

IMPROVING MEDICAL DECISION-MAKING USING ELECTRONIC HEALTH RECORD SYSTEMS

Research-in-Progress

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Abstract

This paper evaluates the contribution of an electronic health records (EHR) system to efficient decision-making by physicians, and investigates whether these systems lead to more efficient medical care in emergency departments (ED). Log-files of patient visits and admissions were retrieved from an integrative EHR system that serves seven main hospitals owned by a large health maintenance organization (HMO). This study focused on readmissions within seven days and single-day admissions, problems that concern hospitals around the world. The findings indicate that using an EHR system in the EDs correlates with a decreased number of readmissions within seven days as well as with a reduced number of single-day admissions. The results provide evidence that using EHR system may contribute to efficiency in an ED by assisting decision-making. We believe this is the first data set that investigates the impact of an EHR on hospital efficiency at the scale of HMO.

Keywords: Healthcare information systems, health informatics, medical IS, health information exchange, electronic medical records.

Introduction

The healthcare sector has invested heavily in IT in recent years to enhance medical decision-making and increase its efficiency through improved medical processes and the use of integrative and interoperable electronic health record (EHR) information systems (IS) (Goldschmidt 2005). EHR IS compiles data from multiple health sources such as laboratories, other hospitals, specialized clinics, etc. (Dogac 2012; Waegemann 1996). Despite the advantages of IT, physicians consult medical information required for critical decision-making infrequently (Ben-Assuli et al. 2012). The lack of such information may result in a decreased level of quality of care and unnecessary costs (Lawson and Daniel 2011; Walker 2005).

One of the most important decisions a physician has to make based on medical information in an emergency department (ED) is whether to admit a patient or not. Admissions and readmissions are a key measure of healthcare efficiency (Silow-Carroll et al. 2011). If a patient is readmitted shortly after a hospital stay, this might indicate that the hospital discharged the patient without proper care or the right diagnosis. In addition, existing scales have shown that unnecessary short-term admissions can also be reduced and even eliminated if physicians have access to proper medical history (Ben-Assuli et al. 2012).

Readmissions are of particular concern in the United States because Medicare, the main provider of healthcare services, will no longer reimburse hospitals for readmissions. A report prepared for Congress details the rationale for the new policy that hopes to curb hospital costs and improve overall quality (Stone and Hoffman 2010). The report discusses the comprehensive health care reform legislation, the Patient Protection and Affordable Care Act (PPACA; P.L. 111-148), that was signed into law on 2010 by President Obama. The PPACA legislation contains a number of provisions that make changes to Medicare.

This paper seeks to understand the role that EHR can play in improving the decision-making process, thus leading to a reduced number of hospital readmissions (namely, admissions within a short period of time since a previous discharge of an admitted patient from the hospital) and single day admissions (i.e., the equivalent of a 24 hour ED stay, excluding 12-24 hours observation periods).

The paper is organized as follows: The following section provides a literature survey and introduces the focal EHR. Section 3 describes the methodology and Section 4 details the results. The final sections discuss the implications of the results, provide a discussion and mention the limitations of the study and avenues for further research.

Background

Theoretical Studies of Medical Information Systems

Both the increase in national health expenditures and the continual moves toward improving the quality of healthcare are behind the widespread adoption of health information technology (HIT). The effects of medical information systems at the point of care have been studied from a variety of perspectives. There is a consensus among medical staff that access to a comprehensive electronic record of medical history benefits patients (Boonstra et al. 2008). Yet despite the increasing perceived use of these systems by clinicians, there has been less research documenting the medical effectiveness of their use (Basu and Meltzer 2007) as opposed to their administrative, managerial and financial aspects (Mantzana et al. 2007).

