DOI: 10.1111/1475-6773.13210

RESEARCH ARTICLE

HSR Health Services Research

# Health information exchange between hospital and skilled nursing facilities not associated with lower readmissions

Dori A. Cross PhD[1] | Jeffrey S. McCullough PhD[2] | Jane Banaszak-Holl PhD[3] | Julia Adler-Milstein PhD[4]

[1]Division of Health Policy and Management, School of Public Health, University of Minnesota, Minneapolis, Minnesota

[2]Department of Health Management and Policy, School of Public Health, University of Michigan, Ann Arbor, Michigan

[3]School of Public Health and Preventive Medicine, Monash University, Melbourne, Vic., Australia

[4]Department of Medicine, University of California San Francisco, San Francisco, California

**Correspondence**
Dori A. Cross, PhD, Division of Health Policy and Management, School of Public Health, University of Minnesota, 420 Delaware Ave SE, MMC 729, Minneapolis, MN 55455.
Email: dcross@umn.edu

## Abstract

**Objective:** To assess whether an electronic health record (EHR) portal to enable health information exchange (HIE) between a hospital and three skilled nursing facilities (SNFs) reduced likelihood of patient readmission.

**Setting/Data:** Secondary data; all discharges from a large academic medical center to SNFs between July 2013 and March 2017, combined with portal usage records from SNFs with HIE access.

**Design:** We use difference-in-differences to determine whether portal implementation reduced likelihood of readmission over time for patients discharged to HIE-enabled SNFs, relative to those discharged to nonenabled facilities. Additional descriptive analyses of audit log data characterize portal use within enabled facilities.

**Data Collection:** Encounter-level clinical EHR data were merged with EHR audit log data that captured portal usage in the timeframe associated with a patient transition from hospital to SNF.

**Principal Findings:** Declines in likelihood of 30-day readmission were not significantly different for patients in HIE-enabled vs control SNFs (diff-in-diff = 0.022; $P$ = .431). We observe similar null effects with shorter readmission windows. The portal was used for 46 percent of discharges, with significant usage pattern variation within/across facilities.

**Conclusions:** Implementation of a hospital-SNF EHR portal did not reduce readmissions from enabled SNFs. Emergent HIE use cases need to be better defined and leveraged for design and implementation that generates value in the context of postacute transitions.

KEYWORDS
care transitions, electronic health records, health information exchange, postacute care

## 1 | INTRODUCTION

Millions of clinically complex and vulnerable patients transition from hospitals to skilled nursing facilities (SNFs) annually; in fact, 20 percent of all Medicare hospitalizations result in discharge to a SNF.[1,2] Significant quality and safety concerns during these transitions contribute to frequent adverse patient events and avoidable hospital readmissions, resulting in higher costs and compromised patient experience.[3-10] Poor information sharing between institutions—issues of missing, delayed, or difficult-to-use data—is a frequent and

  

critical barrier to effective hospital-SNF transitions.[4,7,11-13] One organizational strategy hospitals are actively pursuing to address coordination challenges is electronic health information exchange (HIE) connections with SNFs.[14,15]

Hospitals are increasingly incentivized, through payment reforms such as readmissions penalties, shared savings models, and bundled payment initiatives, to address problems of information discontinuity that threaten transitional care quality with SNFs.[16] SNFs are also increasingly motivated to collaborate on improved care practices due to payment changes and market-based pressures. While SNF payment is still predominantly fee-for-service, recent changes toward prospective, value-based payment are only expected to accelerate.[17,18] Further, facilities need to act strategically to maintain high occupancy, particularly in competitive markets. SNFs face significant pressure to market themselves as willing collaborative partners in an environment where hospitals are increasingly looking to tighten their referral network and develop more integrated care practices.[16,19,20]

While the evidence base demonstrating positive impact of HIE on cost and outcomes continues to grow,[21,22] there has been no empirical examination of whether HIE in the context of SNF transitions results in improved patient outcomes. This particular type of handoff merits special consideration, as information needs and organizational contexts differ substantially across these settings.[4,11-13,23] There is particular value in studying widely adopted HIE approaches, such as EHR portals that allow view-only access by outside providers, to specifically assess the transferability of common HIE approaches to meet SNF needs. Data from the 2017 American Hospital Association demonstrate that, in the absence of true interoperability, portals are among the most common mechanisms for information sharing; 58 percent of hospitals report regular use of portals to send information to other health care organizations.[24]

Therefore, in this study, we evaluate the impact of an effort to enable hospital-SNF electronic information sharing by providing SNFs with portal access to the hospital's electronic health record. Using data from a large academic medical center and the SNFs to which patients are discharged, we assess whether HIE in this context results in a lower likelihood of patient readmission over time by comparing patients discharged to HIE vs non-HIE-enabled SNFs. We also look descriptively at whether and how the portal is utilized across HIE-enabled facilities to contextualize these findings. As significant and sustained spending on postacute services continues to be a national policy priority, policy makers and payers will increasingly push payment and delivery changes that necessitate improved coordination with these organizations.[25] Our findings—identifying whether current health system information sharing strategies with postacute care demonstrate value, and characterizing variation in these information-seeking patterns—respond directly to calls from the Centers for Medicare and Medicaid Services (CMS) for information to support rulemaking around effective information sharing that better supports postacute transitions.[26]

## 2 | METHODS

### 2.1 | Setting

The study was conducted at a large US academic medical center that implemented an Epic electronic health record (EHR) in 2012. In June 2014, the hospital extended the EpicCare Link portal to three local high-volume SNFs that together make up over 40 percent of the hospital's SNF referrals. (See Table S1 for descriptive facility characteristics of these SNFs.) The portal enabled "view-only" access for outside providers to view hospital patient records for assigned patients (ie monodirectional use). Because it was intended to be used by a variety of different community provider types, the portal interface was a general patient record view not tailored to postacute care users. When offered to SNFs, the portal was intended as a supplemental resource, in addition to standard protocol (ie a paper discharge summary and nurse-to-nurse phone call) that applies to all hospital-to-SNF discharges.

Offering the portal was one resource intended to strengthen coordination and integration; around the same time, the hospital was also placing site-designated, hospital-employed physicians and advanced care practitioners inside each of these SNFs to provide continued care for their patients. These providers have their own direct log-in to the Epic EHR and do not use the portal. Thus, the portal was primarily designed to support interorganizational handoffs rather than provider-to-provider handoff.

