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ORIGINAL RESEARCH

Health Information Exchange Systems and Length of Stay in Readmissions to a Different Hospital

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BACKGROUND: Readmission to a different hospital than the original discharge hospital may result in breakdowns in continuity of care. In different-hospital readmissions (DHRs), continuity can be maintained when hospitals are connected through health information exchange (HIE) systems.

OBJECTIVE: To examine whether length of readmission stay (LORS) differs between same-hospital readmissions and DHRs, and whether in DHRs the LORS differs by the availability of HIE.

DESIGN: A retrospective cohort study of all internal medicine 30-day readmissions in 27 Israeli hospitals between January 1, 2010 and December 31, 2010.

SETTING: Clalit Health Services—Israel's largest integrated healthcare provider and payer.

POPULATION: Adult Clalit members (aged 18 and older) with at least 1 readmission during the study period.

METHODS: A multivariate marginal Cox model tested the likelihood for discharge during each readmission day in same-hospital readmissions (SHRs), DHRs with HIE, and DHRs without HIE.

RESULTS: Of the 27,057 readmissions, 3130 (11.6%) were DHRs and 792 where DHRs with HIE in both the index and readmitting hospital. Partial continuity (DHRs with HIE) was associated with decreased likelihood of discharge on any given day compared with full continuity (SHRs) (hazard ratio [HR] = 0.85, 95% confidence interval [CI]: 0.79–0.91). Similar results were obtained for no continuity (DHRs without HIE) versus full continuity (HR = 0.90, 95% CI: 0.86–0.94). The difference between DHRs with and without HIE was not significant.

CONCLUSIONS: The prolonged LORS in DHRs versus SHRs was not mitigated by the existence of HIE systems. Future research is needed to further elucidate the effects of actual use of HIE on length of DHRs. *Journal of Hospital Medicine* 2016;11:401–406. © 2015 Society of Hospital Medicine

Readmissions within a relatively short time after discharge are receiving considerable attention as an area of quality improvement,[1,2] with increasing emphasis on the relatively large share of readmissions to different hospitals, accounting for 20% to 30% of all readmissions.[3–6] Returning to a different hospital may affect patient and healthcare outcomes due to breaches in continuity. When information from the previous recent hospitalization is not transferred efficiently and accurately to the next admitting hospital, omissions and duplications can occur, resulting in delayed care and potentially worse outcomes (compared to same hospital readmissions [SHRs]), such as longer length of readmission stay (LORS) and increased costs.[7]

Electronic health records (EHRs) and health information exchange (HIE) systems are increasingly used for storage and retrieval of patient information from various sources, such as laboratories and previous physician visits and hospitalizations, enabling informational continuity by providing vital historical medical information for decision-making. Whereas EHRs collect, store, and present information that is locally created within a specific clinic or hospital, HIEs connect EHR systems between multiple institutions, allowing providers to share clinical data and achieve interorganizational continuity. Such integrative systems are increasingly being implemented across healthcare systems worldwide.[8–10] Yet, technical difficulties, costs, competitive concerns, data privacy, and workflow implementation challenges have been described as hindering HIE participation.[11–14] Moreover, major concerns exist regarding the poor usability of EHRs, their limited ability to support multidisciplinary care, and major difficulties in achieving interoperability with HIEs, which undermine efforts to deliver integrated patient-centered care.[15] Nonetheless, previous research has demonstrated that HIEs can positively affect healthcare resource use and outcomes, including reduced rates of repeated diagnostic imaging in the emergency evaluation of back pain,[16] reduction in admissions via the emergency department (ED),[17] and reduced rates of readmissions within 7 days.[18] However, it is not known whether HIEs can

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contribute to positive outcomes when patients are readmitted to a different hospital than the hospital from which they were recently (within the previous 30 days) discharged, potentially bridging the transitional-care information divide.

