Brief Communication

Usage of query-based health information exchange after event notifications

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ABSTRACT

Objectives: This study sought to quantify the association between event notifications and subsequent query-based health information exchange (HIE) use among end users of three different community health information organizations.

Materials and Methods: Using system-log data merged with user characteristics, regression-adjusted estimates were used to describe the association between event notifications and subsequent query-based HIE usage.

Results: Approximately 5% of event notifications were associated with query-based HIE usage within 30 days. In adjusted models, odds of query-based HIE usage following an event notification were higher for older patients and for alerts triggered by a discharge event. Query-based HIE usage was more common among specialty clinics and Federally Qualified Health Centers than primary care organizations.

Discussion and Conclusion: In this novel combination of data, 1 in 20 event notifications resulted in subsequent query-based HIE usage. Results from this study suggest that event notifications and query-based HIE can be applied together to address clinical and population health use cases.

Key words: clinical information systems, health information exchange, ambulatory care facilities

BACKGROUND AND SIGNIFICANCE

Community health information organizations (HIOs) generally offer multiple health information exchange (HIE) services to meet different use cases.[1–3] For example, event notifications (also known as alerts) help inform providers about their patients' contact with other health care organizations, particularly emergency department (ED) admissions and discharges.[4–7] Encounters, or other key events, trigger the delivery of information identifying the patient, the facility, and diagnoses to the patient's primary care physician, nurse, or care manager via secure email to electronic health record systems (EHRs) or DIRECT inboxes, so that all providers are better informed or able to take action to address the patient's needs.[8–10] In addition, community HIOs can also offer end users access to community-wide longitudinal records from a centralized source (either a centralized data repository or federated system of multiple repositories).[11] Query-based exchange approaches provide access to detailed information such as prior laboratory reports, imaging results, or clinical notes from multiple-providers within an entire community or a set of providers. Usage of query-based exchange is associated with changes in care delivery such as avoiding hospital admissions,[12,13] reducing repeat procedures,[14,15] and identifying medication discrepancies.[16]

While these two approaches to HIE were introduced to address different use cases, previous survey, and qualitative analyses suggest

that end users may combine event notifications and query-based exchange to meet their information needs. In our previous study of one community HIO, more than half of the respondents reported accessing a query-based HIE portal in response to an event notification.[6] Also, interviews with primary care clinicians have suggested that end-users view query-based HIE as a means to obtain additional information to provide context and a fuller picture of the events prompting alerts.[4]

OBJECTIVE

This study sought to quantify the association between event notifications and subsequent query-based HIE use among end users of three different community HIOs. Specifically, we describe the days between receipt of an event notification and subsequent query-based HIE use and determine which organizational and patient characteristics are associated with usage.

MATERIALS AND METHODS

Setting

Three community HIOs serving different regions of New York State supplied data for this study: Healthix (serving the New York City area), the Rochester Regional Health Information Organization (serving the western upstate region), and HealtheLink (serving the Buffalo area). All three HIOs offer event notification services for consented patients and a query-based HIE via web portals. While the three HIOs differed slightly, for the most part all three settings offered similar functionality. During the study period, the predominate use case for event notification services for all three HIOs was alerting outpatient providers and staff of hospital or ED encounters. Depending on the technological capabilities of the organization receiving the event notification, they could be sent as a message to the provider's EHR, to a DIRECT Secure Messaging account, or a secure web portal. At a minimum, alerts contained information to identify a patient and the service location. All three HIOs maintain robust community-wide longitudinal patient record systems that are accessed via web portals. Depending on a participating provider's preferences and EHR vendor, the web portal may be integrated with single sign-on from the EHR or usage may require leaving the EHR to access it through a web browser.

Data

We combined system logs of the event notification systems and query-based HIE portals from all three community HIOs. The event notification logs were restricted to all hospital-based events (ie, inpatient admissions and emergency department visits) that reflected encounters from April 2016 and June 2017. Since multiple event notifications may be triggered during a single health care encounter (eg, admission and then discharge), we created a single event-based file constructed from the unique combination of the patient, event notification date, sending organization, and receiving organization. We linked the query-based HIE access logs to these event notifications by patient id, dates, and receiving organization. We excluded any queries for administrative purposes (such as database administration or consent management only).