### 2.2 | Data and measures

Our study includes clinical data from the hospital's EHR for all patients discharged to a SNF between July 2013 (12 months preimplementation) and March 2017. Our primary outcome from this data is whether the patient was readmitted to the discharging hospital within 30-days; 30-day readmissions is used by Medicare for the Hospital Readmissions Reduction Program and is a common measure of interest in evaluative studies of hospital-to-PAC transitional care quality.[10,27-30] We also examine 14- and 7-day readmissions as alternate outcomes that may be more sensitive to the quality of hospital-SNF information sharing. Data also included the following patient encounter and demographic information: date/timestamp of hospital admission and discharge, age, gender, race, reason(s) for hospitalization, current diagnoses, and name of the SNF to which the patient was discharged. We used these longitudinal hospitalization and discharge location data to generate an additional "returning SNF patient" measure; a hospitalization was flagged as involving a returning SNF patient if that patient had experienced another hospitalization in the preceding 30 days, with both that prior admission and the more recent hospitalization both resulting in discharge to the same SNF.

Finally, EHR audit log data from the post-HIE implementation period included whether a specified patient's record was ever accessed via an authorized portal user from any of the three

HIE-enabled SNFs. Audit log data include time-stamped records of each specific information retrieval action taken for a specified patient (eg, operating room transcription note viewed, upcoming ambulatory appointments viewed), along with the associated facility name. Individual system user ID was also present, but not used for analysis due to known issues of system log-in information being shared across staff.

We capture all portal use associated with any patient in our dataset. We then define a 16-day window—up to 2-day prehospital discharge and up to two weeks post-transfer (or until the time of readmission, whichever occurred first)—for each patient in which to look for portal use that supports transitional and post-transition care. This window was selected based on interviews that were designed to understand motivations and barriers to portal utilization by SNF staff to support care transitions (full qualitative results reported elsewhere).[31]

Given the granularity of the information retrieval actions in the audit log data (117 total types of actions), we sought to create higher-level categories to capture the type of information retrieved. We found that thirty-seven information retrieval actions comprised over 98 percent of all actions taken. These actions were consolidated into 10 information type categories: Patient Summary Review; Inpatient- Surgical; Inpatient- Other; Ambulatory; ED/Outpatient; Lab/Imaging/Results; Orders; Problem Detail; Demographics/Billing; and Patient History/Health Maintenance. (Full categorized list is included in Table S2) These actions were initially categorized by one author (DAC) and then subsequently reviewed by one additional co-author (JAM), a clinician advisor to the project, and an Epic IT specialist from the hospital familiar with EpicCare Link audit logs.

## 2.3 | Analytic approach: difference-in-differences

We suspect use of the portal is driven by a number of unobservable factors that we cannot control for and are also associated with our outcome of interest. We also were unable to define at the outset what types of usage to look for that might be value-generating—that is, targeted use in a narrow percent of difficult cases vs higher-volume, more consistent patterns of retrieval across all patients. We thus assess the impact of hospital-SNF HIE using a difference-in-differences approach as a straightforward intent-to-treat analysis. We compare the difference in the likelihood of 30-day readmission for patients discharged to the three HIE-enabled SNFs ("treatment SNFs") before vs after portal access and compare this to the difference in likelihood of readmission for patients discharged to SNFs that were not offered HIE access over the same period ("control SNFs"). The control SNFs group is comprised of eight other SNFs that are within a 30-mile radius of the hospital and received at least 100 patients from the hospital during the study period. Because the study hospital is an academic medical center that serves as a regional referral center, this selection excludes comparison to patients discharged to more geographically distant SNFs that only get a small number of patients from, and who are much less likely to be readmitted to, the study hospital.

We control for possible changes during our study period in the clinical and/or demographic profile of patients discharged to treatment vs control SNFs. To do so, we include indicators for age, sex, race, number of active diagnoses present upon discharge, length of hospitalization, and clinical condition listed as the reason for hospitalization. We run all analyses with and without these controls and repeat analyses with 14- and 7-day readmissions as alternate outcomes.

To check the appropriateness of our approach, we first plot raw and risk-adjusted 30-day readmission rates, by calendar quarter, for treatment vs control SNF patients throughout the entire study period (Figure S1). We also include a preimplementation test of parallel trends to address potential concerns caused by the hospital's closer relationships with the treatment SNFs (in terms of geographic proximity and volume of referred patients). We conduct monthly difference-in-difference tests in the year of preimplementation data to ensure that changes, relative to the first observed month as a reference group (July 2013), do not differ significantly when comparing patients from treatment to control facilities. This method best accounts for nonlinearity in observed monthly readmission rates.

We then calculate, in both the pre- and postperiod, basic summary demographics (patient age, sex, race, number of diagnoses, and percent of new vs returning SNF patients) as well as utilization measures (length of index hospitalization, 7-, 14-, and 30-day readmission rates, time until readmission, and length of readmission stay) for patients discharged to treatment SNFs vs those discharged to control SNFs. We also calculate the percent of the hospital's "discharge to SNF" patients sent to treatment vs control facilities in the pre- and postperiods. We compare treatment vs control for all characteristics in the preperiod. We then look at change, pre to post, within treatment and within control to see whether the referral patterns and/or clinical profile of patients discharged to treatment or to control facilities changed over the study period. We use *t* tests to evaluate significance in difference of means for each of these measures.

General advantages of a difference-in-differences model include the ability to control for time-invariant differences between treatment and control facilities, such as the greater likelihood of capturing readmissions of patients discharged to treatment SNFs because of their geographic proximity to, and closer affiliation with, the study hospital. This approach also accounts for time trends that affect all facilities, including any shifts in patient demographics and the national downward trend in readmission rates due to factors other than HIE, such as targeted Medicare payment reforms. We use probit models to account for the binary nature of the outcome variable. Because of known complications using interaction terms in nonlinear models, results represent treatment effect on the treated rather than average treatment effect.[32]

Finally, we conduct two alternate model specifications. First, we include models that account for an HIE learning period by excluding patient data during the first 3 months postimplementation; this strategy is recommended to account for an initial period of time where staff are changing workflows and learning how to incorporate and use new systems.[33] We then rerun our analyses with a model that includes calendar year fixed effects and a fixed effect for each SNF

in our sample. This approach better accounts for unobserved heterogeneity across each facility in the sample, and temporal changes in the postperiod. However, because this model uses a collapsed binary indicator (equaling 1 for patients discharged to a treatment SNF in the postperiod), rather than an interaction between time (pre/post) and treatment (treatment/control), interpretation of the marginal effects is compromised. We therefore use this alternate specification to look for consistency in our estimated treatment effect and report these results as secondary.