In Israel, an innovative HIE system, OFEK (literally *horizon*), was implemented in 2005 at the largest not-for-profit insurer and provider of services, Clalit Health Services (Clalit). Clalit operates as an integrated healthcare delivery system, serving more than 50% of the Israeli population, as part of the country's national health insurance system. OFEK links information on all Clalit enrollees from all hospitals, primary care, and specialty care clinics, laboratories, and diagnostic services into a single, virtual, patient file, enabling providers to obtain complete, real-time information needed for healthcare decision making at the point of care. Like similar HIE systems, OFEK includes information on previous medical encounters and hospitalizations, previous diagnoses, chronically prescribed medications, previous lab and imaging tests, known allergies, and some demographic information.[19] At the time of this study, OFEK was available in all Clalit hospitals as well as in 2 non-Clalit (government-owned and operated) large tertiary-care centers, resulting in 40% coverage of all hospitalizations through the OFEK HIE system. As part of a large organization-wide readmission reduction program recently implemented by Clalit for all its members admitted to any hospital in Israel, aimed at early detection and intervention,[20] OFEK was viewed as an important mechanism to help maintain continuity and improve transitions.

To inform current knowledge on different-hospital readmissions (DHRs) and HIEs, we examined whether having HIE systems can contribute to information continuity and prevent delays in care and the need for more expensive, lengthy readmission stays when patients are readmitted to a different hospital. More specifically, we tested whether there is a difference in the LORS between SHRs and DHRs, and whether DHRs the LORS differ by the availability of an HIE (whether index and readmitting hospital are or are not connected through HIE systems).

METHODS

Study Design and Setting

We conducted a retrospective cohort study based on data of hospitalized Clalit members. Clalit has a centralized data warehouse with a comprehensive EHR containing data on all patients' medical encounters, administrative data, and clinical data compiled from laboratories, imaging centers, and hospitals. At the time of the study, OFEK was operating in all 8 Clalit hospitals and in 2 large government-owned and operated hospitals in the central and northern parts of the country. Information is linked in the Clalit system and OFEK-affiliated hospitals through an individual identity number assigned by the Israeli Interior Ministry to every Israeli resident for general identification purposes.

Population

The study examined all internal medicine and intensive-care unit (ICU) readmissions of adult Clalit members (aged 18 years and older) previously (within the prior 30 days) discharged from internal medicine departments during January 1, 2010 until December 31, 2010 (ie, index hospitalizations). Only readmissions of index hospitalizations with more than a 24-hour stay were included. A total of 146,266 index hospitalizations met the inclusion criteria. Index admissions that resulted in a transfer to another hospital, a long-term care facility, or rehabilitation center were not included (N = 11,831). The final study sample included 27,057 readmissions (20.1% of the 134,435 index admissions), which could have resulted in any type of discharge (to patient's home, a long-term care or rehabilitation facility, or due to death). The study was approved by Clalit's institutional review board.

Outcome Variable

We defined the LORS as the number of days from admission to discharge during readmission.

Main Independent Variable

We assessed information continuity as a categorical variable in which 0 = no information continuity (DHRs with either no HIE at either hospital or an HIE in only 1 of the hospitals), 1 = information continuity through an HIE (DHRs with both hospitals having an HIE), and 2 = full information continuity (readmission to the same hospital).

Covariates

We examined the following known correlates of length of stay (LOS): age, gender, residency in a nursing home, socioeconomic status (SES) based on an indicator of social security entitlement received by low-income members,[21] and the occurrence of common chronic conditions registered in Clalit's EHR registries[22]: congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), chronic renal failure (CRF), malignancy, diabetes, hypertension, ischemic heart disease, atrial fibrillation, asthma, and disability (indication of a functional limitation). To provide comorbidity adjustment we used the Charlson Comorbidity Index.[23] Additionally, we assessed LOS of the index hospitalization. We included an indicator for the size of the index hospital: small, fewer than 100 beds; medium, 100 to 200 beds; and large, more than 200 beds. Finally, to account for a well-known correlate of length of hospital stay,[24] we included an indicator for an ICU stay during the readmission.

