

## RESEARCH REPORT

# The implications and impact of 3 approaches to health information exchange: community, enterprise, and vendor-mediated health information exchange

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**Abstract**

**Introduction** Electronic health information exchange (HIE) is considered essential to establishing a learning health system, reducing medical errors, and improving efficiency, but establishment of widespread, high functioning HIE has been challenging. Healthcare organizations now have considerable flexibility in selecting among several HIE strategies, most prominently community HIE, enterprise HIE (led by a healthcare organization), and electronic health record vendor-mediated HIE. Each of these strategies is characterized by different conveners, capabilities, and motivations and may have different abilities to facilitate improved patient care.

**Methods** I reviewed the available scholarly literature to draw conceptual distinctions between these types of HIE, to assess the current evidence on each type of HIE, and to indicate important areas of future research.

**Results** While community HIE seems to offer the most open approach to HIE allowing for high levels of connectivity, both enterprise HIE and vendor-mediated HIE face lower barriers to formation and sustainability. Most existing evidence is focused on community HIE and points towards low overall use, challenges to usability, and ambiguous impact. To better guide organizational leaders and policymakers in the expansion of beneficial HIE and anticipate future trends, future research should work to better capture the prevalence of other forms of HIE, and to adopt common methods to allow comparisons of rate of use, usability, and impact on patient care across studies and types of HIE.

**Conclusions** Healthcare organizations' choice of HIE strategy influences the set of partners the organization is connected to and may influence the benefit that efforts supported by HIE can offer to patients. Current research is not fully capturing the diversity of approaches to HIE and their potentially varying impact on providers and patients.

**KEYWORDS**

Health Information Exchange, Electronic Health Record, Quality of Care, Review, Health Information Technology

## 1 | INTRODUCTION

Policy makers in the United States have long pursued the goal of increasing electronic patient health information exchange (HIE) between healthcare organizations, believing that increased availability of such information is an essential foundation to facilitate a learning

health system to improve the quality and efficiency of patient care.<sup>1</sup> Despite continued support for HIE, growth in its adoption and use by healthcare organizations have been relatively slow.<sup>2,3</sup> Traditionally, policy efforts have aimed to support the development of third-party entities, often known as regional healthcare information organizations or more recently as community HIEs (used hereafter), to coordinate

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HIE between multiple stakeholders in an area.<sup>1,4,5</sup> However, community HIEs have struggled to engage healthcare organizations and other relevant entities, to create a sustainable business model and to develop a technical architecture.<sup>2,6-8</sup> This has led to slow growth among many community HIEs and to the closure of others.<sup>4,9-11</sup>

These challenges, combined with a shift in policy towards supporting HIE in varied form, created the opportunity for new approaches to HIE to emerge. Specifically, large healthcare organizations support HIE with other organizations via enterprise HIE, and electronic health records (EHR) vendors have begun to develop HIE for their customers within the EHR.<sup>12-14</sup> These different approaches to HIE vary along several dimensions, such as their openness to participation by competitive providers and their ability to establish rich data exchanges that are integrated with providers' EHRs. Enterprise and vendor-based HIE provide the underpinning for newer initiatives to expand the reach of HIE, such as the CommonWell Health Alliance and the Sequoia Project's Carequality and eHealthExchange, such that future developments may be imbued with the strengths and weaknesses of each type.<sup>15,16</sup> Because differences in characteristic of each type of HIE can impact the ability to develop a learning health system and improve patient care,<sup>17</sup> it is critical to assess the impact that each type of HIE has had on patients and providers to help guide investment decisions by healthcare organizations and policy makers as they navigate and try to support the continually changing HIE landscape.

## 2 | RESEARCH INTERESTS

In this study, I build from existing definitions of different types of HIE<sup>12,18</sup> to better characterize types of HIE both conceptually and empirically. Specifically, I address 3 research objectives. First, I define 3 forms of HIE and identify their key characteristics, including who facilitates sharing of data, the rationale of participation in each form, and the particular costs and benefits offered by each approach. Second, I identify the current prevalence, use, and impact on cost and patient outcomes of each type of HIE. Third, I propose future directions for research on HIE that will allow for better assessment of the relative benefits to patients and providers from each approach.

