Review

Linking the health data system in the U.S.: Challenges to the benefits

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ABSTRACT

In order to improve patient care in the United States there, the government made a mandate called HIE (Health Information Exchange). This order was created from the belief that sharing digital health information between, across, and within health communities will improve one's healthcare experience across their lifespan. Patient health information, i.e. the personal health record, should be shareable between healthcare providers; such as private practice physicians, home health agencies, hospitals and nursing care facilities. Most of the U.S. hospitals now have electronic health records, however, with a lack of standards for structuring health information and unified communication protocols to share health information across providers, only a small percentage of U.S. hospitals engage in computerized HIE. In order to understand barriers and facilitators in the U.S. of HIE adoption, we reviewed the published research literature between 2010 and 2015. Our search yielded 664 articles from Medline, PsychInfo, Global health, InSpec, Scopus and Business Source Complete databases. Thirty-nine articles met our inclusion criteria. This article presents the compiled organizational and end user barriers and facilitators along with suggested methods to achieve continuity of care through HIE.
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1. Background

Health information exchange (HIE) has been labeled the process of electronically exchanging patient information among different hospitals, physicians, and other healthcare providers in a community at the point of care. This process of sharing health data is considered a solution to enable healthcare providers to access patients' information properly, proficiently, and securely [1,2]. The U.S. government created a plan to adopt health information technology (IT) in the 2009 Health Information Technology for Economic and Clinical Health Act (HITECH Act). The ultimate plan mandated building a nationwide health information communication infrastructure [3]. From the HITECH Act, 'Meaningful Use' requirements were established with financial incentives to encourage healthcare organizations and providers to adopt the usage of Electronic Health Records (EHRs). Once EHRs are used the health information in the records should be shared across the community of providers. Thus, HIE is occurring in nearly every state within the continental United States. For example, in 2010 the U.S. Department of Health and Human Services awarded more than $548 million through the State HIE Cooperative Agreement Program [4]. During that time there were more than 234 active HIEs identified by the eHealth Initiative report [5]. In 2011, a mail survey with telephone follow-up of 4,326 national respondents found that a majority of office-based physicians could exchange lab and medication data, and about one third could exchange clinical summaries with patients or other providers [6]. The strongest predictor of health data exchange capability is EHR adoption [7]. However, organizational and physicians' capabilities to exchange health data varies by EHR software vendor and the communication technology infrastructure in each of the 50 states [7,8]. HIE usage still remains low among small practices and community health centers in spite of financial incentives from the Meaningful Use requirements [9]. This article explores the barriers and facilitators to HIE adoption in the U.S. as presented in the available literature.

The U.S. has a complicated organization of healthcare providers, payers, and healthcare delivery setting [10]. Independent practice of healthcare delivery in the U.S. has created fragmented health information that impedes patient care continuity through the health system and their health safety [11]. In order to ease and improve the care continuity of patients and their health safety, communication of health data within the health marketplace must improve. There are two types of HIE in the United States: public HIE

and private HIE [12]. The public HIEs serve broader regions and encompass a specific region involving multiple hospital-based organizations. The public HIEs usually cost more than or equal to $10 million and are operated by public or government entities [13]. Private HIEs are typically based on two integrated delivery networks or large hospital organizations that are funded and governed by private sponsoring entities, mostly by the integrated delivery network itself [14]. The majority of private HIEs have a 501(c) (3) status, which denotes that it has been designated a unit of the U.S. tax code (Internal Revenue Code) that offers 29 types of nonprofit organization exemptions from federal income taxes [12]. Organizations with a 501(c) (3) status are the most common type of tax-exempt nonprofit organizations in the U.S. [15]. Therefore, most private HIEs have an apparent advantage of mitigating funding challenges [14]. Usually, small regional HIEs can cost less than $5 million and operate on $200,000 per year [12]. For this reason, small regional private HIEs are more competitive financially than public HIEs.