TABLE 1. Characteristics of Readmissions Within 30 Days

Characteristics	All Readmissions, n = 27,057	SHR, n = 23,927	DHR With HIE, n = 792	DHR Without HIE, n = 2,338	*P* Value
All personal characteristics					
Age, n (%)					<0.001
18–44 years	1,328 (4.9)	1,095 (4.6)	58 (7.3)	175 (7.5)	
45–64 years	5,370 (19.8)	4,597 (19.2)	197 (24.9)	576 (24.6)	
65–84 years	14,059 (52.0)	12,500 (52.2)	402 (50.8)	1,157 (49.5)	
85+ years	6,300 (23.3)	5,735 (24.0)	135 (17.0)	430 (18.4)	
Female sex, n (%)	13,742 (50.8)	12,040 (50.3)	418 (52.8)	1,284 (54.9)	<0.001
Low socioeconomic status, n (%)	15,473 (57.2)	13,670 (57.1)	453 (57.2)	1,350 (57.7)	
Residency in a nursing home, n (%)	1,857 (6.9)	1,743 (7.3)	27 (3.4)	87 (3.7)	<0.001
Common chronic conditions, n (%)					
Hypertension	20,797 (76.9)	18,484 (77.3)	588 (74.2)	1,725 (73.8)	<0.001
Ischemic heart disease	14,150 (52.3)	12,577 (52.6)	397 (50.1)	1,176 (50.3)	0.052
Diabetes	13,052 (48.2)	11,589 (48.4)	345 (43.6)	1,118 (47.8)	0.024
Arrhythmia	10,306 (38.1)	9,197 (38.4)	292 (36.9)	817 (34.9)	0.003
Chronic renal failure	9,486 (35.1)	8,454 (35.3)	262 (33.1)	770 (32.9)	0.034
Congestive heart failure	9,216 (34.1)	8,232 (34.4)	270 (34.1)	714 (30.5)	0.001
Disability	8,362 (30.9)	7,600 (31.8)	165 (20.8)	597 (25.5)	<0.001
Chronic obstructive pulmonary disease	7,671 (28.4)	6,888 (28.8)	201 (25.4)	582 (24.9)	<0.001
Malignancy	7,642 (28.2)	6,763 (28.3)	220 (27.8)	659 (28.2)	0.954
Asthma	4,491 (16.6)	4,040 (16.9)	109 (13.8)	342 (14.6)	0.002
Charlson score, mean [SD]	4.54 [3.15]	4.58 [3.14]	4.14 [3.08]	4.25 [3.24]	0.043
Index hospitalization characteristics (LOS during index hospitalization), n (%)					<0.001
2–4 days	14,961 (55.3)	13,310 (55.6)	428 (54.0)	1,223 (52.3)	
5–7 days	6,366 (23.5)	5,654 (23.6)	174 (22.0)	538 (23.0)	
8 days and more	5,730 (21.2)	4,963 (20.7)	190 (24.0)	577 (24.7)	
Hospital size in index hospitalization (no. of hospitals in each category), n (%)					<0.001
Small, <100 beds (8)	1,498 (5.5)	1,166 (4.9)	23 (2.9)	309 (13.2)	
Medium, 100–200 beds (9)	8,129 (30.0)	7,113 (29.7)	316 (39.9)	700 (29.9)	
Large, >200 beds (10)	17,430 (64.4)	15,648 (65.4)	453 (57.2)	1,329 (56.8)	
Intensive care unit during readmission, n (%)	869 (3.2)	647 (2.7)	73 (9.2)	149 (6.4)	<0.001

NOTE: **Abbreviations:** DHR, different hospital readmission; HIE, health information exchanges; LOS, length of stay; SD, standard deviation; SHR, same hospital readmission.

Statistical Analysis

We first examined the study populations' characteristics and calculated the average LORS for each SHR and DHR category. Due to the skewed distribution of LORS, we also calculated the median and interquartile range (IQR) of LORS and evaluated the difference between categories using the Kruskall-Wallis test.[25] Sample-size calculations showed that we would need a sample of >3000 admissions to have 80% power to detect a difference of 0.8 hospitalization days given the 1:3 ratio between the DHR groups. To examine the association between LORS and information continuity, we employed a univariate marginal Cox model.[26] Variables that were significantly ($P < 0.05$) associated with LORS in the univariate model were entered into a multivariate marginal Cox model, clustering by patient and using a robust sandwich covariance matrix estimate. Additionally, we performed a sensitivity analysis using hierarchichal modeling to account for potential variations due to hospital level factors. A low hazard ratio (<1) represented an association of the covariate with decreased likelihood of discharge, that is, longer LORS. All analyses were conducted with SPSS version 20 (IBM, Armonk, NY) and SAS version 9.3 (SAS Institute Inc., Cary, NC).

