Journal of Gastrointestinal Surgery (2019) 23:1643–1651
https://doi.org/10.1007/s11605-018-4033-1

ORIGINAL ARTICLE

Complete Impact of Care Fragmentation on Readmissions Following Urgent Abdominal Operations

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Received: 29 August 2018 / Accepted: 23 October 2018 / Published online: 8 January 2019

Abstract

Background Urgent abdominal operations commonly occurred in low-volume hospitals with high failure-to-rescue rates. Recent studies have demonstrated a survival benefit associated with readmission to the original hospital after operation, presumably due to improved continuity of care. It is unclear if this survival benefit persists in low-volume hospitals. We seek to evaluate differences in mortality between readmission to the original hospital and a higher-volume hospital after urgent abdominal operations.

Methods A retrospective cohort study using the National Readmissions Database from 2010 to 2014 was performed. Propensity score-weighted multilevel regression analysis was used to examine the association between readmission destination and mortality after accounting for hospital volume.

Results A total of 71,551 adult patients who experienced 30-day readmission following urgent abdominal operations were identified, among whom 10,368 (14.5%) were readmitted to a different hospital. Patients with higher baseline comorbidity scores, lower income, less comprehensive insurance coverage, systemic complications, prolonged length of stay, or non-home disposition were more likely to experience readmission to a different hospital. Following stratification by readmission hospital volume and propensity score weighting to adjust for baseline mortality risk differences, readmission to a different hospital is still associated with higher mortality rates than the original hospital.

Conclusions The adverse outcomes associated with case fragmentation are present even after adjusting for readmission hospital volume. Patients who received urgent abdominal operations at low-volume hospitals should return to the original hospital for concern of care fragmentation.

Keywords Care fragmentation · Care discontinuity · Readmission · Abdominal surgery

Meeting Presentations Podium presentation at the 89th Pacific Coast Surgical Association Annual Meeting on February 17, 2018, in Napa, CA

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11605-018-4033-1) contains supplementary material, which is available to authorized users.

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Introduction

Nationwide, a few abdominal operations, including appendectomy,[1] cholecystectomy, urgent colectomies,[2] and exploration for bowel obstruction,[3] incarcerated hernia,[4] and perforated ulcers[5] accounted for more than 80% of the urgent operation case volume, mortality, complications, and inpatient costs in 2016.[6] A number of studies have suggested that a substantial proportion of postoperative complications occur after initial discharge[7,8] and up to one in every four patients is readmitted within 30 days.[9–13] These unplanned rehospitalizations, in turn, have been associated with significant mortality and costs.[7] While factors affecting in-hospital outcomes of these operations have been well characterized, little is known regarding variables contributing to their readmission outcomes. Therefore, metrics associated with poor outcomes during readmission may provide valuable targets for surgical quality improvement.

Several recent studies have demonstrated a survival benefit for patients readmitted back to the original hospital due to the presumed preservation of continuity of care.[13–15] Care fragmentation, broadly defined as any disjointed care due to discontinuity between healthcare systems,[16,17] has been found to be a major risk factor for worsened outcome during readmission.[17–19] Most hospitals do not share inpatient data with one another[20] and discharge summaries are frequently incomplete and finished in a delayed fashion.[21] Readmission to a different hospital, i.e., non-original hospital readmissions, can negatively impact information continuity. However, the unpredictable nature of urgent abdominal operations (UAO) frequently predisposes patients to choose hospitals out of expediency rather than quality.[22] Therefore, a sizable proportion of UAO is regularly performed at low-volume non-metropolitan hospitals.[15] Moreover, previous studies have demonstrated low institutional case volume to be associated with a higher failure-to-rescue rate when postoperative complications occur.[3,23,24] It is unclear whether the original hospital remains the optimal readmission destination if it is a low-volume center. We hypothesized that care fragmentation would adversely affect readmission mortality, length of stay, and discharge destination regardless of the operative volume at the readmission hospital. The present study aimed to compare clinical outcomes of rehospitalizations following UAO between patients readmitted to the original and non-original hospitals with different case volumes.

Methods

Data Source

We used the Nationwide Readmissions Database (NRD)[25] to study patients who were readmitted within 30 days of discharge following six UAO categories between January 1st and November 30th in each year from 2010 to 2014. The NRD is a nationally representative repository, sampling 21 State Inpatient Databases maintained by the Healthcare Cost and Utilization Project (HCUP), designed to allow analysis of national readmission patterns for all payers and the uninsured. It employs a stratified, single-stage cluster sampling algorithm to enable estimation of up to 35 million discharges annually. Both patient-specific and hospital identification numbers were available to allow tracking of a patient across hospitalizations in multiple institutions within a state in the same year.