### 2.4 | Analytic approach: descriptive analyses

We use the postimplementation portal usage data from HIE-enabled SNFs to characterize overall and facility-specific portal use. We calculate and compare the same summary demographic characteristics and utilization measures listed above for patients that did have the portal used in the context of their discharge to SNF (and subsequent stay), compared to those who did not.

For patients with associated portal use, we then sought to measure the frequency and timing of use, the volume of use, and the types of information retrieved. First, we measure an overall portal usage rate by calculating the percent of hospital discharges to HIE-enabled SNFs for which the receiving facilities ever used the portal in the defined 16-day discharge/post-transition period. Second, we calculate an elapsed time measure. For each discharge with associated portal use, we calculate the time difference between that patient's hospital discharge timestamp and *every* information retrieval action logged for that patient within our defined window. We then use histograms to represent elapsed time measures, visualizing concentrations of portal use timing relative to (ie, centered on) patients' time of hospital discharge.

Third, to capture volume of information retrieval, we sum the total number of information retrieval actions taken within each patient's associated 16-day usage window. Fourth, we group consecutive retrieval actions into usage sessions; greater than 15 minutes between two actions signaled the start of a new session. Length of each session was calculated by subtracting the timestamp of the first action from the last within these sequences. Single action use sessions were excluded from length calculations since we were unable to define an end-time.

Finally, we used the 10 aggregated information categories to characterize the types of information most frequently sought by SNFs. We report the proportion of all information retrieval actions that fell into each category. We also calculate the average "viewing time" spent per action across each category. We then conducted simple sequence analyses to visualize common retrieval patterns at each facility in accessing these different information categories.

## 3 | RESULTS

### 3.1 | Difference-in-differences

The final dataset contains 15 999 hospital discharges, of which 8825 (55.2 percent) were discharged to one of the designated treatment or control SNFs. Preimplementation summary characteristics in Table 1 demonstrate that, relative to patients discharged to control SNFs, patients discharged to treatment facilities were more complex (ie more active diagnoses, longer hospitalization stays). As anticipated, readmission rates to the study hospital are also higher for treatment SNFs, perhaps due to differences in complexity but most likely because of closer geographic proximity and more established relationships. Testing of the parallel trends assumption reveals no difference in monthly variation in preimplementation readmission rates between treatment and control facilities (see Figure S2).

Comparing pre- vs postimplementation, the proportion of hospital patients discharged to the treatment SNFs grew from 33.2 percent to 46.0 percent, a 12.8 percentage point increase. Discharges from the control SNFs dropped from 13.8 percent to 12.0 percent. The demographic and clinical profile within the treatment facilities did not change appreciably over time, except for a slight increase in the percent of non-White patients and a longer length of stay upon readmission in the postperiod. Control SNF patients appear slightly less complex in the postperiod (fewer diagnoses, lower length of index hospitalization) and have lower unadjusted 30- and 14-day readmission rates to the study hospital.

We do not observe a significant relationship between hospital-SNF HIE and change in likelihood of readmissions in any of our model specifications (Figure 1). Our marginal effects (ME) estimate pre- to postperiod changes in likelihood of readmission for patients in treatment SNFs, relative to declines also observed in the control group. All differences in declining likelihood of readmissions over time between treatment and control SNFs were found to be nonsignificant. Estimated risk-adjusted likelihood of 30-day readmissions for treatment SNF patients declined 3.9 percent compared to a 6.1 percent decline for patients in control facilities (+2.2 percentage points; $P$ = .431). Estimated likelihood of 14-day readmissions declined 2.6 percent for treatment facilities compared to 6.2 percent in control SNFs (+3.7 percentage points; $P$ = .136). Treatment SNF patients did see a 1.2 percentage point *greater* decline in estimated likelihood of 7-day readmissions (−2.5 percent) compared to decline in control (−1.3 percent), but results are again insignificant ($P$ = .548). Removing the risk-adjustment controls included in the model does not meaningfully change these results.

Results remain insignificant and directionally consistent when accounting for a learning period. When we use the alternate model with SNF and calendar year fixed effects, coefficients across all three outcomes become negative, suggesting greater declines in estimated likelihood of readmission for patients in treatment vs control SNFs (−1.2 percent for 30-day readmissions; $P$ = .516; −0.1 percent for 14-day readmissions; $P$ = .951; −2.4 percent for 7-day readmissions; $P$ = .083). All treatment effects, however, remain insignificant.

### 3.2 | Descriptive statistics of portal usage

The portal was used for 46 percent of discharges for which it was available (range: 37.6 percent to 49.8 percent across facilities). A

