AHRQ Grant Final Progress Report

Title of Project: Exploring the Utilization of and Outcomes from Health Information Exchange in Emergency Settings

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Structured Abstract

Purpose: To understand use of health information exchange (HIE) by utilizing existing patient records as well as evaluate health outcomes that may be associated with the use of HIE.

Scope: To evaluate and understand the use of HIE in the emergency department setting. We leveraged retrospective electronic health records and user logs from a robust HIE network to quantitatively evaluate the use of health records in the HIE. We also completed qualitative interviews with health care staff to evaluate reasons for use or non-use of HIE.

Methods: We employed mixed methods to examine the use of HIE over time. Quantitative analysis focused on provider use of HIE in the emergency department setting over time by various patient, hospital, and user characteristics. Qualitative interviews with healthcare professionals examined the motivations for using HIE, as well as barriers to use.

Results: Overall, we found that HIE use increased over time. We further found that specific functionalities that make HIE easier to use resulted in greater use by clinicians. For example, clinicians suggested that "single sign on" (SSO) features make it easier to access HIE records. Instead of logging into the HIE with a distinct username/password, they can view patient records with the click of a button from their EHR system. After implementing this feature, usage increased 2-fold within the HIE network. Yet in general only 5-25% of patient encounters involve clinician use of HIE.

Key Words: Health Information Exchange; Healthcare Utilization; Health Outcomes

Purpose (Objectives of Study)

The overall purpose of this study was to better understand the usage and impact of HIE. This was accomplished through the utilization of mixed methods approaches to address the specific aims described below.

Specific Aim 1

We characterized the use of health information exchange over time by leveraging a robust, mature health information exchange system, the Indiana Health Information Exchange. This evaluation focused on the ED setting over 6 years among more than 90 EDs participating in the Indiana Network for Patient Care.

Specific Aim 2

We explored the antecedents, motivations for use, and other factors that may have influenced use of health information exchange by conducting qualitative interviews with health care providers in a variety of healthcare organizations.

Specific Aim 3

We examined the association between HIE use and the utilization of healthcare services as well as health outcomes among individuals who presented to the emergency department (ED).

Scope

Background

Health information exchange (HIE) involves the transfer of electronic health records between health systems, hospitals, and data repositories. Widespread HIE use has the potential to improve healthcare

outcomes and reduce the costs of care by making key health data, such as past lab tests or procedures, available even when care was completed elsewhere. Furthermore, several healthcare reform strategies have focused on increasing HIE as a strategy to reduce unnecessary care and procedures and improve costs. To increase HIE use, the federal government and individual states have invested millions to develop the infrastructure to share health data.

Despite these investments and the potential benefits of increasing HIE use, limited data exists to conclusively show the value of HIE. Most studies focus on whether or not an organization has adopted HIE, rather than on the actual use by individuals within that organization. Furthermore, only two studies have examined the impact of HIE adoption to actual health outcomes, and only one of these explored actual staff use of an HIE. None of these studies explored the actual user log data within the HIE system.

The purpose of this study, then, was to address this gap in research by characterizing the actual use of HIE in a large, robust HIE system; understand barriers and facilitators to use; and evaluate the impact of HIE use on healthcare utilization.

Context

The study occurred in the context of the Indiana Health Information Exchange (IHIE). The Indiana HIE is a mature HIE network consisting of more than 100 hospitals as well as outpatient clinics, commercial laboratories, payers, and public health departments (1). IHIE is statewide, covering 75-80% of patients in the State of Indiana. The exchange began in the mid-1990s but grew in the early 2010s following the HITECH Act of 2009. The study included data on HIE use between 2011 and 2017.

Settings

We examined HIE use in the emergency department (ED) across multiple hospitals in Indiana. We focused on the ED as patients often present with the need to query medical records from a variety of sources, which is the primary use case for HIE. We examined ED patients and clinician use of HIE in urban, suburban, and rural hospitals across the state.

