The potential for community-based health information exchange systems to reduce hospital readmissions

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ABSTRACT

Background Hospital readmissions are common, costly, and offer opportunities for utilization reduction. Electronic health information exchange (HIE) systems may help prevent readmissions by improving access to clinical data by ambulatory providers after discharge from the hospital.
Objective We sought to determine the association between HIE system usage and 30-day same-cause hospital readmissions among patients who consented and participated in an operational community-wide HIE during a 6-month period in 2009–2010.
Methods We identified a retrospective cohort of hospital readmissions among adult patients in the Rochester, New York area. We analyzed claims files from two health plans that insure more than 60% of the area population. To be included in the dataset, patients needed to be continuously enrolled in the health plan with at least one encounter with a participating provider in the 6 months following consent to be included in the HIE system. Each patient appeared in the dataset only once and each discharge could be followed for at least 30 days.
Results We found that accessing patient information in the HIE system in the 30 days after discharge was associated with a 57% lower adjusted odds of readmission (OR 0.43; 95% CI 0.27 to 0.70). The estimated annual savings in the sample from averted readmissions associated with HIE usage was $605 000.
Conclusions These findings indicate that usage of an electronic HIE system in the ambulatory setting within 30 days after hospital discharge may effectively prevent hospital readmissions, thereby supporting the need for ongoing HIE efforts.

INTRODUCTION

Readmission to hospital is common and costly. In the USA, readmission rates range from 18% to 25% of discharges[1–3] and have been estimated to cost about $17 billion each year.[4] In addition, poor information exchange between providers after patient discharge contributes to the occurrence of readmissions.[5,6] In fact, patients often report that their primary care providers have little information about recent hospitalizations and that post-discharge follow-up is often insufficient.[7,8] Because of the high incidence, cost, and potential preventability, hospital readmissions have been targeted as a key area for quality improvement and payment reforms. Electronic health information exchange (HIE), by improving provider access to patient information and enhancing care coordination, may reduce hospital readmissions.[9]

HIE systems electronically share identified, patient-level information with providers and organizations across the continuum of care. This information sharing enables clinical personnel point-of-care access to patient data about recent encounters that occurred at other points-of-care, such as discharge summaries, prescribed medications, laboratory tests, imaging studies, and other information. Improving access to the information that ambulatory providers need after their patients are discharged, particularly discharge summaries with active medication lists and pending laboratory tests, may reduce errors and facilitate follow-up. Ultimately, acting on HIE data could enhance patient safety, improve quality of care, and avert potentially avoidable readmissions.[10,11]

Despite these potential benefits, reports on the effectiveness of HIE for reducing hospital admissions and readmissions have been mixed. A few studies have identified reductions in hospital admissions,[12–14] but several studies have found no effect.[15–19] However, the studies published to date have been heterogeneous, varying in settings, patient populations, types of exchange partners, and technology platforms.

In this study, we sought to determine the association between usage of an HIE system post-discharge and 30-day same-cause hospital readmissions. Because examinations of hospital readmissions have not concurrently analyzed the broad array of factors that contribute to readmission rates,[20] we quantified the effects of HIE while controlling for factors related to the patients, their post-discharge healthcare utilization, and the hospitals' organizational characteristics.

METHODS

We conducted a retrospective cohort study of hospital readmissions among adult patients in the Rochester, New York area during 2009–2010. This study was part of a broader evaluation of the Capital Grants program of New York State's Healthcare Efficiency and Affordability Law for New Yorkers (HEAL NY), which was passed in 2004 to establish a statewide electronic health information infrastructure for healthcare system transformation and is the largest state-based public investment to promote HIE development and electronic health record adoption.[21]

Setting

The primary setting included 38 healthcare organizations in an 11-county region of western

New York State. Data were accessed via the Rochester Regional Health Information Organization (RHIO), a non-profit, community-run, data management organization that facilitates secure HIE access for authorized clinicians.[21][22] RHIO information exchanged via a web-based portal includes discharge summaries, diagnoses, radiology reports and images, medication history, and payer information.[23] More than two-thirds of the region's 24 hospitals and physicians currently participate.[24] The HIE system became fully operational in March 2009 and at the time of the study included data on more than 800 000 patients (>70% of the area's adult population). Usage of the RHIO's HIE system is described elsewhere.[13][25]

Data

We analyzed claims files from two health plans that insure more than 60% of the area population. Claims data provided all patient demographics, diagnoses, and encounter information. The claims files consisted of services for patients aged ≥18 years who had consented during 2009–2010 to have their information accessible to participating providers via the HIE system. To be included in the dataset, patients needed to be continuously enrolled in the health plan with at least one encounter with a participating provider in the 6 months following consent, which ensured that each patient in the claims files was also included in the HIE system (196 314 patients met these requirements). The cohort included only the patient's first hospital admission within the first 5 months after consent. Each patient appears in the dataset only once and each discharge could be followed for at least 30 days.