## 3 | METHODS

To develop a conceptual understanding of the types of HIE currently in use, I revisited articles cited in 2 recent systematic reviews that summarized the empirical literature on HIE<sup>19,20</sup> and surveyed additional works that either cited or were cited in those articles to develop a conceptual overview of the available HIE types. Drawing from this literature, I first sought to describe HIE types on the basis of core characteristics, including the rationale for participation, role of competition, technical barriers, expectation for patient's benefit, and prospects for growth that influence participation, use, and success of each HIE tool.

Next, I categorized the empirical literature by HIE type to capture the extent of the evidence, prevalence, usage, usability, and impact on usage and patient outcomes of each type of HIE. Because of the varied methods used and results presented in the reviewed studies, I qualitatively summarized the literature to describe each facet of HIE.

To estimate prevalence, I used the most recently available studies on each type of HIE. I summarized the frequency of use by drawing on 21 studies from recent reviews and citing publications that described use (Appendix Table 1). To summarize usability issues, I synthesized the key conceptual issues from these studies and additional articles. Finally, to assess the impact of each type of HIE, I included 25 of the 28 studies on impact cited in recent reviews as well as 1 additional study published after these reviews (Appendix Table 2). I excluded 3 studies because I could not categorize them by type of HIE used. Eighty-four percent of included studies focused on HIE efforts in the US while 16% of studies were set outside of the US. Unless otherwise noted, cited findings come from studies of the U.S.

## 4 | RESULTS

### 4.1 | A taxonomy of health information exchange

HIE is the process of electronically sharing health data between healthcare organizations.<sup>21,22</sup> To occur, HIE requires technological and governance structures between unaffiliated organizations, both of which require a facilitating convener. Experts believe that HIE will reduce the frequency of medical errors—such as adverse drug events—associated with missing information, will improve medical decision-making and efficiency, and will reduce redundant diagnostic tests.<sup>23-25</sup>

Despite sharing an overarching definition and set of goals, existing HIE efforts vary along several technical and social dimensions. I follow Vest, Campion, and Kaushal's (2013) division of HIE into types based on the entity providing the convening role for the HIE effort.<sup>12</sup> The convening dimension of HIE is essential because each convener establishes the rules and rationale for participation by outside organizations in different ways, which may drive participation from specific groups, and participation is particularly salient because adoption of HIE remains far from complete.<sup>2,26</sup>

The most studied type of HIE, community HIEs, are third-party organizations created specifically to provide the infrastructure to connect healthcare organizations.<sup>27</sup> These organizations are expected to build consensus and participation among healthcare organizations.<sup>9</sup> The Mid-South eHealth Alliance (MSeHA), which covers the metropolitan Memphis area and connects 16 of the 17 hospitals in the area, is a prominent example of a community HIE. Enterprise HIE is convened by a large healthcare organization like a multihospital system to create connections with select providers with whom sharing information is in the convening organizations' interest.<sup>12</sup> Enterprise HIE can involve "rolling out" the convener's EHR system to unaffiliated healthcare organizations, creating an interface between different EHRs, or sharing a portal that allows others to view their information. Finally, EHR vendor-mediated HIE is convened by an EHR vendor that offers technical and networking support to establish connections between their customers. For instance, Epic Systems' Care Everywhere platform is included as part of their EHR and facilitates information sharing between all of their customers.

Along with differing convener, each type of HIE is characterized by varying levels of 7 key characteristics related to participation and growth: (1) Openness, the extent to which the HIE form is designed

to allow for participation from a broad group of health care organizations; (2) The logic of participation, the reasons why a healthcare organization might be interested in joining each type of HIE; (3) the role of competitive motivation in spurring or slowing each form of HIE; (4) The apparent difficulty of establishing and sustaining each form of HIE; (5) The level of expected patient benefit from each form of HIE, which is based on the likelihood that the HIE connects necessary organizations in valuable ways; (6) The prospects for growth of each form of HIE in the future; and (7) the scalability of each form of HIE into a single unified network.

