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Barriers to Successful Health Information Exchange Systems in Canada and the USA: A Systematic Review

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ABSTRACT

Background: Despite the potential benefits of health information exchange (HIE) and the two decades of efforts from the Canadian and the American governments to promote health exchange projects, failures far outnumber successes. **Objective:** To better understand the barriers influencing the adoption and implementation of inter-organization HIE systems in Canada and the USA. **Method:** A systematic literature review was conducted to examine English-language studies that identified barriers to HIE in Canada and the USA between 1995 and 2016. Electronic databases, backward searching and expert consultations were used. **Results:** 31 articles have been included. There is a dearth of publications reported on the HIE barriers in Canada. A total of 33 barriers have been identified. **Conclusion:** There are noticeable differences in the barriers reported in these countries. Privacy concerns and a lack of stakeholder buy-in are recurring barriers over time in the USA. Low adoption of electronic medical records is the main barrier in Canada.

KEYWORDS

Barriers, Canada, Health Information Exchange, HIE, Literature Review, Privacy, USA

INTRODUCTION

Patients normally receive care from multiple providers for many reasons including the mobility and availability of specialty care providers (Eden et al., 2016; Gottlieb et al., 2005). Unfortunately, as different providers often maintain separate medical records, a patient's medical record can be fragmented and incomplete in any one given location (Grossman et al., 2006). This fragmentation negatively impacts the patients and the providers. For example, physicians have limited information to make timely clinical decisions, resulting in an increased use of administrative resources to locate the missing information, which may in turn lead to delays in care and redundant procedures such as duplication of laboratory tests and medications (Foldy, 2007). Therefore, to improve healthcare quality and efficiency, healthcare organizations should share data electronically to allow physicians access to patient clinical data across sites of care to better support their decision-making process.

Health information exchange (HIE) is the electronic sharing of clinical information among healthcare organizations to facilitate care coordination and transitions across settings (Grossman, Kushner, & November, 2008). The main goal of HIE is to deliver the right information to the right person at the right time. Generally, HIE is based on the premise that timely access to health information should improve healthcare efficiency, reduce medical errors, decrease costs, and increase patient satisfaction (Hincapie et al., 2011). Furthermore, data exchange also has benefits other than direct patient care, such as supporting quality improvement, public health, and clinical research (Grossman et al., 2008).

In Canada, the Canada Health Infoway (Canada Health Infoway, 2016) works with the provinces and territories to accelerate the development, adoption, and use of digital health solutions across the country. One of its adopted strategies is to develop interoperable electronic health records (iEHR), which are secure, integrated views of a person's medical records from all systems in the network (Interoperable EHR, 2016). The purpose of iEHR is to provide a comprehensive view of a patient's medical history that is available to authorized health providers and individuals anywhere, anytime. The main goal is to connect patient health records in each province and connect the entire country by unifying the architecture and standards in every jurisdiction.

In the USA, under the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act, the plan is to adopt health information technology in order to build a nationwide information infrastructure. The aim is to start by setting policies to achieve widespread use of electronic health records (EHR) which, as a result, will later facilitate the exchange of data. Then, under the same act, incentive programs, commonly called the Meaningful Use programs, have been initiated to encourage healthcare organizations and providers to participate in HIE. The government in this program provides financial incentives for the adoption of EHRs that conform to nationwide standards and where providers meet certain performance thresholds (Department of Health & Human Services, 2010). Regional Health Information Organizations (RHIOs), which are generally not-for-profit regional organizations created to bring together provider organizations and initiate health data exchange, are one of the known efforts in the USA to support HIE.

Despite the potential benefits to patients, practitioners, and hospitals, and despite the two decades of efforts from both the Canadian and the American sides to promote HIE, failures far outnumber successes. For instance, according to the 2014 National Physician Survey in Canada, 78.8% of family physicians do not share data with other organizations (National Physician Survey, 2014). In the USA in 2013, only 30% of hospitals were participating in HIEs (Adler-Milstein, Bates, & Jha, 2013).

The objective of this review is to study the barriers that affect the implementation and adoption of HIE in different healthcare models in order to learn from previous efforts and increase the probability of successful HIE in the future.

This systematic review targets studies that reported on barriers to successful HIE systems in Canada and the USA to answer the following research questions:

RQ1: What are the barriers that have an influence on the success of HIE systems in each country?

RQ2: What are the changes in barriers over time?

RQ3: Are the barriers in the USA different from the barriers in Canada?

However, differences in the nature of healthcare models between Canada and the USA should be taken into consideration (Zimlichman et al., 2012). The Canadian healthcare model is composed of a group of socialized health insurance plans that provide coverage to all Canadian citizens. It is publicly funded and administered on a provincial or territorial basis, within guidelines. The American model, on the other hand, is a mix of some publically funded programs that cover eligible citizens such as the very poor, disabled persons, seniors and children, and private health insurance plans.

The rest of the paper is structured as follows. The literature review methodology is first defined, followed by a description and categorization of the results. The discussion section uses these results to answer the research questions. Limitations and threats to the validity of the review are also discussed prior to the presentation of the conclusions and future work. This systematic review is about collecting and categorizing barriers to HIE adoption, and making explicit the differences between the ones from

Canada and the ones from the USA. In this particular context, it does not include another “literature review” section.

This paper contributes answers to the above three research questions. It brings novelty as the Canadian-specific barriers are reviewed for the first time, before being contrasted with US-specific barriers, which are far better documented. The significance of this systematic review is that Canadian solutions to solve HIE barriers need to differ in a number of ways from US solutions, as will be seen in the discussion and conclusion.

METHODOLOGY

Our main goal in conducting the review is to provide a comprehensive summary of the current literature to answer the research questions. This systematic review is inspired by Kitchenham’s (2004) systematic literature review approach. The review, in summary, was conducted through three stages:

1. **Searching** all relevant published evidence according to a search query;
2. **Evaluating** the retrieved publications against inclusion and exclusion criteria to only keep the most relevant studies; and
3. **Synthesizing** by aggregating the findings from individual studies and then interpreting the findings and drawing conclusions.

Search Methods

A review of key terms related to HIE was conducted using selected databases. The search was restricted to English-language publications that investigated barriers in exchanging health information, specifically in Canada and the USA.