In addition, to ensure a sufficient sample size for robust hospital-level measures, we limited our data to include only those hospitals (n=11) with at least 30 observations in the dataset. This excluded a small number of discharges (0.67% of the sample) from small specialty care hospitals or those hospitals in nearby areas of the state that had an occasional admission of a patient from the Rochester area. Publicly available data from the Centers for Medicare & Medicaid Services and the American Hospital Directory provided hospital-level characteristics. Hospital characteristics are given in the online supplementary appendix.

Measures

The outcome of interest was a readmission within 30 days of discharge for the same cause as the index hospitalization. Same-cause readmissions were defined by the presence of the same category for the index hospitalization and the readmission based on the Agency for Healthcare Research and Quality clinical classification software.[26] We selected same-cause readmissions to align our sample with current federal policy which is focused on reducing readmissions for select same causes and not all-cause readmissions.[27] Furthermore, we reasoned that same-cause readmissions may be more sensitive to HIE than readmissions for unrelated issues.

The primary independent variable was HIE system usage. The web portal system automatically records users' activity during each session, including the patient viewed and the date and time of system access. HIE system usage was defined as any access of a patient's information through the web-based portal after his/her discharge from the index hospitalization and before the date of his/her readmission. If the patient was not readmitted, then HIE system usage was defined by any HIE system access in the 30 days after his/her discharge from the index hospitalization. Usage could occur in ambulatory care settings or emergency departments (EDs). If the HIE system was not accessed in the

30 days after the patient's index hospitalization, these discharges were classified as 'no access.'

We derived additional independent variables from the claims files: patient sex, age, and insurance (private, Medicare managed care, or Medicaid managed care). We measured patient disease severity as the count of Major Aggregated Diagnostic Groups (ADGs) in the 12-month period before patient consent using the Johns Hopkins Adjusted Clinical Groups Case-Mix System.[28][29] Furthermore, we determined if the patient had any primary care, specialty care, or ED visits in the 30 days after the index hospitalization (or up until the date of readmission). We controlled for these utilization measures as lack of access to post-discharge healthcare is an important risk factor for readmission.[20]

We described the index hospitalization site according to several organizational-level factors important to readmissions and hospital quality including hospital bed size, teaching status (indicated by membership in the Council of Teaching Hospitals of the Association of American Medical Colleges), affiliation with a multi-hospital healthcare system, and critical access hospital classification.[30] Each hospital's case mix index was obtained from the Centers for Medicare & Medicaid Services. A hospital's case mix index was derived from the relative values of diagnosis-related groups seen at the hospital. The higher the case mix index, the sicker the patients.

Analyses

We compared the characteristics of patients for whom the HIE system was accessed to the characteristics of patients for whom the HIE system was not accessed using the χ^2 test for dichotomous variables and t tests for continuous variables.

We measured the association between HIE usage and 30-day same-cause readmission with random effects logistic regression models.[31] To highlight the potential influence of categories of different factors, we constructed a series of models adjusting for patient characteristics, then adding post-discharge utilization measures, and lastly including hospital-level characteristics. We controlled for potential hospital-level clustering using the index admission hospital as a random intercept.

We are aware that accessing the HIE system may be more likely for patients with more post-discharge encounters. Therefore, to explore the robustness of our findings and the importance of this potential source of bias, we undertook two sensitivity analyses. First, we created a matched (one to one) sample using propensity scores. We modeled the predicted probability of HIE access using the reported patient, post-discharge utilization, and hospital measures. We estimated the association between HIE access and readmission in this matched sample using logistic regression. Second, to explore the effect of differing times from discharge to readmission, we fit a Cox proportional hazard model using days to readmission. Non-readmission events were censored at 30 days. Again, we controlled for all factors included in the fully adjusted logistic regression models and used cluster-robust SEs.