The characteristics of each type of HIE are briefly summarized in Table 1. In general, community HIEs are appealing because of their openness and the possibility that they will lead to a nationwide, inclusive system of HIE; however, other options may be more appealing to key stakeholders, fulfill different needs and face fewer technical barriers.

## 4.2 | Does HIE type matter?

Although the evidence on vendor-mediated and enterprise HIE is relatively limited, it is clear that each form of HIE is used by a substantial group of providers and offers key differences in usability and impact.

## 4.3 | Community HIE

### 4.3.1 | Extent of evidence

Community HIEs are the most frequently studied form of HIE with 2 sources of national data on community HIE participation (the American Hospital Association's [AHA] Information Technology [IT] survey and annual surveys of community HIEs), and many study on their usage and impact. However, most existing studies on the impact of HIE have focused on a few large community HIE efforts, including several efforts in New York State, the Integrated Care Collaborative in the Austin Texas area, and the MSeHA in the Memphis Tennessee metropolitan area. As a result, the generalizability of these studies may be questionable.

### 4.3.2 | Prevalence

Since 2008, the AHA IT supplement has asked hospitals whether they actively share data through a community HIE, and about one third of hospitals reported exchanging data and participating in a community HIE in 2013.<sup>36</sup> In addition, an annual survey of community HIE entities identified 119 active in 2012 and estimated that 30% of hospitals and 10% of ambulatory providers participated.<sup>2</sup> However, case studies have reported the failure of several community HIEs, and the overall number of community HIEs declined in 2014.<sup>4,10,11</sup>

### 4.3.3 | Usage and usability

Several studies have reported on the usage and usability of community HIEs. Five studies on the use of community HIEs found that data from the HIE was used in 2%-4% of all visits.<sup>37-41</sup> Community HIEs were found to be more frequently used for certain types of visits, and in particular, repeated emergency department (ED) visits, especially for back pain and headache, have been found to be associated with much higher rates of HIE use, ranging from 12.5%-21.9%.<sup>41-43</sup> A different

study reported much higher overall rates of HIE use, at 21%,<sup>44</sup> indicating that many implementation and social factors including integration with the EHR and success convincing providers of the value of HIE, might influence the rate of use of HIE.

Other studies assessed usage at the physician or patient level. A study of the Integrated Care Collaborative indicated that 57% of patients had their exchanged information accessed at some point over the course of 2 years.<sup>44</sup> In 2 community HIEs in New York, 80% of physicians reported using the community HIE.<sup>45</sup> Yet again, there is a great deal of variation in use. Within the same community HIE, usage rates varied enormously at 3 sites depending on local implementations and policies: 1% of patients at 1 community and 5% of patients at another had their information accessed, while at the third, over 50% did.<sup>46</sup>

The low use of community HIE may be because of several factors related to usability. Community HIE systems often relied on web-based portals or read-only documents and rarely provided structured data that was integrated with providers' EHR. As a result, providers report that the systems were often slow, disrupted their workflows, needed a separate log-in and password from the EHR, and required providers to look up patient's information in a separate system.<sup>45,47,48</sup> In general, systems lacked advanced functionality like automated querying of the HIE from the EHR that might ameliorate these challenges and raise usage rates.<sup>48</sup> Community HIEs may be unlikely to offer integration with EHRs because they sought to function similarly when used by stakeholders using many different EHRs, making investment in integration with any 1 system unlikely.<sup>33,47</sup> Several studies noted the providers' frustration with missing data and that failed attempts to look up patients discouraged future use of the HIE.<sup>41,47,49</sup> Community HIEs may be particularly susceptible to missing data because organization participation is voluntary and usually relatively low in an area, so that their coverage of the history of any given patient may contain gaps.<sup>47,50</sup> Finally, and somewhat paradoxically, when patient's data are presented, it was often of overwhelming quantity, coming from all visits to all organizations, and relevant information was not extracted for easy review.<sup>45</sup>

