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Summer 9-4-2014

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# USAGE PATTERNS OF HEALTH INFORMATION EXCHANGE: ANTECEDENTS AND CONSEQUENCES

*Research in Progress*

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## Abstract

*Health information exchange (HIE) systems integrate patient-level data that originates in several health information systems (HISs). As these systems bridge information gaps, they are expected to improve the caregiving process in terms of resource utilization and quality of care. Nevertheless, effective use of the system is a hurdle in realizing these benefits fully. Understanding actual individual use of the system is therefore of great importance. Several studies described factors that result in the use of the system, yet seldom examined their affect on characteristics of use. Furthermore, few studies empirically evaluated the association between the characteristics of actual individual use and decisions made during treatment.*

*In this study, we intend to identify the antecedents of pattern of system use, namely patient-related, user-related, and environmental factors. The pattern of use is described by several variables. We then explore the link of the pattern of use and potential antecedents to clinical decisions, specifically the unit to which patients were admitted and the number of ancillary tests ordered. Our hypotheses are tested using clinical data and HIE log files of an emergency department (ED) in a large Israeli hospital.*

*Keywords: Health Information Systems, Health Information Exchange, Usage Patterns, Clinical Decisions.*

# 1 Introduction

Health information systems (HISs) are a varied set of technologies used for transmitting and managing health information (Blumenthal and Glaser, 2007). As information management is fundamental to healthcare delivery (Chassin and Galvin, 1998), HIS proliferation has been promoted as having great promise in terms of improving efficiency, quality, and safety of healthcare services (Chaudhry et al., 2006). Senior management in the healthcare sector, as well as numerous studies, have focused on measuring the value of HISs to the healthcare sector, as this value often undermatches investment (Jones et al., 2012).

Health information exchange (HIE) systems form a sub-category of HISs. These systems integrate patient-level health data from different multiple data sources, which are arranged in an architecture that defines the way the data is stored, accessed, and shared (Vest and Jasperson, 2010). This enhances the accessibility of health information in various points of care, thus weakening the effect of inner and inter-organizational boundaries (Hersh, 2009; Vest et al., 2011b). The concept underlying HIE has evolved mainly as a response to patients' need for healthcare services from multiple organizations and organizational units. This resulted in information "blind spots" and caused healthcare service providers to base their decisions on partial patient data. The consequent need for duplicate lab tests and patient information updating raised expenses and compromised patient safety. HIE systems have been designated to increase data availability and work efficiency, while decreasing duplication of procedures and services (Johnson et al., 2011).

Healthcare sector leaders and researchers have often referred to HIE systems as key HISs, having an immense potential to transform the healthcare sector (Vest et al., 2011a; Vest and Jasperson, 2012). Studies show that even at a state of partial or lack of patient data, providers that use some form of HIE are likely to make safer decisions (Sutcliffe et al., 2004), meaning that HIE has the potential to improve patient safety and the quality of care (Kaelber and Bates, 2007). HIE systems are also effective in bridging information gaps among healthcare providers and patient hand-offs, which have been identified as a key point of breakdown in patient safety (Kaelber and Bates, 2007). HIE systems are also believed to have the potential to improve resource utilization and reduce costs (Fontaine et al., 2010; Frisse and Holmes, 2007). Finally, from a technological point of view, HIE systems increase IT flexibility and scalability by facilitating communication among systems of different structures and supported data types (Halamka et al., 2005).

However, the realization of the benefits of HIE systems is contingent on the use of the system (Frisse and Holmes, 2007). The mere availability of an HIE system neither guarantees the achievement of the abovementioned benefits, nor does it assure the system's use (Vest et al., 2011c). Understanding patterns of use of HIE systems as well as their antecedents may therefore support endeavours of utilizing the systems' potential benefits.