Research has documented that HIE technology becomes a method to lower the cost and improve quality of healthcare because it allows healthcare providers to efficiently access health information, avoid redundant testing and treatment, reduce time to obtain health information, improve productivity at initial visit, improve completeness of patient records, improve non-visit consult, improve workflow, and increase healthcare provider awareness of patient interactions within the healthcare system (Table 1) [2,11,16–19]. HIE effectively decreases the length of stay, reduces hospital readmissions [20], makes faster and accurate billing, improves the quality of documentation [21], improves patient satisfaction by decreasing waiting time and enhances the patient perception of impact on care coordination [12,18,22,23]. Additionally, technologies to support inter-organizational HIE make electronic information sharing more attainable. A recent study using qualitative interviews and template analyses concluded that HIE supports public health practice [24]. More importantly, studies illustrated that physicians ($n = 1296$, 77% response rate), pharmacists ($n = 358$, 19% response rate), nurses ($n = 2383$, 23.8% response rate), Veterans Affairs healthcare providers ($n = 73$), and veterans ($n = 50$) generally have positive views of HIEs [16,25–27].

According to a KLAS research report, private HIE growth is exceeding public HIE growth. The report stated three possible reasons for slow adoption of public HIE: Firstly, governance typically was the reason for the restricted growth of public networks. Secondly, public HIEs usually depend on public or government surveillance due to tighter rules and complex regulations. Finally, the financial models for public HIEs are more complicated than a pay per service, or 'out of the box' service [28] which are commonly used via private HIEs. A Black Book report in 2014 found that 33% of multi-provider networks and hospital systems are investigating private HIEs for more standardized sharing of patient data. Eighty-two percent of all payers and providers believe that operational national public HIEs are at least 10 years behind private HIEs. Meanwhile, 98% of healthcare organizations believe that private, community or regional HIEs are more effective in achieving accountable care delivery organizations [29]. The reasons may be either these organizations have wealthier patients or private, community, or regional HIEs are easier to manage. Although HIEs have potential benefits of improving continuity of patient care, HIE adoption is still limited [11]. There are opportunities for HIE vendors and healthcare organizations to recognize the barriers and facilitators to HIE in order to facilitate HIE adoption in the U.S. This article analyzes potential challenges and promoters to HIE adoption from the published literature up to 2015.

2. Methods

Using select databases for health literature, any peer-reviewed or non-peer-reviewed publications that focus on barriers or facilitators of HIE adoption in the U.S. were considered. The authors consulted with a trained medical librarian to design the search strategy. The exploded MeSH term *health information exchange* and then the keywords *barriers.mp. barriers.tw. and barrier$.tw.*, *facilitators.mp., facilitators.tw., facilitator$.tw. were used* to search. The.mp. and.tw. extensions were used to ensure all sections of the article record in the database were searched for the key word. The $ was used as a wild card to find either the plural or the singular version of the keyword. The keywords were searched independently and then combined with the Boolean operator OR to make one large set. The Boolean operator AND was then used with the large keyword set and the exploded MeSH term, *health information exchange.*

The search structure was replicated in the Ovid databases: (34 retrieved) Ovid Medline, Ovid Medline daily update, Ovid Medline in-process & other non-indexed citations, Ovid Old Medline, Global health, PsycInfo 1806 to April, week 4 2017, Books@Ovid, then InSpec (325 retrieved), Business Source Complete (7 retrieved), and Scopus (281 retrieved) databases between January 2010 and June 2015.

All years of PubMed, up to April 2017, were searched with the same search structure noted above but the appropriate database wildcard – the asterisk, with the select keywords. The search retrieved 445 articles. The *United States* was then added to the

Table 1
HIE benefits [2,11,16–18,20–24].

#	HIE Benefits
1	Allow healthcare providers to directly access patient health data
2	Avoid redundant testing and treatment
3	Improve productivity at initial visit
4	Improve completeness of patient records
5	Improve quality of documentation
6	Improve non-visit consul
7	Improve workflow
8	Make faster and accurate billing
9	Increase healthcare provider awareness of patient interactions with the healthcare system
10	Method to lower cost and improve healthcare quality
11	Provide healthcare provider a historical view of patients usage of healthcare system
12	Reduce time to obtain patient data
13	Reduce hospital readmissions
14	Decrease LOS
15	Increase patient satisfaction
16	Support public health practice

search with the Boolean operator AND. This resulted in 185 articles. After manually removing duplicates, and screening the search results for only HIE in the U.S. a total of 39 peer-reviewed articles were retrieved and reviewed.