Search results were limited to peer-reviewed articles published between January 1995 and March 2016 to ensure the relevance of retrieved papers. The start date has been chosen because it was the time where a wide interest in HIE emerged; findings from older studies have far less relevance today, and two decades is deemed sufficient to capture interesting trends.

Data Sources

To locate the relevant articles, three data sources were used: electronic databases, backward reference and author searching (via citations and authors of already retrieved papers), and expert consultations.

Electronic database searches were conducted first as the key source. The main search started with two databases:

- **Scopus:** because it covers multiple research fields such as science, engineering, technology, health, medicine, and social sciences. It also covers all the journals included in PubMed/Medline and Embase from 1996.
- **Ovid MEDLINE:** because it covers the international literature on biomedicine, including the allied health fields and the biological and physical sciences, humanities, and information science as they relate to medicine and healthcare.

The initial set of articles were mainly about the USA and only a few studies considered the Canadian experience. As a result of this lack of Canadian data, other databases (Web of Science, Embase, CINAHL, and Google Scholar) were searched to double-check the initial results and to look for additional articles that cover the Canadian experience with HIE. Lists of references from earlier reviews were also considered. Finally, the authors consulted four experts in the field at universities in Ottawa and Montreal, by email and in person.

Search Strategy

Specific search strategies were developed for the selected databases above. To further refine the search, given the large number of citations, the search was limited to include only citations that discussed barriers, obstacles, impediment or challenges. Scopus was used as the main database and the returned publications were evaluated. Then, Ovid MEDLINE was searched and most of the retrieved articles had already been covered by Scopus. Because almost all the retrieved publications were only discussing the USA, the search was expanded to include the four extra databases mentioned above. The result was that most of the papers were already covered in Scopus and only two articles discussing Canada's experience were retrieved. The search query was:

```
("health information exchange" OR "healthcare information  
exchange" OR "healthcare information exchange" OR "medical  
data exchange" OR "clinical data exchange" OR "regional health  
information organization*" OR rho OR "regional health information  
exchange*" OR "regional health information network*" OR "regional  
health information system*" OR "regional HIE" OR "interoperable  
electronic health record*" OR "interoperable clinical information  
system*" OR "interoperable health information" OR "interoperable  
health data" OR "health  
information shar*" OR "National electronic health record*" OR  
iher)  
AND  
(US OR USA OR "United States" OR Canada OR Canadian)  
AND  
(barrier* OR hurdle* OR impediment* OR obstacle* OR obstruct* OR  
challeng* OR problem* OR threat*)
```

Selection Criteria

The aim of this review is to find and compare the barriers that prevent the success of HIE in Canada and the USA. For that reason, the first author manually screened the titles and abstracts (and full-text for some) of the retrieved papers to only keep the papers that met the inclusion criteria for the final analysis. Table 1 summarizes the inclusion and exclusion criteria. Included were the papers that consider the barriers influencing the adoption and implementation of inter-organization HIE systems in Canada and the USA in the period between 1995 and 2016. Any paper that was not in the English language, not peer reviewed, or published before 1995, was excluded. Also omitted were the papers that either considered HIE only in countries other than Canada and the USA or considered HIE within the same organization.

Due to the drought in the number of publications about the Canadian experience, some exceptions were made and some papers that have not matched the criteria were still included. Table 2 summarizes the articles exceptionally included along with the reasons to include them.

After removing duplicates, and screening the search results against inclusion and exclusion criteria, a total of 31 articles were retrieved and reviewed. Figure 1 shows the selection process.

Data Extraction

After scanning the papers against the inclusion and exclusion criteria, the reviewers retrieved the full-text version of all included papers and started reading and extracting data. The extracted data includes details about each study's title, date, location, study type, data sources, time frame, settings and perceived barriers.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
The paper's content deals with electronic HIE	Not in the English language
The exchange of health data involves more than one organization	Published before 1995
Includes information about the barriers to adopting and implementing HIE	Non-peer reviewed
The paper's focus is on Canada's or USA's experience.	Not applicable to Canada or the USA
	Considers HIE within a single organization