Some empirical work has been done on measuring the individual use of HIE systems and on assessing factors that affect the general use of the system (Johnson et al., 2011; Vest et al., 2011a; Vest et al., 2011b; e.g., Vest et al., 2011c; Vest and Jasperson, 2012). Nevertheless, these studies seldom attempted to examine the associations of these factors with characteristics of system use, such as the volume and diversity of information. Similarly, few studies examined the manner in which patterns of HIE use are associated with clinical decisions. The few that examined such associations found them to be significant (e.g., Ben-Assuli et al., 2013).

Salient potential benefiters of an information exchange process are emergency departments (EDs), which are abundant with uncertainty and subjected to time constraints (Shapiro et al., 2007). This is

especially the case of critically-ill ED patients. As these patients are typically uncommunicative, vital information in such cases is often retrieved from information systems and family members. The care of such critical patients in the ED, on the one hand, presents one of the scenarios in which an HIE would be most beneficial to clinical decision making (Hripcsak et al., 2007b; Shapiro et al., 2007) and, on the other hand, often requires rapid decisions in which the perusal of an HIE might not be practical.

The goals of this study are therefore to identify the antecedents of patterns of HIE system use and the associations between these patterns and clinical decisions. We pursue these goals in the specific context of critically-ill patients treated at the internal ED of the Soroka University Medical Center (SUMC) in Israel.

# 2 Background: Factors associated with HIE use

Although use patterns vary among different users (Vest and Jasperson, 2012), HIE systems are generally accessed in a small percentage of encounters with patients, regardless of the user (Johnson et al., 2011; Shapiro et al., 2007; Unertl et al., 2012). Moreover, the nature of HIE system use is often basic and includes viewing a summary of patient demographic information, concise history of prior visits, and hospitalizations and lab test results (Vest et al., 2011b; Vest and Jasperson, 2012).

Studies attempted to link various factors to HIE use patterns, including factors that are patient-related, user-related and environmental/organizational:

- While in theory *unfamiliar patients* are more likely to prompt use of an HIE system, these patients were negatively associated with the usage of HIE (Vest et al., 2011a; Vest et al., 2011b). Similarly, the use rate of HIE was lower in encounters in which there were lower *chances of finding existing external information* (i.e., patients who have never visited "an exchange site" linked to the HIE system) than in cases where information could be retrieved via the HIE system (Johnson et al., 2011).
- The HIE system is sometimes accessed when the information given by the *patient is perceived as dishonest or unreliable*, in order to verify the patient's narrative (Unertl et al., 2012).
- In encounters with patients with *prior hospitalizations*, the use of the HIE system is more likely to be elaborate (Johnson et al., 2011; Unertl et al., 2012; Vest et al., 2011a; Vest et al., 2011b; Vest et al., 2011c). Elaborate use was characterized by the access of more detailed screens, rather than a summary of the patient's clinical data (Vest et al., 2011c). The same conclusion was found in regard to patients with *frequent primary care visits*.
- A factor of *recent hospitalizations* was not always found significant in relation to HIE use. While in some studies recent hospitalizations was not significant as a predictor of use (Vest et al., 2011b; Vest et al., 2011c), another study showed a higher chance of HIE system use in encounters with patients who had been recently admitted (Vest et al., 2011a).
- HIE access is more prevalent in cases that involve patients with one or more *comorbidities* or chronic conditions (Johnson et al., 2011; Vest et al., 2011a; Vest et al., 2011c).
- Expectations of finding decreased HIE use in cases that *do not require external clinical information* (and therefore require little to no information exchange), such as injuries and accidents, were partially contradicted (Vest et al., 2011c).
- The patient's ethnicity was found to be associated with system use (Vest et al., 2011c).