We also estimated the financial savings associated with usage of the HIE system in our study sample following an existing method.[12] First, we determined the difference in the marginal means of a readmission when the HIE was accessed and when it was not. We used the fully adjusted multivariate models with the hospital entered as a fixed effect to calculate the marginal means. Next, to estimate the number of avoided readmissions, we multiplied the difference in marginal means with the number of index admissions in which the HIE system was accessed. We then multiplied the number of estimated avoided

readmissions with the estimated average cost of a readmission in New York State and annualized the savings. For the readmission cost, we used mean hospital costs as reported in the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project State Inpatient Database,[32] adjusted for the reported cost difference between readmission and index admissions in New York State.[33]

RESULTS

The sample included 6807 patients with an overall 30-day same-cause readmission rate of 9.8% (table 1). Of all readmissions, 29.6% occurred at a facility other than the index hospital. The HIE system was accessed for 5.8% (n=394) of patients during the 30-day post-discharge period. The HIE system was accessed for patients discharged from all 11 study hospitals (see online supplementary appendix for additional details). Of the patients whose data were accessed in the HIE, 5.1% were readmitted to the hospital within 30 days. In contrast, of the patients whose data were not accessed, 10.1% were readmitted within 30 days for the same condition (p=0.001).

In addition, patients whose data were accessed in the HIE were typically male, older, and more likely to have a post-discharge primary care visit (42.1% compared to 32.8%; p<0.001) or a specialty care visit (49.0% compared to 25.5%; p<0.001). The percentage of patients with an ED visit after discharge was similar regardless of HIE access.

Table 2 displays the association between HIE system usage and 30-day same-cause readmission. If the HIE system was accessed, the unadjusted OR of a readmission was 54% lower in the 30 days post-discharge compared to if it was not accessed (OR 0.46; 95% CI 0.29 to 0.73). After controlling for patient characteristics, HIE access was associated with a 55% lower odds of readmission. After adding post-discharge utilization measures, HIE access was associated with a 57% lower odds of admission (OR 0.43; 95% CI 0.27 to 0.70). Lastly, in the full model that controlled for patient characteristics, patient post-discharge utilization, and hospital characteristics, HIE system access was significantly associated with a 57% lower OR of readmission (OR 0.43; 95% CI 0.27 to 0.70; p<0.001).

The results of the sensitivity analyses were consistent with the main findings (see the online supplementary appendix for full results). In the propensity score matched sample, HIE access was associated with a 47% reduction in the odds of readmission (aOR 0.53; 95% CI 0.30 to 0.94). Modeling time to readmission, HIE access was still negatively associated with same-cause readmissions (adjusted HR 0.53; 95% CI 0.40 to 0.69).

In this study sample of 6807 discharged patients, the estimated financial savings associated with HIE system usage totaled $605 472 annually, accounting for an estimated 48 potentially avoided readmissions each year. The potential savings for the broader community and state would be greater (see online supplementary appendix for estimations).

DISCUSSION

Provider access of patient information from an HIE system post-discharge was associated with a 57% lower odds of a 30-day same-cause readmission controlling for patient, utilization, and hospital factors. These findings indicate that provider usage of community-wide, longitudinal patient records via an HIE system may be an avenue to reduce hospital readmissions and save costs.

The HIE system may have enabled provider access to relevant clinical data that would have not been otherwise available in as a complete or as timely a manner. For example, the HIE could have provided clinicians with up-to-date discharge summaries and complete medication lists, diagnoses made in the hospital, recent laboratory and radiology results, and laboratory and radiology tests still pending at the time of discharge that required ambulatory follow-up. Hospitalizations nearly always result in important changes in medication regimens and/or diagnoses, yet

Table 1 Patient characteristics by readmission status

Characteristic	Total n (%)	HIE access* n (%)	No HIE access n (%)	p Value
	6807 (100)	394 (5.79)	6413 (94.21)	
Readmitted within 30 days	668 (9.81)	20 (5.08)†	648 (10.10)	0.001
Men	2548 (37.43)	159 (40.36)	2389 (37.25)	0.031
Age, years				
18–44	1495 (21.96)	59 (14.97)	1436 (22.39)	0.002
45–64	1774 (26.06)	122 (30.96)	1652 (25.76)	
65–74	1343 (19.73)	88 (23.34)	1255 (19.57)	
≥75	2195 (32.25)	125 (31.73)	2070 (32.28)	
Insurance				
Private	3156 (46.36)	174 (44.16)	2982 (46.50)	0.190
Medicaid managed care	860 (12.63)	37 (9.39)	823 (12.83)	
Medicare managed care	2791 (41.00)	183 (46.45)	2608 (40.67)	
Type of visit				
Primary care*	2272 (33.38)	166 (42.13)	2106 (32.84)	0.0001
Specialty care*	1826 (26.83)	193 (48.98)	1633 (25.46)	0.0001
Emergency department*	838 (12.31)	56 (14.21)	782 (12.19)	0.236
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	
Major ADG count	1.51 (1.50)	1.44 (1.47)	1.51 (1.50)	0.346
Length of index stay	4.61 (6.36)	4.57 (5.00)	4.62 (6.43)	0.887
Days before readmission‡	9.42 (8.50)	14.85 (10.16)	9.25 (8.40)	0.004