**TABLE 1** Patient and encounter demographics for patients discharged to treatment and control SNFs

| | Preimplementation | | | Comparing changes within treatment and control, pre- vs postimplementation | | | |
|---|---|---|---|---|---|---|---|
| | Treatment SNFs Preportal | Control SNFs Preportal | Tx vs Control Difference of means *P*-values | Treatment SNFs Postportal | Control SNFs Postportal | Change for treatment (absolute), pre to post | Change for control (absolute), pre to post |
| Number of facilities | 3 | 8 | | | | | |
| No. of patient encounters | 1350 | 560 | | 5487 | 1428 | — | — |
| Percent of *all* hospital "discharge to SNF" patients received (not geographically restricted) [N = 4071 total patients preportal; N = 11 928 postportal] | 33.2% | 13.8% | | 46.0% | 12.0% | +12.8% | −1.8% |
| Patient demographics | | | | | | | |
| Age (SD) | 70.1 (14.5) | 72.7 (13.6) | ≤.001 | 69.7 (14.2) | 73.0 (12.8) | −0.4 | +0.3 |
| % Male | 43.7% | 41.8% | .550 | 45.7% | 43.0% | +2.0% | +1.2% |
| % White | 79.8% | 84.8% | .006 | 78.6% | 87.6% | −1.2%** | +2.8%* |
| Num. of diagnoses (SD) | 20.0 (9.2) | 21.0 (9.4) | .018 | 20.4 (9.2) | 20.3 (8.3) | +0.4 | −0.7* |
| % Returning (not new) patients to SNF discharge location | 13.4% | 14.9% | .400 | 10.6% | 9.2% | −3.6% | −5.7% |
| Patient utilization | | | | | | | |
| Avg. length of hospital stay, d (SD) | 9.0 (10.1) | 9.2 (10.3) | .603 | 10.3 (12.8) | 8.6 (7.8) | +1.3 | −0.6* |
| 30-d readmission rate to study hospital | 32.3% (46.7) | 28.9% (45.4) | .203 | 28.4% (45.1) | 24.2% (42.9) | −3.9% | −4.7%* |
| 14-d readmission rate to study hospital | 22.4% (41.7) | 22.0% (41.4) | .924 | 19.8% (39.9) | 16.5% (37.2) | −2.6% | −5.5%** |
| 7-d readmission rate to study hospital | 14.1% (34.8) | 12.1% (32.7) | .335 | 11.7% (32.1) | 10.3% (30.4) | −2.4% | −1.8% |
| Average length of readmission stay, d (SD) | 5.0 (8.0) | 5.0 (6.5) | .968 | 5.6 (7.4) | 6.2 (8.7) | +0.6* | +1.2 |

*$P \leq .05$.
**$P \leq .01$.

demographics and outcomes profile of patients that did and did not have associated portal use is presented in Table 2. Major unexplained differences in readmission rates between these groups reaffirmed our decision to use an intent-to-treat analysis.

Usage patterns varied significantly across the three facilities (see Figure 2). We observe a clustering of retrieval activity around the timing of transition; 55 percent of all data retrieval (ie information retrieval actions) occurred within 3 days before or after transfer from hospital to SNF. Usage close to timing of discharge was more pronounced in Facilities 2 and 3, with significant use in the days just prior to hospital discharge. The largest spike in portal use in Facility 1 occurred 8 days after discharge.

Table 3 characterizes the type and volume of information retrieved for patients, overall and across facilities. On average, SNF users conducted 10.5 information retrieval actions per patient for whom the portal was used (range: 7.1-12.6). This retrieval took place across an average of 3.2 usage sessions, with average session length ranging from 2.4 to 4.8 minutes across the three facilities. Facility 1 had the fewest average usage sessions (1.9 per patient), but longest average session time (4.8 minutes).

Across all facilities, the top three categories of information accessed included information from surgical care provided during hospitalization (45.1 percent of total retrieval actions, range of 15 percent-55 percent by facility), the summary patient review screen (21.7 percent of all actions, range of 18 percent-31 percent), and information regarding patients' ambulatory visit history and record details (18.3 percent of actions, range of 12 percent-44 percent). Average time per action within each information category ranged from 11.4 seconds for labs/imaging up to 72 seconds viewing a patient history/health maintenance information retrieval action.

We also observed variation across the three facilities in less common, or secondary, uses of the portal. Facilities 2 and 3 sometimes utilized the portal to retrieve orders and results related to laboratories and imaging (6.3 percent and 11.6 percent of total actions, respectively, compared to 1.1 percent in Facility 1). Facility 2 also utilized other inpatient documentation—primarily the inpatient physician clinical overview note (5.7 percent of total actions, range of 1.4 percent-2.4 percent in other facilities). Facility 1 was more likely to use the portal to pull up "problem detail" notes (4.4 percent of total actions, 0.3 percent-0.4 percent in other facilities).

Visualization of the sequencing of information retrieval is included as Figure S3. Users across facilities primarily started with the patient summary review screen. Use in Facility 1 then transitioned to looking at Ambulatory Data—documentation related to prior and upcoming scheduled patient care in ambulatory settings; Facilities 2 and 3 pursued a mixed approach of retrieval actions categorized under Ambulatory Data as well as Inpatient-Surgical documentation (the most common action in this category was viewing transcription of operating room notes). We observed a fair amount of back-and-forth "tabbing" between information categories within a use session across all facilities. Facility 3 was unique in the segment of portal uses that exclusively accessed information around patient history and records of health maintenance (ie immunization records).

## 4 | DISCUSSION

The use of a view-only EHR portal as an HIE mechanism to improve information sharing between a large academic hospital and three SNFs had no effect on the likelihood of patient readmissions, a key indicator of transitional care quality. Evaluating portal-based exchange is particularly important given how widely used these tools are as a relatively low-investment method to initiate data sharing with other

| Change in likelihood of readmission in treatment SNFs pre vs. post-portal, relative to control SNFs | | | |
|---|---|---|---|
| | Estimate (SE) | P-Value | 95% Confidence Interval |
| 30-Day Readmissions | | | |
| Main Model | 0.022 (0.027) | 0.431 | [-0.033– 0.076] |
| Main model, no controls | 0.017 (0.028) | 0.529 | [-0.037– 0.072] |
| With Learning Period | 0.017 (0.028) | 0.539 | [-0.038 – 0.072] |
| Alternate specification with facility and year fixed effects | -0.012 (0.019) | 0.516 | [-0.049 – 0.025] |
| 14-Day Readmissions | | | |
| Main Model | 0.037 (0.025) | 0.136 | [-0.012 – 0.087] |
| Main model, no controls | 0.034 (0.025) | 0.166 | [-0.014 – 0.083] |
| With Learning Period | 0.034 (0.025) | 0.182 | [-0.016 – 0.084] |
| Alternate specification with facility and year fixed effects | -0.001 (0.016) | 0.951 | [-0.034 – 0.032] |
| 7-Day Readmissions | | | |
| Main Model | -0.012 (0.020) | 0.548 | [-0.052 – 0.028] |
| Main model, no controls | -0.011 (0.020) | 0.568 | [-0.051 – 0.028] |
| With Learning Period | -0.012 (0.021) | 0.569 | [-0.052 – 0.029] |
| Alternate specification with facility and year fixed effects | -0.024 (0.014) | 0.083 | [-0.052 – 0.003] |