- *Time constraints* due to high workload in the ED have been shown to be positively (Ben-Assuli et al., 2012a) and negatively (Vest et al., 2011a; Vest et al., 2011b; Vest et al., 2011c) associated with HIE use.
- HIE use patterns may be affected by other non-clinical factors, namely those related to the organization's usage policy, such as *insurance issues* (Vest et al., 2011c).
- An alert presented by the system to the user, indicating that a patient's medical record *contains data* that originate in *external sources* (e.g., other hospitals) was found to increase the rate of system use (Hripcsak et al., 2007b; Johnson et al., 2011).
- The following physician-related factors also emerged in previous studies: *physicians' gender* was not found to be associated with particular use patterns, whereas *age* was found to be slightly negatively associated with the general use of HIS (Ortega Egea et al., 2010) and with the use of an HIE system shortly after its implementation (Brainin et al., 2005). Although part of these findings relate to HIS use, it is not unlikely to assume similar associations for HIE systems.

Nevertheless, the studies above did not take into consideration the following factors, which may have an effect on HIE system use:

- Non-clinical factors such as *time of day* and *day of week*.
- Patient-related factors: while the clinical condition of the patient was taken into consideration, the patient's *gender* and *age* were generally not. Age was sometimes indirectly taken into account through the inclusion of the Charlson comorbidity index (Johnson et al., 2011; Vest et al., 2011a).
- Physician-related factor of *level of expertise*.

A drawback of previous studies is their prediction of use on a dichotomous level (use or no-use) or on a trichotomous level (no-use, basic use, or advanced use). An alternative, more elaborate approach to characterizing use includes variables that describe use in terms of its length and breadth (Vest and Jasperson, 2012). However, these variables have not yet been examined as dependent variables or as predictors of clinical decisions.

# 3 Model

The conceptual model tested in this study is presented in Figure 1. The *patient, physician, and environment* construct includes the following variables:

- Patient variables: age on encounter, gender, ethnicity, and previously-diagnosed comorbidities.
- Physician variables: gender and level of expertise.
- Environment variables: time constraints, time of day, and day of week.

The *pattern of use construct* consists of variables that describe the information displayed to the user during the use of the system. The construct includes the variables of total volume, diversity, and granularity.

The *clinical decision construct* contains the unit to which the patient would be admitted and the number of ancillary tests ordered during the patient encounter.

The pattern of use is associated with the need for information that is contingent on the patient (e.g., comorbidities), the user (e.g., gender, expertise), and environmental characteristics (e.g., current workload in the ED). Previous studies have associated these variables with use of the HIE system

(Vest et al., 2011a; e.g., Vest et al., 2011b; Vest et al., 2011c) and we hypothesize that these associations hold for more elaborate definitions of HIE system use. Moreover, the characteristics mentioned above are also likely to be the basis for many clinical decisions (e.g., Stiell and Wells, 1999). We therefore hypothesize that:

H1: Patient, physician, and environmental characteristics are associated with the pattern of HIE system use.

H2: Patient, physician, and environmental characteristics are associated with clinical decisions made in the ED.

The effectiveness of a treatment plan conceived upon arrival of a patient to the ED is linked to the inspection of the patient's medical condition and history (Hripcsak et al., 2007a; Hripcsak et al., 2007b). Information made accessible by the HIE system is expected to have an effect on medical decisions, which, in turn, will influence patient safety and resource utilization (Frisse and Holmes, 2007; Kaelber and Bates, 2007). Hence, we hypothesize that:

H3: The pattern of use of the HIE system is associated with clinical decisions made in the ED.