3. Results: HIE adoption challenges

3.1. Organizational challenges (Table 2)

The first adopters discovered many barriers to using HIE. Organizational barriers include privacy and security [12,16,30–33], sustainability, proprietary issues [2,12,34], funding [35], governance [31], legal barriers and regulation [31,36,37], lack of data standards that permits the exchange of clinical data, complex systems [34,38], and a low number of patient consent [39]. Legal barriers to IT adoption (including HIE systems) existing in the U.S. involve numerous laws related to fraud, abuse, antitrust, liability, malpractice, etc. [2]. Additionally, there are other non-technological factors, such as loss of competitive advantage, uncompensated care burden, issues of patient consent, limited understanding of HIE, and differences of business models [31,40]. Moreover, lack of published evidence showing that HIE is effective [41] might be another issue which could hinder HIE implementation and information sharing among hospitals. Even though the above is a daunting list of discovered barriers, the many anticipated benefits of HIE on healthcare have promoted its implementation and adoption in the United States.

A 2011 study [42] published showed that only 10.7% of U.S. hospitals ($n = 344$) used HIEs with unaffiliated healthcare providers, i.e. out of network. It also found that for-profit hospitals and smaller hospitals (6–99 beds) were much less likely to use HIEs than those nonprofit hospitals or larger ones ($\geq$400 beds). Interestingly, a cross-sectional designed study found out that HIE is more prevalent in for-profit skilled nursing facilities than nonprofit skilled nursing facilities [21]. Hospitals in markets with higher Medicare spending were less likely to exchange data whereas hospitals with more concentrated markets were more likely to exchange data. The researchers believed that competition might be the reason healthcare providers are not exchanging data [38,42]. When the researchers tried to do a similar study by using the annual American Hospital Association Information Technology supplement survey data in 2012, they found the same characteristics of HIE-adopted hospitals as their former research findings except that more U.S. hospitals (30%, $n = 689$) were using HIE with unaffiliated providers by the end of 2012. However, HIE adoption rates vary dramatically among the individual states. For example, three very small states (Rhode Island, Delaware, and Vermont) had more than 70% participation while other states only had minimal participation [8].

In 2012, a study showed that 18 out of 18 representatives from nine organizations believed in some potential benefits from HIEs while some expected overall advantages and none of them expected net financial benefits. Surprisingly, more benefits were expected for the poorest and sickest patients. Few concerns with losing patients to other organizations or publishing unfavorable quality data were noticed. However, many concerns were present about HIEs increasing the risk of data hacking, especially among larger ($\geq$400 beds) organizations [43]. In 2013, interviews of 17 state and national health informatics policy experts concluded that HIE was hard to implement because of political and economic reasons and that organizational issues and geographic challenges existed with the data exchange of regional health information organization (RHIO) model, which was considered as basic building blocks of the national health information infrastructure [44]. The U.S. HIE has been organized around RHIOs which only a small

number have begun to exchange clinical data based on reports. Furthermore, the financial sustainability of RHIOs as a critical factor in their long-term success remained unknown [45]. Security, data storage, database administration, technical support, and $2,000,000 to $3,000,000 in annual operating costs were some of these challenges [46]. Also, it is very complicated to govern how organizations access, control, and use data within the RHIO model, especially if they are competitors. Thus, running RHIOs has become a trust issue creating a need for policies rather than a technical issue. For instance, such as: how many RHIOs should a state have? What factors can guarantee that all regions progress appropriately and cooperate efficiently [44]? Although other alternative exchange models, such as direct project, enterprise HIE, and vendor-mediated HIE exist, similar dilemmas need to be solved.