Table 2. Summary of the Canadian articles

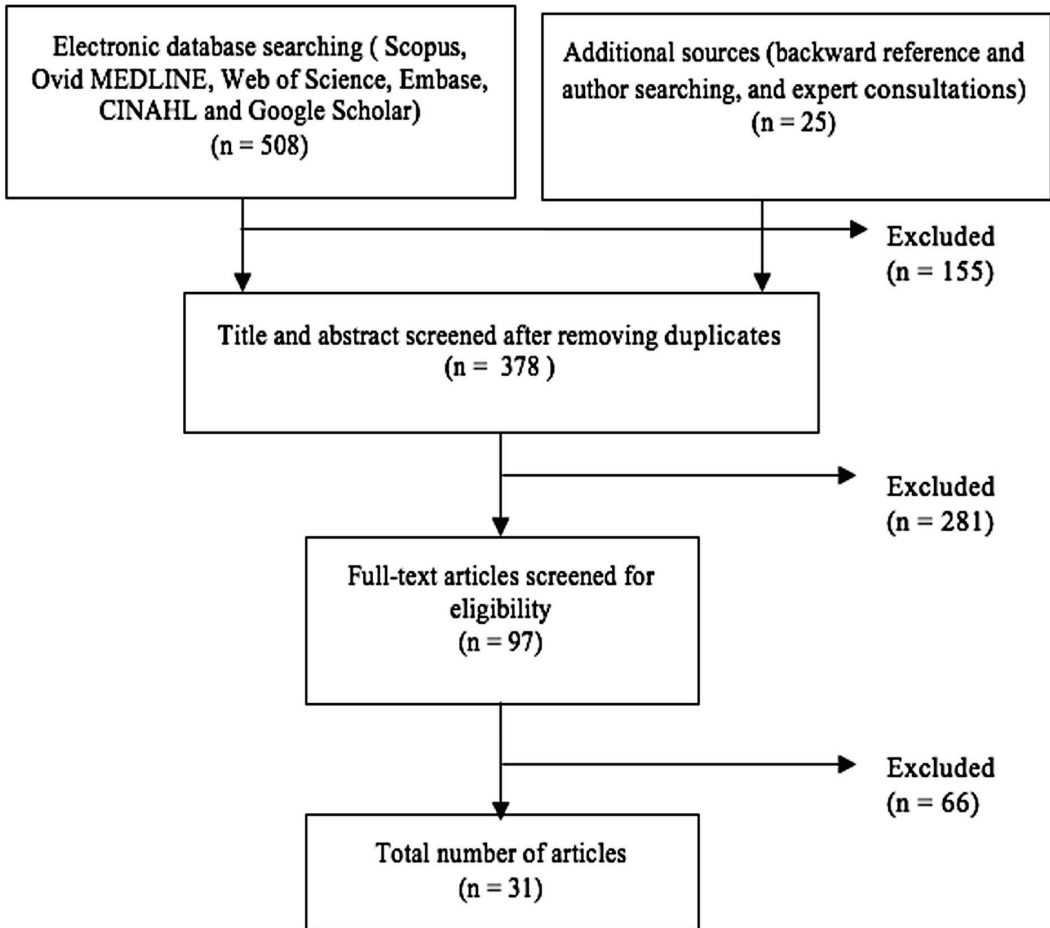
Ref	Year	Source	Criteria Omitted	Why?	Barriers
Sicotte & Paré	2010	Scopus	Includes information about the barriers to adopting and implementing HIE	The authors observed the risk factors, during HIE implementation, which can be considered as barriers.	<ul style="list-style-type: none"> • Lack of organizational support for the implementation • Lack of comprehensive strategy to support implementation
Rozenblum et al.	2011	Backward searching	The paper's content deals with electronic HIE.	Because it considers the Canada Health Infoway's plan to implement a national system of interoperable EHR.	<ul style="list-style-type: none"> • Lack of meaningful engagement of clinicians. • Poor alignment of the e-health plan and implementation strategy with the clinical and business needs of clinicians and the healthcare system. • Lack of flexibility in incorporating change. • Focus on national rather than regional interoperability.
Vest	2012	Google Scholar	The paper's focus is on Canada's or USA's experience.	Canada's experience has been mentioned as one of the HIE examples in the world.	<ul style="list-style-type: none"> • Low adoption of EHR among primary care providers. • High cost and difficulty in achieving interoperability of legacy IT investments • The move toward EHRs in Canada is not wholly a mandatory proposition.
Paré et al.	2014	Backward searching	The paper's content deals with electronic HIE.	It considers the barriers to the adoption of EMR, the latter being one of the barriers to HIE in Canada.	<ul style="list-style-type: none"> • Lack of computer skills • Lack of technical support • High start-up costs • Lack of interoperability of EMR systems • Poor quality of EMR systems on the market • EMR systems on the market do not meet the needs of physicians in the practice • Lack of stakeholders buy-in • Lack of interest of physicians towards computers in general.
Gagnon et al.	2016	Backward searching	The paper's content deals with electronic HIE.	It considers the barriers to the adoption of EMR which is one of the barriers to HIE in Canada.	<ul style="list-style-type: none"> • Lack of benefit assessment when using the EMR • Lack of computer skills

RESULTS

Overview of Results

Tables 4-8 (in the Appendix) summarize the retrieved studies, sorted by publication year. For each article, the tables list its authors, full title, publication year, country, specific location and settings where the study has been done, the study type, the data source, the population that exchanged health information, and the time frame for the study. It is noticeable that no article considered barriers to HIE before the year 2005. As papers since 1995 were collected here, this 10-year buffer (1995-2004)

Figure 1. Selection process



increases the confidence that relevant information has not been missed. In addition, the value of barriers from before 1995 would be questionable in 2016 given the rapid evolution of technologies and solutions in the HIE field.

All but five of the articles described the US experience with exchanging health information. There is not much research published about the Canadian experience with HIE. Most of the retrieved articles about Canada discuss electronic health records or health information technology in general. This drought might be influenced by the disparity in the population sizes, the cultural, political and economic dynamics, and healthcare models in Canada and in the USA.

Different types of studies have been used to investigate HIE in diverse settings. Eight of the studies used a qualitative approach. Eight other studies used a case study method, including one comparative case study (Grossman, Kushner, & November, 2008) and a longitudinal multiple-case study (Sicotte & Paré, 2010). Five papers applied a cross-sectional approach. Also, quantitative study methods were used in four studies. Other approaches have been used such as a pilot project (Gottlieb et al., 2005), an inventory (Foldy, 2007), reviews of the literature (Carr et al., 2013; Vest, 2012) and a case report (Richardson, Malhotra, & Kaushal, 2014).

The data required to conduct the different studies were collected from multiple sources. The most used source was semi-structured interviews, either in person or by telephone. Surveys and

questionnaires were also an important data source. Discussions (on-site or by telephone), focus groups, databases and direct observations have provided valuable data about HIE. It is a usual practice to use multiple data sources for one study. Reviewing the literature and national reports and documents has been reported as a source of valuable data.

Multiple care settings for exchanging health information have been considered such as HIE in emergency departments and ambulatory safety net clinics, skilled nursing facilities, primary care practices, and underserved settings (such as smaller-sized physician practices and federally qualified health centers). Emergency departments are one of the first and most important settings to deploy automated health information exchange due to the critical physicians need for the information to make timely decisions.

Most of the studies have been conducted to identify all relevant barriers, while some studies have been set out to focus on one or a few specific barriers such as regulatory and policy barriers, stakeholders' attitudes toward the system, and sustainability.

Categorization of Barriers

The identified barriers have been grouped into four main categories considering the results of previous reviews (Fontaine, Ross, Zink, & Schilling, 2010; Kruse, Regier, & Rheinboldt, 2014; Wu, & Larue, 2015; Eden et al., 2016). Each category, along with its subcategories, is discussed below. An overview of the 33 identified barriers is given in Figure 2 whereas details (by category) are presented in Table 3.

