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ABSTRACT

Medical organizations are implementing electronic health record (EHR) systems in order to improve medical decision-making. The goal of this study was to characterize the specific data components that improve the process of medical decision-making in an emergency department (ED). The outcome measures were the decision to admit/discharge a patient, and differences in single-day admission rates with/without EHR IS. A database containing 3.2 million ED referrals from seven main Israeli hospitals was subjected to log file analysis. We found that viewing medical history via the EHR IS significantly affects admission decisions. The data show a reduction in the number of avoidable single-day admissions but an increase in the rate of prolonged admissions. Previous admissions, laboratory tests, imaging and previous surgeries were the most influential information components.

Keywords

Admission decision, electronic health record, information components

INTRODUCTION AND BACKGROUND

The healthcare sector has integrated information systems in recent years to improve the medical decision-making process. These technologies including EHR systems were integrated into many points of care including the ED settings. The ED is a major gateway for patient care, where physicians need information not only about immediate symptoms, but also past medical treatment, family history, and lifestyle. The availability of patients' long term health conditions, including information about medications, diagnoses, recent procedures, and recent laboratory tests, is critical to forming an appropriate plan of care (Hripsak, Sengupta, Wilcox and Green, 2007). When asked, most physicians state that all types of clinical information are very important. However, most of them rated their use of the clinical information as moderate or low, and only three types of information (diagnoses, previous medications and allergies) were rated high (Panjamapirom, Burkhardt, Volk, Rothschild, Bates, Glandon and Berner, 2010).

Nevertheless, in actual practice, physicians do not wait for the results of time-consuming diagnostic procedures (Walter, Kostopoulos, Haass, Lesmeister, Grasu, Grunwald, Keller, Helwig, Becker, Geisel, Bertsch, Kaffiné, Leingärtner, Papanagiotou, Roth, Liu, Reith and Fassbender, 2011), and even when such information is available, time constraints can restrict access (Tierney, 2001). One study showed that even though many ED physicians believe that the majority of their patients would benefit from longitudinal patient health information, they attempted to obtain such data less than 10% of the time (Hripsak et al., 2007).

This article examines to what extent physicians utilize the various information components in diagnosing and admitting patients, especially in the highly-stressful ED context, with its complex conditions for providing medical care including time constraints and the enormous number of patients.

The study focused on the main health maintenance organization (HMO) in Israel, which is also one of the world's largest non-governmental HMOs. The HMO owns seven general hospitals (all surveyed in this research). In 2004, the HMO deployed the EHR IS analyzed here. The EHR IS retrieves data from many medical systems. The system gathers historical patient data from the other healthcare information systems at the HMO's hospitals and clinics include chronic medications, adverse reactions, detailed lab and imaging results, past diagnoses, healthcare procedures etc.

OBJECTIVE AND RESEARCH HYPOTHESES

Objective

The objective of this research is to assess the contribution of various information components (see at Table 1) retrieved from an EHR IS (such as lab tests and previous admissions) to the physician's admission decisions in EDs.

Hypotheses

Walker, Pan and Johnston, Milstein, Bates and Middleton (2005) argued that there is a relationship between the viewing of medical history and an improved medical care including admission decisions. To better understand this link, we examined the relationship between EHR IS usage and general admission decisions and formulated the following hypotheses:

H1: There is a relationship between using information components via the EHR IS and admission decision to a hospital. This was divided into two specific hypotheses:

H1.1: There is a positive relationship between using information components via the EHR IS and the decision to admit a patient to a hospital.

H1.2: There is a negative relationship between using information components via the EHR IS and the decision to admit a patient to a hospital, resulting in a single-day admission.

METHODS

The research method selected for this study is track log-file analysis. This method typically employs statistical tools such as T-tests and logistic regressions (Long, Chang, Li and Chiu, 2008; Vest, Jasperson, Zhao, Gamm and Ohsfeldt, 2011). The log-files were based on data from seven main hospitals owned by the main HMO in Israel from 2004-2007, which uses an EHR IS to share medical information from distributed health suppliers. The log-file consisted of about 3.2 million referrals (921,386 admissions and 2,298,524 discharges) i.e., the whole population in these hospitals.

The Dependent Variables

Admission decisions

One of the most important decisions in an ED is whether to admit or discharge a patient. We thus analyzed the impact of using information components via the EHR IS on the proportion of admissions (out of the total number of referrals to the EDs).