Finally, delays in EHR interface development [35] and interoperability is always an issue no matter what model or HIE system is adopted. Twenty-four providers, administrators, and office staff from 16 underserved locations in two states were interviewed. It was discovered that and there was a lack of well-functioning area-level exchange as well as the challenge of achieving a tremendous amount of EHR users. In short, there was no direct interoperability within the hospital systems. Data ownership and provider liability concerns were other organizational barriers reported. It is generally technically difficult to incorporate a large number and diverse range of partner organizations [2]. Currently, significant hindrances of solving the interoperability problem include the necessity for clinical data standards, the need to identify patients continuously as they moved among different healthcare providers, and a framework to assure the patient's privacy [47].

3.2. End user challenges (Table 3)

Clinical staff acceptance is always a challenge to any new technology adoption. Several barriers from end users of HIE usages are: lack of access to incentives/capital by healthcare providers [12], start-up costs [6], time burdens/constraints [48,49], resources to select and implement a system (38%) [7], multiple logins [12,39], prolonged data retrieval time, frequent system timeouts [16], redundant data, inconsistencies and physiological incompatibilities [39,50], misalignment with current clinical workflows [19,32,39,51], vulnerable information accessibility and misuse [48], and trust in external HIE partners [52].

There were 105,705 unique user sessions analyzed from the Integrated Care Collaboration of Central Texas. Distinct types of user behaviors were found to exist and vary among jobs, organizations, and time within a single HIE system [53]. Moreover, usages differ from the patient encounter times. For example, repetitive searching was the most common in hospital settings and uncommon in Emergency Departments. Surprisingly, physicians used HIE least and nurses used HIE most. Overall, most users used HIE very little [53]. However, this finding may not represent all HIE usage pattern in any healthcare settings. A few physicians who were interviewed [54] stated their concerns of distrust of unknown resources. Plus, redundant and inaccurately categorized information presented in some HIE systems discourage the doctors to use it due to time constraints. This is consistent with the finding of other researchers [53] who stated that physicians seldom repeat HIE data searching.

Another study found different HIE-related workflows among 14 clinical sites. Two general role-based HIE usage models include nurse-based and physician-based. User access review discovered information retrieved using the HIE is related to roles. Nurses retrieve recent hospitalization data while nurse practitioners and physicians prefer more open-ended usage [55]. However, user-unfriendliness in the interface design, disrupted workflow, and

low desirability are factors affecting HIE usage reported by 15 Emergency department (ED) physicians [56]. Finally, while it is difficult to calculate, reduction of duplicative testing, quality improvement, care coordination, and decreased readmission rates have greatest potential to show the return on investment [57].

4. Results: HIE adoption promoters

4.1. Organizational promoters (Table 4)

Several studies tried to investigate effective methods to improve HIE adoption. Researchers found that non-profit public hospitals with more functioning software applications, more ED visits, network membership, and physician portals would increase HIE adoption [40]. Professional and social network are proved to be favorable settings for HIE adoption [52]. It is precious for small-to-medium sized primary care practices to receive financial incentives [52] and pair HIE adoption with workflow redesigns [58]. The persistent attention to workflow modification may be necessary for HIE adoption [2,39]. Obviously, subsidies and performance incentives by payers and government are welcome [43]. On the other hand, it is crucial to have certification and standardization of vendor applications that can permit clinical data exchange [34].

Technical assistance and support during and after implementation [52] are other facilitators for HIE adoption. Proper human resources should be allocated at the beginning of HIE implementation, and timely and accurate communication is necessary for successful implementation [59]. Non-clinical members of the healthcare organization, such as front desk staff, have important roles of facilitating HIE usage by obtaining more patient consent [39]. Organizations should provide additional training and support for them. It is crucial to have seamlessness and interoperability within all existing health IT systems [36]. Therefore, technology-based improvements are always needed to improve the usability of HIE systems [39]. While implementing a HIE, or any other Internet-based software application, data security, and privacy protection are important factors for long-term HIE adoption consideration [38]. Potential methods to data security and privacy protection include but are not limited to: reinforce consent, add prohibitions, limit data recipients, and develop privacy rules as a federal mandate.