Outcome

The primary outcome was use of query-based HIE at the receiving organization after an event notification alert. We created a

categorical measure of usage based on the time from the alert to system access: no usage, usage within 1 week, and usage between 8 and 30 days. Each event notification was limited to a maximum of one instance of query usage by the receiving organization within the 30-day window.

Measures

For each event notification, we described the setting triggering the alert (ED, hospital, or both), the timing of the alert (at admission, at discharge, or both) and the type of organization receiving the alert: primary care clinic, federally qualified health center (FQHC), specialty/multispecialty clinic, nursing facilities/home health agency, health home,[17] behavioral health, payer, or other. For the event notifications themselves, we also noted whether the alert was delivered directly to the recipient's EHR. Also, one of the participating HIOs had the ability to attach a clinical care document to the alert. The only available patient characteristics across all three settings were gender and age.

Analyses

We compared event notifications with and without subsequent use of query-based HIE using frequencies and percentages. Differences between characteristics and usage were assessed using X^2 tests. To describe the factors associated with query usage, we fit a multinomial logistic regression model adjusted for patient and organizational characteristics. The data did not meet the parallel regression assumptions for an ordered logit model, nor the assumptions necessary for a continuous dependent variable in a hazard model. The model included HIO fixed effects and robust standard errors adjusted for clustering at the HIO level. The project was approved by the Institutional Review Boards of the Weill Medical College of Cornell University and Indiana University with a waiver of consent for use of a limited data set.

RESULTS

The study sample included 555 758 event notifications, of which 4.3% were associated with subsequent query-based HIE usage within 7 days and an additional 0.8% between 8 and 30 days (Table 1). Query-based HIE usage in conjunction with receiving an alert was more common in the older patient age categories and for alerts pertaining to discharges. Usage within 7 days and between 8 and 30 days of the event notification was highest among specialty and multispecialty clinics and FQHCs. Query usage was less common when the event notification alert was direct to the EHR as opposed to other modes of delivery.

The odds of query-based HIE usage within one week after an event notification (Table 2) were significantly higher for event notifications triggered by a discharge event (56% higher) and those associated with an inpatient visit (49% higher) after adjusting for patient demographics, event notification characteristics, and the type of receiving organization. Compared to primary care clinics, event notifications delivered to specialty clinics had nearly 15 times the odds of subsequent query usage within 1 week. Query usage within 1 week was also 18% higher for individuals age 65 and older than for patients less than 18 years old. Query-based HIE usage between 8 and 30 days after the event notification was also associated with event notifications triggered by discharges (odds ratio = 2.80; 95% CI = 1.64–4.79). Between 8 and 30 days after event notification, specialty clinics, FQHCs, payers, and behavioral health settings

Table 1. Characteristics of query-based health information exchange system usage within 1 week and between 8 and 30 days of an event notification alert in three community health information organizations