RESULTS

The study included a total of 27,057 readmissions, of which 23,927 (88.4%) were SHRs and 3130 (11.6%) were DHRs. Of all DHRs, in 792 (2.9%) of the cases, both hospitals had HIEs (partial information continuity), and in 2338 (8.6%), either 1 or both did not have an HIE system (thus meaning there was no information continuity). Characteristics of the study population are shown in Table 1. Most (75%) of the readmissions were of patients over the age of 65 years, though only 7% were nursing home residents. More than half the study's population consisted of patients with low SES. The most common chronic conditions were hypertension (77%), ischemic heart disease (52%), and diabetes (48%). Other chronic conditions were arrhythmia (38%), CHF (35%), disability (31%), COPD (28%), malignancy (28%), and asthma (16%). In more than 55% of the index hospitalizations, the LOS was 4 days or less, and most index admissions (64%) were in large hospitals. Table 1 also displays the study population by the type of readmission: SHR, DHR with HIE, and DHR without HIE. As compared to patients readmitted to the same hospital, patients with DHRs were younger ($P < 0.001$), less likely to be nursing home residents ($P < 0.001$), and

TABLE 2. LORS by Information Continuity

Information Continuity	No. of Readmissions	Mean LORS (95% CI)	Median (Q1–Q3)	Kruskal-Wallis *P* Value
SHRs	23,927 (88.4)	6.3 (6.2–6.4)	4 (2–7)	
DHRs	3,130 (11.6)	7.3 (7.0–7.6)	4 (2–8)	
DHRs with HIE	792 (2.9)	7.6 (7.0–8.3)	4 (2–9)	
DHRs without HIE	2,338 (8.7)	7.2 (6.8–7.6)	4 (2–8)	
Total	27,057	6.4 (6.3–6.5)	4 (2–7)	<0.001

NOTE: **Abbreviations:** CI, confidence interval; DHRs, different hospital readmissions; HIE, health information exchanges; LORS, length of readmission stay; SHRs, same hospital readmissions.

had longer LOS during the index admission ($P < 0.001$). Additionally, patients with SHRs were more likely to have their index admission at a large hospital ($P < 0.001$), had a higher comorbidity score ($P < 0.043$), and were less likely be treated in the ICU during their readmission ($P < 0.001$) compared to their DHR counterparts. Patients with DHRs without an HIE were similar in most characteristics to those with an HIE, except for having an ICU stay during their readmission (6.4% compared with 9.2%, respectively).

The mean LORS in SHRs was shorter by 1 day than the mean LORS for DHRs: 6.3 (95% confidence interval [CI]: 6.2-6.4) versus 7.3 (95% CI: 7.0-7.6), respectively. Mean LORS in DHRs with or without HIE was 7.6 (95% CI: 7.0-8.3) and 7.2 (95% CI: 6.8-7.6), respectively. Although median LORS was similar (4 days), the IQR differed, resulting in significant differences between the SHR and DHR groups (Table 2).

In the multivariate model, partial continuity (DHRs with an HIE) was associated with decreased likelihood of discharge on any given day compared with full continuity (SHR) (hazard ratio [HR] = 0.85, 95% CI: 0.79-0.91). Similar results were obtained for no continuity (DHRs without an HIE) (HR = 0.90, 95% CI: 0.86-0.94). The difference between DHRs with and without an HIE was not significant (overlapping confidence intervals). Other factors associated with a lower HR for discharge during each day of the readmission were older age, residency in a nursing home, CHF, CRF, disability, malignancy, and long LOS (8+ days) during the index hospitalization. Patients with asthma or ischemic heart disease had a higher HR for discharge during each readmission day (Table 3). We performed a sensitivity analysis using hierarchical modeling (patients nested within hospitals), which resulted in similar findings in terms of directionality and magnitude of the relationships and significance levels.