There are several studies dealing with the impact of medical systems on the process of decision-making in the stressful ED environment. Walker et al. (2005) showed that the exchange of information from different sources (known as interoperability) between healthcare providers enabled a computer-assisted reduction of redundant tests and led to positive financial returns. Although clinicians expressed a high level of confidence after receiving the information (Hersh and Hickam 1998), the introduction of additional information and care options has been shown to increase decision complexity (Redelmeier and Shafir 1995). In practice, physicians cannot wait for the results of time-consuming diagnostic procedures, and even if information is available to physicians, time constraints can restrict their availability to pursue it (Tierney 2001). In fact, physicians retrieve only a limited amount of relevant information even without time constraints (Hersh and Hickam 1998) and use EHR systems for far fewer tasks than the systems support (Laerum et al. 2003). One study reported that even though many ED physicians believe a majority of their patients would benefit from longitudinal patient health information, they attempted to obtain such

data less than 10% of the time (Hripcsak et al. 2007). Duncan (2011) pointed out that interruptions, overload and physician-patient barriers are the major factors that can interfere with proper history-taking. All of these factors are more common in the ED. Mazer et al. (2011) found that a high percentage of medication histories taken in ED triage were inaccurate and incomplete. Similar results were obtained by Caglar et al. (2011).

Sox et al. (2007) emphasized the importance of medical history as a way to draw medical decisions. Paley et al. (2011) found that proper history-taking alone was the most valuable to making an accurate diagnosis. This is in line with Walker et al. (2005), who argued that there is a relationship between reviewing medical history and improved medical care including admission decisions. Goldman et al. (2006) showed, for instance, that children with abdominal pain receive more efficient medical care (including better admission decisions) when the physicians review their medical history. Chang et al. (2012) pointed out that in psychiatric EDs, external sources of information such as healthcare providers are underused, thus leading to lengthy, excess ED waiting times.

As detailed later, it is likely that a large portion of “bounce-back” readmissions (short-term readmissions) as well as some single-day admissions are unnecessary and could be easily eliminated if physicians had access to proper medical history. Existing scales have shown that such short-term admissions can be reduced (Denman-Johnson et al. 1997). These conclusions and more general studies have shown that medical technologies can efficiently triage patients in an ED using a limited amount of information (Wiler et al. 2010). Nevertheless, they leave many basic questions unanswered, one of which is the role of the EMR (Electronic Medical Record) in decision-making in an ED. Hence, this study focused on the impact of a special type of integrative EMR, the EHR systems, as the source of medical history in EDs, rather than on other sources of medical information such as hard-copy patient records, physical examinations, or patient complaints.

The Main Health Maintenance Organization (HMO) and the Focal EHR IS

This study focused on one of the world’s largest HMOs, a non-profit organization that serves over 3.8 million customers. All seven general hospitals owned and operated by the HMO were included in this research. The population of the study is Israel’s citizens. In Israel there are four HMOs. Every citizen is required by law to be a member of one of the four HMOs.. Every citizen might visit one of the seventh hospitals. We analyzed an advanced EHR system implemented by this HMO. This system provides and shares integrated real-time virtual patient records with all points of care of the HMO (including hospitals and clinics). The log-file used in this study covered patients’ data from 2005 to 2007 (after the EHR IS had been integrated into all hospitals). The data included demographic information, previous encounters data, past diagnoses, permanent medications, adverse reactions, detailed lab and blood tests, imaging results, a list of past surgeries, etc. This EHR IS provided full integrative medical information only on patients of the main HMO. On all other HMO patients, only partial information was collected (only information regarding previous encounters with the same hospital). It is important to note that in this study we controlled for the insurance type, and therefore also for the quantity and type of information available.

Research Objective

In this paper we examined the relationship between the use of information provided by the system at the point of care and the physicians' admission decisions. Namely, we investigated the likelihood of (a) readmissions within a short period of time since a previous discharge, and (b) single day admissions, when physicians used the EHR IS compared to when physicians did not use the EHR IS. Arendts et al. (2012) showed that even small changes in admission rates can result in meaningful reductions in hospital occupancy and improve system capacity.