Admission decision was defined as a dichotomous variable to admit the patient to the ED (1 for admit decision and value=0 for discharge decision). This measurement scale has been used in previous research (Richardson, 1998).

Single-day admission

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 such short-term admissions can be reduced using medical information (Ben-Assuli, Leshno and Shabtai, 2012; Denman, Bingham and George, 1997; Shabtai, Leshno, Blondheimc and Kornbluth, 2007). We examined whether the proportion of single-day admissions fluctuates when patients' medical history is consulted via EHR IS. The measurement scale of single day admissions filtered out patients who intentionally sought and received treatment involving a single day admission. Only admissions from an ED to a specific hospital department were recorded and included. In addition, similar to many EDs around the world, hospitals in Israel maintain observation wards in which patients are monitored for a period of 12-24 hours. This period of observation was not included in the calculations.

The Independent Variables

Using the EHR IS

The patients in our study were divided into two groups: patients whose medical history was viewed via the EHR IS and patients whose medical history was not viewed. Vest (2009) found that system access was not random, and that specific patient factors increased the odds of information access. Shabtai et al. (2007) showed that the use of medical records depends on the patients' specific problem, and Ben-Assuli et al. (2012) showed that the use of medical IS depends also on the crowdedness level at the point of care.

The term 'Using the EHR IS' refers to access to at least one of several medical information components in the EHR IS (see Table 1). This was measured as a dichotomous variable (1=the EHR IS was accessed; 0 if not).

Type of medical information components	Specifics
Hospitalizations	Previous visits and hospitalizations
Blood pressure	Patient's prior blood tests results
Community Records	The patient's clinical record, generated by family physicians
Laboratories	Previous lab tests
Pathology history	Patient's pathological history
Imaging	An online retrieval of patient's imaging
Demography Details	Information regarding the demography of the patient
Surgical History	A list of previous surgeries

Table 1. Types of patient medical histories available to physicians via the EHR

We created a set of dichotomous variables to measure the impact of medical components on the dependent variables. These variables were measured as dichotomous variables (as used at Table 3 in the Results):

1. Value=1: If a specific information component was viewed via the EHR during the period of evaluation in the ED.
2. Value=0. If a specific information component was not viewed via the EHR during the period of evaluation in the ED.

Type of insurance

The parameter of insurance is highly important for distinguishing between cases in which the medical history of patients is available and cases in which it is only partially available. A previous study (Connelly, Park, Du, Ampornpant, Gordon, Bershaw, Gensinger, Shrift, Routh and Speedie, 2011) shows that EDs internals (patients with prior information in the EHR upon ED presentation) had lower odds of mortality if hospitalized, required fewer laboratory tests during the ED visit as well as fewer medications than the external population.

The EHR IS chosen for this study only provides full integrative information on patients belonging to the main HMO, and only information regarding previous admissions to the same hospital are available for patients from other HMOs. To control for major discrepancies in the quality and the amount of medical information between the HMOs, a dichotomous variable was created (1—if the patient was a member of the main HMO or 0—if the patient was from other HMO).

RESULTS

In order to test for differences in the continuous variables between the two groups, a t-test for independent samples was performed. To test for differences in continuous variables between more than two variables, a one-way analysis of variance (one-way ANOVA) was performed. Associations between dichotomous variables were tested by the Pearson Chi-Square test (the standard test to compare proportions) or Fisher's Exact Test.

Descriptive Statistics

Properties*		Number of Referrals	Number of Admissions
		Total study sample: n=3,219,910 (100%)	Total study sample: n=921,386 (100%)
All Insurances (%)***	EHR System was Accessed	519,132 (16.12%)	218,606 (23.73%)
	EHR System wasn't Accessed	2,700,778 (83.88%)	702,780 (76.27%)
The Main HMO (%)***	EHR System was Accessed	410,959 (17.42%)	175,933 (25.20%)
	EHR System wasn't Accessed	1,947,937 (82.58%)	522,265 (74.80%)
Other HMO (%)***	EHR System was Accessed	108,173 (12.56%)	42,673 (19.12%)
	EHR System wasn't Accessed	752,841 (87.44%)	180,515 (80.88%)

* The total number of referrals and admissions is divided into patients whose historical data were viewed via the EHR and patients whose were not, and also between the main HMO population and other HMO populations. Each of these groups was similarly divided in terms of viewing or not viewing patients' historical data. For instance, if we add the number of main HMO admissions whose historical data were viewed (175,933) to the number of other HMOs admissions whose historical data were viewed (42,673), the result is the total number of patients whose historical data were viewed (218,606).

