

Barriers to Use of Health Information Exchange (HIE) in Clinicians Practices: An Empirical Study in the United States

Pouyan Esmaeilzadeh*

Department of Information Systems and Business Analytics, College of Business, Florida International University (FIU), Modesto A. Maidique Campus, 11200 S.W. 8th St, RB 261B, Miami, FL 33199, United States

Abstract

Background: Health information exchange (HIE) programs as a policy subject in several developed countries can enable information sharing across providers and healthcare organizations to improve care coordination. However, besides the expected benefits of participating in HIE in enhancing coordination, reducing costs, and improving patient safety, previous studies report that clinicians' rate of using HIE mechanisms is still low. Insufficient participation of clinicians in data exchange networks can diminish the value of HIE. Based on utility theory, this study aims to identify and categorize barriers associated with the implementation of HIE projects in healthcare organizations and develop a comprehensive model to empirically examine the effects of HIE inhibitors on clinicians' intention to engage in HIE networks.

Methods: Data was collected using an online survey from 318 clinicians working in different healthcare settings in the United States.

Results: Results show that internal inhibitors (including technological and organizational barriers) and external inhibitors (including partners, patients, vendors, and legal barriers) strongly influence clinicians' intention to engage in HIEs. Taking an integrated approach, this study can contribute to the existing literature by providing a more informed way of conceptualizing and explaining HIE adoption in healthcare organizations.

Conclusion: The findings can help HIE decision-makers, healthcare organizations, and providers to identify key HIE inhibitors and take corrective actions to address them. Addressing both internal and external inhibitors would increase the

likelihood of widespread implementation of HIEs in different healthcare settings and facilitate interoperability and connectivity in regional and community health information networks.

Keywords: Health information exchange • Electronic medical records • Clinicians • Internal inhibitors • External barriers

Introduction

Background

Traditionally, healthcare providers used conventional methods (such as phone, fax, or mail) to exchange patients' records. However, previous studies reported serious issues associated with non-electronic data exchange among providers, such as the inability to provide timely access to patients' medical records and unnecessary tests [1]. Health information exchange (HIE) enables electronic access and sharing of patient medical records and health information across different healthcare settings among healthcare providers and clinicians [2]. HIE networks facilitate interoperability across multiple healthcare entities to improve care quality, streamline clinical workflow, provide timely access to patient records, enhance inter-organizational connection, and enhance healthcare efficiency [3]. There are three types of HIE mechanisms, direct, look-up, and patient-based exchanges. The direct exchange is the point-to-point data sharing between authorized and trusted providers, look-up systems enable data exchange through a central database that allows other providers

to send a query message and request patient records, and patient-based HIE grants more control to patients by allowing them to aggregate health information from different providers and share them with other healthcare entities as required [4].

Financial resources and mandates have been supplied in the United States to encourage providers and clinicians to participate in HIE projects [5]. For instance, the federal Meaningful Use program demonstrates the requirements of implementing certified electronic health records [6] and seamless flows of health information to improve collaboration and care coordination and reduce unnecessary tests, diagnostics, and ultimately healthcare costs [7]. The Office of the National Coordinator for Health Information Technology (ONC) (in the department of health and human services), the Centers for Medicare & Medicaid Services (CMS), and state governments play critical roles in advancing interoperability and increasing transparency of providers' progress in achieving interoperability [8].

However, evidence shows that the provision of these policies and incentives does not automatically guarantee widespread providers' and clinicians' participation in HIEs. For example, previous studies indicate hospitals that implemented an HIE, but

their clinicians have not fully used it for sharing all types of clinical information with all other healthcare entities (affiliated and unaffiliated) [1]. Several studies mention various barriers and challenges to HIE implementation and explain why the usage of HIE is still low compared to the set goals [9]. Moreover, different studies examine HIE inhibitors from various beneficiaries' perspectives, for example, patients, hospital managers, or physicians. Clinicians are one of the most important stakeholders of HIE implementations and are considered a vital user group to engage in regional or state-based information exchange networks. The low use of HIE by clinicians is challenging as the ultimate benefits and promises of HIE will be difficult to achieve unless clinicians actively participate in the electronic exchange of clinical information with other providers (either inside or outside their healthcare delivery system).

***Address for Correspondence:** Pouyan Esmaeilzadeh, Department of Information Systems and Business Analytics, College of Business, Florida International University (FIU), Modesto A. Maidique Campus, 11200 S.W. 8th St, RB 261B, Miami, FL 33199, United States, Tel: +(305) 348-3302; E-mail: pesmaeil@fiu.edu

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Studies investigating physicians' opinions are mainly conducted in different settings such as primary care, ambulatory clinics, emergency, etc. [10] or focus on a particular specialty [11]. Given the diverse nature of clinical workflow, the extent of information shared, healthcare work done in different healthcare contexts, and the resource restrictions they encounter, there is uncertainty about the applicability of what we know about HIE use by a hospital, clinic, or a group of healthcare professionals to various clinicians working in different healthcare settings. Moreover, some studies assign more weight to internal factors (e.g., organizational barriers), while others focus on external factors (e.g., patient roles) [12]. Despite the growing attention to HIE success and failure factors, there is a need to further study the HIE barriers experienced by clinicians. As far as we know, there is no comprehensive model of factors that prevent clinicians from joining these efforts and the problems they may encounter in deciding whether to participate in HIE.

This research aims to address these essential gaps and concerns by investigating how HIE inhibitors during HIE project implementation in healthcare organizations may discourage clinicians from using HIE in their practices. More precisely, the objectives of this study are as follows:

1. To identify and categorize the main barriers to using HIE in healthcare organizations.
2. To develop a comprehensive model using the identified inhibitors to explain and predict how these barriers may affect clinicians' intention to engage in HIE networks.

We analyze data from 318 clinicians (with various specialties) working in different healthcare settings in the United States to examine the defined research objectives and contribute some important implications to theory and practice. First, this study sheds light on the main barriers clinicians in different healthcare contexts encounter to share medical records electronically. Second, we contribute to knowledge by developing a comprehensive model that integrates all internal and external HIE inhibitors. Third, our findings have practical implications for healthcare organizations by highlighting key barriers that need to be addressed to increase the success of HIE implementation.

Theoretical foundation

Participating in HIE networks may have several desirable outcomes. For instance, HIE can help store comprehensive records from different providers, enhance collaboration, improve medical decision-making, and find timely treatment options and care planning [13]. However, potential undesirable outcomes in activating HIE projects (such as lack of collaboration with external parties) are negative incentives or disutility. Utility theory is the theoretical lens that can help us define constructs that influence clinicians' decisions to participate in HIE networks. According to utility theory, people make decisions by maximizing their utility function; for instance, the disutility of some attributes may fade the utility of other

features and vice versa [14]. Thus, potential benefits (desirable features) clinicians receive from participating in HIEs, such as timely access to patients' records regardless of where they were treated before, can increase the utility of such decisions. On the other side, potential concerns and risks negatively affect the overall utility level, increasing decisions' disutility to participate in HIE efforts.