Participants

HIE Use and Impact (Aims 1 and 3)

For the quantitative analyses, we extracted medical records for patients in Indiana who sought emergency care between 2011 and 2017. We first examined medical records for all care settings then narrowed in our analysis on ED visits. We examined only records for adult (18+ years) patients, excluding records on children and adolescents. We did not exclude records based on sex, race, ethnicity, or geography.

Provider Interviews (Aim 2)

We interviewed 20 healthcare providers from different health systems and hospitals around the state of Indiana. Selected characteristics of healthcare providers who participated in these interviews are included below in Table 1.

Table 1. Characteristics of healthcare providers

Site	Urban/Rural	Small/Large	MD	NP/PA	RN/Other	Total
A	Urban, Suburban	Large	4	2	1	7
B	Urban	Large	2			2
C	Rural	Small	1		3	4
D	Suburban	Large	3			3
E	Urban	Large	1			1
F	Rural	Small			1	1
G	Urban, Suburban	Small		2		2
Total			11	4	5	20

MD=Medical doctor; NP=Nurse practitioner; PA=Physician assistant; RN=Registered nurse

Methods

The study employed mixed methods to examine HIE use. Quantitative methods were used to examine HIE usage over time by participating hospitals in IHIE, as well as outcomes for patients who presented in EDs where the clinicians had access to IHIE records. We used qualitative methods to understand ED clinician perspectives about HIE use, especially under what circumstances do they use HIE to access outside medical records for a patient.

Research Questions

Mixed methods studies require that research questions be linked to and drive data collection and analysis methods, as well as inform the study design, sample size, sampling, instruments developed and administered, and data analysis techniques (2). Our primary research questions were:

1. Which factors contribute to HIE use within a particular ED and across multiple ED settings?
2. What are the facilitating factors versus barriers to HIE use?
3. How has HIE use within the ED changed over time?
4. Does the utilization of HIE result in better, worse, or the same outcomes for patients?

Data Collection

We collected a variety of quantitative and qualitative data to support mixed methods.

Quantitative Data Collection

Access log files were obtained from the Indiana Network for Patient Care (INPC), a mature statewide community HIE network (1). The INPC connects 117 hospitals representing 38 hospital systems; over 17,000 practices; over 48,000 providers; and contains data on roughly 15 million patients with a total of more than 12.5 billion data points. (3). We focused on user logs in the ED between 2011 and 2017. In order to add more information regarding the ED encounter such as payer, provider role, and rurality of the hospital, the access log files were linked to encounter-level clinical data using unique identifiers assigned to each encounter. When patients used more than one payer to pay for services received during a single encounter, only the payer that paid for majority of encounter's cost (i.e. priority payer) was retained.

Qualitative Data Collection

Semi-structured interviews were used to collect qualitative data regarding provider perceptions of HIE, barriers and motivations to HIE use, and provider knowledge of their HIE use system. Interviews (n=20) included healthcare providers from a range of hospitals, regions, and roles. Interviews were audiotaped and transcribed to obtain broadly generalizable results.

Data Analysis

Quantitative analysis provides measurable evidence of the use of HIE over time as well as the impacts of HIE use on outcomes and healthcare utilization. Qualitative analysis provides insights into the motivations and barriers to HIE use.

Data Analysis (Quantitative)

Descriptive statistics were used to summarize HIE usage over time as well as patient and facility information. We further employed bivariate analysis to explore the relationship of each independent variable (e.g., provider specialty, hospital) with HIE use.

We also employed a logistic model to evaluate our primary hypothesis: HIE use in ED encounters is likely to reduce admissions that occur in the ED. For our secondary outcomes, we used a count model. Models were fit at the user level with year, ED and user level fixed effects. Fixed effects control for unobserved differences across EDs and users by including a dummy variable for each ED and user.