### 4.3.4 | Impact

Taken together, recent empirical studies have generated ambiguous results. Early estimates of the savings generated by MSeHA pointed towards large financial benefits<sup>24</sup> and a later study indicated lower, but substantial, benefits from it.<sup>51</sup> Several studies have demonstrated that community HIEs can reduce the rate of imaging.<sup>42,43,52</sup> Community HIE participation in Wisconsin that linked 5 competitive systems was shown to save \$29 per visit.<sup>53</sup> A Colorado-based community HIE demonstrated that community HIE adoption was associated with reduced lab testing, but the benefits were smaller than anticipated, and another examination of lab testing showed no effect.<sup>54,55</sup> On the other hand, use of the Texas-based community HIE was associated with a higher likelihood of admission and little financial benefit.<sup>39</sup> Use of an HIE in Finland had similarly mixed effects.<sup>56</sup> Finally, patient benefit was found in 1 of 2 studies of similar public health-driven community HIEs, illustrating the challenge in identifying consistent effects in the available literature.<sup>57,58</sup>

**TABLE 1** Key characteristics and differences between community health information exchanges (HIEs), enterprise HIE, and vendor-mediated HIE

	<i>Convener</i>
Community	Neutral third-party organization
Enterprise	Large healthcare organizations
Vendor	EHR vendor
	<i>Openness</i>
Community	Open view of HIE available to all participants, regardless of affiliation, or competitive interests. <sup>6,28</sup>
Enterprise	More closed-system HIE than community HIEs. <sup>28</sup> Specifically include key partners of convening organizations and may exclude competitors. <sup>12,29</sup>
Vendor	Designed to facilitate exchange within a vendors' customers. Few incentives encourage HIE across vendors.
	<i>Logic of participation</i>
Community	Driven by geographic proximity and shared patients.
Enterprise	Gathers participants from healthcare organizations that are either already officially affiliated, such as physician offices and hospitals owned by the same healthcare system, or are close informal partners that privately agree to collaborate.
Vendor	Driven in large part by provider choice of vendor, which may not relate strongly to vendor HIE capability or other participating organizations. Vendors may be effective conveners because they hold the technical expertise to support infrastructure development, and build close relationships with multiple healthcare organizations as part of the implementation process. <sup>30</sup>
	<i>Competitive motivation</i>
Community	Because of the high level of openness, community HIEs have struggled to deal with healthcare organizations' reluctance to share information with their competitors.
Enterprise	Development may be a competitive advantage because it can provide efficiency gains to providers within a large organization or can tie loosely affiliated outside healthcare organizations closer to the organization. <sup>13,31</sup>
Vendor	EHR vendors may find it in their competitive interest to facilitate HIE within their customer base, the vendors may also block information sharing with healthcare organizations using other vendors to increase the appeal of selecting their system. <sup>32</sup>
	<i>Apparent difficulty</i>
Community	In part due to their openness and intended wide participation, community HIEs have faced many challenges including cost to join; technical and usability issues; security, privacy and liability issues; and concerns about loss of market competitiveness. <sup>6,28,33</sup>
Enterprise	Because enterprise HIE usually involves participants with a history of collaboration, increasing participation among collaborators may be easier than other HIE approaches which may connect competitors or unaffiliated organizations.
Vendor	Simplified because each implementation of the same vendor's EHR system share similar—though not necessarily identical—data structures.
	<i>Expected patient benefit</i>
Community	Could logically extend to all healthcare organizations in an area, offering relatively high potential value to patients. However, many community HIEs share a limited set of data.
Enterprise	May provide lower benefit to the local community as a whole because it can exclude some healthcare organizations, limiting the extent to which patient data is shared. However, it may connect the most frequent healthcare provider partners together, supporting the sharing of information necessary for collaboration-based initiatives like bundled payments and accountable care organizations.
Vendor	May provide less value to the community of patients than a more open approach to the extent that vendors block information sharing across organizations that use different vendors. Relative to enterprise HIE, vendor HIE may connect providers that happen to share vendors, but may not connect the most frequent collaborators. Vendors may provide highly functional systems.
	<i>Growth</i>
Community	Given the difficulties encountered by many community HIEs, their future growth seems in doubt.
Enterprise	Likely to grow as more organizations gain sophistication in IT support through their own EHR implementation.
Vendor	An increasing number of vendors offer easily implemented vendor-mediated HIE, and many vendors are developing these tools. <sup>34,35</sup>
	<i>Scalability</i>
Community	As community HIEs grow they may be logically combined into a single network. <sup>21</sup>
Enterprise	Growth may be driven by increases in the number of enterprise HIEs, rather than growth towards an interlinked network.
Vendor	Vendor networks may result in silos of information unless vendors and healthcare organizations can overcome important competitive barriers to cross-vendor HIE, and transfer technical benefits from enabling HIE on a single vendor system towards sharing across vendors. Several cross-vendor initiatives are being developed but not yet widely used. <sup>15,16</sup>