According to utility theory, in the absence of negative utilities, clinicians may participate in HIE to reap the potential benefits from involving in a network of providers for data exchange purposes [15]. Potential benefits from HIE are not the focus of this study. The main focus of this study is on concerns and barriers to HIE participation. Thus, this study attempts to identify factors that may increase disutility (disutility enhancers). The key disutility enhancers (i.e., internal and external inhibitors) are described in the next section, and their role in physicians' decisions to participate in HIE is examined.

Internal and external inhibitors to HIE use

Literature on HIE indicates various barriers to HIE implementation in healthcare organizations (such as hospitals). This study attempts to identify and categorize barriers into two main categories, internal and external inhibitors, to develop a comprehensive model. Internal inhibitors refer to all challenges

associated with the managerial, cultural, and technological infrastructures of healthcare organizations participating in HIEs. External inhibitors consist of all obstacles to data exchange among providers with roots in their relationships and collaborations with other HIE stakeholders.

Internal inhibitors: Internal inhibitors have two key dimensions, organizational and technological barriers.

Organizational barriers: Organizational barriers can be formed by the following factors: first, lack of senior leadership support and involvement in HIE efforts. For instance, if hospital managers and executives do not believe in HIE, successful implementation and use of these projects would be challenging for the whole organization [16]. Second, unclear return on investment (ROI) from HIE investment. For example, one of the common factors affecting HIE evaluation is the high investment that the healthcare organization has to incur to implement the ability to exchange data electronically [17]. The costs associated with health information technology (IT) systems and network use that enable electronic exchange. The expected value needs to be estimated in the cost-benefit analysis of implementing HIE to determine if the investment is worth the cost. Third, the complexity of workflow changes required by HIE. Implementing and participating in an HIE network may considerably change physicians' workflow [18]. For instance, using a central data repository to look up patients' records may change the routine data exchange mechanisms by removing the need to log on to another portal to get medical records. However, it may load additional tasks to clinicians' work, and they may concern about the impact of HIE on productivity and clinical workflow. Therefore, proper workflow integration and process redesign are required to facilitate HIE participation.

Fourth, lack of support from organizational culture when information sharing is not included in the internal norms. Previous studies indicate that market size and market share can build information-sharing cultures in hospitals, as the larger the market size and market share, the more likely hospitals develop HIE culture [19]. Participation in HIE networks will not be perceived as valuable when the organizational culture of a healthcare provider is not supportive of information sharing initiatives as a norm [16]. Fifth, lack of internal awareness about HIE projects. Organizational awareness, which is the initial stage of HIE assimilation, refers to the extent to which healthcare organizations and potential users are aware of HIE efforts [20]. For instance, clinicians may not be aware of regional or state-based HIE networks facilitating information sharing among healthcare entities. Without internal communication platforms and organizational awareness-building programs to disseminate the potential benefits of joining an HIE network, potential users are not likely to consider HIE in their practices. Finally, lack of user groups' involvement in making decisions about HIE. Previous studies demonstrate that clinicians' engagement in the planning, design, implementation, and evaluation of participating in HIE networks can increase their commitment to information-sharing efforts [1]. If clinicians help shape organizational strategies about information exchange with other providers, they are more likely to participate in HIE networks. Also, providing economic incentives could motivate clinicians to pursue HIE for health information sharing [21]. Thus, clinicians' attitudes and preferences towards HIE can be significantly formed by their involvement in the planning, needs assessment, analysis, and set-up phases of HIE projects.

Technological barriers: Technological barriers consist of the following factors: first, inadequate technological infrastructure to implement HIE. When a healthcare organization does not have the appropriate technological infrastructure, participation in HIE networks will be difficult [22]. The key technical infrastructure required in an organization for the electronic exchange of information is the internal technology such as the internet, broadband, hardware, software, network, and database. The infrastructure explains the strength of a healthcare organization's technological architecture that helps set up requirements for HIE efforts. Second, lack of technical standards for saving data, messaging systems, enforcing security measures, and sharing information among various health care entities. Technical standards should support interoperability to facilitate data exchange among providers. There are some technical standards for interoperability, such as using an interface engine (e.g., HL7) that manages data transfer between different applications or applying the ONC's US Core Data for Interoperability (USCDI), a standardized set of data elements that should be included in nationwide HIE [23]. Third,

difficulty in EHR data integration. Participating in different HIE networks (e.g., regional or state-based) requires healthcare organizations to integrate external health data (sent by other providers) with their EHR systems [24]. Issues with standardizing processes and definitions of data elements across multiple organizations (e.g., various structures for the same data element in different systems) can harm information quality. Lack of certified EHRs (that meet the technological capability and functionality requirements adopted by the department of health and human services (HHS)) can cause the emergence of workflow hurdles and increase data integration difficulties [25].

Fourth, security concerns about data breaches, secondary use of data, and unauthorized access. Due to additional security regulations specific to healthcare, such as the Health Insurance Portability and Accountability Act (HIPAA), data security, protection programs, and data retention strategies of organizations participating in HIEs should be transparent [13]. For instance, previous studies report considerable data security concerns regarding the HIE's central repository model [26]. Therefore, an important issue associated with health data storage in an HIE network is data security and security safeguards and measure that healthcare organizations use to ensure data protection. Fifth, inadequate technical support for HIE. A study indicates that the most significant facilitator of HIE adoption is technical assistance and support during and after implementation [21]. Lack of accessible technical support in case of systematic errors (such as system downtime) or random errors (such as human mistakes) can hamper data exchange with other healthcare entities. Thus, insufficient technical assistance to providers through regional HIE centers can impair the development of HIE within states [27]. Finally, inadequate medical staff training on HIE mechanisms. Problems in training may cause physicians to obtain clinical records with more effort, anywhere and anytime they need them [28]. Technical training is required since many clinicians are unfamiliar with different technologies used to exchange information electronically (such as direct, query-based, and patient-oriented models). Due to lack of clear value, clinicians as potential user groups may need additional training to reconsider contributing information to HIEs.

External inhibitors: External inhibitors have four key dimensions, HIE vendors factors, partners factors, patients factors, and legal factors.