Data Analysis (Qualitative)

Transcribed interviews were loaded into qualitative data analysis software (NVivo 9.0, QSR Int. USA) and underwent a series of well-established steps to identify emerging themes and trends. The process developed a coding scheme from combining concepts derived *a priori* from the conceptual frameworks driving the study and inductively as the analysis proceeded. Content was grouped into nodes, a codebook built, and codes or code combinations summarized and stratified by contextual factors such as demographics, respondent role, etc. Two medical students from the IU School of Medicine worked with Dr. Dixon to code all of the interviews. The students were first trained by experienced qualitative coders then reviewed their work frequently with Dr. Dixon to ensure consistency. Final analysis was conducted by Dr. Dixon with input from the other co-investigators.

Limitations

While the HIE utilized for this study is one of the oldest and largest in the country, much of the data used in this study was acquired from large, urban hospital systems. While we made substantial efforts to gain data and insights from health systems and practitioners in rural health systems, some conclusions may not be generalizable to smaller or rural health systems. Furthermore, despite the large size of the user logs and encounter-level data, many variables were missing due to inconsistencies in what is captured by IHIE. Therefore, the data may not generalize to other states and regions.

Ethics

The project received approval by the Institutional Review Board of Indiana University. All data was kept on secure drives accessible only to study team personnel who had a need to access them. Furthermore, data are retained on secure drives.

Results

Overall, we found that HIE usage increased over time as more health systems adopted HIE. Furthermore, clinicians use HIE more frequently when it fits into their clinical workflow. Making systems easy to use

encourages their usage. At the time of submission, our team continues to work on the analysis of HIE use and its association with patient-level outcomes. These findings will be published later.

Principal Findings

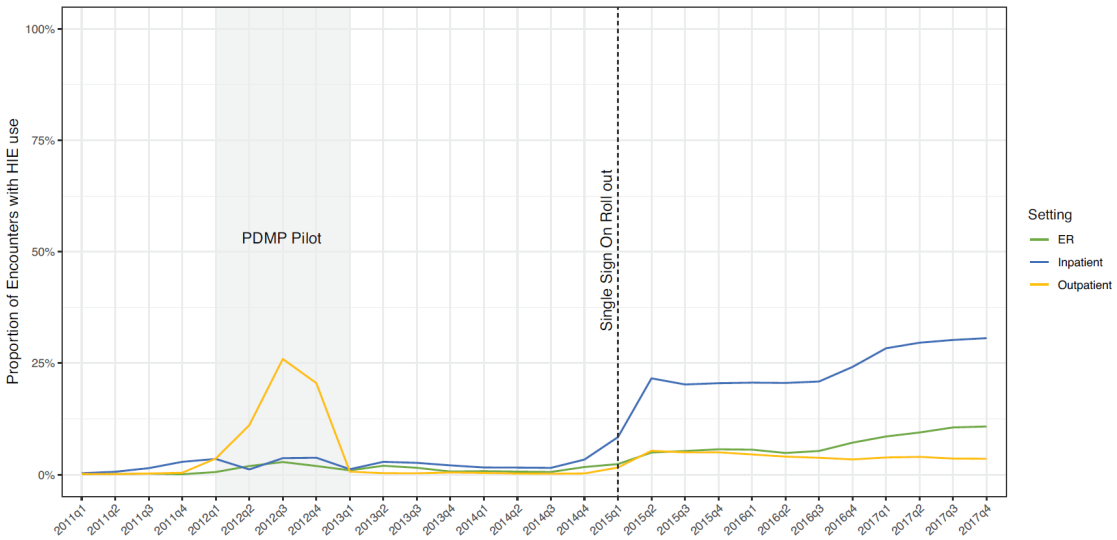
Characterization of HIE Use

We examined a total of 1,159,144 inpatient; 14,932,164 outpatient; and 3,006,972 ED encounters between 2011–2017 from the INPC. Of the encounters examined, 15.5% took place in rural settings. Overall, 4.7% of all encounters across all settings resulted in the user accessing external patient information. Further, HIE use was greatest in the inpatient setting (17.6%), followed by the ED (4.4%), and the outpatient (3.7%) settings. HIE use increased by 29%, 3.5%, and 9% in the inpatient, outpatient, and the ED settings, respectively, over time. Figure 1 summarizes HIE use over time.