	Query-based HIE usage			
	None % (*n*)	Within 1 week % (*n*)	Between 8 and 30 days % (*n*)	*P* value
Patient characteristics	527 389	24 057	4312	
Female gender	56.2 (295 440)	58.1 (13 971)	58.6 (2526)	.266
Age category				
<18	4.5 (26 607)	4.7 (1120)	2.9 (125)	<.0001
18–29	10.7 (56 167)	9.4 (2253)	9.8 (422)	
30–44	17.3 (91 005)	13.7 (3305)	19.3 (832)	
45–64	34.7 (182 950)	27.6 (6649)	36.2 (1560)	
≥65	32.9 (173 660)	44.6 (10 730)	31.8 (1373)	
Event notification characteristics				
Timing				
Admission	35.8 (188 773)	27.5 (6626)	15.1 (652)	<.0001
Discharge	35.9 (189 560)	43.5 (10 455)	46.1 (1988)	
Both	28.3 (149 056)	29.0 (6976)	38.8 (1672)	
Setting				
ED	65.2 (344 019)	56.8 (56.81)	70.1 (3024)	<.0001
Inpatient	27.5 (145 109)	34.7 (8348)	27.8 (1200)	
Both	7.3 (38 261)	8.5 (2042)	2.0 (88)	
Receiving organization type				
Primary care	15.2 (80 344)	8.8 (2114)	3.5 (152)	<.0001
Specialty clinic	5.3 (28 002)	42.0 (10 095)	25.3 (1089)	
FQHC	18.7 (98 652)	25.9 (6227)	41.8 (1801)	
LTC	31.4 (113 480)	5.7 (1610)	5.8 (252)	
Health home	21.5 (165 684)	6.7 (1379)	15.4 (663)	
Payer	1.3 (6576)	2.6 (1110)	1.8 (76)	
Other	4.2 (21 894)	4.6 (613)	3.0 (127)	
Behavioral health	2.4 (12 757)	3.8 (909)	3.5 (152)	
CCD attached[a]	93.1 (215 826)	82.9 (8794)	94.7 (960)	<.0001
Direct to EHR	44.7 (235 480)	37.1 (8913)	23.4 (1007)	<.0001

[a]This feature was available in one HIO only (other observations excluded).

each had higher odds of query-based HIE usage than primary care clinics. Direct-to-EHR delivery of event notifications significantly reduced the odds of subsequent query-based usage between 8 and 30 days.

DISCUSSION

In three community HIOs, query-based HIE usage occurred after 5% of event notification alerts. The evidence of subsequent query-based HIE usage suggests that these two approaches to HIE can be applied together to address clinical and population health use cases.

Overall, about 1 in 20 event notifications resulted in subsequent query-based HIE usage. While this level of usage appears to be infrequent, it is reflective of purposeful information-seeking behavior in a query-based HIE system and is also substantially higher than a prior report examining only whether patient information delivered in response to a transition in care settings was accessed or not.[18] In addition, the expected, optimal, or necessary level of HIE usage has never been established. Most estimates suggest that HIE usage, and query-based systems in particular, is low.[19,20] Moreover, providers report that not all event notifications result in an organizational response[6] and, given the sheer number of alerts delivered to organizations, any expectations of higher levels of subsequent query-based HIE usage may be unwarranted.

The combination of system logs from three different community HIOs mitigates concerns, to a degree, over the generalizability of single-site health information technology studies.[21,22] Unfortu-

nately, the combination of sites limited the analysis to commonly available data elements. As such, we do not have patient-level clinical information to elucidate the reasons for end users subsequent query-based HIE usage or to understand patients' varying levels of risk. Nevertheless, the findings do provide some tentative insights into how these two approaches to information exchange together support care delivery. For example, we see that subsequent query-based HIE usage was associated with more information-dense care transitions, such as hospital discharges. Also, FQHCs were significantly more likely to use query-based HIE than other primary care organizations, which may indicate that their generally disadvantaged populations have more fragmented care overall, that FQHCs have more of a longitudinal perspective on patient care, or both. Additionally, the lower rates of query usage for ED visits (in comparison to admissions) may relate more to the underlying effect of event notification alerts: increased awareness. With short duration events, such as ED encounters, awareness of the visit may be sufficient and the time investment required for additional information searching through query-based exchange may not be feasible or of sufficient value. Query-based HIE access was also more common for older patients, who are likely to have more complex medical needs; it is likely that the additional information available in query-based HIE is more important for the care provided to higher need patients compared to relatively healthy patients.