Research Model and Hypotheses

An accumulating body of evidence suggests that the use of EHR IS impacts medical decision-making. Specifically, using EHR IS is likely to lead to more efficient decision-making (Daniel et al. 2010; Fichman et al. 2011). Given that single-day admissions and readmissions are common indicators of medical efficiency and the quality of care (Adeyemi et al. 2013), we used these to evaluate the impact of EHR IS on medical decision-making. A decrease in these measures was considered to indicate a more efficient

decision-making process.

Based on extended work that has examined the contribution of IS to enhancement of decision-making and organizational performance (Aron et al. 2011; Gorla et al. 2010; Sox et al. 2007), we hypothesized that:

H1: There is a negative relationship between the use of EHR IS and readmission within seven days.

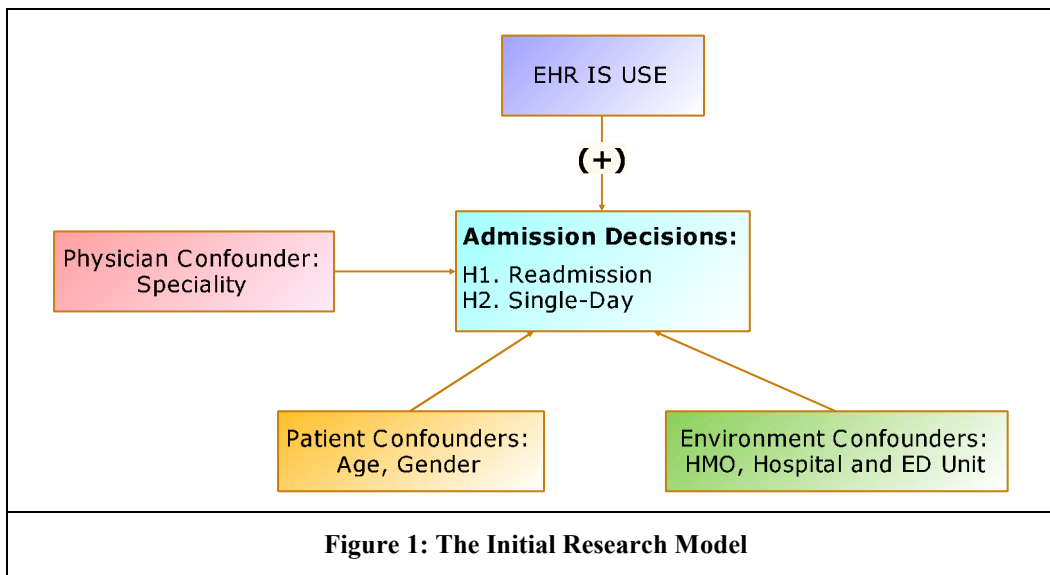
The readmission measure is widely used to monitor the efficiency of critical care pathways (Adeyemi et al. 2013; Axon and Williams 2011). A decreasing incidence of readmission has increasingly become a goal of caregivers, hospital administrators, and policy makers (Schneider et al. 2012; Silow-Carrol 2011). An accepted notion is that the shorter the period between discharge and readmission, the more likely that the patient was discharged prematurely (Ather et al. 2004; Moore et al. 2013). Readmission rates are also used as a proxy for quality of care rendered during hospitalization (Ather et al. 2004; Welch et al. 1992).

In order to control other time periods of readmissions and to examine the robustness of our results, we also tested these hypotheses on readmissions within thirty days (in addition to seven days), and although both the seven and thirty day readmission categories have been used in previous papers (Slamowicz et al. 2008; Carlisle et al. 2012), the former is considered to be a more sensitive indicator for avoidable readmissions (Ather et al. 2004).

H2: There is a negative relationship between the use of EHR IS and the decision to admit a patient to a hospital resulting in a single-day admission.

Existing scales have shown that such short-term admissions can be reduced using medical information (Ben-Assuli et al. 2012; Cooke et al. 2003; Denman-Johnson et al. 1997). A single-day admission is equivalent to a 24 hour ED stay. In similar to many EDs around the world, the hospitals in this study maintain observation wards in which patients are monitored for periods of 12–24 hours; this observation period was not included in the calculations.