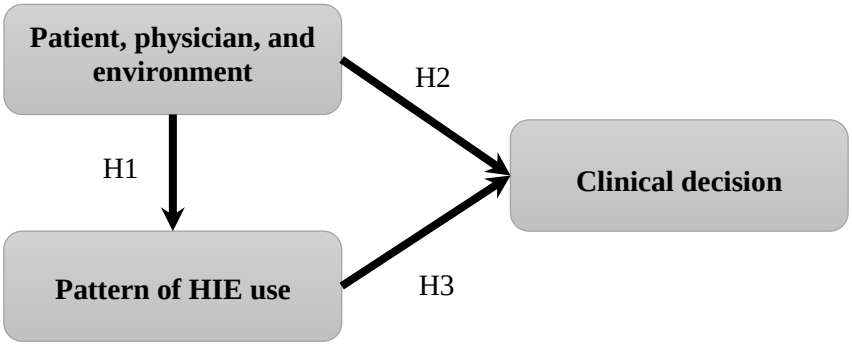


*Figure 1. Research model.*

# 4 Method

## 4.1 Research setting

Clalit Health Services is the largest healthcare provider in Israel and treats over 3.8 million insurees, who make for approximately 53% of the Israeli healthcare "market". Clalit operates more than 1,300 community clinics, 14 hospitals, 400 pharmacies, and hundreds of medical institutes and laboratories, and it employs over 30,000 medical and administrative employees. Soroka University Medical Center (SUMC) is the fourth largest hospital in Israel. It serves over one million people and its internal ED treats over 100,000 patients annually.

OFEK, an HIE system, is widely implemented in hospitals and facilities owned by Clalit, including SUMC. OFEK integrates patient-level data that originate in several Clalit HISs. These data include history of diagnoses, previous visits in hospitals, community and outpatient clinics, discharge summaries, medication history, and laboratory and radiograph results.

Several studies explored the actual use of OFEK and the effects of its implementation and use on performance measures of the healthcare process, such as admission decisions (Ben-Assuli and Leshno,

2012; Ben-Assuli et al., 2012a; Ben-Assuli et al., 2012b) and rates of ordering ancillary tests (Nirel et al., 2010). These studies included no physician-related variables and typically measured system use based on a dichotomous use/no-use approach.

## 4.2 Dataset and variables

This study focuses on critically-ill patients who arrived to SUMC's internal ED between January 1, 2010 and December 31, 2012. During this period, a total of 1001 patients had 1051 treatments. Contingent on their medical condition, critically-ill patients are treated in a resuscitation room (RR) either upon arrival to the ED or after being triaged by a nurse.

All data regarding the patients, physicians, and medical environment were retrieved from Clalit's HISs after obtaining IRB approval. This dataset enabled the operationalization of the following constructs and variables:

The patient, physician, and environment construct includes the following variables:

- Patient variables: age on encounter, gender, place of birth (Israel or otherwise), and the Charlson comorbidity index calculated based on the ICD-9-CM coding (Quan et al., 2005).
- Physician variables: gender and level of expertise (coded as 1 for intern, 2 for resident, and 3 for senior resident). In order to control for the variance introduced by the specific physician and for physician-related dependence across encounters, physicians were considered as a random factor in regression analyses.
- Environment variables: ED workload (measured as the total number of patients that arrived to the internal ED in the period between 30 minutes before and after the specific patient had arrived), time of day, and day of week (middle of the week vs. weekend).

The *clinical decision construct* includes the following variables: the unit to which the patient was admitted (intensive care unit vs. regular ward) and the number of ancillary tests ordered during the encounter with the patient.

Patterns of use of the HIE system were operationally defined based on log-file analysis, which is considered a recommended instrument for measuring system use (Johnson and Gadd, 2007). The log file, extracted from the OFEK database, documents all screens that were displayed during encounters with the abovementioned patients by physicians only. The HIE system was used during 893 encounters, which are 84.97% of all relevant encounters.

The log file was used to compute the following variables, which describe the *pattern of HIE system use* for a specific encounter: information volume (measured as the total number of displayed screens) (Vest and Jasperson, 2012), information diversity (measured as the number of different screens displayed) (Vest and Jasperson, 2012), and information granularity (the level of information specificity, measured by the maximal granularity of the accessed screens).

### 4.3 Methods of analysis

We intend to test our hypotheses using the following statistical methods:

- The prediction of information volume and diversity (H1) as well as the number of ordered ancillary tests (H2-H3) will be conducted using mixed-effects linear regressions.
- The prediction of information granularity (H1) and clinical admission decision (H2-H3) will be executed by mixed-effects logistic regressions.

## 5 Preliminary results

We are currently in the preliminary stages of data analysis. We intend to present our preliminary findings at the conference.

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