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

Table 2. The distribution of referrals by type of insurance and viewing medical history:

Table 2 indicates that the majority of the ED patients in the seven hospitals belonged to the main HMO (2,358,896 out of a total of 3,219,910 referrals). It is important to note that the medical history of the patient was viewed in only 16.12% of all the referrals to hospitals. Thus, 83.88% of all referrals did not include any use of medical history. Moreover, in approximately a quarter of the admissions to an ED (23.73%), medical history was viewed whereas in more than 76% of all admissions medical history was not viewed at all. Thus consistent with previous studies, there was a relatively low level of use of medical history. Furthermore, there was greater use of medical history for patients who were members of the main HMO, for whom more extensive data were collected, compared to other HMOs (25.20% in the main HMO compared to 19.12% to the others). Still, even among members of the main HMO, the extent of use of medical history was low.

Results of Regressions of Information Components

Multivariate logistic regressions were calculated on the independent variables: Admission Decisions and Single-Day admissions (yes/no). Three blocks of variables were run: 1) Block 1: Treatment variables (EHR component (see at Table 1) viewing, age, insurance provider and gender), 2) Block 2: Control variables for type of department (for example internal medicine and surgical), and 3) Block 3: Control variables for different hospitals (due to various differences such as policies). These regressions reflected the pure contribution of EHRs' information components to the rate of admissions and single-day admissions.

Table 3 presents the impact of medical components on admission decisions adjusted for age, type of insurance, gender, type of department and type of hospital. Past surgeries had the greatest impact on admission decision; when viewing this information component, the total number of admissions increased by 62.2%. This component affected single-day admissions as well, leading to a 17.3% reduction. Another reverse admission/single-day admission effect was found with regard to previous hospitalizations where viewing such protocols increased (52.3%) the total number of admissions and decreased (12.4%) the number of single-day admissions. A similar effect was found for the pathology component as well.

Generally, viewing information components led to a decrease in the number of single-day admissions and to an increase in the amount of the longer admissions (supporting our two hypotheses). However, viewing laboratory results from the system reduced both the number of admissions and the number of single-day admissions. Demography and community record results were not significant. Therefore, the use and consumption of medical services appears to depend on the patients' specific problem.

Theory Variables in the Equation	Admission Decision / Single-day Admission	B	S.E.	OR [95.0% C.I.]
Hospitalizations	Admission Decision	.421 ^{***}	.013	1.523 [1.484-1.564]
	Single-day Admission	-.132 ^{***}	.025	.876 [0.834-0.921]
Blood Pressure	Admission Decision	-.047 ^{n/a}	.061	.954 [0.846-1.076]
	Single-day Admission	.209 ⁺	.124	1.232 [0.967-1.570]
Community Records	Admission Decision	.027 ^{n/a}	.029	1.028 [0.971-1.087]
	Single-day Admission	.047 ^{n/a}	.060	1.048 [0.931-1.180]
Laboratories	Admission Decision	-.071 ^{***}	.005	.932 [0.923-0.941]
	Single-day Admission	-.227 ^{***}	.010	.797 [0.781-0.814]
Pathology	Admission Decision	.125 ^{***}	.024	1.134 [1.081-1.189]
	Single-day Admission	-.080 ⁺	.050	.923 [0.836-1.018]
Imaging	Admission Decision	.159 ^{***}	.007	1.173 [1.157-1.188]
	Single-day Admission	-.262 ^{***}	.015	.770 [0.748-0.792]
Demography	Admission Decision	-.041 ^{n/a}	.032	.960 [0.902-1.022]
	Single-day Admission	.016 ^{n/a}	.064	1.016 [0.896-1.151]
Surgical	Admission Decision	.484 ^{***}	.024	1.622 [1.546-1.702]
	Single-day Admission	-.190 ^{***}	.049	.827 [0.752-0.911]
Age	Admission Decision	.033 ^{***}	.000	1.033 [1.033-1.033]
	Single-day Admission	-.021 ^{***}	.000	.979 [0.979-0.980]
Insurance	Admission Decision	-.091 ^{***}	.003	.913 [0.908-0.919]
	Single-day Admission	-.065 ^{***}	.006	.937 [0.925-0.948]
Gender	Admission Decision	.148 ^{***}	.003	1.159 [1.152-1.166]
	Single-day Admission	.050 ^{***}	.006	1.051 [1.038-1.064]
Constant	Admission Decision	-3.950	.007	.019
	Single-day Admission	-.354	.022	.702

Block 2 (control for type of department), Block 3 (control for type of hospital) are not shown here, but were also included in the regression.