Figure 1 shows the initial model along with variables.



Material and Methods

To explore the impact of viewing medical history on physicians' decisions to admit patients, a large database of ED referrals was analyzed.

Track Log File Analysis

Log-files provide an objective and unbiased measure of system usage and are recommended for evaluating health IS (Yen and Bakken 2012). Nowadays, log files are a standard and essential part of any large application, and they are commonly used for the purpose of software monitoring. However, although these

large files are continuously generated and occupy valuable storage space, they are rarely utilized.

The log-files were retrieved from the main HMO databases for ED referrals from 2005 to 2007 (after the EHR IS was integrated into all seven hospitals). The log-file consisted of 2,397,878 referrals (689,317 admissions and 1,708,561 discharges) from seven main hospitals owned by the main HMO. The EDs in the log file were restricted to internal medicine, surgical, obstetrics, orthopedics, gynecology, ENT (ear, nose, throat), primary, and dermatology. The data examined via the EHR IS included previous hospitalizations, past diagnoses, chronic medication, detailed lab and imaging results, patient's known allergies, healthcare procedures, etc.

Independent Variables

Main Independent Variable: EHR IS viewed: The patients were divided into two groups: patients whose medical history was viewed via the EHR IS and patients whose medical history was not viewed via the IS. The "EHR IS viewed" refers to access to at least one of several medical history components in the EHR IS. This was measured as a dichotomous variable (1=history viewed; 0 if not).

Physician Confounders: (Surgical Physician) - physician specialty refers to the physician having a surgical specialty versus internal medicine specialties. It was coded as a binary variable that described the specialty of the physician (1 for surgical physician and 0 for an **internist**).

Environment confounders included type of HMO, hospital and type of ED unit in which the patient was treated. Jha et al. (2009) found that hospitals that care for poor patients and patients of minority groups fall behind in adopting HIT. It was therefore important to control for possible effects of hospital on the level of EHR IS adoption. Following are these confounders:

1. Medical Insurance (HMO) - This dichotomous variable was created to control for major discrepancies in the quality and the amount of medical information between patients insured by different HMOs (1 for the main HMO insured patients and 0 other HMO insured patients).

2. ED Department - This variable refers to the type of ED sub-department the patient was evaluated in, such as internal medicine or surgical.

3. Hospital - This variable represented the hospital the patient was evaluated in. Each one of the seven hospitals was coded into this variable.

Patient confounders refer to personal characteristics that may impact the physicians' decision to use the EHR IS, namely **Age** and **Gender**.

Dependent Variables

Readmission within seven days: Quantified whether a patient was readmitted to a hospital within seven days since a previous discharge from the hospital for a closely related condition (coded 1) or otherwise (coded 0). A closely related condition was defined as a condition that clinically resembles the main diagnosis, which led to the previous admission. Studies have indicated that more than half of readmissions incidents could be avoided by implementing more efficient procedures (Nahab et al. 2012; Yam et al. 2010).

Single-day admissions: Quantified whether a patient, as a result of the decision to admit, was admitted for a single day (coded 1) or for a longer period of time (coded 0). Existing scales have shown that short-term admissions can be reduced using medical information (Ben-Assuli et al. 2012; Denman-Johnson et al. 1997). This measurement scale filtered out patients who intentionally sought and received treatment involving a single-day admission as well as patients that stayed for 24 hours observatory periods.

Findings

Characteristics	Total Sample n = 2,397,878	EHR Was not Viewed n = 1,929,474 (80.47%)	EHR Was Viewed n = 468,404 (19.53%)
Age (years) ± s.d.	39.28±24.92	36.36±23.91	51.29±25.38
Male (%)	1,107,537 (46.2%)	897,303 (46.5%)	210,234 (44.9%)
Surgical Physicians (%)	537,998 (22.4%)	471,955 (24.5%)	66,043 (14.1%)
Insurance (% main HMO)	1,756,126 (73.2%)	1,384,450 (71.8%)	371,676 (79.4%)
Admissions	689,317 (28.8%)	492,892 (25.6%)	196,425 (41.9%)
Admission days ± s.d.	3.10±4.49	2.86±4.11	3.68±5.27
Readmission within Seven Days	250,369 (36.3%)	214,444 (43.5%)	35,925 (18.3%)
Single-day Admissions	139,012 (20.2%)	105,013 (21.3%)	33,999 (17.3%)

Data is the mean or proportion of subjects; all univariate comparisons were significant at 0.001.