4.2. End user promoters (Table 5)

Based on a survey taken by 144 physicians from New York, NY, technical assistance (70%) was ranked the first facilitator followed by financial incentives to use (65%) or purchase health IT systems (54%) [6]. Findings from this literature review stated that end users prefer that HIEs be useful, useable [56] and user-friendly [6]. A

Table 3
End users HIE adoption challenges [2,6,12,16,19,32,37,39,49—53].

#	End users HIE Adoption Challenges
1	Incentives
2	Lack of access to capital by healthcare providers
3	Start-up costs (57%)
4	Time burdens and constraints
5	Resources to select and implement a system (38%)
6	Multiple logins
7	Prolonged data retrieval time and frequent system timeouts
8	Data redundant, inconsistencies, and physiological incompatibilities
9	Misalignment with current clinical workflows
10	Vulnerable information accessibility and misuse
11	Trust in HIE partners

single automated login [60] is highly desired and HIEs should contain all proper data through seamless access [12]. Role-specific customization for display to accommodate different healthcare providers' workflow and information needs [55] is highly recommended because it is critical for providers to accept and continually use high-performance HIE which does not disrupt workflow [17,55,61]. Automatic notification of HIE data availability [60] would be an excellent feature as well as improving system and data retrieval response time [16]. For the long-term HIEs success, researchers believed that understanding end users' HIE perspectives and requirement is crucial as well as to engage end users from the beginning [51,55]. Early user engagement pays off as physicians who prefer viewing patient health information electronically are at least three times more likely to adopt and use HIE [6].

5. Discussion

Some organizations refuse to adopt HIE due to political and economic reasons, although the U.S. government offers financial incentives and financial punishment (gives fines to those healthcare organizations or providers that will not adopt certain health IT systems after certain dates) through the Meaningful Use requirements. Using states as middlemen and mandating exchange under public health law may avoid the data exchange challenges [44], such as data standard and interoperability, which is impossible to be provided by any single healthcare organization. Policymakers need to develop new policies which can counteract the weaknesses of each HIE model, ensure data is shared among healthcare providers effectively, and offer incentives for organizations to help clinicians use HIEs, as well as for clinicians to add data to HIEs [8,44,62]. Organizations must shift from an ownership view of health data to a continuity of care perspective where they share data with each other. Healthcare providers must understand potential benefits of external health information in order to build a

Table 2
Organizational HIE adoption challenges [2,12,21,32,33,35—40,42,48].

#	Organizational HIE Adoption Challenges
1	Privacy and security
2	Interoperability and sustainability
3	Proprietary issues
4	Funding
5	Governance
6	Legal barriers and regulation
7	Lack of publications showing that HIE is effective
8	Lack of data standards that permit exchange of clinical data
9	Complex systems
10	Relationships or previous experiences with exchange partners
11	Other non-technological factors, i.e. loss of competitive advantage competition, uncompensated care burden, patient consent, limited understanding, and business model
12	Low number of patient consent

Table 4
Organizational HIE adoption promoters [2,36,37,39,40,53,59,60].

#	Organizational HIE Adoption Promoters
1	Non-profit status, public hospitals, more live and operation applications
2	More emergency room visits, network membership, and physician portals
3	Removal of legal barriers
4	Rich professional and social networks are favorable settings for HIE adoption
5	Subsidies and performance incentives by payers and government
6	Certification and standardization of vendor applications that permit clinical data exchange
7	Technical assistance and support during and after implementation
8	Greater security of medical data to persuade healthcare providers and patients
9	Pair HIE adoption with workflow redesigns and pay persistent attention to workflow modification
10	Allocate proper human resources at the beginning with timely and accurate communication
11	Seamlessness and interoperability within existing health IT systems
12	Train non-clinical members to obtain more patient consent

Table 5
End-users HIE adoption promoters [6,12,16,17,52,56,57,61,62].

