



Use patterns of health information exchange through a multidimensional lens: Conceptual framework and empirical validation



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ARTICLE INFO

Article history:

Received 25 April 2014

Accepted 5 July 2014

Available online 14 July 2014

Keywords:

Use pattern

Health information exchange

Log file

Multidimensional analysis

ABSTRACT

Insights about patterns of system use are often gained through the analysis of system log files, which record the actual behavior of users. In a clinical context, however, few attempts have been made to typify system use through log file analysis. The present study offers a framework for identifying, describing, and discerning among patterns of use of a clinical information retrieval system. We use the session attributes of volume, diversity, granularity, duration, and content to define a multidimensional space in which each specific session can be positioned. We also describe an analytical method for identifying the common archetypes of system use in this multidimensional space. We demonstrate the value of the proposed framework with a log file of the use of a health information exchange (HIE) system by physicians in an emergency department (ED) of a large Israeli hospital. The analysis reveals five distinct patterns of system use, which have yet to be described in the relevant literature. The results of this study have the potential to inform the design of HIE systems for efficient and effective use, thus increasing their contribution to the clinical decision-making process.

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1. Introduction

Health information exchange (HIE) systems are health information systems (HISs) that enable the electronic exchange and integration of patient-level health information across and within organizational boundaries [1,2]. HIE systems allow clinicians, regardless of their location and employers, to electronically exchange information about common patients [3]. This enables the data to “follow” the patient, allowing “re-use” of clinical data [1]. Potential advantages of these systems include improved quality of care and patient safety, cost reduction, and increased efficiency, e.g., [4,5].

Several studies have established that the extent to which these benefits are fulfilled depends on the implementation of the HIE system and its integration into clinicians’ workflow [6]. Hence, shedding light on HIE usage patterns may promote the successful realization of their potential benefits. Such an analysis can address the components of the information technology (IT) productivity paradox – mismeasurement, mismanagement, and poor usability [7] – in the context of HISs.

Previous studies that empirically analyze patterns of HIE use are scarce. Prior studies measured organizational use as well as use

made by individuals, which are the ultimate HIE end users and are therefore of great importance [8]. As the measurement of use at the individual level is difficult, several studies have turned to the analysis of system log files [2,9]. Nevertheless, using log files to explore healthcare processes is challenging due to their inherently complex, variable, and caregiver-contingent nature [10].

Individual usage patterns were usually characterized through the sequence, number, and types of screens viewed by HIE system users, while disregarding temporal traits, e.g., [10,11]. Another shortcoming of previous research is that the small number of studies that classified usage patterns generally used categories such as no use, basic use, or advanced use e.g., [2,12].

Against this backdrop, the present study offers a framework for identifying, describing, and discerning among patterns of use of a clinical information retrieval system. Although we focus our discussion on HIE systems, the proposed framework should be applicable for studying the use of electronic medical records (EMRs). In this framework, we suggest attributes that describe both the general and context-related use of the system and we account for temporal aspects of system use. We recommend a multilayered method of analysis to examine the attributes of system use and the associations among them.

The setting in which we empirically validate the proposed framework is the emergency medicine departments (EDs), specifically in the care for critically-ill patients. Effectively and correctly

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diagnosing these patients in a timely manner is an important challenge physicians constantly face. These patients are typically not able to provide a medical history, and information is obtained from secondary sources such as family members and information systems. In this scenario, an HIE system is likely to have a significant impact on clinical decision making if information is readily accessible; the need for rapid decisions might render the scrutiny of an HIE system impractical.

We therefore chose to validate the framework with track log data from a widely-used HIE system in Israel, through which the medical data for over 50% of the Israeli population are accessible. To control for organizational and contextual factors, we focus on the use made by physicians within the busiest ED in Israel. Using the activity documentation of actual HIE users enables the identification of several multidimensional patterns of use. The main contribution of this study is in constructing and validating a framework for understanding HIE use. Gaining deep understanding of use patterns will assist in designing HIE systems to match clinical needs and incorporating the system into the decision-making process, thus enhancing its value to the clinicians and patients.