Table 1 reveals several differences among the variables. According to Table 1, patients' medical histories were viewed in only 19.53% of all referrals to hospitals, a large portion of which resulted in a decision to admit. According to Table 1, medical history was used in the medical cases that involved older patients and probably in cases that tended to be more severe that ended in a decision to admit (25.55% admission rate when the EHR IS was not viewed vs. 41.93% when it was viewed). There were also major associations between viewing medical history and both the number of readmissions within seven days and single-day admissions. These effects are explored further in the regression analyses.

We ran the logistic regression using several blocks of variables: **theory variable** (EHR IS viewed), **physician confounder** (surgical physician), **medical environment confounders** (type of insurance, type of department, type of hospital) and **patient confounders** (age and gender). The confounders for type of department and hospital are omitted in the table for greater readability but were included in the analyses.

Variables in the Equation	β	Standard Error	Odd Ratio	95% C.I. for Odds Ratio	
				Lower	Upper
EHR IS Viewed***	-.305	.007	.737	.727	.746
Surgical Physician***	-.478	.043	.620	.570	.675
Insurance***	.264	.005	1.302	1.289	1.316
Age***	.002	.000	1.002	1.002	1.002
Gender***	.027	.005	1.027	1.017	1.038
Constant	-2.094	.045	.123	-	-

Note: *** p<0.001, ** p<0.01, *p<0.05, + p<0.1; n/a not applicable (Table 3 below uses the same conventions).

Table 2 shows that when the EHR IS was viewed, the odds of readmissions to the ED within seven days decreased (**H1 confirmed**) by 26.6% (p<0.001, adjusted OR=0.734). As for the confounder, for surgical physicians, readmission odds decreased significantly by 38% as compared to internists. Insurance type also had a substantial effect, where the odds of readmission within seven days increased by 30.4% for a member of the main HMO. This result is reasonable, since we expected non-HMO insured patients to visit their own HMO hospital and not to necessarily revisit the main HMO's hospitals. Both age and gender had negligible effects on readmission within seven days.

Continuing to Table 3, when the EHR IS was viewed, the odds of single-day admission to the ED decreased (**H2 confirmed**) by 17.5% ($p < 0.001$, adjusted OR=0.825). When the physician had a surgical specialty, the odds of single-day admissions showed a significant increase of 23.2% as compared to internists. Insurance type, age, and gender also played significant though considerably smaller roles as follows: when the insured patients were members of the main HMO, the odds of single-day admission decreased by 5.8%, when the age of the patients increased by an additional year, the odds of single-day admissions decreased by 2.1% - apparently due to longer admission periods that correlate with greater age - and, for male patients, the odds of single-day admission increased by 5.7%.

Variables in the Equation	β	Standard Error	Odd Ratio	95% C.I. for Odds Ratio	
				Lower	Upper
EHR IS ***	-.184	.008	.832	.819	.845
Surgical Physician+	.209	.122	1.232	.970	1.565
Insurance**	-.057	.007	.945	.931	.958
Age***	-.021	.000	.979	.979	.980
Gender**	.036	.007	1.037	1.023	1.052
Constant	-.629	.123	.533	–	–

Discussion

The main purpose of this study was to provide additional insights into the fields of information system management, information economics and medical informatics. We focused on the stressful point of care of the ED, and used a unique and large database containing an entire population of patients (2.4 million referrals to the ED) rather than using small samples. We examined the use of integrative real-time medical information from decentralized medical suppliers by using EHR IS. Finally, and more importantly, we shed light on the positive relationship between using medical history and more efficient admission decisions.