DISCUSSION

This study shows that readmission to a different hospital results in longer duration of the readmission stay compared with readmission to the same index hospital. Our results also show that having HIE systems in both the index and readmitting hospitals does not "protect" against these negative outcomes, as there was no difference in the length of the readmission stay based on the availability of HIE systems. Factors that were found to be associated with longer readmission stays are well known indicators of the complexity of the patient's medical condition, such as the presence of disability, comorbidity, and ICU treatment during the readmission.[24,27]

The shorter LORS in SHRs may be due to the familiarity of physicians and other healthcare providers with the patient and his or her condition, especially as the policy in SHRs in Israel is to readmit to the same unit from which the patient was recently discharged. This same hospital familiarity is especially important as hospital care in Israel follows the hospitalist model, in which responsibility for patient care is transferred from the patient's primary care physician to the hospital's physician, resulting in increased need for integration through HIE systems, especially when patients are readmitted to a different hospital.[28,29]

Our findings, congruent with previous research on DHRs and poor outcomes,[7] could also be explained by the inefficiency associated with transitions. For example, patients frequently leave the hospital with pending lab tests, often with abnormal results that would change the course of care.[30] Because these pending tests are often omitted from the hospital discharge summaries,[31] if patients are hospitalized in a different hospital, the same tests may be ordered again, or a course of treatment that does not acknowledge the test results could be taken. Such time-consuming duplication can be prevented in SHRs, where the index-hospital records may be already more complete.

Our null findings regarding the contribution of HIE systems may be explained by the low levels of HIE actual use. Although we did not directly assess use, previous research reports that actual use of HIE is limited.[12] An Israeli study on the effects of the use of the OFEK system on ED physicians' admission decisions found that the patient's medical history was viewed in only 31.2% of all 281,750 ED referrals.[19] In another Israeli-based ED study, even lower usage levels were found, with the OFEK system having been accessed in only 16% of all 3,219,910 ED referrals.[32] Low levels of HIE use have also been reported in the United States. An additional study, which tested the implementation of HIE in hospitals and clinics, showed that in only 2.3% of encounters did providers access the HIE record.[33] Another study conducted in 12 ED sites and 2 ambulatory clinics reported rates of 6.8% HIE use.[34] Moreover, the null effect of integrated health information reported here is congruent with findings from a US study on implementation of an electronic discharge instructions form with embedded computerized medication reconciliation, which was not found to be associated with postdischarge outcomes.[35]

A wide range of factors may influence decisions on HIE use: patient-level factors,[36] perceived medical

TABLE 3. Univariate and Multivariate Marginal Cox Model Predicting Time to Discharge in Readmissions

Characteristics	Univariate Model		Multivariate Model	
	Hazard Ratio (95% CI)	*P* Value	Hazard Ratio (95% CI)	*P* Value
Information continuity				
SHR	Reference		Reference	
DHR with HIE	0.87 (0.81–0.93)	<0.001	0.86 (0.80–0.93)	<0.001
DHR without HIE	0.91 (0.87–0.94)	<0.001	0.90 (0.87–0.94)	<0.001
Age				
8–44 years	1.22 (1.18–1.26)	<0.001	1.14 (1.07–1.22)	<0.001
45–64 years	1.16 (1.14–1.18)	<0.001	1.11 (1.06–1.1)	<0.001
65–84 years	1.01 (0.99–1.02)	0.53	0.99 (0.96–1.02)	0.60
85+ years	Reference		Reference	
Sex				
Male	0.97 (0.95–0.99)	0.008	0.98 (0.96–1.01)	0.19
Female	Reference		Reference	
Socioeconomic status				
Low	0.98 (0.97–0.99)	0.11		
Other	Reference			
Residency in a nursing home				
Nursing home	0.90 (0.88–0.92)	<0.001	0.90 (0.86–0.95)	<0.001
All others	Reference		Reference	
Common chronic conditions (reference: without condition)				
Hypertension	0.94 (0.93–0.96)	<0.001	1.01 (0.97–1.04)	0.69
Ischemic heart disease	1.00 (0.99–1.01)	0.93	1.06 (1.03–1.09)	<0.001
Diabetes	0.97 (0.95–0.98)	0.004	0.99 (0.97–1.02)	0.64
Arrhythmia	0.96 (0.95–0.97)	0.002	1.01 (0.98–1.04)	0.39
Chronic renal failure	0.92 (0.91–0.93)	<0.001	0.96 (0.93–0.99)	0.01
Congestive heart failure	0.93 (0.92–0.94)	<0.001	0.96 (0.93–0.99)	0.01
Disability	0.86 (0.85–0.87)	<0.001	0.90 (0.87–0.92)	<0.001
Chronic obstructive pulmonary disease	0.99 (0.98–1.01)	0.66		
Malignancy	0.97 (0.96–0.98)	0.03	0.98 (0.96–1.01)	0.28
Asthma	1.04 (1.02–1.06)	0.03	1.04 (1.00–1.07)	0.03
Charlson score	0.99 (0.98–0.99)	<0.001	0.99 (0.99–1.00)	0.04
LOS during index hospitalization				
Days 2–4	1.52 (1.49–1.54)	<0.001	1.49 (1.45–1.54)	<0.001
Days 5–7	1.21 (1.19–1.23)	<0.001	1.20 (1.16–1.24)	<0.001
8 days and more	Reference		Reference	
Hospital size in index hospitalization				
Small, <100 beds (8)	0.94 (0.92–0.97)	0.02	1.00 (0.95–1.05)	0.93
Medium, 100–200 beds (9)	1.00 (0.99–1.02)	0.78	1.01 (0.99–1.04)	0.38
Large, >200 beds (10)	Reference		Reference	
Intensive care unit in readmission				
Yes	0.75 (0.70–0.80)	<0.001	0.74 (0.69–0.79)	<0.001
No	Reference		Reference	