*Any in the 30 days post-discharge or until readmitted.
†These 20 discharges represented 5 different index hospitals.‡Number of days from index discharge to readmission among the readmitted group (n=668) only.
ADG, Aggregated Diagnostic Groups; HIE, health information exchange (system).

Table 2 Association between patient characteristics, hospital factors, post-discharge utilization, HIE usage, and 30-day same-cause readmissions

Variable	Unadjusted OR (95% CI)	Patient-level factors aOR (95% CI)	Patient-level factors and post-discharge utilization aOR (95% CI)	Full model aOR (95% CI)
HIE system access*	0.46 (0.29 to 0.73)†	0.45 (0.28 to 0.71)‡	0.43 (0.27 to 0.71)‡	0.43 (0.27 to 0.70§)†
Patient characteristics				
Men	1.40 (1.19 to 1.65)‡	1.22 (1.03 to 1.45)§	1.26 (1.05 to 1.52)†	1.27 (1.06 to 1.53)†
Age, years				
18–44	1.00	1.00	1.00	1.00
45–64	1.77 (1.35 to 2.32)‡	1.56 (1.17 to 2.08)†	1.81 (1.33 to 2.45)‡	1.77 (1.30 to 2.40)‡
65–74	1.99 (1.50 to 2.62)‡	1.26 (0.88 to 1.81)	1.40 (0.95 to 2.05)	1.38 (0.94 to 2.02)
≥75	2.21 (1.71 to 2.85)‡	1.35 (0.95 to 1.91)	1.36 (0.94 to 1.96)	1.35 (0.93 to 1.96)
Insurance				
Private	1.00	1.00	1.00	1.00
Medicaid managed care	1.02 (0.77 to 1.36)	1.20 (0.89 to 1.63)	0.95 (0.69 to 1.31)	0.96 (0.69 to 1.33)
Medicare managed care	1.75 (1.47 to 2.09)‡	1.60 (1.27 to 2.01)‡	1.68 (1.31 to 2.15)‡	1.67 (1.31 to 2.14)‡
Length of index stay	1.00 (0.99 to 1.01)	0.99 (0.98 to 1.01)	0.99 (0.97 to 1.00)	0.99 (0.97 to 1.00)
Major ADG count	1.19 (1.13 to 1.25)‡	1.12 (1.06 to 1.19)‡	1.07 (1.01 to 1.14)§	1.07 (1.01 to 1.14)†
Post-discharge utilization				
Primary care visit*	0.56 (0.46 to 0.68)‡	–	0.47 (0.39 to 0.58)‡	0.48 (0.39 to 0.59)‡
Specialty care visit*	0.73 (0.60 to 0.88)†	–	0.67 (0.54 to 0.83)‡	0.67 (0.54 to 0.82)‡
ED visit*	8.71 (7.29 to 10.41)‡	–	9.33 (7.73 to 11.25)‡	9.30 (7.72 to 11.21)‡
Hospital characteristics				
Hospital size (beds)				
<100	1.00	–	–	1.00
100–199	0.73 (0.49 to 1.08)	–	–	0.72 (0.46 to 1.11)
200–299	0.55 (0.41 to 0.75)‡	–	–	0.49 (0.35 to 0.69)‡
≥300	0.69 (0.53 to 0.90)†	–	–	0.57 (0.37 to 0.89)§
System member¶	0.80 (0.61 to 1.05)	–	–	–
Teaching hospital¶	0.89 (0.54 to 1.47)	–	–	–
Critical access hospital¶	2.60 (1.24 to 5.43)§	–	–	–
Case mix index	0.61 (0.29 to 1.30)	–	–	0.91 (0.48 to 1.74)

*Post index discharge.
†p<0.01.
‡p<0.001.
§p<0.05.
¶Organizational factors not included in full model due to sample size restrictions or constant with other organizational-level factors.
ADG, Aggregated Diagnostic Groups; ED, emergency department; HIE, health information exchange (system).