Privacy and Security

Privacy was commonly reported as a major barrier to the adoption of HIE systems in the USA. Patients hesitate to participate and consent to the use of their health information because of concerns about their privacy (Marshall, Gillespie, & Fox, 2009; McGraw, Dempsey, Harris, & Goldman, 2009). Concerns include i) identity theft or fraud, ii) unauthorized access of information about a patient's mental health, chemical dependency, and genetics, and iii) using information for purposes other than for patient care (Carr et al., 2013). One explanation for this concern is that patients may not have had enough education concerning the value of HIE and how it would benefit the quality of their care (Kierkegaard, Kaushal, & Vest, 2014). Two models have been suggested to control the patients'

Figure 2. Overview of Barriers in the USA and Canada (black for after 2013, grey for 2011-2013, and light gray for before 2011)

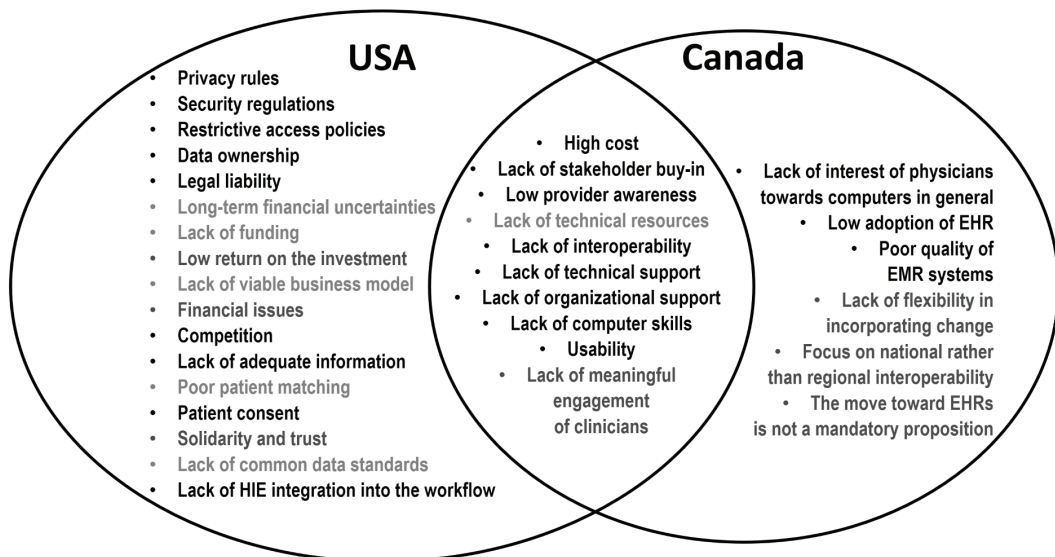


Table 3. Identified barriers in every country and the years of mention

Themes	Barriers	Canada	USA	Years
Security and Privacy	Privacy rules		√	2005 – 2014
	Security regulations		√	2005 – 2014
	Restrictive access policies		√	2005 – 2014
	Data ownership		√	2006 – 2014
	Legal liability		√	2009 – 2014
Finance and Sustainability	Lack of funding		√	2009
	High cost	√	√	2007 – 2014
	Low return on the investment		√	2007 – 2011
	Long-term financial uncertainties		√	2010
	Lack of viable business model		√	2006 – 2010
	Financial issues		√	2006 – 2013
Participation of Stakeholders	Lack of stakeholder buy-in	√	√	2007 – 2014
	Competition		√	2006 – 2014
	Lack of adequate information		√	2005 – 2014
	Poor patient matching		√	2005 – 2011
	Patient consent		√	2011 – 2014
	Lack of HIE integration into the workflow		√	2010 – 2014
	Solidarity and trust		√	2010 – 2013
	Low provider awareness	√	√	2012 – 2016
	Lack of interest of physicians towards computers in general	√		2014
	Low adoption of EHR	√		2011 – 2016
Technical and Organizational Barriers	Lack of common data standards		√	2005 – 2007
	Lack of technical resources	√	√	2006 – 2010
	Lack of interoperability	√	√	2010 – 2014
	Lack of technical support	√	√	2007 – 2014
	Lack of organizational support	√	√	2010 – 2014
	Lack of computer skills	√	√	2011 – 2016
	Usability	√	√	2010 – 2014
	Poor quality of EMR systems	√		2014
	Lack of meaningful engagement of clinicians	√	√	2011
	Lack of flexibility in incorporating change	√		2011
	Focus on national rather than regional interoperability	√		2011
	The move toward EHRs is not a mandatory proposition	√		2012

consent. First, the opt-in model in which patients have the option to permit access to their information or not. Second, the opt-out model that includes the patient’s information without the need for consent but offers an option for the patient to opt out. The opt-out model has shown success in encouraging patients to participate and share their health information (Campion et al., 2012).

Several policies imposed by privacy and security concerns proved problematic, including security regulations related to the release of data and restrictive access policies. For example, adding drug filters to prevent the display of sensitive drug information, such as HIV/AIDS, mental health disorders, or

substance abuse, may result in missing important information that is both critical to medical decision making and often difficult to ascertain accurately from patients (Gottlieb et al., 2005).

Data ownership and healthcare providers' legal liability for information from outside labs is one of the barriers that hold care providers from participating in HIE (Salzberg et al., 2012; Thorn, Carter, & Bailey, 2014). For example, physicians may reorder some tests regardless of the available data in the HIE system to reduce their liability for information from outside sources (Thorn, Carter, & Bailey, 2014). In addition, not being able to integrate the data from HIE into a patient's medical chart increases physicians' concerns about liability for decisions based on those data (Yeager et al., 2014).

For Canada, no article has reported barriers related to patients' privacy or security.

Finance and Sustainability

High cost has been reported as an indirect barrier to HIE in Canada. It is one the barriers that slow the adoption of EMR, which in turn affect the adoption of HIE. From the all the Canadian articles, financial barriers have not gone beyond high cost of achieving interoperability of legacy IT investments (Vest, 2012) or the high start-up cost of EMR (Paré et al., 2014).

In the USA, the high cost of implementing HIE systems and the lack of adequate funding have been key challenges for many HIE initiatives. RHIOs face unexpectedly high running costs (Adler-Milstein et al., 2009), especially for low volume facilities with low return on the investment and limited public/external funding (Foldy, 2007). Ross et al. (2010) considered financial issues as a secondary barrier behind technical and workflow issues. On the other hand, Patel et al. (2011) found that cost and return on investment is a major barrier to the physicians' adoption and use of HIE.

Financial concerns include start-up costs and ongoing cost (Ross et al., 2010; Vest, Campion, & Kaushal, 2013), long-term financial uncertainties and sustainability concerns (Carr et al. 2013; Dullabh & Hovey, 2012; Vest & Gamm, 2010), subscription fee pricing (Yeager, 2014) and low financial return on investment (Foldy, 2007; Ross, 2010).