The sharp increase in HIE use in 2012 was likely due to a pilot interoperability program implemented in a large safety-net hospital in Indianapolis. In this program, data from the state prescription drug monitoring program (PDMP) was integrated with the INPC and providers were encouraged to use the HIE network to access prescription drug histories. Further, prescription history was automatically extracted from the PDMP at registration for all patients in all care settings. This pilot was terminated at the end of 2012 coinciding with the HIE use trends returning to normal.

In late 2014, the INPC introduced a "single sign-on" (SSO) feature making it easier for providers to access ‘outside information’ on patients. Instead of opening a web browser, navigating to the HIE site, logging into the INPC, and looking up the patient using information such as a name and birthdate, the SSO functionality allows providers to click on a button within their EHR system and automatically login to the INPC to view medical records for the patient. This increased ease of use may likely be the reason for the steady rise in INPC use starting in late 2014 which continued through 2017. Further, SSO was incrementally rolled out to hospitals thus accounting for bumps in HIE use seen later in 2016 and 2017 as more hospitals adopted this feature (4).

Figure 1. Trends in proportion of encounters in each quarter where HIE data was accessed in the ED, Inpatient, and Outpatient care settings. Source: INPC log files, 2011–2017.



Drivers and Barriers to HIE Use

Providers reported being motivated to use HIE systems when encountering patients who were seen at outside facilities, were unable to communicate, or provided an incomplete or unreliable history. Many

reported seeking outside records to decrease unnecessary or redundant care, with providers noting utility especially for patients with recurrent complaints or drug-seeking behavior. Providers also reported using HIE to determine patient outcomes, through chart reviews for quality improvement as well as informal follow-up and education. Additionally, all clinicians reported their colleagues approved of their use of HIE, although many reported receiving limited or no training on how to use it. Many clinicians reported learning about HIE through residency, and their institutions do not ever provide in-service training. The lack of training showed in their responses to questions about specific newer functionality. They did not, for example, realize they could search in the chart to find something.

Clinicians reported their favorite functions of HIE were single sign on (SSO), which allows them login to the HIE through Cerner or Epic via a one-click button. Some physicians were aware of the chart search feature, and they enjoyed quickly finding the encounter or lab value they sought to find.

HIE Use Impact on Outcomes

This analysis is ongoing and should be completed in early 2021. These findings will be published with attribution to the grant.

Discussion

In this study of HIE usage, we found that use increased over time across a variety of settings including the emergency department. Increased use is associated with the introduction of functionalities that add value to clinicians' information seeking activities, such as single sign on. We further explored whether HIE is associated with better patient outcomes (results pending).

A key finding from this study is that HIE usage is unlikely to be 100%. Current use in the ED is around 12.5% of patient encounters, approximate 1 in 8 patients. Aiming for 100%, if ensconced in legislation or administrative rules like the Promoting Interoperability program, would be an unreasonable target for the health care system. We heard from clinicians they need to access the HIE for only some patients. For the clinicians who regularly used HIE, they suggested a proper benchmark would be somewhere in the neighborhood of 20% to 50% for ED clinicians. Many patients have acute needs that don't require extensive past medical record reviews, and some patients are frequent fliers so their information is in the local EHR system. Yet there does exist a sizable population of patients for whom obtaining outside records is necessary for clinical decision-making and care delivery. Therefore, HIE use should be encouraged in policy and supported by health care system leaders.

Overall, HIE is superior to traditional methods of accessing outside records. Many clinicians informed us that they still seek records periodically using phone calls and fax machines. This is because while IHIE is mature and broadly adopted, it is not universal. In these instances, clinicians say it can take hours or days to track down the outside records. This is not efficient for the ED, especially compared to IHIE where the information is available in 3-5 minutes. Most clinicians enjoy using the IHIE platform to retrieve records, especially since it is easy to get there via a button embedded in their EHR system.