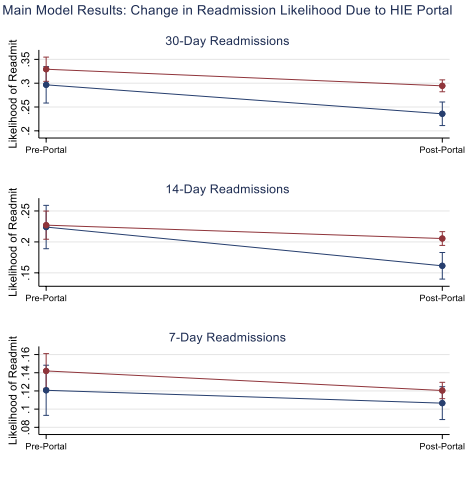


**FIGURE 1** Estimated effects of HIE on likelihood of hospital readmissions [Color figure can be viewed at wileyonlinelibrary.com]
*Note.* ‡Patient-level control variables included in these models: age, race, length of hospitalization, total number of diagnoses, whether patient is a new or returning SNF patient, and primary health condition related to reason for hospitalization, categorized based on the Clinical Classification Software used by the Agency for Healthcare Research and Quality.

**TABLE 2** Demographics and outcomes profile for patients with and without associated HIE portal use at HIE-enabled SNFs

| | Patients with HIE use[a] | Patients with no HIE use | Difference of means *P*-values |
|---|---|---|---|
| No. of patient encounters | 2420 | 2889 | |
| Patient demographics | | | |
| Age (SD) | 70.5 (14.0) | 69.4 (14.1) | .007 |
| % Male | 45.6% | 45.5% | .965 |
| % White | 78.9% | 78.6% | .807 |
| Num. of diagnoses (SD) | 19.4 (8.7) | 21.6 (9.2) | ≤.001 |
| Percent that are new vs returning SNF patients | New: 93.1%<br>Returning: 6.9% | New: 86.2%<br>Returning: 13.8% | ≤.001 |
| Patient utilization | | | |
| Average length of index hospitalization (SD) | 8.4 (7.7) | 10.2 (9.0) | ≤.001 |
| 30-d readmission rate to study hospital | 24.3% | 32.5% | ≤.001 |
| 14-d readmission rate to study hospital | 16.2% | 23.4% | ≤.001 |
| 7-d readmission rate to study hospital | 8.1% | 14.9% | ≤.001 |
| Average time until readmission, days (SD) | 11.5 (7.3) | 9.7 (7.5) | ≤.001 |
| Average length of readmission stay, days (SD) | 5.1 (6.4) | 5.9 (7.9) | .054 |

[a]Use within the defined 16-d window.

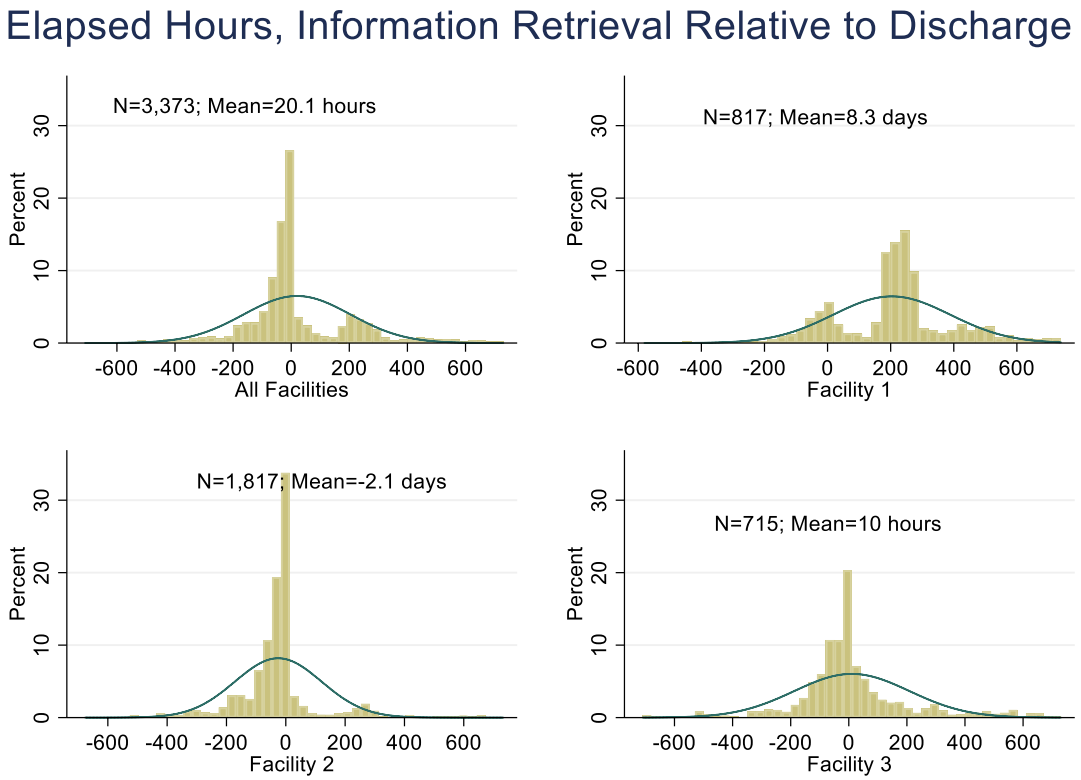


**FIGURE 2** Timing of information retrieval via portal, overall, and by facility. X axis represents number of hours elapsed from time of discharge [Color figure can be viewed at wileyonlinelibrary.com]