#	End users HIE Adoption Promoters
1	Technical assistance (70%)
2	Financial incentives to use (65%) or purchase (54%) health IT systems
3	Useful, useable and user-friendly
4	A single automated login
5	Contains all proper data in one database with seamless accessibility
6	Role-specific customization to accommodate different workflow and information
7	Automatic notification of HIE data availability
8	Improves system and data retrieval response time
9	Engaging end users from the beginning
10	Understanding end users' HIE perspectives and requirement is crucial to the long-term success
11	Preferring viewing patient health information electronically at least 3 times more likely to adopt and use HIE

successful HIE network and effectively integrate external health data into clinical practices [11].

Better designed HIEs that are useful, usable, and user-friendly will have a broader user market. A study suggested better data delivery through simpler methods such as default views based on various healthcare providers or working locations, or match distinct users' information needs [53]. For instance, targeting different healthcare providers' data needs will increase the adoption of HIEs because adoptions in diverse settings are affected differently by dissimilar influences [63]. A study used adoption data from 1060 primary and secondary care physician practicing over 32 consecutive months and tested HIE adoption. Its results showed that physicians' geographical locations are determining factors in their HIE adoption as they are more affected by other similar specialty physicians due to sharing more common patients. Rural-areas practice physicians/providers are highly affected by those urban-areas practice physicians/providers in HIE adoption [63]. Specifically, primary care physicians were more enthusiastic than specialists about the benefits (reducing costs, improving quality, and saving time) of HIE [26]. However, infection preventionists' awareness and engagement in EHR/HIE was not great from an online survey [64]. Clinicians, EHR/HIE vendors, and trainers should work together and integrate HIE into current clinical workflows [41]in order to meet healthcare providers' needs and promote adoption and usage [56]. Improving healthcare providers' HIE knowledge should be the first step to promote adoption.

ED physicians' adoption of HIE is always crucial due to possible significant HIE benefits of improving patient safety, decreasing duplicate testing, avoiding unnecessary admissions, and tailoring proper care to patients. Researchers suggested to enhance ED adoption because a 2011 study [60] showed that it was still a challenge for some ED physicians to integrate their HIE into their current workflows. ED physicians in the study did not understand all the data elements and sites information accurately even though

they were very satisfied with their HIE training [60]. Therefore, follow-up HIE training might be a good strategy to prevent similar events from happening. Meeting ED physicians' data needs are always important. Electrocardiograms and discharge summaries are on ED physicians' rank-order list. Specifically, laboratory results, imaging, medication lists, discharge summaries and ECG interpretations are valued [65].

Offering nurses their preferred HIE data is significant to enhance nursing HIE adoption. A web-based survey of home health workers in New York with 566 participants found that almost all registered nurses (RNs) (96.7%) agreed that rapid access to outside information without effort would benefit their care delivery. Those RNs' top five most desired data in their patients' HIE profiles are as follows: inpatient discharge summaries (81.5%), medication lists (80%), PCP contact information (67.7%), laboratory data (58.8%), and ED clinical notes (56.8%) [25]. However, different RNs might have distinct preferences for their patients' HIE data. A duplication of this study would be beneficial to examine nurses' workflow and data preference in order to improve nursing HIE adoption.

Wu and LaRue conducted semi-structured interviews with nine healthcare providers, including registered nurses, physicians, physician assistants, nurse practitioner, and an informatics nurse in two Magnet-designated urban hospitals in 2014 [54]. They visited a cancer center in a 249-bed acute care and teaching hospital as well as an Ambulatory Surgery Center and Day of Admission Surgery unit in a 490-bed tertiary care teaching hospital that offers a broad range of specialties. Both of these hospitals are using the same HIE, which was ranked by Black Book Ranking Report in 2014 as one of the five best in the United States. All of the interviewees used the same HIE in different hospital settings as diverse roles, and all of them complained about all of the HIE adoption barriers presented in this article. Verifying that user types want and need specific data, the interviewed oncologists desired certain historical lab data over seven years, and staff in the Day of Admission Surgery unit wanted

a scanned documentation feature (such as PCP's EKGs, OR consents, medication orders and other scanned documents from surgeons' offices).