Single sign on (SSO) was an incredibly popular functionality that clinicians brought up during the interview's multiple times. The quantitative data revealed that after introducing SSO usage in IHIE increased dramatically. Those clinicians working at institutions that had not yet implement SSO reported that access was okay and they tolerated the minor inconvenience of needing to login to another system since the alternative would require significant more time to track down records. Functionalities like SSO that integrate into clinical workflows and make using HIE easy are well received by clinicians and encourage its use.

Another key finding from the interviews with clinicians is that most institutions do not train staff on how to use the HIE. Most of the interviewees learned how to access and use the HIE as a resident in training in

an Indiana-based hospital. Almost none of them reported being shown how to use it as an incoming staff physician following medical school. One clinician said she worked months before knowing about the system and then had to petition administrators to get access. There is no official onboarding procedure or in-service training for staff physicians. This would be highly recommended as several clinicians we interviewed did not know about some of the advanced features of the IHIE platform, such as Chart Search where clinicians can search across the patients' longitudinal HIE-based medical record (5). Training is critical to successful adoption and use of health information technologies.

We further observed that HIE usage increased most in the inpatient setting (nearly 30%) over time. Inpatient clinicians use HIE about twice as frequently as ED clinicians. This surprised us, because the ED is one of the most studied areas of HIE adoption, and the ED is highlighted as the quintessential use case for HIE as individuals often arrive without extensive knowledge of their past medical history. Given that inpatient use is significantly higher than ED use, we believe that future HIE studies should examine how HIE supports inpatient care and what functions of HIE might drive use in those clinical settings/contexts. Furthermore, given that HIE is not used much in the outpatient setting, we further advocate for additional study of HIE in various outpatient contexts. There is significant potential for HIE to improve inpatient and outpatient care, yet we have just begun to understand its use and impact.

An important limitation of our existing and forthcoming quantitative analysis is the detail provided by health systems to HIE networks on their users. Although we accessed thousands of clinical user accounts over multiple years, many user profiles were incomplete. We had few details on users in rural systems in particular. Larger health systems often provided details about the user's role (e.g., physician, nurse) but not their specialty. User log files need to be enhanced by HIE networks, not only to strengthen audit records but enable detailed customer analytics. HIE networks should profile their users the same way that Netflix and Facebook do, so they can deliver tailored functions and information to them based on their years in practice, specialty, or preferences. In recent years EHR systems offered users the ability to customize the forms with which they interact when entering clinical data or reviewing records. HIE networks also allow users to store some preferences. Yet to fully support clinicians' experiences with HIE systems, existing networks like IHIE should better profile users and use those data to support clinical decision-making and patient care delivery processes. Based on our experiences in this study, IHIE is not in a position to do this, yet user analytics would likely improve use of HIE and make it easier for clinicians to find the information they seek. This should be a focus of future studies.

Challenges

We encountered several challenges, some of which resulted in substantial delays in the project. While delays and challenges are inevitable, we were able to overcome these challenges to complete the overall purpose of the study:

1. A major challenge was the availability of user log-in data as well as user characteristics in the health information exchange. We acquired log data from the Indiana Health Information Exchange for encounters from 2011-2017, which showed when, who, and how often a provider accessed the HIE data for a given encounter. The log data took a substantial amount of time to acquire from the HIE and understand the data.
2. Additionally, while the HIE collects some user data from organizations, it did not collect this information consistently from all organizations. We therefore had to reach out to individual hospitals to acquire user data (such as physician specialty, years in practice, gender, age, etc). We were not able to contact all hospitals in the HIE and some hospitals/health systems did not have the data readily available in a way that could be shared with us. We therefore had to limit the analysis to a smaller group of encounters and physicians.
3. We further suffered setbacks in the form of study personnel. Several personnel changed over time, especially our biostatistics support staff. The personnel we desired left the organization to

pursue another job. The individuals hired thereafter lacked experience with large datasets. And one of them ended up leaving within 2 weeks due to a medical issue. The user log data, once linked to clinical encounters, proved to be quite unwieldy for most biostatisticians. Delays in replacing staff caused several months delay in the analysis.

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