One of the most important decisions in an ED is whether to admit or discharge a patient. This critical question has been used in previous research (Ben-Assuli and Leshno 2013). Arendts et al. (2012) showed that even small changes in admission rates can result in meaningful reductions in hospital occupancy and an improvement in system capacity. The Frisse et al. (2011) study of an EHR in an ED setting also found that admission reductions accounted for 97.6% of total cost reductions. Both of our hypotheses were confirmed in that our results showed a reduction in the volume of readmissions within seven days as well as in single-day admissions, some of which are likely to be unnecessary and preventable. Previous findings showed similar outcomes (Cooke et al. 2003).

The current results suggest that viewing historical medical information using EHR IS associates significantly with more efficient admission decisions. Nonetheless, alternative interpretations of our results are possible and should be examined in future research. For instance, it could be argued that viewing a patient's detailed information may lead some physicians to prolonging unnecessary hospitalization, instead of a short hospitalization. Nevertheless, recent findings (Bardhan and Thouin 2012) have shown that physicians' use of HIT was associated with greater adherence to treatment guidelines among patients. Such usage pattern could also account for our results. The findings showed that EHR use has negative correlation with readmissions within seven days (re-admission is an indication of the inefficacy of the healthcare pathway). Given the growing importance of readmissions as regards both the quality and cost of healthcare, our findings are a first step toward a better understanding of the impact that IT systems can have on readmission decision making in the ED context.

In this study, we included several possible confounders. Analyzing physicians' specialties produced inconclusive results, with a decrease in readmissions within seven days and a slight increase in single-day admissions in favor of surgical physicians as compared to internists.

Being insured by the main HMO was associated with an increase in readmissions within seven days, and a

moderate decrease in single-day admissions. The latter may relate to the fact that patients of the main HMO had more information regarding their history in the EHR IS. In that sense, this finding is in line with our hypotheses, as it demonstrates an association between richer, more elaborate medical history and efficient decision-making. The patient's age had small though significant association with readmission within seven days and fewer single-day admissions, which is reasonable given that older patients often display more complex clinical cases.

Our study offers substantial contribution, not only to academia, but also to practice. The study depicts rather straightforward outcomes, following an examination of an advanced information system that offers retrieval of information from numerous dispersal health suppliers. Most hospitals still lack such real-time access to wide-spreading resources of information; our results can offer invaluable insights for those planning on such systems in the following years.

Limitations and Future Research

This study also has a number of limitations. It should be made clear that our results do not prove causality. While causality is a possibility, other possibilities should be considered. For instance, the results may suggest that the patient did not follow the doctor's orders for various reasons, for example, because the prescribed medicine was costly. In addition, there is recent criticism regarding the use of readmission rate as a measure of care quality (Fischer et al. 2012; Srivastava and Keren 2013).

Additionally, different ED units might have different policies regarding the use of the EHR system. The specifics of the ED unit (including type of management, admission policy, vacant beds, users, the deployment stage of the selected IS, etc.) impact on the hospital's ability to fulfill the potential and utilize a new IS to the maximum. We partially controlled for these differences using regressions with controls on fixed effects of the ED units' representative variable.

Future work should involve deeper examination why we observed both lower levels of readmissions and single-day admissions after using the EHR in the ED context. Although there is prior work on ED decision making, it provides few insights into actual practices resulting from the introduction of the EHR, except that more information leads to better decision making (Frisse et al. 2011). Furthermore, future studies may seek for alternative interpretations for the outcomes and implications of the usage of historical medical data at the point of care. As well as to look for other various clinical and economic outcomes. Further studies might also concentrate on adding the physicians' attributes or identification to the log file. Those attributes may provide more insights regarding the need and benefits of healthcare information technologies. Finally, other statistical methods and procedures, such as data mining, could be used as a predictive tool. We examined the value of information, rather than developing a predictive model for the future behavior of decision makers or extracting patterns from the data.

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