**TABLE 3** Portal information retrieval, volume, and categories of information sought

| | All facilities | | | Facility 1 | | Facility 2 | | Facility 3 | |
|---|---|---|---|---|---|---|---|---|---|
| **Volume of information retrieved** | **Average (SD)** | | | | | | | | |
| Average number of retrieval actions taken, total duration of stay | 10.5 (11.1) | | | 7.1 (4.9) | | 12.6 (12.1) | | 8.9 (12.3) | |
| Average number of portal usage sessions/patient, total duration of stay | 3.2 (3.0) | | | 1.9 (1.0) | | 3.7 (4.2) | | 3.4 (2.9) | |
| Average time spent during retrieval session[a] | 3.96 (6.88) | | | 4.79 (6.35) | | 2.40 (4.57) | | 4.11 (7.4) | |
| **Information category** | **Number of actions** | **(%)** | **Avg. time per action (s)** | **Num.** | **(%)** | **Num.** | **(%)** | **Num.** | **(%)** |
| Inpatient surgical | **15 638** | **45.1** | 46.2 | 889 | 15.1 | **12 492** | **55.1** | **2257** | **36.8** |
| Summary review screen | 7519 | 21.7 | 19.8 | 1806 | 30.7 | 4214 | 18.6 | 1499 | 24.4 |
| Ambulatory | 6358 | 18.3 | 54.0 | **2582** | **43.9** | 2639 | 11.6 | 1137 | 18.5 |
| Lab/imaging/results | 2210 | 6.4 | 11.4 | 63 | 1.1 | 1437 | 6.3 | 710 | 11.6 |
| Inpatient, other | 1511 | 4.4 | 41.4 | 139 | 2.4 | 1288 | 5.7 | 84 | 1.4 |
| Demographics/billing | 384 | 1.1 | 45.6 | 20 | 0.3 | 300 | 1.3 | 64 | 1.0 |
| Problem detail | 344 | 1.0 | 63.6 | 258 | 4.4 | 62 | 0.3 | 24 | 0.4 |
| Orders | 304 | 0.9 | 18.6 | 6 | 0.1 | 148 | 0.7 | 150 | 2.4 |
| History/health maintenance | 271 | 0.8 | 72.0 | 92 | 1.6 | 40 | 0.2 | 139 | 2.3 |
| ED/outpatient | 155 | 0.5 | 49.2 | 32 | 0.5 | 47 | 0.2 | 76 | 1.2 |
| Total | 34 694 | 100% | — | 5887 | — | 22 667 | — | 6140 | — |

[a]Excludes sessions with just one retrieval action (time cannot be calculated).

organizations. To our knowledge, this is the first outcomes evaluation of HIE specifically in the context of SNF transitions. Our null findings are consistent with the most recent HIE evidence review, which finds that studies with a utilization outcome (ie readmissions) are the most commonly conducted yet least likely to demonstrate benefits (relative to studies with cost, quality, or public health surveillance outcomes).[21]

Hospitals are facing increasing financial accountability for patients' total cost of care and are tightening referral networks with select postacute providers, investing more selectively with these organizational partners in improved infrastructure and integrated handoff processes. As such, implementing HIE to support transitions of care is rarely an isolated strategy.[15,19,20] However, even with other concurrent changes our study hospital may have made around the time of HIE rollout, our results suggest no overall beneficial treatment effect from these efforts. This null average treatment effect could, however, be muting beneficial impact for certain patient subpopulations in ways we are not well-positioned to detect. Other recent research, for example, illustrates that the pressures and effectiveness of resulting strategies to control postacute utilization and quality do in fact vary by patient condition and encounter-specific incentives.[30]

In our study, we observed a nearly 13 percentage point increase in the percent of the hospital's "discharge to SNF" patients directed to the treatment SNFs pre- vs postportal implementation. Shifting organizational relationships may have modified the distribution of patient clinical profiles in our treatment SNFs in ways that we were unable to observe. It is unclear, however, in what direction those changes might occur. Being a primary referral partner might mean your facility is obligated to take the more complex, difficult-to-place patients; on the other hand, there is some evidence that SNFs can leverage this preferential relationship to admit more "preferred" (ie low complexity) patients.[20] In our study, the minimal difference in results between our models with and without controls leaves open the possibility that significant unobservable changes are taking place in the postperiod. In future work, it will be critical to better describe how changing referral patterns alters patient characteristics and volumes across postacute settings, and how that influences whether and for whom we might be able to detect measurable improvements from efforts to strengthen integrated transitional care processes.

Significant variation observed in when and how we identified HIE being used is likely reflective of both the broad scope of potential information needs that prompt system use, as well as implementation challenges that hinder the value of available IT resources.

Measurable improvements in outcomes resulting from health IT are unlikely unless systems are implemented in a way that supports workflow integration; further, those usage practices must deliver sufficient user value for workflow changes to be sustained.[34] Our data show that the HIE portal was used only 46 percent of the time when available, and at variable timing relative to patient transition. Though this rate is higher than HIE use reported elsewhere,[34,35] a significant portion of this use (over 40 percent) occurred well outside the window of patient transition (ie the days just prior to and following discharge from hospital to SNF, when opportunity for errors or gaps in care are most likely to occur). Overall use less than 50 percent of the time suggests that IT-enabled information retrieval was not incorporated as a standard component of SNF transitional care workflows. This could be due to known operational challenges facing SNF leadership and management, including high staff turnover and resource constraints, as well as historically weak hospital relationships that result in issues such as lack of predictable timing as to when patients will arrive from the hospital at the SNF.[36] Each of these issues may create barriers to technology integration. SNFs also may not have prioritized HIE use because it did not facilitate access to the specific information needed to reduce readmissions, particularly given that the portal was not customized for SNFs.[31]

Our results do, however, offer insights into what some unique SNF information needs may be, which could serve to support such customization in the future. The differences we observe in the type of information retrieved by SNFs, and how it correlates with timing of use, suggest that inpatient-surgical documentation is a type of information that is particularly valuable to SNFs around the time of hospital discharge. This may be because management of pain medication and wound care associated with recent surgery are particularly time-sensitive patient needs; accessing information regarding prescriptions or materials that need to be specially ordered in advance of SNF admission could help avoid possible delays in needed care.[12] Similarly, review of laboratories and imaging as well as inpatient provider notes could reveal other needs (ie oxygen, patient isolation precautions) to help SNFs prepare for patient arrival.[31]

Finally, our observation of significant back-and-forth "tabbing" between information categories, revealed in sequence pattern analyses, underscores the cognitive complexity of developing a complete picture of patient needs during and after discharge from hospital to SNF. This user behavior could be indicative of significant (but ultimately satisfied) informational needs, or evidence of SNF providers seeking information that was ultimately unavailable through the portal. The former points to the need to redesign the portal to better facilitate usability of SNF-relevant information. If the latter, it is important to understand what these desired data elements are, and how to make this information available. Future system design and implementation efforts require a better typology of the types of information needs and information-seeking behavior that may prompt use of available electronic data sharing tools. Knowing whether data systems are meeting provider needs requires knowing what information was being sought and why; these needs vary by patient, by provider, and by encounter-specific context. For example, information retrieval can and should look different when used as an ad hoc searching resource complementary to other handoff processes vs as a substitute for complete information transfer in the absence of other meaningful coordination. Ultimately, higher-value information sharing systems require that hospitals and SNFs work together to build capacity for monitoring and assessing when systems are proving helpful or not. These data should be fed back in to design, implementation and use strategies better tailored to support postacute transitional care.