## 4.4 | Enterprise HIE

### 4.4.1 | Extent of evidence

In contrast to community HIEs, there is no clear, national data on the extent of enterprise HIE participation. A few studies using qualitative data or small-group surveys focus on the usability of physician portals and other forms of interorganizational enterprise HIE. Most of what is known about the impact of enterprise HIE comes from studying a few specific hospitals or systems, most notably the Clarit health maintenance organization in Israel.<sup>59-61</sup>

### 4.4.2 | Prevalence

While there are no clear national assessments of the extent of enterprise HIE participation, available evidence points towards wide prevalence. Unlike community HIEs, which are specifically focused on linking disparate healthcare organizations, enterprise HIE is used to connect both affiliated and unaffiliated organizations, and links between affiliated healthcare organizations appear to be more common. For instance, in 2013, thirty-nine percent of physicians indicated that they shared information with other groups within their organization and 15% said they shared with outside organizations.<sup>3</sup> Many large, multi-hospital systems engage in HIE, including Clarit in Israel and Kaiser Permanente, one of the largest healthcare organizations in the United States. Both of these systems use HIE tools to exchange data across multiple instances of their EHR, and in large part led development of these interfacing tools.

Enterprise HIE between unaffiliated organizations also appears to be widespread. In 2012, fifty-eight percent of US hospitals reported on the AHA IT survey that they exchanged some information with outside organizations—approximately twice the percentage that reported participating in a community HIE.<sup>62</sup> Similarly, 15% of physician offices reported sharing information with outside organizations—50% more than participated in community HIEs.<sup>3</sup> It is therefore likely that current studies that only focus on community HIEs may have underestimated the number of organizations engaged in HIE.

### 4.4.3 | Usage and usability

Studies of Clarit's within-system HIE showed that information generated outside of the site where the patient was being seen was viewed 4.3% of the time for the entire referral population, and 7% of the time among patients who received a specific lab test.<sup>59-61</sup> A study in Sweden found that a hospital-based HIE there was used 7% of the time.<sup>63</sup> Finally, a study in the US examining use of a physician portal focused on 3 separate 6-month time periods and found that only 29% of physicians used the portal in all 3 periods.<sup>64</sup>

Usability appears to vary across enterprise HIE systems. In cases like Clarit or Kaiser Permanente, enterprise HIE is integrated into providers' EHR, allowing for fewer obstacles than community HIEs. In other cases, because providers have access to multiple different enterprise HIEs, any given hospital-provided portal requires yet another password and time consuming patient lookup process, likely limiting use.<sup>28</sup> Access to multiple enterprise HIEs could be challenging because each system contained different information, making it hard to find specific information.<sup>13,50</sup> This has the potential to exacerbate problems accessing information or logging into systems reported in studies of

community HIEs.<sup>65</sup> Enterprise EHRs were also sometimes designed using proprietary data structures, making them challenging to scale.<sup>66</sup>

