 2.9% (in comparison to the above finding of a 10% increase in the general case of

viewing a patient's history). The DDs most positively associated with EHR use of external information were UTI and AP (32.6% and 3.6% respectively). Large, negative associations were found for CP and GE (-33.7% and -21.8%). These results differ from the results in Table 2. Two DDs were strongly and negatively associated with external information examination. These results suggest that some DDs may require little use of external information in comparison to other DDs.

Age was again associated with EHR use, this time more moderately so. Regarding physician specialty, internal medicine considerably impacted external EHR use (compared to a surgical specialty), similar to the results presented earlier.

Variable	External History Viewed		
		B (S.E.)	Odds Ratio –OR
Admitted		0.028 (0.01)	1.029 **
СР		-0.412 (0.019)	0.663 ***
AP		0.035 (0.02)	1.036+
GE		-0.246 (0.038)	0.782 ***
UTI		0.282 (0.031)	1.326 ***
Age		0.004 (0.000)	1.004 ***
Surgical- Physician		-0.666 (0.196)	0.514 **
Insurance		0.567 (0.013)	1.762 ***
Gender		-0.063 (0.009)	0.939 ***
Constant		-3.619 (0.197)	0.027

Table 3.Logistic regression on the use of external information via the EHR

We found that for male patients, the rate of using the external information via the EHR decreased by 6.1% compared to female patients, and that the external data of current main HMO insured patients was more frequently examined than that of former main HMO insured patients who currently have insurance at another HMO (simply because more information was available).

8 Discussion

IS usage is both a critical and very solid "bottom-line" indicator for the successful implementation and assimilation of HIT. This study was aimed at contributing to a better understanding of HIT usage by exploring the factors associated with EHR usage among physicians in the stressful environment of an

ED. Our focus was on personal attributes of the patient – current health status (diagnoses, demographics) as well as her or his insurance type – along with the physician specialty.

The findings strongly supported our hypotheses. First, we found that EHR usage increased when the patient's medical condition was more severe or complex. Physicians' attention and selectivity on more severe cases (such as admitted patients and older age) in the EDs expresses their need for fast and efficient access to data while dealing with harsh time constraints (Ash et al, 2004).

Second, we found that internists used the EHR more than surgeons. This result strongly supports accumulating research data (Burt & Sisk, 2005; Ip et al, 2012; Jensen and Aanestad, 2006; Appari et al, 2012). Along these same lines we also found that a diagnosis of GE, had the lowest association with EHR usage, extending previous literature. However, it should be made clear that association does not imply causality; hence it is possible to claim, alternatively, that surgeons' resistance to IT usage is rather unjustified, and that policy making and organizational governance would provide a more suitable solution and incentives that would increase their meaningful use of IT.

Third, we found a significant association between type of patient insurance and system use. EHR was used more frequently for the main HMO insured patients. The greater availability of information for the main HMO insured patients may have led to more system use for this group.

Last, we found that some DDs required little use of external information. For instance, CP DD was strongly negatively associated with external information usage, although it had no such association regarding the examination of general EHR use. In particular, for GE DD, we found a strong and negative association with EHR in both our examinations, whereas for AP and UTI the association was positive.

The findings strongly suggest that when planning assimilation projects for EHR systems and HIE networks, attention should be paid to those factors associated with system usage. Specifically, in order to accelerate the diffusion time, to increase the efficiency of the system, and enhance its use in the ED environment, physicians' preferences and practice-related needs need to be taken into account.

9 Contributions, Limitations and Future Research

The main contribution of this study was to shed a light on the factors that lead to meaningful use of EHR systems. Specifically, we aimed to contribute to the assessment of the motivation, and factors associated with HIT usage by physicians. Efficient HIT implementation as well as meaningful use can lead to improvement in the quality of healthcare. Moreover, this research showed differences in the use of the EHR between different types of physicians. The findings broaden our understanding of factors that may contribute to meaningful use of HIT, by adding case-specific features to the already studied role of physician and hospital characteristics. The study also looked at external information usage, and revealed different needs with regard to data interoperability. The findings also emphasized the differences in the use of EHR between different types of physicians.

This study had a number of limitations. One of the major limitations is we do not have enough information regarding the physicians' characteristics and preferences. We only knew their medical specialization and their decision to use or not use EHR as the source of medical history. More information about their experience with technology and especially about their attitudes toward technology could help better analyze their decisions to use EHR.

One future avenue could be delineating concerns the disparity between intentions and actual usage of HIT. Wu and Du (2012) indicated that the intention to use a system is more highly correlated with situational determinants and personal factors than with actual usage. This association should be addressed in the healthcare sector to enable a fuller grasp of the usage-determinant interplay. We suggest developing a prediction model for future behavior of decision makers regarding the use of the system, which would address the above issues.

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