5.1. Global HIE lessons

It is helpful to facilitate HIE adoption in the U.S. by understanding another country's perspective on HIE. Several nations realized the potential benefits of HIE and initiated national and international efforts. Globally, fully functioning HIE is uncommon. Challenges of HIE adoption included incentives, interoperability, record linking, inadequate infrastructures, governance, and inter-organizational relationships. Solving HIE's cost and quality issues will facilitate HIE adoption in many countries. However, HIE adoption raised policy concerns of central planning, national identifiers, standards, and exchanged data types. Although an in-depth qualitative study illustrated that unprecedented growth happened in HIE infrastructure between 2011 and 2012 [66], the U.S. lags many developed countries in electronic HIE adoption [3,67]. Thus, there are so many similar barriers affecting HIE adoption in the U.S. compared to other countries.

5.1.1. South Korea

South Korean researchers conducted a survey through a structured questionnaire on physicians' perceived needs, benefits, and concerns regarding HIE prior to implementation (n = 197, 35% response rate) [68]. Those South Korean physicians had an overall positive perception of HIE and its benefits and believed that the most potential quality benefits through HIE adoption included: eliminating duplicated medication, lab, imaging tests, preventing drug-drug interaction, expediting diagnosis, and making better care plan decisions. However, they seemed least worried about revenue reduction, time-saving, and cost savings. Physician practice settings significantly influenced their perceptions of HIE in South Korea. Physicians' concerns regarding HIE included information safety and security, system costs, and malpractice. South Korean physicians and American physicians might have different opinions on HIE adoption benefits; however, their concerns about HIE are similar. The South Korean's most valued information included: pathology, lab results, diagnostic imaging, medication, and working diagnosis. Lately, the same group of Korean researchers analyzed data from 35 HIE and 59 non-HIE clinics during a 17-month period [69]. They found that total charges and charges for diagnostic tests were lower in the HIE group than in the non-HIE group by about 13%. The costs for medications were also lower in the HIE than in the non-HIE group, but the difference was not significant. Physicians agreed that the potential benefit of HIEs regarding healthcare quality provided to patients was bigger than the potential benefits of cost savings.

5.1.2. Other developed countries

The Swiss researcher [70] reported that it took more than 10 years to implement e-toile (the Geneva health information exchange) in Switzerland because of the highly fragmented Swiss health system that was based on a complicated interaction of private and public stakeholders. Non-technical obstacles, such as eHealth laws, eHealth strategies, and increased financial pressure on all healthcare stakeholders also slowed down the HIE process. Geissbuhler did not believe that it was as constructive to deploy eHealth systems in Switzerland as in most other developed countries due to these obstacles [70]. These experiences and lessons are valuable to their American peers.

Combined with literature review and interviewing with experts in individual nations, Jha and colleagues [45] examined rates of EHR use in ambulatory care and hospital settings, along with current

activities in HIE in seven countries: Australia, Canada, Germany, New Zealand, the Netherlands, the United Kingdom, and the United States. They found that clinical data exchanged across providers were in the initial phases in each country despite widespread interest. There was a nearly universal use of EHRs (>90%) by general practitioners in Australia, the Netherlands, New Zealand, and the United Kingdom, 40—80% in German, and only 10—30% of ambulatory care physicians using EHRs in the United States and Canada. Australia has the National E-Health Transition Authority to plan for HIE implementation and a New South Wales pilot project encouraging hospitals and community providers to exchange clinical data. Both Australia and New Zealand allow general practitioners with EHRs to automatically download pathology and imaging reports from a diversity of public and private diagnostic sectors. Moreover, both countries have national electronic immunization registries (Australia also has a cervical smear registry). Both hospitals, specialists, and general practitioners in Australia and New Zealand were increasingly communicating electronic discharge summaries, referrals and other communications to each other. However, the lack of a single national identifier code in Australia had delayed HIE development, whereas New Zealand might create a national HIE program easier due to having a single consumer health identifier [45].