The lack of viable business model has been cited in multiple studies as a barrier to HIE adoption (Adler-Milstein et al., 2009; Grossman et al., 2006; Vest & Gamm, 2010).

Participation of Stakeholders

Stakeholders (physicians, healthcare organizations, patients, etc.) have a significant effect on the success and failure of any HIE in both countries. The lack of stakeholders buy-in can stop any project completely. Many elements that may influence the stakeholders' adoption and engagement in HIE projects have been cited in the reviewed literature.

For healthcare organizations in the USA, one of the most cited barriers to participation is competition with other organizations. HIE initiatives require competing and adversarial parties to cooperate and share their most valued assets, i.e., patients and their data (Grossman et al., 2006). Organizations are usually concerned about data ownership and control (Carr et al., 2013; Grossman et al., 2006; Vest & Gamm, 2010), inappropriate access and use of the data (Grossman et al., 2008), and losing money to competitors by giving patients information and eliminating redundant test and x-rays (Ross et al., 2010; Vest et al., 2013). In Canada, competition is not a big issue because of the social healthcare model, but the situation might change with new performance-based incentives in some provinces.

For physicians, one very common barrier is incomplete information (Gadd et al., 2011; Gottlieb et al., 2005; Rudin et al., 2011; Thorn et al., 2014). Physicians stop using proposed systems when they fail to find information. The lack of adequate information is due to many factors:

1. Failure to obtain sufficient participation (critical mass) (McCullough et al., 2014; Yeager et al., 2014);
2. Poor patient matching process (Gottlieb et al., 2005; Hincapie et al., 2011);

3. Lack of certain types of clinical information such as discharge summaries (Gadd et al., 2011) or behavioral and mental medications (Hincapie et al., 2011); and
4. Patient consent (Johnson et al., 2011; Kierkegaard et al., 2014).

Physicians interviewed by Kierkegaard et al. (2014) have reported a low tolerance for failures to find information; if physicians failed in their first three attempts, they would stop using the system altogether.

Another barrier to physician adoption of HIE is related to the impact of HIE on their productivity by the lack of HIE integration into workflows (Johnson et al., 2011; Kierkegaard et al., 2014; McCullough et al., 2014; Patel et al., 2011; Ross et al., 2010; Rudin et al., 2011; Sicotte & Paré, 2010; Yeager et al., 2011). Finally, a lack of technical skills can cause physicians to abandon HIE systems (Hincapie et al., 2011).

Similarly, in Canada, physician participation is limited by how a system has succeeded in meeting their needs (Paré et al., 2014; Rozenblum et al., 2011). Additionally, physicians' skepticism about the value of EMR for the healthcare can obstruct the adoption of EMR directly and HIE indirectly. A lack of computer skills has also been reported as a barrier to physician participation (Gagnon et al., 2016; Paré et al., 2014).

For patients' participation, the main barriers are the lack of trust in the HIE's ability to protect data from misuse (Grossman et al., 2008) and the lack of clear value of how HIE could improve their care (Yeager et al., 2011). On the contrary, in Canada, patients have no apparent role in impeding the success of HIE.

In addition, solidarity and trust have been reported as common factors that affect the stakeholders' attitude towards HIE in the USA. This trust does not only include trust in a system's ability to protect the data from misuse and providing quality data, but also includes the trust of stakeholders in each other.

Technical and Organizational Barriers

In the words of the former Secretary of the US Department of Health and Human Services, Michael Leavitt, "It's not the technology, it's the sociology". Barriers related to technology have been reported in many studies as secondary to other barriers (Gravely & Whaley, 2009).

Among the most discussed organizational and technological barriers in the USA, several authors observed a lack of common data standards (Foldy, 2007; Gottlieb et al., 2005), a lack of appropriate technical resources (Foldy, 2007; Hincapie et al., 2011), a lack of interoperability with existing systems (Fontaine, Zink, et al., 2010; Ross et al., 2010), a lack of technical support (Fontaine, Ross, et al., 2010), usability issues that may affect the workflow such as multiple logins or a separate login from the existing system (Gadd et al., 2011, Hincapie et al., 2011; Patel et al., 2011; Rudin et al., 2011; Sicotte & Paré, 2010; Thorn et al., 2014; Yeager et al., 2014), and a lack of organizational support and training for potential users (Hincapie et al., 2011; Kierkegaard et al., 2014, Thorn et al., 2014).

From the Canadian side, technical barriers are related to EMR and include a lack of technical support, a lack of interoperability of EMR systems, and poor quality of EMR systems on the market (Paré et al., 2014).

Furthermore, organizational barriers seem to be the main barriers to HIE in Canada. For instance, Sicotte and Paré (2010) have noted that the lack of organizational support and the lack of comprehensive strategy are main barriers to the success of HIE implementation. Moreover, the lack of flexibility in incorporating change and the focus on national rather than regional interoperability barriers have been mentioned by Rozenblum et al. (2011).

DISCUSSION

The main purpose of this review was to identify and compare the barriers of HIE systems in Canada and the USA. However, due to the limited number of articles about the Canadian experience, the review has been mainly focused on the American experience.

The reviewed articles identified many challenges that can be categorized in four main themes: security and privacy; finance and sustainability; participation of stakeholders; and technical and organizational barriers. It is noticeable that barriers to HIE are not just technological barriers. Many of the non-technological barriers, such as cost and privacy, impede on the adoption and implementation of HIE systems among different settings. However, barriers, in general, are interdependent. For instance, the lack of participants is one of the reasons behind the information incompleteness, which results in discouraging physicians from using the system. Furthermore, privacy concerns and high costs affect the participation rate.

The lack of stakeholders' acceptance is a recurrent barrier over time. Stakeholders play an important role in funding, providing and using data (Grossman et al., 2008). Engaging all participants from the beginning will facilitate the adoption process and increase the acceptance level. For instance, involving clinicians in the design phase can help ensure that the system can adapt to their needs, and be useful to and usable by them. Thus, enlightening stakeholders about the HIE values will help them understanding and accepting the system faster. In some situations, where stakeholders continue to resist sharing the data for no valid reasons, mandating the participation and providing penalties may become a necessary solution.