This article is organized as follows: in Section 2 we review past research on HIE patterns of use, explaining the motivation behind this stream of research. In Section 3 we outline a framework for describing patterns of use, drawing on the main attributes examined in previous studies within and outside the domain of health information. In Section 4 we apply the framework to HIE system logs that document use by physicians in an Israeli ED, demonstrating the meaningful conclusions that can be derived from using the proposed framework. In Section 5 we discuss this study's contributions and limitations, and offer avenues for future research.

2. Patterns of use of HIE systems

2.1. Research motivation

The potential advantages of HIE systems are not attained by merely implementing the systems. A two-level effort should guide the system implementation. First, a considerable effort should be made toward integrating the system into the users' workflow [6,12,13]. Nevertheless, studies have shown that placing the HIE system in the users' workflow does not necessarily lead users to fully utilize the system's abilities [2,9,14]. Significant effort should therefore also be placed on efficient use, which is contingent on system design. Successful implementation of an HIE system ought to include sufficient and directed endeavors that attend to these deficiencies [15]. Moreover, an examination of actual use may contribute to improving the system [9] and to estimating its impact on performance [16].

An exploration of HIE usage therefore involves the investigation of the system's integration into the workflow, followed by in-depth examinations of actual system use. Actual information system use can be defined as the act of accessing the system and utilizing its features in the end-user's workflow and can be stratified into several levels: individual, team, organizational, and inter-organizational [8]. We next briefly review the literature on these topics.

2.2. Use of HIE systems at the organizational level

In spite of the potential benefits of HIE systems, their adoption rates remain relatively low, although they are increasing. Whereas primary care practices present high adoption levels [17], inpatient care services are making their way more slowly [18]. Hospital implementation rates rose significantly in the past few years [19]. Hospitals with highly active EDs or those that maintain inter-organizational relationships are more likely to deploy HIE methods and systems [19,20].

HIE system users are diverse and pose different information needs [9,13]. Different users in the same organizational unit may integrate the system into their work patterns in different ways [21]. The organizational level of analysis may therefore miss out on important aspects of HIE use at the individual level.

The majority of studies on HIE systems use have focused on the individual level, specifically on the patterns of use exercised by physicians and nurses [8]. Despite the variance in the manner of use among individuals, some common role-based workflow patterns have been described by characteristics such as the timing of HIE use, types of accessed information, and main consumers of the retrieved data [21]. The notion of common workflow integration patterns supports the idea of common patterns of actual use.

2.3. Use patterns of HIE systems at the individual level

The individual level of analysis highlights the diversity of methods and measures for HIE system use. While some studies analyzed use patterns by observing and interviewing users [21], others utilized electronic log files of HIE systems, occasionally combined with semi-structured interviews [2,22–25]. Transaction log files contain documentation of electronic interactions between users and information retrieval systems [26], showing what information was displayed to the users at their request.

Studies that used log file analysis described patterns of use by means of measuring and analyzing the following indicators:

- *Types of users* that accessed the system, including physicians, nurses, administrative employees, and pharmacists [9,22], sometimes taking into account the additional variable of workplace (e.g., pediatric care, ambulatory care, hospital ED) [9,27].
- *Rate of patient encounters* in which the system was accessed [2,12,14,22].
- *Timing in relation to the encounter* in which the system was accessed (e.g., before the encounter, during the encounter, and retrospective use) [9,12].

Going beyond the dichotomous use/no-use approach applied in the previous measures is preferable when thoroughly describing the use of a system [9,28]. The following indicators delve into the attributes of each system access:

- *Time spent* per system access or per screen [23]. This temporal measure has been absent in most HIS use studies.
- *Diversity and types of accessed information* [9,24,27,29].
- *Frequency of basic access and of use of more advanced features* [2,14].
- *Sequence of screens* accessed by the user [9,11,23,25].

Although use patterns vary across users, the indicators summarized above have been employed to classify the use of HIE systems into relatively broad patterns. Two prominent classifications, which generally address the "breadth" of use, are:

- *No use, basic use, and advanced use*: These patterns were distinguished by the number and type of screens that were accessed during use. Basic access included a summary of patient history, lab results, and medications. The novel use pattern incorporated basic access with any additional views or inquiries [2,12,14].
- *Minimal (basic) use, repetitive searching, clinical information, mixed information, and demographic information*: This classification differs from the previous one mainly in the resolution by which novel use patterns were specified [9].

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