## 5 | LIMITATIONS

This study has several key limitations. One key challenge is that we cannot observe if a patient was readmitted to a hospital other than the focal hospital. We attempted to address this limitation through our modeling approach and by using a geographically proximate control group. However, it is still possible that HIE had an effect that we could not observe because of our inability to capture all readmissions.

Second, the intervention of interest (ie the portal implementation) occurred around the same time as other key interorganizational changes such as the hospital implementing onsite, hospital-employed physicians, and advanced care providers within the treatment SNFs. Had our results been significant, we would have had trouble disentangling the effect of these two different changes. However, our current results suggest that these combined efforts still did not move the needle on readmissions.

Third, we feel somewhat limited in our ability to include risk adjustment in our models, given the minimal differences between models with and without available controls. Unobservable differences in how the patient profile is changing between treatment and control SNFs are possible, given the rapid increase in the percent of patients being referred to the treatment SNFs. If the treatment SNFs are getting an increasingly clinically complex patient population relative to the control SNFs, inadequate risk adjustment could be masking some measurable, beneficial effect of the portal. If treatment SNFs are getting less complex patients over time, the lack of relative improvement in readmissions offers an even stronger signal to further evaluate and refine care integration efforts.

Fourth, in analyzing portal usage patterns, we were somewhat limited in our knowledge and interpretation of what type of information retrieval was actually taking place. We were only able to view information retrieval activity by SNF nurses and administrators in the context of a care transition; the subacute care team from the hospital had their own direct EHR access and these logs were unavailable to the research team. We also did not have access to paper discharge records. We are therefore not able to fully contextualize the volume or value of information retrieval through the portal relative to these other mechanisms of sharing. Second, actions recorded within the audit log were not always clear. For example, if the audit log revealed the action "Inpatient physician note viewed" three consecutive times, we are unable to discern if

that is the same note viewed three times, or three distinct notes. This is a common challenge in using EHR audit data, which is not originally intended to be used for research purposes. However, we try to work around this limitation by using multiple descriptive measures to characterize portal activity—looking not just at categories of information accessed, but also number of discrete actions and time spent within a portal usage session to understand depth of information retrieval.

Finally, in terms of external validity, the study took place within a single academic medical center and three local skilled nursing facilities that used one type of electronic information sharing within one vendor system. Epic is a dominant commercial vendor, and portals are a common application for electronic information sharing.[24,35] However, it is important to study the relationship between HIE and hospital-SNF transitions in a broader group of institutions using a wider variety of HIE approaches.

## 6 | CONCLUSION

Analysis of the impact of an HIE portal to enable information sharing between a large academic medical center and three skilled nursing facilities revealed no effect on patient likelihood of readmissions, relative to patients discharged to facilities without portal access. Descriptive, contextual data revealed that the portal was utilized inconsistently within the window surrounding patient handoff—and with variation in the types of information sought. These patterns suggest challenges with HIE implementation and usability as well as continued lack of understanding of the information needs and types of information searching that best support such complex transitions. Ultimately, creating greater value through HIE will require more targeted efforts to develop and make available tailored design and usage approaches that are responsive to the needs and challenges of postacute providers.

## ACKNOWLEDGMENTS

*Joint Acknowledgment/Disclosure Statement*: Dori Cross was supported by a Rackham Predoctoral Fellowship from the University of Michigan to complete this work.

*Disclosures*: Julia Adler-Milstein now holds a Hartford Foundation grant on the topic of information sharing between hospitals and skilled nursing facilities.

## ORCID

*Dori A. Cross* https://orcid.org/0000-0003-3489-3954
*Julia Adler-Milstein* https://orcid.org/0000-0002-0262-6491