### 4.4.4 | Impact

Many of the assessments of enterprise HIE come from international studies. Four studies on Clarit's HIE demonstrated that using HIE was associated with positive outcomes.<sup>59-61,67</sup> One randomized control study in the Netherlands showed that use of an HIE was associated with improved diabetes care.<sup>66</sup> US-based studies showed that an HIE link between 2 affiliated academic hospitals reduced redundant imaging and that use of a physician portal was associated with closer adherence to clinical guidelines.<sup>68,69</sup> Use of the HIE within the veterans' affair system of hospitals is associated with reduced redundant tests and other utilization.<sup>70</sup> However, a randomly assigned control study of a link between an ED and associated physicians demonstrated no benefit, despite physician's perception of value<sup>64</sup> and another randomized trial, undertaken in Sweden, showed no benefit from a hospital sending information from their ED to outpatient care.<sup>63</sup> In general, observational studies of large integrated systems seem to point towards benefits from enterprise HIE; however, smaller scale studies using more randomized designs did not find evidence of benefit.

## 4.5 | Vendor mediated HIE

### 4.5.1 | Extent of evidence

In part because HIE mediated by a shared EHR vendor is relatively new, there are few studies on the prevalence, usage, or impact of this form of HIE, and no national estimates.

### 4.5.2 | Prevalence

While there are no good measures of how much HIE occurs through EHR vendor-based solutions, Epic Systems alone reports including 293 healthcare organizations in their Care Everywhere Network including many very large healthcare organizations, like Kaiser Permanente, Geisinger, and Sisters of Saint Mary.<sup>71</sup> In 2013, six other EHR vendors announced their commitment to working together to launch a collaboration to foster HIE.<sup>16</sup>

### 4.5.3 | Usage and usability

Two studies have evaluated the use of a vendor-mediated HIE, and both focused on Epic Systems. In 1 study in the ED, Epic's HIE was used in 1.46% of patient encounters.<sup>30</sup> In a second study, the rate of use was measured for multiple types of encounters and ranged from less than one half of a percent for specialty care encounters to 3.5% for ED encounters.<sup>14</sup> These rates are notably lower than those reported for either enterprise or community HIEs in comparable encounters. On the other hand, Epic's HIE uses the Consolidated Clinical Document Architecture, which should provide structured data in a commonly used format,<sup>72</sup> and usability and perceived value were reported to be quite high in both studies, and appear to be higher than for community HIEs or enterprise HIE.

#### 4.5.4 | Impact

Only 1 study has examined vendor-mediated HIE (Epic Systems').<sup>30</sup> This study focused on the 1488 patient encounters in the EDs of 4 hospitals in an integrated delivery system. Through chart review, the investigators found that use of the HIE was associated with 560 avoided duplicative diagnostic tests and 28 fewer cases of drug seeking behavior within those patient encounters.

The evidence for each type of HIE is summarized in Table 2. As noted in the discussion above, much more evidence exists on the prevalence and use of community HIE, but some initial findings are available for the other 2 types of HIE.

## 5 | FUTURE DIRECTIONS

A focused research agenda will help guide organization leaders to the choices that might facilitate transformation into part of a learning health system and provide the most benefit for their patients and organization. Research may also inform policy developments to encourage adoption of HIE that most benefits patients. Such an agenda must start with a better understanding of the current prevalence of each type of HIE and the reasons for that prevalence to provide a better sense of the prospects for. Research should continue on to issues of usage, usability and impact of each type of HIE to provide a comprehensive assessment of the value of each type of HIE.

It may be relatively straightforward to obtain better quantitative estimates of the prevalence of vendor-mediated and enterprise HIE. Much of this work might be completed by modifying existing surveys, including the AHA IT supplement and National Ambulatory Medical Care Survey, to account for adoption of these types of HIE by hospitals and ambulatory providers, respectively. Both surveys already include questions related to HIE that could be expanded.