Barriers associated with vendors: Issues with HIE vendors may begin with the problem with HIE vendor selection and fit. Healthcare organizations need to prepare a highly detailed and costly request for proposal (RFP) to ensure that the potential vendor can meet a comprehensive list of system requirements, features, and functions needed for HIE. Another concern is contractual agreements with vendors such as warranties, payment schedule, vendor responsibility, quote on the cost of the system, and system support. On the one hand, vendors may exhibit a lack of interest and ability to facilitate HIE among affiliated and unaffiliated health care organizations at different levels [29]. For example, some vendors offer systems designed for information exchange in a specific health setting (for instance, data sharing at clinic-level or hospital-level only). On the other hand, vendors may use coercive efforts on providers to purchase specific tools or solutions to enable interoperability [30]. Moreover, EHR vendors' costs and time delays in developing HIE interfaces can be problematic. Fees charged by EHR vendors and working with them to build interfaces are an essential impediment in the HIE adoption stages [31]. Previous studies demonstrate that EHR vendor delays are common, inhibiting the instant exchange of medical data with other providers [26]. In addition, healthcare organizations may encounter a lack of collaboration needed with vendors for successful HIE (such as providing a technical strategy to create interoperability).

Barriers associated with partners: Any HIE network needs active partners (i.e., healthcare entities) ready to participate in exchange efforts. Lack of partners' readiness and willingness or their inability to effectively engage in HIE can hinder successful exchange projects. Previous studies imply that the lack of inter-organizational collaborations with other health care organizations is a crucial barrier to HIE [32]. The absence of trusting relationships with other affiliated or unaffiliated healthcare entities (such as hospitals, clinicians, physicians' offices) may negatively affect their willingness to fully participate in HIE networks. The existence of competition among healthcare providers in different settings may erode required inter-organizational alignment. The HIE

literature demonstrates that healthcare providers are concerned about the loss of patients and linked revenue that could be because of sharing data with other competitor organizations [30]. The information-blocking may be considered a competitive advantage for competing healthcare organizations by controlling patient flow [33]. Competing entities may partially exchange health information with each other or engage in information blocking to keep their competitive position in the market. In addition, difficulty in framing HIE agreements with partners and complexity in reaching data use agreements about HIE are vital barriers associated with HIE partners.

Barriers associated with patients: Since patients' medical records are exchanged among various providers, patients are one of the most important beneficiaries of HIE efforts. Patients may not have the power to decide or dictate which exchange model should be used in a healthcare system as a standard data transfer model. However, examining the public perceptions can help policymakers recognize potential concerns, risks, and barriers that may discourage patients from sharing their sensitive health information with providers in a timely manner [34]. One of the common challenges is managing patient consent to share health data. In the United States, different states follow various consent policies (i.e., opt-out or opt-in patient consent requirements) [35]. Issues about patient education have gained more attention recently since patients may not recognize the potential benefit of opting into the HIE. Therefore, how health care organizations inform patients about HIE efforts and their benefits remains a challenge that should be effectively addressed. Previous studies show heightened concerns about collaborations with patients about information sharing [36]. Some robust evidence in the literature reports that patients with privacy and security concerns may not grant consent to have their data exchanged among different healthcare providers [2]. Moreover, serious problems may arise when patients exhibit information-blocking behaviors. HIE efforts' value may be diminished due to patients not granting permission to include their data in the HIE databases. HIE volume of data directly depends on patients [22]. Thus, if patients are willing to provide incomplete, inaccurate, inconsistent, missing, and outdated health information to healthcare organizations, HIE systems cannot integrate essential clinical records from various data sources (such as patients). It should be mentioned that in the patient-based barriers, we only focus on patients' perceptions about HIE systems and their intention to give permissions for data sharing.

Barriers associated with legal requirements: Another factor that healthcare organizations encounter is legal concerns related to sharing health data. Transparency of information-sharing processes such as what patients' records will be shared, why health information is exchanged, and who can access such data should be ensured [37]. Previous studies imply that privacy concerns about sharing sensitive health records with other providers are the most salient factor associated with HIE [38]. Special federal and state law protections for particular types of sensitive health data are reported as the most important perceived legal barriers to HIE [39]. Due to privacy concerns, several providers emphasize legal risks with sharing health information and may decide not to actively engage in HIE networks [10].

Privacy concerns highlight compliance issues regarding HIPAA guidelines. The Health Information Technology for Economic and Clinical Health (HITECH) Act amended HIPAA and added HIE organizations to the list of business associates as a category of covered entities [40]. Healthcare organizations should comply with baseline health information protections in all stages of collection, storage, and share of personal health information. Accrediting bodies, state facility licensure rules, and the government dictate that healthcare organizations follow standard practice, state and federal laws to ensure the confidentiality and security of patient information. Moreover, healthcare organizations participating in HIE networks are concerned about legal accountability and responsibility in data exchange processes. According to HIPAA, entities that improperly handle protected health information can be charged under criminal law and punished [8]. Healthcare organizations are also subject to legal ramifications if they do not appropriately meet the Meaningful Use program requirements. In addition, regional HIE organizations established guidelines to encourage and monitor clinical data exchange based on legal requirements. Thus, concerns about penalties and ramifications in case of data breaches and failing to meet legal requirements can discourage providers from participating in HIE networks.

Materials and Methods

Research model and hypothesis development

Based on the mentioned categories of HIE inhibitors, this study proposes a research model to address the second objective. Figure 1 shows the proposed model. In this study, internal and external inhibitors are modeled as second-order constructs. According to MacKenzie SB, et al. [41], the identified higher-order constructs should be considered to define various HIE inhibitors' aspects. This would indicate that the identified HIE barrier dimensions should be modeled as formative indicators of the HIE inhibitor construct [42]. We follow MacKenzie SB, et al. [41], to decide a construct's directionality. They suggested considering whether changes in one of the sub-dimensions would be associated with a change in the focal construct. By examining the relationship between the first-order factors (dimensions) and the second-order constructs (HIE inhibitors), it can be concluded that the sub-dimensions define the characteristics of barriers to HIE. Therefore, HIE inhibitors should be modeled formatively. For instance, it is reasonable to state that an increase in the level of barriers associated with vendors would be associated with an increase in the overall external inhibitors of a given HIE network, without necessarily being associated with any changes in the patient-based barriers. The same arguments could be made for both second-order constructs. Thus, we model HIE inhibitors as a function of the higher-order constructs shown in Figure 1. Moreover, following the discussion in the previous section, we hypothesize that higher internal and external inhibitors will lead to lower clinicians' intention to participate in HIE (the outcome variable). Thus, formally stated:

H1: Internal inhibitors negatively influence clinicians' intention to participate in HIE

H2: External inhibitors negatively influence clinicians' intention to participate in HIE

Moreover, to examine the effects of factors associated with HIE implementations, we control for the possible impacts of clinicians' characteristics. Thus, we control for demographic variables and contextual factors such as age, gender, specialty, type of hospitals, healthcare setting, length of participation in an HIE project, trust in the exchange mechanism, trust in recipients of data, and computer self-efficacy, which prior research has tested and found to be important factors affecting clinicians' intention to participate in HIE.