## REFERENCES

1. Tian W. *An All-Payer View of Hospital Discharge to Postacute Care, 2013*. Agency for Healthcare Research and Quality, Healthcare Cost and Utilization Project; 2016.
2. Medicare Payment Advisory Commission. *Report to the Congress: Medicare payment policy [Internet]. Chapter 7, Medicare's post-acute care: trends and ways to rationalize payments*; [cited 2019 Jun 17]. Washington, DC: MedPAC; 2015. http://www.medpac.gov/docs/default-source/reports/chapter-7-medicare-s-post-acute-care-trends-and-ways-to-rationalize-payments-march-2015-report-.pdf
3. Boockvar K, Vladeck BC. Improving the quality of transitional care for persons with complex care needs. *J Am Geriatr Soc*. 2004;52(5):855-856.
4. LaMantia MA, Scheunemann LP, Viera AJ, Busby-Whitehead J, Hanson LC. Interventions to improve transitional care between nursing homes and hospitals: a systematic review. *J Am Geriatr Soc*. 2010;58(4):777-782.
5. Naylor MD, Brooten DA, Campbell RL, Maislin G, McCauley KM, Schwartz JS. Transitional care of older adults hospitalized with heart failure: a randomized, controlled trial. *J Am Geriatr Soc*. 2004;52(5):675-684.
6. Popejoy L, Galambos C, Vogelsmeier A. Hospital to nursing home transition challenges: perceptions of nursing home staff. *J Nurs Care Qual*. 2014;29(2):103-109.
7. Murray LM, Laditka SB. Care transitions by older adults from nursing homes to hospitals: implications for long-term care practice, geriatrics education, and research. *J Am Med Direct Assoc*. 2010;11(4):231-238.
8. Tjia J, Bonner A, Briesacher BA, McGee S, Terrill E, Miller K. Medication discrepancies upon hospital to skilled nursing facility transitions. *J Gen Intern Med*. 2009;24(5):630-635.
9. Gurwitz JH, Field TS, Avorn J, et al. Incidence and preventability of adverse drug events in nursing homes. *Am J Med*. 2000;109(2):87-94.
10. Mor V, Intrator O, Feng Z, Grabowski DC. The revolving door of rehospitalization from skilled nursing facilities. *Health Aff*. 2010;29(1):57-64.
11. Georgiou A, Marks A, Braithwaite J, Westbrook JI. Gaps, disconnections, and discontinuities—the role of information exchange in the delivery of quality long-term care. *Gerontologist*. 2013;53(5):770-779.
12. King BJ, Gilmore-Bykovskyi AL, Roiland RA, Polnaszek BE, Bowers BJ, Kind AJ. The consequences of poor communication during transitions from hospital to skilled nursing facility: a qualitative study. *J Am Geriatr Soc*. 2013;61(7):1095-1102.
13. Shah F, Burack O, Boockvar KS. Perceived barriers to communication between hospital and nursing home at time of patient transfer. *J Am Med Direct Assoc*. 2010;11(4):239-245.
14. Cross DA, Adler-Milstein J. Investing in post-acute care transitions: electronic information exchange between hospitals and long-term care facilities. *J Am Med Direct Assoc*. 2017;18(1):30-34.
15. Zhu JM, Patel V, Shea JA, Neuman MD, Werner RM. Hospitals using bundled payment report reducing skilled nursing facility use and improving care integration. *Health Aff*. 2018;37(8):1282-1289.
16. Mechanic R. Post-acute care—the next frontier for controlling Medicare spending. *N Engl J Med*. 2014;370(8):692-694.
17. Grabowski DC, Stevenson DG, Caudry DJ, et al. The impact of nursing home pay-for-performance on quality and Medicare spending: results from the nursing home value-based purchasing demonstration. *Health Serv Res*. 2017;52(4):1387-1408.
18. Centers for Medicare & Medicaid Services (CMS), HHS. Medicare Program; prospective payment system and consolidated billing for skilled nursing facilities for FY 2017, SNF Value-Based Purchasing Program, SNF Quality Reporting Program, and SNF Payment Models Research. Final rule. *Fed Reg*. 2016;81(151):51969.
19. McHugh JP, Foster A, Mor V, et al. Reducing hospital readmissions through preferred networks of skilled nursing facilities. *Health Aff*. 2017;36(9):1591-1598.
20. Shield R, Winblad U, McHugh J, Gadbois E, Tyler D. Choosing the best and scrambling for the rest: hospital-nursing home

relationships and admissions to post-acute care. *J Appl Gerontol*. 2018;38(4):479-498.
21. Menachemi N, Rahurkar S, Harle CA, Vest JR. The benefits of health information exchange: an updated systematic review. *J Am Med Inform Assoc*. 2018;25(9):1259-1265.
22. Yeager VA, Vest JR, Walker D, Diana ML, Menachemi N. Challenges to conducting health information exchange research and evaluation: reflections and recommendations for examining the value of HIE. *eGEMs*. 2017;5(1):15.
23. Ackerly DC, Grabowski DC. Post-acute care reform—beyond the ACA. *N Engl J Med*. 2014;370(8):689-691.
24. Johnson C, Pylypchuk Y, Patel V. *Methods Used to Enable Interoperability among U.S. Non-Federal Acute Care Hospitals in 2017*. ONC Data Brief, No. 43. Washington, DC: Office of the National Coordinator for Health Information Technology; 2018.
25. MedPAC. *Data Book: Health Care Spending and the Medicare Program*. Washington, DC: Medicare Payment Advisory Commission; 2018.
26. Centers for Medicare and Medicaid Services. *CMS Advances Interoperability & Patient Access to Health Data through New Proposals [Internet]*. 2019. https://www.cms.gov/newsroom/fact-sheets/cms-advances-interoperability-patient-access-health-data-through-new-proposals. Accessed June 30, 2019.
27. Rahman M, Foster AD, Grabowski DC, Zinn JS, Mor V. Effect of Hospital–SNF referral linkages on rehospitalization. *Health Serv Res*. 2013;48(6pt1):1898–1919.
28. Konetzka RT, Stuart EA, Werner RM. The effect of integration of hospitals and post-acute care providers on Medicare payment and patient outcomes. *J Health Econ*. 2018;1(61):244-258.
29. Kripalani S, Theobald CN, Anctil B, Vasilevskis EE. Reducing hospital readmission rates: current strategies and future directions. *Annu Rev Med*. 2014;14(65):471-485.
30. Colla CH, Lewis VA, Stachowski C, Usadi B, Gottlieb DJ, Bynum JP. Changes in use of postacute care associated with accountable care organizations in hip fracture, stroke, and pneumonia hospitalized cohorts. *Med Care*. 2019;57(6):444-452.
31. Cross DA, McCullough JS, Adler-Milstein J. Drivers of health information exchange during postacute care transitions. *Am J Manage Care*. 2019;25(1):e294-e300.
32. Puhani PA. The treatment effect, the cross difference, and the interaction term in nonlinear "difference-in-differences" models. *Econ Lett*. 2012;115(1):85-87.
33. Adler-Milstein J, Daniel G, Grossmann C, et al. *Return on Information: A Standard Model for Assessing Institutional Return on Electronic Health Records*. Washington, DC: National Academy of Sciences, Institute of Medicine; 2014:1-21.
34. Rudin RS, Motala A, Goldzweig CL, Shekelle PG. Usage and effect of health information exchange: a systematic review. *Ann Intern Med*. 2014;161(11):803-811.
35. Everson J. The implications and impact of 3 approaches to health information exchange: community, enterprise, and vendor-mediated health information exchange. *Learn Health Syst*. 2017;1(2):e10021.
36. Gadbois EA, Tyler DA, Shield R, et al. Lost in transition: a qualitative study of patients discharged from hospital to skilled nursing facility. *J Gen Intern Med*. 2018;18:1-8.

## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**How to cite this article:** Cross DA, McCullough JS, Banaszak-Holl J, Adler-Milstein J. Health information exchange between hospital and skilled nursing facilities not associated with lower readmissions. *Health Serv Res*. 2019;54:1335–1345. https://doi.org/10.1111/1475-6773.13210