Although Canada has Infoway (a national effort to increase the national adoption of EHRs) and has been developing privacy and security standards, poor EHR use in the primary care and hospital settings have delayed widespread HIE [45]. No single approach to HIE was found in Germany while two pilot projects were focusing on offering HIE capabilities: "D2D" (a secure communication standard to exchange billing information and patient data), and "Vita X" (provides EHRs and supports provider-to-provider exchange). The researchers [45] believed that the most promising approach to HIE in Germany was the electronic health insurance card which would expand from current administrative data only to an emergency data set, medication history, and all key elements of a patient's EHR. Netherlands has a pilot phase for a HIE that involves nearly 20% of the population with the primary focus to obtain interoperability through National SwitchPoint; a program helping providers share medication lists and clinical summaries. The United Kingdom has several programs in a process while a small portion of general practitioners can create summary records. Its full record exchange is still in infancy [45].

Governmental infrastructure, stronger policies, and standardized data at a national or state level will dramatically facilitate HIE adoption. User-friendly HIE tailoring to different healthcare providers' workflows and consistent technical assistance and system improvement will help clinicians to use manageable data and contribute structured data. Appropriate human resource allocation and effective communication are significant for HIE implementation. Even non-clinical members have a vital role to facilitate more HIE usage by obtaining more patient consent. Because the HITECH Act does not specify how HIE should be accomplished, there are many gaps for policy-makers, healthcare organizations, vendors, and clinic staff to fill. The lack of specification can bring in creativity. Therefore, all stakeholders need to work closely and creatively in order to overcome all of these barriers and utilize facilitators to expedite nationwide HIE adoption, minimize data breach, and, eventually, achieve continuity of care.

6. Limitation

The findings and implications are subject to limitations. Even though it is believed that HIEs are critical to the continuum of care and possess all potential benefits mentioned above, little generalizable evidence exists regarding benefits attributable to HIE based

on currently published scientific studies [71]. A recent systemic review on usage and effect of HIE concluded that HIE might reduce ED usage and costs in some cases, but effects on other outcomes are unknown. Although the researchers found that all stakeholders value HIE, there are many barriers regarding HIE adoption and sustainability. Moreover, only a small portion of operational HIEs was evaluated in the published literature [32].

The potential benefits of HIEs, such as more efficient workflow, improved quality of care, cost reduction, and increased revenue, in ambulatory primary care practices and emergency medicine are well recognized in twenty peer-reviewed articles with original findings [72,73]. However, there are many different settings other than primary care providers in any healthcare organizations. Limited published research data regarding HIE in such settings were found. Finally, there are few longitudinal studies and retrospective quality reviews related to HIE evaluation, best HIE practice, patient safety and quality of care after HIE implementation. Such published studies are necessary to give healthcare providers and policymakers evidence and confidence to adopt HIE.

7. Recommendations

In order to promote widespread adoption, better utilization, and sustainability of HIE, summary recommendations are as follows. US Government should develop or encourage vendors to develop common data standards, plan nationwide HIE infrastructure, and provide practical ongoing funding support for the long-term success of HIEs. Policy-makers should focus on developing policies which help to remove all common obstacles, such as continuous funding, payer engagement, data ownership, data standards for exchange of health information, privacy and liability protection, etc. which are clearly validated by supporting evidence found in published literature.

Vendors should work with clinicians to design customized user-friendly, useful, and usable HIEs which are interoperable, can integrate into current workflows, and have assorted desired clinical information specific to different specialists and clinical staff. Also, vendors should provide technical assistance and support during and after implementation to facilitate HIE adoption and sustainability. Healthcare organizations should follow all federal and state-level laws/regulation regarding HIEs, allocate appropriate human resource and effective communication as well as shifting from an ownership view of health data to a continuity of care perspective.

Clinicians should understand the value of HIEs, learn proper usage of HIEs, and provide feedback regarding HIEs to informatics staff. A cross-disciplinary workforce should be built as well as IT and informatics staff should be dedicated to developing HIE infrastructure, overcoming HIE Interoperability obstacles, and maintaining HIE sustainability. Researchers should implement more randomized controlled trials or quasi-experiments to support and improve HIE adoption, implementation, improvement, and sustainability as well as developing standard metrics to calculate the return on investment of HIE.

Disclosure

The authors have no financial conflict of interest to disclose.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijnss.2017.09.006.

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