Technology availability is not a big challenge anymore as mentioned before; the challenge now is how to make systems user-friendly. Considering various user needs and integrating the HIE system to the existing system is a critical measure to increase the HIE adoption.

The results reviewed showed that the lack of trust was reported as a barrier only in the period between 2010 and 2013. Fear of legal liability and of losing data control are among the main barriers to trusting and adopting HIE. Current policies are developed mainly to protect patients' privacy. In practice, there is a need for a comprehensive legal framework to protect other stakeholders and gain their trust in the system. A combination of grants, incentives, and mandates may increase this trust.

Even though one of HIE's purposes is to reduce test redundancy, some end-users see this advantage as a barrier to using the system for two reasons. First, healthcare organizations want to reduce their legal liability (Thorn et al., 2014). Second, many organizations make profits on redundant tests and x-rays (Vest et al., 2013).

In Canada, the main barrier to HIE is the low rate of electronic health records (EHR) adoption, especially among primary care providers (Paré et al., 2014; Rozenblum et al., 2011). Since an EHR is a key element to the exchange process, missing this element should negatively affect any attempt to adopt electronic HIE (Vest, 2012). Therefore, identifying the barriers to adopting EHR is the first step in paving the road for the adoption of HIE in Canada. Many barriers to EHR in Canada have been identified by the literature (Gagnon et al., 2016; Paré et al., 2014). These barriers include the lack of an e-health policy, inadequate involvement of stakeholders, lack of a viable business model, a focus on national rather than regional interoperability, high cost, lack of incentives, and technology usability. Despite the similarity between the barriers to adopting EHR in Canada and those in the USA, the barriers cannot be generalized to HIE systems in Canada due to the different healthcare models of these two countries. Therefore, more intensive work to examine HIE in Canada in general and barriers specifically is required before making such a conclusion.

All things considered, the three research questions can be answered.

RQ1: What are the barriers that have an influence on the success of HIE systems in each country?

During the review, a total of 33 barriers have been identified for Canada and the USA. Table 3 presents a summary of all identified barriers along with their general themes, the countries where they have been observed, and the range of dates of the papers where they have been reported.

RQ2: What are the changes in barriers over time?

Privacy, security, and access restriction concerns are consistently discussed in the USA as main barriers in almost every year. They have been discussed in 8 years out of the 12 years considered for the research and the trend is not slowing down.

The second most persistent barriers are the lack of adequate information and the high cost of implementing HIE systems. As early as 2005 and 2007 respectively, the two barriers have been recognized and continue to appear during recent years.

The lack of stakeholders buy-in and the competition between them have been reported as early as 2006 and are still discussed today. In many cases, competition is the reason for the lack of participation in HIE initiatives.

Finally, the lack of technical support has impeded the stakeholders' adoption of HIE systems, especially with physicians with low computer skills. Many physicians need short training and support to show them how the system functions and to answer their questions in order to speed up learning and encourage usage (Thorn et al., 2014).

On the other hand, older barriers such as the lack of technical resources and the lack of common data standards have not been reported as barriers recently.

Moreover, during recent years, other barriers have occurred such as a lack of HIE integration into the workflow, a lack of interoperability and system usability, which have not been mentioned before 2010. Additionally, patients' consent to use their health information has started to appear as a barrier in 2011. Low provider's awareness about available technologies and their benefits is now reported as an obstacle that can hinder HIE projects from moving forward.

Other barriers have appeared only once in the literature. For instance, the lack of funding (2009), long-term financial uncertainties (2010), the lack of interest of physicians towards computers in general (2014), poor quality of EMR systems (2014), the lack of meaningful engagement of clinicians (2011), the lack of flexibility in incorporating change (2011), a focus on national rather than regional interoperability (2011), and the move toward EHRs as a non-mandatory proposition (2012).

RQ3: Are the barriers in the USA different from the barriers in Canada?

Yes, the barriers in the USA differ from those in Canada. In general, 6 unique barriers have been identified for HIE in Canada and 17 unique barriers in the USA, with 10 barriers common to the two countries (see Table 3).

In fact, many of the consistently discussed barriers in the USA, such as privacy and security concerns, the lack of adequate information, and competition, have not been reported for the Canadian side. Similarly, other barriers have been delaying the success of HIE systems in Canada but not in the USA. One main barrier is the low adoption of EMR in Canada, which is not the case for the USA.

Although not observing a barrier for a country in scientific publications does not necessarily mean it does not exist, some differences between the two countries can be explained in part by two reasons:

1. The major differences in the healthcare models between Canada and the USA; and
2. The incentives model that was proposed by the American government to accelerate the adoption of EMR (e.g., Meaningful Use).

In Canada, the public funding and universal insurance have limited the competition impact on HIE systems.

In spite of different healthcare models, HIE systems in both countries suffer from common barriers such as i) high implementation costs, ii) a lack of stakeholders' interest and computer skills, iii) a lack of technical resources and support, iv) low provider awareness, v) interoperability, vi) organizational support, vii) system usability, and viii) the lack of meaningful engagement of clinicians.

LIMITATIONS AND THREATS TO VALIDITY

Research validity is an indication of how research conclusion answers the research questions given the design, research method, and analysis of the collected data (Feldt & Magazinius, 2010). In the systematic literature review approach of Kitchenham (2004) and in many other such approaches, threats to the validity of the methodology and the results need to be discussed after their description. There are many threats that can limit the internal and external validity of the research presented in this particular review, and this section discusses the most important one and the extent to which they were mitigated.

Internal Validity

Internal validity considers selection bias and confounding factors. All the retrieved papers were reviewed by a single researcher (the first author), which increases the risk of bias in selecting papers and extracting data. Having more than one reviewer for each paper would have helped but was impossible due to resource limitations. In this review, several strategies were used to mitigate this threat, such as:

1. Considering prior reviews to verify research strategy and add missing papers
2. Using multiple databases
3. Using clear inclusion/exclusion criteria
4. Discussing related issues with other experts in the field

Another threat is that the search was limited to English-language and peer-reviewed publications only. Other languages such as French could lead to other useful publications, especially in Canada. In addition, many HIE initiatives may not be available via peer-reviewed journals and conferences.

The number and quality of papers discussing the Canadian experience with HIE are much smaller than for the USA, which may negatively affect the conclusion.