Survey development

We constructed an online survey instrument to collect data on clinicians' perceptions about HIE inhibitors. The questionnaire consisted of five sections. Section 1 provided respondents with brief descriptions of the HIE technology. Section 2 obtained information about respondents' opinions about internal and external inhibitors and concerns regarding the HIE. Section 3 asked questions about respondents' familiarity with HIE programs and their computer self-efficacy. Section 4 requested information concerning respondents' practice and demographic characteristics. Section 5 defined four options for sharing patients' health information with other providers: traditional exchange (i.e., fax, paper mailing, or phone calls), electronic direct exchange, electronic query-based exchange, and electronic patient-mediated exchange. In this section, we obtained information about respondents' preferences.

To develop the survey, we adapted items from previous studies and made little changes to fit the context of this study. We drew upon the existing literature to measure the research model's variables. The operational definitions of constructs and measure items for internal HIE inhibitors were adopted from studies such as Guerrazzi C and Feldman SS [22] and Yeager, VA, et al. [26], for external HIE inhibitors were adopted from Chandrasekaran R, et al. [43], and Patel V, et al. [18], and for intention to participate in HIE from Lin HS and Chang CM [44] and Bansal G, et al. [14].

Pilot test

After developing the initial questionnaire, we consulted three professionals in the clinical informatics domain to improve the content validity of our study and

finalize the questions used in the survey. According to the experts' suggestions, the terms used to define HIE technology were modified, and the descriptions and questions were improved to ensure they were transparent enough and easy to understand. Next, we conducted a face validity with five physicians (working in a large Southeastern public hospital in the United States) to ensure that the readability and wording of the questions were suitable as per the objectives of our study. Thus, we reworded some ambiguous terms and jargon to exhibit the questions explicitly. Finally, before the main data collection, we conducted a pilot test with 74 physicians (working in the health center at a large Southeastern university in the United States) to ensure that the instrument had adequate reliability and validity. The Cronbach's alpha value for each construct was computed (i.e., technological barriers $\alpha=0.86$, organizational barriers $\alpha=0.85$, partner-based barriers $\alpha=0.86$, legal-based barriers $\alpha=0.87$, vendor-based barriers $\alpha=0.88$, patient-based barriers $\alpha=0.87$, and intention to participate in HIE $\alpha=0.90$). All Cronbach's alpha values were above the threshold value of 0.7, showing that the instrument was internally consistent [45].

Data collection

This study was reviewed and approved by the Institutional Review Board (I.R.B) of the authors' affiliated university, and the data collection was performed confidentially. We defined the study purpose followed by a written consent form on the first page of the survey. We did not ask respondents to disclose any personal information or unique identifier (such as name, hospital or clinic identification, Medical Education Number, zip code, address, etc.). Individuals who received the online invitation had the option to avoid participating in this study at any time voluntarily.

Data were collected from four virtual events in the United States in 2021: two clinical and medical informatics conferences at the national level, an annual healthcare symposium, and a yearly medical association summit. These virtual events were conducted at different times of the year. A web-based survey was conducted to target all clinicians who participated in these events, were familiar with the HIE concept and engaged in clinical work and medical practices in the United States. The online questionnaire was sent to clinicians with an email address registered in these events. Overall, 1214 emails were sent to potential respondents. Two reminders were also sent to them: the first one after two weeks and the second one after one month from the initial email. Finally, 361 respondents filled out the survey entirely.

According to previous studies, a key concern in online data collection is that subjects might choose answers randomly or participate with less attention [46]. One solution for identifying careless, rushed, or haphazard answers in behavioral research is using captcha questions [47]. Thus, two attention-check questions were used to detect and eliminate responses of participants who simply picked an answer choice without reading the questions or did not correctly answer reverse-coded filler items [48]. We dropped responses that failed the response quality questions. After removing unsatisfactory answers (43 data points), the final set of valid and useable responses included 318 samples.

Instrument validation

Next, we validated the scale we used to measure constructs. Confirmatory Factor Analysis (C.F.A) was performed to complete convergent validity and

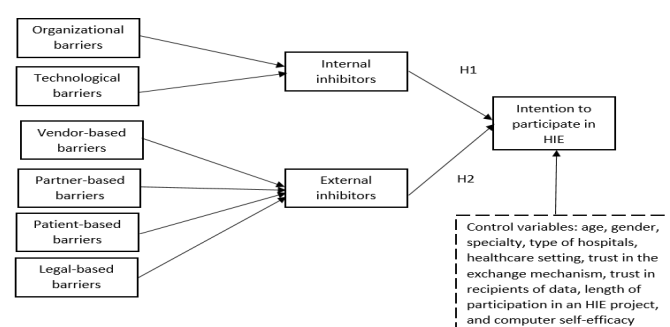


Figure 1. Research model.

discriminant validity. The results of model fit indices for measurement model demonstrated a good fit with goodness of fit indices [$\chi^2/df=2.01$, Goodness-of-fit index (GFI)=0.83, Adjusted goodness of fit index (AGFI)=0.81, Comparative fit index (CFI)=0.90, Normed-fit index (NFI)=0.92, Incremental Fit indices (IFI)=0.90, Standardized RMR (SRMR)=0.03, and the Root Mean Square Error of Approximation (RMSEA)=0.04] where all indices meet their respective common acceptance cutoff points.

We also used the Variance Inflation Factor (VIF) to check for multicollinearity among variables. The VIF values were between 1.34 and 1.72, below the cutoff value of 5 [45]. Thus, we conclude that multicollinearity is not an issue in this study. Additionally, since using a self-report survey can cause the common method variance issue, we carefully examined the potential for common method bias [49]. We used Harman's one-factor test to check if the common method bias would be a significant problem [50]. All factors together could explain 61.21% of the total variance, while none of the factors accounted for most of the covariance among measures (<20%). Therefore, results demonstrate that common method bias is not a significant threat in our sample.

Consistent with Gefen, Straub and Boudreau [51], we examined the measures such as standardized factor loading, composite reliability, and the AVE (Average Variance Extracted) to determine convergent validity. The results of the convergent validity test are displayed in Table 1. The composite reliability values for all of the constructs in the model were above the cutoff value of 0.7, indicating the adequate reliability of constructs [52]. According to previous studies, a factor loading of 0.7 or greater is acceptable. The reported standardized factor loadings for all constructs were greater than 0.7. The AVE was determined using the values of standardized factor loading for each of the constructs. All the reported values of AVE were higher than 0.5, which is the minimum acceptable value [53]. These measures highlighted that the convergent validity of the measurement model was acceptable. As the instrument validation results were satisfactory, no items were removed from further analysis.