An unusual finding is the lack of a positive association between direct-to-EHR delivery and query-based HIE access. For many health information technology innovations, EHR integration is

Table 2. Adjusted associations of patient, alert, and user setting characteristics with usage of query-based health information exchange system after event notification alerts in three community health information organizations

	Within 1 week Odds ratio (95% CI)	Between 8 and 30 days Odds ratio (95% CI)
Patient characteristics		
Female gender	1.08 (0.99–1.17)	1.05 (0.93–1.18)
Age category		
<18	Reference	Reference
18–29	0.69 (0.36–1.32)	0.58 (0.38–0.88)*
30–44	0.67 (0.44–1.01)	0.78 (0.51–1.20)
45–64	0.83 (0.65–1.04)	0.97 (0.71–1.32)
≥65	1.18 (1.06–1.31)*	1.24 (0.94–1.64)
Event notification characteristics		
Timing		
Admission	Reference	Reference
Discharge	1.56 (1.32–1.84)*	2.80 (1.64–4.79)*
Both	1.65 (1.49–1.84)*	2.76 (2.17–3.51)*
Setting		
ED	Reference	Reference
Inpatient	1.49 (1.09–2.02)*	1.09 (0.88–1.36)
Both	1.91 (1.38–2.65)*	0.59 (0.45–0.78)*
Direct to EHR	0.92 (0.60–1.43)	0.51 (0.29–0.89)*
Receiving organization type		
Primary care	Reference	Reference
Specialty clinic	14.83 (7.80–28.20)*	23.39 (4.19–130.64)*
FQHC	3.00 (0.57–15.79)	10.95 (3.99–30.05)*
LTC	0.29 (0.03–2.69)	0.89 (0.21–3.85)
Health home	0.64 (0.02–19.44)	4.20 (0.38–46.80)
Payer	3.86 (0.31–47.4)	7.81 (1.45–42.13)*
Other	1.64 (0.48–5.68)	2.62 (1.51–4.57)*
Behavioral health	3.32 (0.79–13.93)	5.68 (1.77–18.20)*

*$P < .05$.

thought to be associated with increased adoption and impact.[23,24] It is possible that the direct-to-EHR information delivery provided users with enough information that they were *not* prompted to access the query-based HIE system afterward. Alternately, this could be an artifact of lack of single sign-on for different technological approaches; the need to log into a different interface with a different authentication protocol could create a barrier to using query-based HIE for users currently logged into their EHR.

Understanding how end-users utilize disparate systems to access patient information is critical as the options for HIE continue to grow. Community HIOs, such as those in this study, typically offer multiple technical approaches to HIE for their customers.[3] In addition, individual providers and health care organizations may simultaneously engage with more than one HIO, they may also have vendor-provided options to access data from other organizations, maintain DIRECT Secure Messaging accounts, or be part of an enterprise HIE effort.[25] As the potential value of sharing information between organizations becomes more and more apparent, distinct approaches to sharing information may continue to proliferate. As a result, health care organizations and HIOs need to ensure that end users have the organizational policies and procedures, as well as sufficient technological infrastructure, to navigate the multiple information systems necessary to obtain required patient information.

Limitations

This study is subject to several limitations. Most importantly, we did not have any clinical information and were unable to determine the reasons for ED encounters or hospitalizations, nor were we able to adjust for patient risk. Additionally, while our study included multiple HIOs our findings may not be generalizable to use of other query-based exchange mechanisms offered by enterprise HIEs or EHR vendors. In addition, we were not able to establish a cohort of patient encounters with and without event notification, so we could not compare query-usage absent of the event notification. Such a study design would require information on all encounters, and that was not available. Finally, we do not know if end users were successful in their queries or what information they sought.

CONCLUSION

In a novel combination of data from three different community HIOs, 1 in 20 event notifications resulted in subsequent query-based HIE usage. These findings suggest a continued place for query-based exchange to supplement newer forms of HIE.

FUNDING STATEMENT

COMPETING INTERESTS STATEMENT

The authors have nothing to declare.

CONTRIBUTORSHIP STATEMENT

JV, MU, JA, and HJ contributed to the conception and design of the study and obtained funding for the project. JV led the analyses and drafting of the manuscript. KEH managed the data, assisted with analyses, drafting and revising the manuscript. MU, JA, and HJ all assisted with critically reviewing and revising the manuscript for important intellectual content.

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