External Validity

External validity considers the ability to generalize the results outside the scope of the study. Due to limited studies considering the Canadian experience in HIE, general conclusions cannot be drawn accurately. Applying the results of the American experience to Canada may not be possible due to the vast differences in the healthcare models of the two countries.

Although some countries with healthcare characteristics similar to Canada's or the USA's likely share common barriers, the results presented here cannot be generalized to other countries without further studies and evidence.

CONCLUSION

This review has outlined the barriers to successful health information exchange in the USA and Canada. At this time, 6 barriers are unique to Canada, 17 are unique to the USA, and another 10 are common to both countries. Moreover, the review proposed a categorization of the barriers into four groups: security and privacy; finance and sustainability; participation of stakeholders; and technical

and organizational barriers. This knowledge about the key challenges in HIE should be taken into account by decision makers to minimize HIE complications. By identifying reasons for past failures, it is hoped that the rate of successful adoption and implementation of HIE systems will improve as a result. Also, the identification of barriers could lead to an emphasis on the discovery and specification of appropriate requirements for HIE systems so such barriers could be addressed up front.

Multiple reviews have been conducted to identify the HIE barriers (and facilitators) around the world. One recent systematic review was published recently by Eden et al. (2016). Their review's conclusions align with the ones in this paper in three points: most of the available literature is considering the American experience, the lack of adequate information is a major and persistent barrier, and the scarcity in the barriers that consider HIE in Canada is real as Eden et al. have not reported any Canadian study.

For future work, from a research perspective, a potential avenue could involve additional research on HIE systems in Canada in general (e.g., through surveys and interviews) and the facilitators and barriers specifically, with better mitigation of the threats identified in the previous section. Researchers could also survey existing technical, educational, legal, and social mechanisms used to mitigate these barriers, and develop new ones where necessary.

From a practical perspective, the results of this systematic review also imply immediate applications and potential future work items:

1. At a small scale, e.g., during the selection or evaluation of HIE solutions and health information systems in general, these results could be used to educate and engage relevant stakeholders. In addition, the barriers could be transformed into selection criteria to evaluate solutions, especially in terms of mechanisms used to address security/privacy and technical barriers.
2. At a larger scale, there is a need to raise awareness about these barriers among healthcare decision makers (managers, policy officers, IT personnel, etc.) in hospitals, among professors and students in universities, and among politicians and policy makers in governments, especially in Canada.
3. The categorization defined in this review can also help specific stakeholders focus their attention on particular categories, for instance: IT personnel on security/privacy and on technical barriers, managers and politicians on financial/sustainability barriers, physicians and nurses on participation barriers, etc.
4. Although some barriers are currently observed in the USA and not in Canada, there is a good chance some of these barriers will apply to Canada in the future. A prime candidate here is competition. Although this is not a major concern in Canada yet, the situation will likely change in the near future as some provinces (e.g., Ontario) have recently changed their funding model, which now includes performance-based incentives that will effectively trigger competition between hospitals. This review can hence help relevant stakeholders identify such issues and be proactive on ways to solve them, based on the experience acquired in the other country.

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APPENDIX

Table 4. Summary of the studies, sorted by years. Shaded rows are studies about Canada

Ref	Title	Year	Country	Location	Study type	Data source(s)	Settings	Population	Time Frame
Gottlieb et al.	Regulatory and policy barriers to effective clinical data exchange: lessons learned from medsinfo-ED.	2005	USA	Massachusetts	Pilot project	Blue Cross Blue Shield of Massachusetts; Harvard Pilgrim Health Care; Tufts Health Plan; Neighborhood Health Plan; Massachusetts Medicaid (masshealth); and the Massachusetts Group Insurance Commission (GIC, purchaser of health insurance for Commonwealth of Massachusetts employees and retirees).	Patient's medication history in Emergency department	Six Massachusetts-based health plans.	N/A
Grossman et al.	Hospital-physician portals: The role of competition in driving clinical data exchange	2006	USA	Statewide	Case study	Semi-structured interviews were conducted by phone and in person	Large hospitals	Twelve U.S. communities	Between January and June 2005
Foldy	Inventory of electronic health information exchange in Wisconsin, 2006.	2007	USA	Wisconsin	Inventory	A cross-sectional internet survey	Any	Any project where electronic patient information was transmitted by multiple organizations in Wisconsin in 2006.	2006
Grossman et al.	Creating sustainable local health information exchanges: can barriers to stakeholder participation be overcome?	2008	USA	Statewide	Comparative case study	Discussions	Any	Four communities with local HIE	Between February and August 2007
Adler-Milstein et al.	U.S. regional health information organizations: Progress and challenges	2009	USA	Statewide	Quantitative study	Survey	Any	207 organizations	Between 1 January 2007 and 1 June 2008.
Sicotte & Paré	Success in health information exchange projects: Solving the implementation puzzle	2010	Canada	Quebec	Longitudinal multiple-case study	Semi-structured interviews and	Hospitals and primary care clinics	Two large-scale HIE implementation projects	Between January 2001 and 2004.
Ross et al.	Health information exchange in small-to-medium sized family medicine practices: Motivators, barriers, and potential facilitators of adoption	2010	USA	Colorado	Case study with mixed quantitative and qualitative methods	Telephone and on-site guided discussions	Small-to-medium sized primary care practices	Nine small-to medium sized (20 or fewer clinicians) primary care practices	Between November 2008 and April 2009.

Table 5. Summary of the studies, sorted by years, continued

Ref	Title	Year	Country	Location	Study type	Data source(s)	Settings	Population	Time Frame
Wright et al.	Physician attitudes toward health information exchange: results of a statewide survey.	2010	USA	Massachusetts	Cross-sectional	Mail survey	Any	1043 licensed physicians	March 2007
Vest & Gamm	Health information exchange: persistent challenges and new strategies.	2010	USA	Statewide	Case study	Observation	Any	Community health management Information systems, Community health Information networks and Regional health information organizations	Between early 1990s to 2000s.
Vest	More than just a question of technology: Factors related to hospitals' adoption and implementation of health information exchange	2010	USA	Statewide	Case study	Survey	Any	All U.S. hospitals represented in both The 2008-2009 Healthcare Information & Management Systems Society (HIMSS) Analytics database™ and the American Hospital Association's (AHA) Annual Survey Database for fiscal year 2007.	N/A
Fontaine, Zink et al.	Health information exchange: participation by Minnesota primary care practices	2010	USA	Minnesota	Qualitative study	Questionnaires, site visits and interviews	Primary care practices	9 practices with less than 20 providers	Between November 10, 2008 and February 20, 2009.
Rozenblum et al.	A qualitative study of Canada's experience with the implementation of electronic health information technology	2011	Canada	Nationwide	Case study	Canada Health Infoway documents and interviews	Any	National and provincial organizations responsible for establishing policy and strategic direction for health information technology	10 years.