Next, the discriminant validity of the constructs was examined. In Table 2, the main diagonal elements in bold indicate the square roots of the AVEs, and the off-diagonal values denote the correlation coefficients between the constructs. All diagonal values were higher than 0.7 and also greater than correlations between any pair of constructs. Thus, the model satisfied the discriminant validity requirements. We then confirmed that the model also had adequate discriminant validity.

Results

Respondents' characteristics

Table 3 shows the participants' characteristics. IBM SPSS version 27 was used to perform the descriptive statistics. The demographic data highlights

that respondents were fairly distributed by gender, where 53% were male, and 47% were female. Age range and years of practice were normally scattered, with age range between 35 and 44 (49%) years and years of practice between 11 and 15 (47%) were higher ranges among provided categories. Clinicians who participated in this study were from various areas of work and specialty, with physicians working in other inpatient services (31%) and family medicine (33%) slightly represented more than others. 41% of respondents practiced in a private hospital, and slightly more than half of the respondents indicated they worked in an urban setting. 78% of participants rated their computer self-efficacy as either excellent or good. Almost 36% of respondents indicated that the hospital/clinic they worked in either implemented or participated in an HIE program (for instance, regional or state-based HIE networks). Finally, 9% of clinicians stated that they had actually participated in an HIE network to share patients' medical records. Thus, the sample includes physicians who did not participate in an HIE network and were not regular users of the HIE at the research time.

The final question of the survey asked respondents to choose their preferred method of exchange. The first option was the conventional method of sharing, for example, using fax, phone, or mail. The other three options are different types of HIE (i.e., direct, query-based, and patient-mediated exchange). As shown in Figure 2, 86% of respondents preferred one of the HIE models, and only 14% selected traditional exchange as their preferred method of exchange. Among the three HIE models; direct exchange was considered the most preferred method of exchange. We then provided an open-ended question to explore the reasons for selecting one model over the other options. The root causes were categorized into five main groups: privacy and security problems (84%), control and liability issues (71%), trust in the exchange mechanism (67%), trust in recipients of data (59%), risks of medical errors (54%).

Control variables

Some factors do not reflect this study's core variables (i.e., those included in the proposed model); however, they may impact the inter-relationships between the core variables or affect the primary dependent variable. The effects of these variables have been controlled. As mentioned before, we controlled clinicians' age, gender, specialty, type of hospitals, healthcare setting, trust in the exchange mechanism, trust in recipients of data, length of participation in an HIE project, and computer self-efficacy to focus on examining the effects of internal and external barriers associated with HIE implementation in healthcare organizations. Although the categories of concerns seem to shape clinicians' willingness to participate in HIE, we found that the effects of some control variables were not negligible. Findings show that healthcare setting ($B=0.15$, $p<0.05$), length of participation in an HIE project ($B=0.11$, $p<0.05$), trust in the exchange mechanism ($B=0.35$, $p<0.001$), trust in recipients of data ($B=-0.29$, $p<0.01$), and computer self-efficacy ($B=0.21$, $p<0.01$) influence clinicians intention to participate in HIE. The findings confirm that clinicians in a

Table 1. Results of convergent validity.

Construct	Sub-dimensions	Items	Standardized Factor loading (>0.7)	Composite reliability (>0.7)	AVE (>0.5)
	Organizational barriers	OB1	0.82	0.93	0.69
		OB2	0.80		
		OB3	0.88		
		OB4	0.81		
		OB5	0.86		
		OB6	0.84		
Internal inhibitors	Technological barriers	TB1	0.88	0.94	0.72
		TB2	0.84		
		TB3	0.88		
		TB4	0.83		
		TB5	0.85		
		TB6	0.84		

External inhibitors	Vendor-based barriers	VB1	0.81	0.93	0.70
		VB2	0.82		
		VB3	0.86		
		VB4	0.82		
		VB5	0.89		
		VB6	0.85		
	Partner-based barriers	PAB1	0.81	0.92	0.67
		PAB2	0.80		
		PAB3	0.84		
		PAB4	0.81		
		PAB5	0.83		
		PAB6	0.85		
	Patient-based barriers	PTB1	0.83	0.91	0.64
		PTB2	0.82		
		PTB3	0.81		
		PTB4	0.80		
		PTB5	0.78		
		PTB6	0.79		
	Legal-based barriers	LB1	0.80	0.91	0.67
		LB2	0.81		
		LB3	0.87		
		LB4	0.84		
		LB5	0.79		
Intention to participate in HIE	N/A	INT1	0.78	0.90	0.66
		INT2	0.80		
		INT3	0.82		
		INT4	0.82		
		INT5	0.85		

Table 2. Results of discriminant validity.

Construct	Mean	SD	II-OB	II-TB	EI-VB	EI-PAB	EI-PTB	EI-LB	INT
II-OB	3.56	0.81	0.83						
II-TB	3.66	0.82	0.55	0.84					
EI-VB	3.58	0.82	0.57	0.50	0.83				
EI-PAB	3.65	0.81	0.41	0.47	0.38	0.81			
EI-PTB	3.68	0.85	0.43	0.36	0.39	0.35	0.80		
EI-LB	3.79	0.85	0.39	0.46	0.43	0.52	0.50	0.81	
INT	3.71	0.93	0.55	0.57	0.61	0.66	0.64	0.63	0.81

II-OB=Internal Inhibitor-Organizational Barriers; II-TB=Internal Inhibitor-Technological Barriers; EI-VB=External Inhibitor-Vendor Barriers; EI-PAB=External Inhibitor-partner-based Barriers; EI-PTB=External Inhibitor-patient-based Barriers; EI-LB=External Inhibitor- Legal-based Barriers; INT=Intention to Participate in HIE

Table 3. Sample characteristics.