Table 3: Logistic Regression on admission decision and on single-day admissions

DISCUSSION

Using EHR systems including its information components contributes to admission decisions and clearly reduces the number of single-day admissions for all patients, especially for main HMO patients. Additionally, there were higher accessing rates for patients insured by the main HMO, as compared to other HMOs, although both figures remained strikingly low.

A possible explanation for the differences between types of insurance is that the medical history of patients not insured by the main HMO is supplied by a system whose sole source of information is based on the same hospital as the current referral, rather than on integrated medical information; therefore, this information may have been considered less comprehensive (see Coleman, 2003). By contrast, for the main HMO patients, medical history is collected from previous hospitalizations in all hospitals as well as from many health suppliers such as laboratories; therefore, the information is regarded as exceptionally comprehensive.

One possible explanation for the increase in ED admission decisions after accessing the EHR components could be related to the nature of medical problems that may tend to be more severe. However, the findings suggest that short unnecessary admissions which are more related to lack of access to information can be prevented, in significant percentages, by using

EHR components during the course of evaluation in the ED. The information components that contributed the most to reducing single-day admissions were previous hospitalizations, past laboratory results, imaging, and past surgeries. These components should thus be readily available for viewing to assist single-day admission decisions. The decision not to view important information may actually reflect physicians' lack of time. This may encourage them to admit patients for a single day even if the information is readily available (Hripcsak et al., 2007).

Research Contribution

The main goal in this study was to characterize the data components that improve the process of medical decision-making in EDs. Previous research has pinpointed differences in the use of information components across clinical specialties (Shabtai et al., 2007). This characterization may help improve the appropriateness of test orders (Raja, Ip, Prevedello, Sodickson, Farkas, Zane, Hanson, Goldhaber, Gill and Khorasani, 2012).

Second, we expanded research on admission decisions. We extended the results of a critical question in the ED: whether or not to admit the patient. We expanded our analysis to other outcomes (as compared to Cooke, Higgins and Kidd, 2003, and Shabtai et al., 2007). We used a unique comprehensive dataset since our population of patients consisted of the whole population. Consequently, our data included all the general hospitals that use the EHR IS.

Third, the findings may enable developers and designers of EHR IS to better understand the components that affect IS usage and the value of information. This, in turn, may help integrate the necessary information components into new and existing systems. The results suggest that, several changes may be worthwhile to implement in ISs. First, information components in the system screens could be changed to fit specific clinical case properties. Hripcsak et al. (2007) found that even when users were shown that previous data were available and the display was integrated into the user's normal workflow, they generally accessed the data less than half the time. Therefore, it is crucial to supply and promote substantial data for each type of decision and diagnosis (Phansalkar, Edworthy, Hellier, Seger, Schedlbauer, Avery and Bates, 2010). Information components should be designed to help physicians make use of information, to consider this information properly, and to arrive at good decisions (Elwyn, Frosch, Volandes, Edwards and Montori, 2010). Poorly organized information can cause as many errors in decisions as having too little information (Tierney, 2001).

Primary care providers find it difficult to keep up with information generated across different episodes of care. This situation is exacerbated when it is not from the same provider (Panjamapirom et al., 2010; Coleman, 2003). Understanding the most significant information components may provide some guidance in the allocation of resources in this difficult endeavor of keeping up with patients' medical information.

Avenues for Future Research

Adding the physician's attributes to the log file such as personal identification might facilitate research on network externalities, diffusion theory and TAM (Davis, 1989).

Second, a more in-depth analysis of information components regarding several main differential diagnoses, may improve our understanding on the issue. Such specific results may even prove helpful in modifying long-held medical guidelines (Rokos, French, Mattu, Nichol, Farkouh, Reiffel and Stone, 2010).

Third, the results from this research could be used to formulate questionnaires to evaluate physicians' priorities regarding different information components and required medical tests.

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