Table 6. Summary of the studies, sorted by years, continued

Ref	Title	Year	Country	Location	Study type	Data source(s)	Settings	Population	Time Frame
Bouhaddou et al.	The Department of Veterans Affairs, Department of Defense, and Kaiser Permanente Nationwide Health Information Network Exchange in San Diego: Patient Selection, Consent, and Identity Matching	2011	USA	San Diego, California	Cross-sectional study	Database and mail survey	Integrated delivery system	264 patient (veterans)	N/A
Rudin et al.	What Affects Clinicians' Usage of Health Information Exchange?	2011	USA	Northern Berkshire, a community in western Massachusetts	Qualitative study	Interviews	Any	20 key informants which included 15 clinician-users, one HIE trainer, one IT staff member for the HIE, the hospital executive who supervised the HIE's operations, one director of support services for a large medical practice, and an administrative assistant for the same large Medical practice.	Between October 2009 and February 2010.
Patel et al.	Physicians' potential use and preferences related to health information exchange	2011	USA	Brooklyn, New York	Quantitative study	A cross-sectional survey	Any	Physicians who were affiliated with institutions that are members of the Brooklyn Health Information Exchange (BHIX)	Between May and October 2009.
Gadd et al.	User perspectives on the usability of a regional health information exchange	2011	USA	Memphis, Tennessee	Quantitative study	Cross-sectional survey	ED and ambulatory clinics	Healthcare professionals at participating The Mid-South eHealth Alliance (MSEHA) organizations	Between May and November 2009
Hincapie et al.	Physicians' opinions of a health information exchange	2011	USA	Arizona	Cross-sectional study	Focus-groups	Any	Physicians	Three months

Table 7. Summary of the studies, sorted by years, continued

Ref	Title	Year	Country	Location	Study type	Data source(s)	Settings	Population	Time Frame
Johnson et al.	Health information exchange usage in emergency departments and clinics: the who, what, and why	2011	USA	Memphis, Tennessee	Cross-sectional study	Audit log data, semi-structured interviews, and direct observation	Emergency departments and ambulatory safety net clinics	Emergency department (ED) sites and ambulatory groups	Not specified
Vest	Health Information Exchange: National and International Approaches	2012	Canada	World wide	Review	Informatics journals, professional Associations, and government reports.	Any	N/A	Not specified
Campion et al.	Push and Pull: Physician Usage of and Satisfaction with Health Information Exchange	2012	USA	Buffalo and Rochester, New York	Quantitative study	Cross-sectional survey	Any	Physicians whose practices were provided HIE services by Healthlink or Rochester RHIO	Between July and December 2010
Dullabh & Hovey	Large scale health information exchange: Implementation experiences from five states	2012	USA	Maine, Nebraska, Texas, Washington State, and Wisconsin	Qualitative study	Site visits, focus groups, semi-structured discussions and interviews	Any	5 states	Between 29 November 2011 and 21 March 2012.
Carr et al.	Primer in health information exchange for the emergency physician: benefits and barriers.	2013	USA	Statewide	Review	Literature and observation	Emergency department	Emergency departments in various regions throughout the United States	Not specified
Vest et al.	Challenges, alternatives, and paths to sustainability for health information exchange efforts.	2013	USA	New York	Qualitative study	Semi-structured interviews.	Any	State and national health informatics policy Experts	Between March and June 2010
Adler-Milstein et al.	Operational Health Information Exchanges Show Substantial Growth, But Long-Term Funding Remains A Concern	2013	USA	Statewide	Qualitative study	National survey	Any	All organizations that facilitate the exchange of clinical data between independent entities.	Between August and November 2012
Paré et al.	Barriers to organizational adoption of EMR systems in family physician practices: A mixed-methods study in Canada	2014	Canada	Quebec	A mixed-methods study	Delphi study and questionnaire survey	Primary care	Family physicians working in medical practices without EMR systems	In early 2013

Table 8. Summary of the studies, sorted by years, continued

Ref	Title	Year	Country	Location	Study type	Data source(s)	Settings	Population	Time Frame
Thorn et al.	Emergency physicians' perspectives on their use of health information exchange.	2014	USA	Anonymous	Qualitative study	Unstructured Interviews	Emergency department	Urban emergency departments	Not specified
Richardson et al.	A case report in health information exchange for inter-organizational patient transfers.	2014	USA	New York city	Case report	Semi-structured telephone and in-person interviews	Inter-organizational patient transfers between one hospital ED and one skilled nursing facilities (SNF)	HIE organizational informants and providers	Between May and October 2011
Yeager et al.	Factors related to health information exchange participation and use.	2014	USA	Louisiana	Qualitative study	Semi-structured qualitative interviews were conducted with health care representatives throughout the state.	Any	Health care stakeholders (i.e. Representatives of health care organizations and The state designated entity establishing the state HIE)	Between March and April 2013.
Kierkegaard et al.	How could health information exchange better meet the needs of care practitioners?	2014	USA	New York State	Case study	Interviews onsite and by telephone	Any	Communities served by three operational RHIOS	May 2013
McCullough et al.	Electronic health information exchange in underserved settings: examining initiatives in small physician practices & community health centers.	2014	USA	San Gabriel Valley, California and Minneapolis-St. Paul metro area, Minnesota	Qualitative study	Semi-structured key-informant interviews	Underserved settings	Citrus Valley Health Partners (CVHP) and Federally Qualified Health Center Urban Health Network (FUHN),	September 2013
Gagnon et al.	Factors influencing electronic health record adoption by physicians: A multilevel analysis	2016	Canada	Quebec	Prospective cross-sectional study	Survey	Primary healthcare	Primary healthcare organizations in four regions of the province of Quebec	Between April 2010 and July 2011

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