Variables	Categories	Percentage (%)
Gender	Male	53
	Female	47
Age	Under 35	39
	35-44	49
	45-54	7
	55-64	3
	65 or older	2
How long have you been practicing? (years)	Less than 1	3
	1-5	9
	6-10	24
	11-15	47
	16-20	11
	More than 20	6

Area of work	Emergency Department	26
	Intensive Care Unit	20
	Other Inpatient Services	31
	Outpatient Services	21
	Other	2
Specialty	Emergency medicine	18
	Family medicine	33
	Psychiatry	12
	Surgery	10
	Anesthesiology	3
	Pediatric	5
	Internal medicine	5
	Gynecology	2
	General practitioner	9
	Other	3
Type of hospital/clinic	Public hospital	35
	Private hospital	41
	Academic medical center	12
	Nonprofit hospital	3
	Clinics	8
	Rehabilitation	1
Healthcare setting	Rural	37
	Urban	52
	Community	11
Has the hospital/clinic you work in implemented or participated in an HIE program?	Yes	36
	No	64
Have you ever participated in an HIE network to share patients' information?	Yes	9
	No	91
Computer-self efficacy	Excellent	42
	Good	36
	Average	17
	Poor	4
	Terrible	1

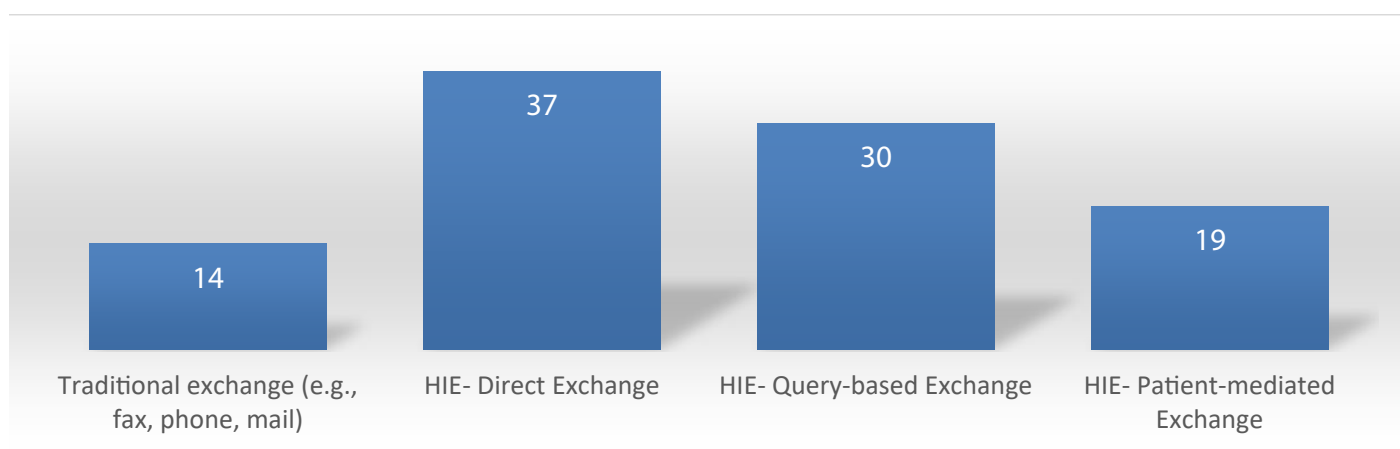


Figure 2. Preferred method of exchange (percentage).

community healthcare setting are more likely to use HIE for information sharing. Moreover, these results demonstrate that clinicians who had experienced an HIE network more than a year, with higher computer self-efficacy and a heightened level of trust in exchange mechanisms and recipients of data, may exhibit a higher intention to use HIE in their practices. However, no effects of age, gender, specialty, and type of hospitals were found on intention to participate in HIE.

Structural model

Smart PLS (Version 3.0) was used to perform hypothesis testing within a structural equation modeling (S.E.M) framework. Based on previous studies, Partial least Squares (PLS) estimation is recommended for formative measurements [54]. Figure 3 displays the weights of formative indicators on their respective higher-order constructs and standardized path coefficients of the structural model.

Findings show that HIE internal inhibitors are measured using two formative

dimensions (organizational and technological barriers), and HIE external inhibitors are measured using four formative dimensions (vendor, partner, patient, and legal barriers). In a formative construct, none of the dimensions necessarily needs to covary [55]. Another reason for modeling HIE inhibitors as multi-dimensional formative constructs is that internal and external inhibitors can be represented by a combination of elements rather than just one factor. Both organizational and technological barriers are significantly loaded to define internal inhibitors (loadings are 0.27 and 0.34, respectively). Moreover, the vendor, partner, patient, and legal barriers are significantly loaded to determine external inhibitors (loadings are 0.36, 0.25, 0.49, and 0.42, respectively). The results imply that the sub-dimensions of internal and external inhibitors as first-order factors load significantly on the second-order construct.

Path coefficients were also examined to test the structural model. We used bootstrapping to determine the significance of each path through t-tests. The results of the hypotheses testing are presented in Table 4. The findings support H1 by confirming that HIE internal inhibitors significantly lower

clinicians' intention to participate in HIE ($\beta = -0.41$ and $p < 0.001$). H2 is also supported where higher HIE external inhibitors significantly reduce clinicians' willingness to participate in HIE ($\beta = -0.58$ and $p < 0.001$). Therefore, we have enough evidence to conclude that multi-dimensional internal and external inhibitors, supporting the proposed model. Finally, the model explained 61% of the variance in the clinicians' intention to participate in HIE. The R² scores suggest that the constructs and their formative dimensions provide reliable explanatory power to predict the variance in clinicians' intention to use HIE in their practices.

Discussion

Principal Findings

Based on utility theory, this study attempts to uncover the key HIE inhibitors (disutility enhancers) to help clinicians and healthcare organizations address the barriers and increase participation in HIE networks. The HIE inhibitors are diverse. Some disutility enhancers have roots in internal factors, and several barriers are due to dependence on other entities and stakeholders involved in HIE. To address the first research question, we categorize the HIE inhibitors. The findings demonstrate that HIE inhibitors are a combination of internal and external barriers. Internal inhibitors consist of obstacles to information sharing inside a healthcare company, such as organizational and technological barriers. External inhibitors entail impediments in relationships with other HIE beneficiaries such as vendors, partners, patients, and legal entities.

To address the second research question, we develop a model to explain and predict the clinician's intention to participate in HIE using the identified categories and sub-dimensions. The HIE inhibitors are modeled as second-order constructs with formative dimensions. Then, we conduct an empirical study to examine their effects on clinicians' willingness to engage in data-sharing activities in their practices. The empirical work confirms the

significant effects of both internal and external inhibitors on clinicians' intention to participate in HIE. Moreover, results indicate that external barriers are more significant than internal impediments in predicting behavioral intention. Therefore, some hospitals may be organizationally and technologically ready to address internal obstacles, but clinicians might not likely participate in HIE due to unsolved issues with external parties such as HIE vendors or partners. This result suggests that HIE projects' policymakers should consider the network effect by exerting a great amount of effort to address potential problems among participating entities in HIE. The network effect entails that more participating parties willing to exchange patients' records with other healthcare organizations can enhance the HIE value. Thus, simply having various providers in an HIE network with no solid partnership will not ensure value for patients [26].