It is likely that the prevalence of each type of HIE is not uniform across organization types, and some research has identified organizational characteristics associated with adoption of community HIEs.<sup>36</sup>

Future research into the prevalence of each type of HIE might focus on factors that determine the fit of each type with organizational strategies and goals, which may be related to observable hospital characteristic such as ownership, market position, and the network of other healthcare organizations surrounding the organization. Identifying trends in engagement in each type of HIE would help in understanding the appeal and scalability of each approach.

A key piece of the prevalence of HIE will be to identify with whom healthcare organizations are being connected and where gaps in the emerging network are likely to persist. As HIE becomes more widespread, it is likely that some organizations will be well connected and others left behind; however, identification of those requiring assistance to connect to the HIE network may be challenging because approaches to HIE continue to evolve. For instance, both the CommonWell and Carequality collaborative projects offer an opportunity for vendor-mediated HIE to cross silos created by HIE tools designed to connect providers on the same EHR platform. Monitoring the success of programs like this will be essential to evaluating the prevalence and connectivity achieved by each type of HIE and the gaps where they occur.<sup>15,16</sup>

The first step towards understanding the value offered by HIE is to conduct additional research on the relative frequency of use of each type. With the current evidence, it is challenging to assess how often systems are used and the drivers of use across studies because of differing definitions of use, different units of observation (encounters, providers, patients) and different encounter types. Despite these limitations, existing research on vendor-mediated HIE indicates that it may be used least frequently, and additional work may provide valuable insight into the reasons for this and whether low use significantly limits its patient's benefit. A key challenge for such analysis is to determine when there is a "need" for HIE. Focusing on care transitions as the common denominator would be consistent with the ONC approach and might provide a useful baseline.

Healthcare organizations are likely adopting multiple types of HIE to meet different needs, and use these tools to different extents. Research into both the prevalence and use of each type of HIE may

**TABLE 2** Evidence of prevalence, use, and impact of each type of HIE

	Community HIEs	Enterprise HIE	Vendor-mediated HIE
Prevalence	<ul style="list-style-type: none"> <li>• estimated 119 community HIEs nationwide.</li> <li>• 30% of hospitals participated in 2012.</li> <li>• 10% of ambulatory providers participated in 2012.</li> </ul>	<ul style="list-style-type: none"> <li>• no direct national quantitative estimates.</li> <li>• physician portals appear widely used.</li> <li>• estimates of overall HIE participation is over 50% higher than community HIE estimates alone.</li> </ul>	<ul style="list-style-type: none"> <li>• leading vendor attests to having 293 participating organizations.</li> </ul>
Use	<ul style="list-style-type: none"> <li>• evidence drawn from 14 available studies.</li> <li>• access ranged from 1% to 5% overall, much higher for ED visits and visits with existing information.</li> <li>• up to 50% of patients had their data accessed at least once.</li> <li>• most physicians used the HIE at least once, though use was infrequent and inconsistent over time.</li> </ul>	<ul style="list-style-type: none"> <li>• evidence drawn from 6 available studies.</li> <li>• patient data accessed in 2%-8% of visits.</li> </ul>	<ul style="list-style-type: none"> <li>• used in only 1.5% and 3.5% of ED encounters in only 2 studies available.</li> </ul>
Impact	<ul style="list-style-type: none"> <li>• evidence drawn from 15 available studies.</li> <li>• mixed evidence of decreased utilization.</li> <li>• mixed evidence of patient benefit.</li> </ul>	<ul style="list-style-type: none"> <li>• evidence drawn from 9 available studies.</li> <li>• evidence for reduced utilization and readmissions from studies on large systems.</li> <li>• no benefits from RCTs of individual linkages.</li> </ul>	<ul style="list-style-type: none"> <li>• evidence from only available study reports reduced use of diagnostic tests.</li> </ul>

Evidence drawn from all studies included in prior systematic reviews or citing included studies.

benefit from understanding when and why healthcare organizations adopt a mix of HIE types, which partner organizations each type connects them to, and the frequency with which each type of HIE is used when adopted alongside others. The key to this will be recognizing that different types of provider organizations have different networks of exchange partners and therefore different needs for HIE connectivity. Researchers may also be able to leverage sites that use multiple types of HIE to compare the benefits offered by each HIE network and how they do (or do not) complement one another.