timely access to this information has been difficult in the paper, fax, and phone environment typical in community settings.[34] Having accurate medication lists can improve medication safety and prevent adverse drug events that trigger readmissions.[5] Similarly, having accurate lists of tests pending at discharge can enable appropriate follow-up and subsequent action in the ambulatory setting.[35]

Reducing the occurrence of readmissions has been difficult to achieve.[36] To our knowledge, this is one the first studies that suggests a beneficial association between HIE system usage and hospital readmissions in the USA. Until now, the studies that have been published about HIE interventions have not reported any association with reductions in readmissions,[15] and in fact, only a few studies have shown that hospitalizations, in general, may be reduced with HIE.[12–14] This study may have been able to identify an association because we examined the relationship between HIE system usage and outcomes at an individual patient level in a community with robust HIE. The level of usage that we found in our study is consistent with usage of other contemporary HIE systems.[12 37 38]

Any potential costs savings associated with HIE system usage would be relevant to current heath information technology policy in the USA. The federal and state governments have invested heavily in HIE and interoperable health information technologies with the anticipation of quality and cost benefits.[39] The findings in our study suggest that those investments may ultimately prove beneficial. This is a critical point in time to identify such potential cost savings. Federal funding for state-level exchange programs is ending in 2014, threatening the financial viability of numerous exchange efforts nationwide.[40]

Additionally, we studied the effect of technology in an advanced community-based exchange effort, but the exchange of clinical information may be accomplished in many different ways. Current exchange approaches in the USA vary by the number and types of participating providers and how patient information is shared.[41 42] Currently, we do not know which forms of HIE will ultimately be most effective, or effective at all. However, this study suggests that the community-wide lookup approach offered by many HIE efforts could have clinical and economic value, particularly in the transition from inpatient to outpatient settings. This approach to exchange has already been associated with reductions in utilization in areas of care such as repeat imaging[43 44] and admissions via the ED.[12 13]

These findings also suggest an avenue for hospitals and healthcare systems to respond to current changes in US healthcare policy. Specifically under the Hospital Readmissions

Reduction Program, the financial responsibility for readmissions for certain conditions lies with healthcare systems and individual hospitals.[27] Unfortunately, these organizations have access to few consistently effective strategies for preventing readmissions. To improve their efforts, future directions could include pairing this HIE technology with the processes and workforce interventions that already demonstrate favorable effects on readmissions, such as discharge planning, improving referrals to primary care, care coordination, and patient education.[45–47] Indeed, the effectiveness of HIE plus one or more of these proven strategies may be greater than any one strategy alone.[48]

This study is subject to several limitations. First, given the observational nature of our data and study design we cannot prove causality. It is possible that residual patient-level and organizational factors still could have confounded results even after adjusting for the observed variables. To progress towards a more causal understanding, we would need more detailed data on providers' actual medical decision making processes around patient care. Also, because usage of the HIE system was voluntary, selection bias may be present. It is possible providers were more likely to access information in situations where a readmission was a greater concern. With our secondary data, we are not able to directly address the potential selection issues, but have used multiple adjustment techniques, including propensity score matching, to address this source of bias.

We examined HIE usage in a single community that has a robust, functional HIE and the data were reflective of the post-discharge experiences of commercially insured (including Medicare and Medicaid managed care) patients from a small set of hospitals. These results may not translate to all other settings. Additionally, our study sample size was small. While all of the hospitals in our study had readmissions and discharges for which the HIE system was accessed afterwards, we did not have sufficient statistical power to look at specific readmission conditions. Future studies could examine other categories of admissions such as ambulatory care sensitive conditions or readmissions for comorbidities and related complications. Likewise, future studies could expand the analysis to look more in-depth at patient post-discharge utilization patterns or the types of information accessed via HIE.

This study took place in a typical community-based setting with private practices, not-for-profit hospitals, multiple payers, and fee-for-service reimbursement. The scope of the HIE in this community included 11 counties, 38 healthcare organizations, over 1300 HIE users, and more than 800 000 patients. This electronic network took years to build, both technically and in terms of winning buy-in from historical competitors. Moreover, this HIE required long-standing commitment from community leaders and a community-based organization whose primary mission was the advancement of this kind of technology.[49] This illustrates the type of integration that American healthcare has not seen outside integrated delivery systems until very recently. Our study showed that the success of the HIE in reducing readmissions was possible in this context.

Accessing patient information via HIE after discharge was associated with a lower odds of readmission within 30 days. To the best of our knowledge, this is the first US-based study to demonstrate the potential effectiveness of HIE on this outcome. Given the importance of hospital readmissions for patients, providers, and policy makers, this represents a potentially valuable application of HIE.

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