Theoretical contributions

Several previous studies focus on either internal or external factors that impede data-sharing activities in healthcare organizations [22]. Another array of research identifies some administrative and environmental barriers [43]. This research differs from previous studies by integrating both internal and external disutility enhancers to develop a comprehensive model for predicting behavioral intention to use HIE at the individual level (i.e., clinicians). This study contributes to the utility literature and existing studies on HIE by proposing a model to better conceptualize and measure HIE inhibitors. The proposed research framework, which presents a relatively strong explanatory power, can deepen the existing knowledge on how the combination of internal and external inhibitors influences HIE adoption. Our findings also have practical implications for stakeholders of HIE by highlighting the key barriers that should be addressed to increase clinicians' willingness to engage in data exchange networks.

Concerning the critical role of organizational barriers, our study provides strong evidence that lack of leadership support, organizational values for

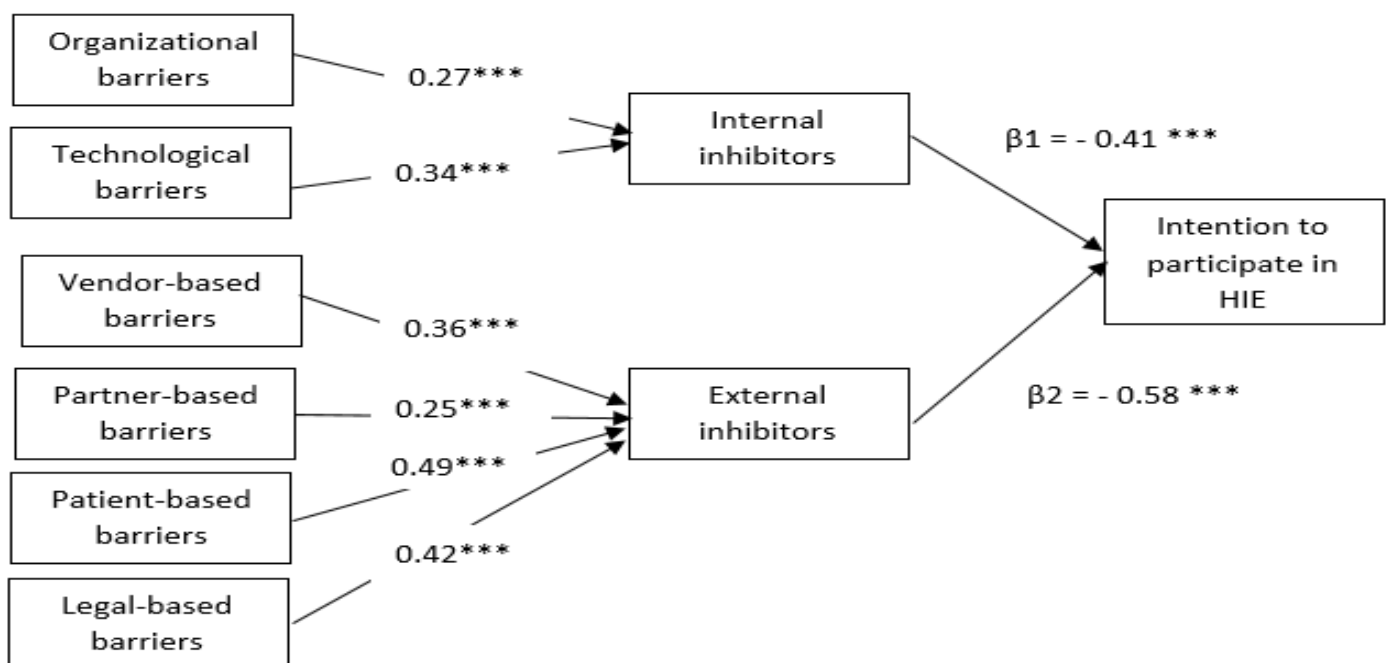


Figure 3. Model paths *** $P < 0.001$.

Table 4. SEM results.

Hypothesis	Path	Standardized Coefficient	Standard Error	T statistic	Results
H1	Internal inhibitors → Intention to participate in HIE	-0.41***	0.09	4.32	Supported
H2	External inhibitors → Intention to participate in HIE	-0.58***	0.04	12.25	Supported

Intention to participate in HIE R²: 0.61, *** $P < 0.001$

sharing data and collaborative culture can strongly hinder HIE efforts. Our results also reinforce barriers from a financial perspective, as healthcare organizations may report that they are less likely to invest money in HIE implementation since they do not see a clear business revenue [26]. Consistent with previous studies, the findings support that lack of awareness about various HIE models (i.e., direct, query-based, and patient-mediated exchange) can negatively affect target users' willingness to adopt HIE [1]. Utilizing organizational communication mechanisms such as web discussion boards, online forums, frequent conference calls, webinars, onsite visits, class-based or virtual training programs can increase clinicians' awareness and foster participation in HIE. Moreover, the difficulty of HIE integration into the standard of care and routine workflow can disengage clinicians from using HIE. Since HIE may create new processes and workflows, healthcare organizations can offer financial incentives to physicians for their time involved in designing and implementing HIE projects and their participation level in HIE networks [8].

In relation to technological barriers, the findings indicate that the lack of required technological resources and technical standards to support interoperability will significantly affect clinicians' decisions to participate in HIE. It should be mentioned that even decisions about technological strategies and infrastructure are made at a higher level than clinicians; however, improper technological readiness can negatively shape users' perceptions of adopting exchange mechanisms. Aligned with previous studies, the absence of supportive technology, difficulty in EHR data integration, the issues of communication between systems from different organizations, and lack of certified EHRs can challenge the technological readiness of healthcare organizations [56]. Technological infrastructure ranges from the Internet connection to adopting certified EHRs. The Internet connection can be an issue, especially in rural areas, where internet coverage is poor or sometimes nonexistent. Although it is worth considering the struggle with fundamental technological underpinnings, this paper suggests that hospitals' policymakers should pay more attention to adopting certified EHRs to meet standard technological capability and requirements set by HHS. One of the most important standards for the exchange of electronic Protected Health Information (ePHI) is security checklists [57]. By complying with HIPAA standard security procedures (i.e., administrative, physical, and technical safeguards), healthcare organizations can ensure the privacy, confidentiality, and security of patient information during online exchanges. For instance, security awareness and training programs on HER log-in guidelines, encryption, and password management can be helpful in addressing clinicians' technical concerns associated with HIE participation.