NOTE: **Abbreviations:** CI, confidence interval; DHRs, different hospital readmissions; HIE, health information exchanges; LOS, length of stay; SHRs, same hospital readmissions.

complexity of the patient,[33,34] and the number of prior hospitalizations.[33,34,36] Healthcare system–level factors may include: time constraints, which may be positively[32] or negatively[33] associated with HIE use, and organizational policies or incentives.[33] Use may also be associated with features of the HIE technology itself, such as difficulty to access, difficulty to use once accessed, and the quality of information it contains.[37] Additionally, there is some evidence of the link between tight functional integration and higher proportions of usage.[38] Although comprehensive studies on factors affecting the use of the OFEK system in Israeli internal medicine units are still needed, the lack of its integration within each hospital's EHR system may serve as a major explanatory factor for the low usage levels.

The findings from this study should be interpreted in light of its limitations. First, compared with previously reported DHR rates (20%–30%),[3,5] the rate observed in our population was relatively low (about 12%). Previous research was restricted to heart failure patients[3] or assessed DHR in surgical, as well as internal medicine, patients.[5] Our lower rates may have been affected by the type of population (hospitalized internal medicine patients) and/or by characteristics of the Clalit healthcare system, which serves as an integrated provider network as well as insurer. Generalization from 1 health care system to others should be made with caution. Nonetheless, our results may underestimate the potential effect in other healthcare systems with less structural integration. Additionally, as noted above, information on the actual use of an HIE in the course of medical decision making during readmission was absent. Future studies should examine the potential benefit of an HIE with measures that capture providers' use of HIEs. Also, the LORS may be influenced by other factors not investigated here, and further future studies should examine additional outcomes such as costs, patient well-being, and satisfaction. Finally, causality could not be determined, and future research in this realm should aim to search for the pathways connecting readmission to a different hospital, with and without HIEs, to readmission LOS and additional outcomes.

To conclude, our findings show that patients readmitted to a different hospital are at risk for prolonged LORS, regardless of the availability of HIE systems. Implementing HIE systems is the focus of substantial efforts by policymakers and is considered a key part of the meaningful use of electronic health information. HIE features in the provisions of the Health Information Technology for Economic and Clinical Health Act[39] because it can furnish providers with complete, timely information at the point of care. Moreover, although there has been substantial growth in the number of healthcare organizations that have operational an HIE, its ability to lead to improved outcomes has yet to be realized.[8,10] The Israeli experience reported here suggests that provisions are needed that will ensure actual use of HIEs, which might in turn minimize the difference between DHRs and SHRs.

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