The next step to understanding the value of different types of HIE is assessing usability of each type of HIE. The technical sophistication of each type of HIE may lead to differing levels of interoperability, usability, and workflow integration. For instance, vendor-mediated HIE is likely to be embedded in the provider's EHR in a familiar format and to use standardized structured data, whereas provision of data to providers through community HIE and enterprise HIE often occurred through portals, free text, and other tools that may provide lower value. Higher quality data sharing may offer greater benefits than simpler free text or portal-based systems, but empirical evidence on this question remains limited. Relatedly, providers have complained about the sheer amount of information provided through HIEs. By utilizing better structured information, different types of HIE may be successful in allowing easy navigation or display of the most relevant items.

An additional key usability issue may arise when organizations participate in multiple HIE networks. Because each HIE network connects the organization to a different set of partners, it may be necessary for clinicians and their staff to search through multiple systems to find the information that they need. This level of effort may strain providers, discouraging use. As HIE approaches become more widespread, the obstacles presented by access to multiple systems are likely to be more widely felt unless they are well integrated.

Existing evidence on the impact of HIE remains ambiguous. In particular, research on enterprise HIE and vendor-mediated HIE is underdeveloped. It seems clear that more attention must be paid to the type of HIE being used and the context of its use. Different types of HIE may be particularly well suited for supporting different use cases—for instance, enterprise HIE may easily connect providers who frequently participate in episodes of care for a patient or who form an accountable care organization and want to monitor shared care, while community HIE may be better suited to monitor population health among more separately connected providers. Future research should leverage the availability of national and longitudinal data on HIE adoption, allowing for large-scale quasi-experimental studies that can identify effects with reduced risk of bias relative to purely observational studies, and without the sample size and power constraints that may reduce the likelihood of finding an effect in purely experimental settings. In addition, continued development of more microlevel studies should strive to understand the mechanisms through which HIE is having a beneficial impact on care, and the barriers slowing realization of benefits from HIE.

## 6 | DISCUSSION

Existing HIE efforts can be divided into 3 different types based on the convener of the effort: community HIE, enterprise HIE, and vendor-

mediated HIE. Each type provides different benefits and challenges, including the openness of each effort to broad participation, the challenges impeding sustainability, and prospects for the future. Although community HIEs appear best designed to include the most participants and thereby provide the most potential to benefit the public, the numerous challenges aligned against their development may make investment in other options more appealing.

This study is subject to a number of limitations. Most importantly, the review aimed to synthesize current research into the prevalence, use, and impact of each type of HIE and as such the conclusions drawn are limited by the studies conducted, which have focused on community HIEs. In addition, I focused on the types of HIE that appear most prevalent based on available information; however, other types of HIE may emerge and gain high use. One key omitted type of HIE is direct exchange, which is designed to limit the need for a convener<sup>21</sup>; however, current apparent low use rates, and the changing regulatory environment that deemphasizes use of direct,<sup>73</sup> may limit the importance of this model. It will also be important to monitor growth in other types of HIE convened by different entities than those identified here.

It appears that only about one half of HIE occurs through community HIEs, with the remaining intraorganizational and interorganizational HIE occurring through enterprise HIE and vendor-mediated HIE. On the basis of the current evidence, it is unclear which of the alternatives—alone or in combination—will facilitate improved sharing of data necessary to provide opportunities for real-time learning and care improvement in a learning health system and other collaboration-based initiatives. Therefore, continued and increased research focused on understanding which entities use each type of HIE and how well these approaches are working for them remains critically important. Without attention to the presence of these different types of HIE, researchers and policymakers will be poorly positioned to guide continued initiatives to increase HIE use that build upon these types of HIE. This work may provide the most benefit if it focuses on key components of HIE that are likely to influence its use, usability, and ultimately, impact on patients and by apply more consistent methodology to allow for clearer inference across studies.

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## SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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