Regarding the important effects of external inhibitors, the relationships and existing tensions with all external parties involved in HIE should be clearly managed. This finding is consistent with a study offering that the main purpose of data exchange activities, agreements, and engagements in HIE should be transparent to all stakeholders [58]. All stakeholders should reach an explicit agreement on when medical records should be shared and what rights providers, patients, and healthcare organizations should retain when such data are required to be shared. For instance, the intentions of using patient records stored in HIE databases for data mining or research purposes must be visible to all stakeholders, including patients [59]. Developing trusting relationships and establishing alliances with other healthcare providers can address one of the main hurdles of data-sharing projects in HIE networks: losing market share and competitive positions. Any possible conflicts with external parties (such as vendors and legal entities) that could influence the objectivity and usability of data-sharing efforts should be transparent and handled with an appropriate governance mechanism at the organizational level. For example, healthcare organizations should cooperate closely with EHR vendors to build interfaces to remove an important obstacle in HIE rollout.

The complexity of workflow changes required by HIE is an organizational barrier. Moreover, findings show that technological barriers can cause the emergence of workflow hurdles. This result suggests that internal or external factors did not seem "not necessarily being associated". For instance, it is reasonable to state that an increase in the level of barriers associated with vendors would be related to a rise in the overall external inhibitors of a given HIE network, without necessarily being associated with any changes in the patient-based barriers.

Practical implications

The success of an HIE network can be directly dependent on patient willingness to disclose PHI and the number of queries from other participating organizations (such as other covered entities and business associates) to collectively improve the quality of care. Consistent with previous studies, our findings also suggest that holding a large amount of ePHI in databases would not necessarily create a competitive advantage for a healthcare organization [22]. A competitive position can be obtained through a robust collaboration with mutual benefits to send/receive patient data electronically to/from other facilities to improve patient safety. Stakeholder engagement to evaluate a regional or state-based HIE value can reduce their concerns about participating in a data exchange network [26]. The findings emphasize that HIE networks can provide value to population health improvement only if more participants are willing to contribute to exchange projects. Patient education can play an important role since patients may not be aware of the potential gain of opting into the HIE. Thus, there may be several patients who will be engaged in information-blocking behaviors. Healthcare policy-makers may find using mass marketing methods and blanket messages practical to educate patients about the potential benefits of participation in the HIE (such as cost savings and enhanced population health).

Among different HIE models, our study demonstrates that clinicians prefer to use direct HIE in their practices. Although several studies analyze the benefits and challenges associated with various exchange mechanisms [60] or examine them from patients' perspectives [61], our findings provide more insights by shedding light on clinicians' preferences. Participants of this study report that using traditional exchange mechanisms (such as fax or mail) is the least favorite, and point-to-point mechanism (EHR to EHR data sharing) is the most favorite exchange model. A plausible reason for this finding could be trust in the competency of exchange procedure, control over the sharing process, visibility into true security, ensuring the privacy of shared PHI, and trust in recipients. Since using this model, a physician can share medical information with a known recipient over a secure network; they may believe that this system would be a better exchange model to ensure patient safety. This finding is consistent with previous studies indicating that using the query-based (i.e., central repository model) and patient-centered HIE can exacerbate security and privacy concerns (due to big data operations) and reduce physicians' direct control over data sharing procedures [62].

Limitations and future studies

This study has several limitations. First, the findings of this study, which focused on a group of clinicians in the US, may not be generalizable to other countries. Second, data were collected from two conferences, a symposium and an association summit. It should be mentioned that this sample can lack representativeness because those participating in conferences and accepting to take the email survey may be more open to new technologies and have higher literacy. Individuals who attend medical informatics events would feel less challenged when facing barriers such as workflow changes. Thus, this sample may be biased in their attitudes towards HIE and health IT. Non-responders may also systematically differ regarding their perspectives of health IT and HIE compared to those who responded. Moreover, we used an online survey to recruit a self-rated sample of participants. Thus, future studies can extend this study using other data collection methods to reach out to clinicians. For example, future researchers can examine the developed model using clinicians directly recruited from hospitals, clinics, and healthcare organizations. Also, more profound insights into HIE barriers can be obtained using in-depth case studies of a regional HIE network.

Third, though this study has attempted to categorize a comprehensive set of HIE inhibitors and test the model, different inhibitors could become salient during various stages of HIE implementation. It is interesting for future studies to examine how different barriers affect HIE adoption at the different life cycles of the rollout. Fourth, the proposed research model explained 61 % of the variance in the clinicians' intention to participate in HIE. It should be noted that other inhibitors such as specific state-based regulations and clinicians' health IT literacy not considered in the model could impact clinicians' intention to share data electronically with clinics and hospitals. Fifth, the main objective

of this study was to examine how barriers to HIE implementation may change clinicians' participation in HIE. Thus, we did not particularly study the clinicians' predictive factors, such as their self-efficacy to use HIE. Future studies can extend this research and include the clinicians' characteristics to explain why hospitals implemented an HIE, but their clinicians still have not fully used it.

Sixth, although we used an open-ended question to dig into clinicians' HIE preferences, future studies can develop a better understanding and acquire new insights about factors affecting clinicians to prefer a particular HIE. Finally, we did not distinguish data exchange with affiliated and unaffiliated healthcare organizations and did not consider types of medical records in the research model. It can be of interest for future research to distinguish HIE requirements among providers with which physicians have no pre-existing relationships and those who have established relationships.

Conclusion

HIE is introduced to facilitate a faster, more efficient, and more accurate exchange of health information to improve health outcomes, patient continuum of care, and population health. The successful implementation of HIE networks is not conceivable when target users (such as clinicians) encounter unsolved barriers in their data-sharing efforts. This study is an attempt to take a comprehensive approach to identify and categorize key HIE inhibitors. Using the identified barrier categories, we develop a conceptual model to examine the effects of HIE inhibitors on clinicians' willingness to participate in HIE efforts. Our model, which consists of two main inhibitors (i.e., internal and external) with multiple sub-dimensions, accounts for 61% of the variance in the clinicians' behavioral intention to adopt HIE. Since the development of regional, state-based, and national-level HIE is considered in the strategic goals of healthcare policymakers, paying attention to challenges and barriers to HIE adoption could be critical to ensuring promising rollouts. By considering inhibitors through internal (i.e., organizational and technological) and external (i.e., partners, vendors, patients, and legal) lenses, this study sheds more light on HIE limitations that may prevent medical records from sharing electronically amongst healthcare entities. The results also highlight that managing relationships with external parties involved in HIE is more leading than focusing on internal resources and capabilities. If not accompanied by sound collaborations with outside entities, internal readiness alone cannot reduce the struggle to engage in HIE. Thus, healthcare organizations first need to strategize cooperation with external organizations participating in HIE networks, besides working within the organization in terms of organizational and technological readiness. This study suggests important practical implications that provide profound insights for healthcare organizations' executives, health administrators, and healthcare professionals.

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