Inclusion and Exclusion Criteria

Patients were included if they underwent one of six urgent abdominal operations. The six procedures were chosen due to their frequency and included appendectomy, cholecystectomy, colectomy, operation for incarcerated ventral hernia, operation for bowel obstruction, and operation for perforated or bleeding peptic ulcer.[6] We used a combination of International Classification of Diseases 9th Revision (ICD-9) procedure and diagnosis codes to identify these procedures (see eTable 1 for the list of ICD-9 codes used). For example, colectomy patients were included only if they had both one of the corresponding procedure codes, including 45.7 partial excision of colon or 45.8 total excision of colon, AND one of the diagnosis codes, including colitis (555–558), colonic obstruction (560), diverticulitis (562.11, 562.13), perforation (569.83), peritonitis (567), or gastrointestinal hemorrhage (578). Patients less than 18 years of age and those whose hospitalization were tabulated as elective or related to trauma were excluded. The resultant cohort was used to estimate national case volume, hospital case volume, and 30-day readmission rates.

Patients were further excluded if not readmitted within 30 days following discharge or were transferred to another inpatient facility. Additionally, we excluded patients who did not survive to discharge or if the identified operation was not the final inpatient surgical procedure for the subject. Figure 1 displays the flowchart for the selection of the study population.

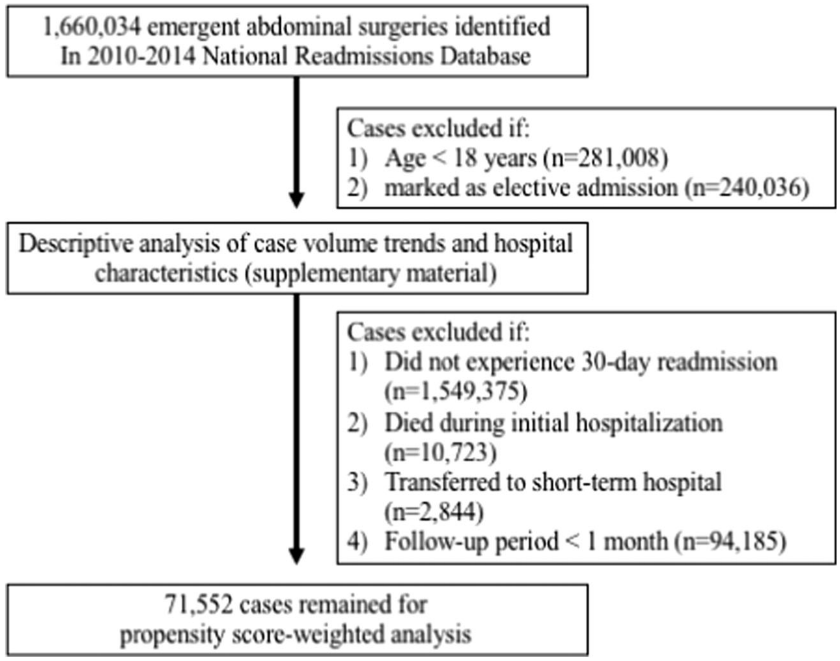
Variables of Interest

The primary exposure variable was the patients' readmission destination: readmission to the original hospital where UAO was performed was designated as "original hospital readmission," while hospitalization at a different hospital was considered "non-original hospital readmission." In the NRD, pairs of records representing a transfer were collapsed into a single "combined" record with the eventual hospital's unique ID being represented in the hospitalization.

Patient- and hospital-level exposure variables included age, gender, Charlson comorbidity index,[26] median household income, insurance status, and population for the county of residence, as well as hospital bed size, teaching status, and annual UAO volume. The Charlson comorbidity index was calculated using a validated formula based on the up to 30 ICD-9 diagnoses that were available with each hospital discharge.[26] Hospital case volume for each category of UAO was used to generate quartiles for comparison.

Outcomes examined during initial hospitalization included in-hospital complications, hospital stay, and discharge disposition. In-hospital complications were identified using ICD-9 codes and classified as either surgical or systemic (see eTable 1 for detailed list of codes). Surgical complications denoted conditions located either at the

Fig. 1 Flow chart of patient population selection process. A total of 71,552 patients were identified as experiencing 30-day readmission after receiving urgent abdominal operations during the study period



surgical incision or the specific organ space where the operation took place. Prolonged hospital stay was defined as a length of stay longer than 12 days based on existing literature.[27] Discharge disposition was classified as either routine home discharge, home with home healthcare, against medical advice, or other, including transfer to skilled nursing facility or intermediate care facility.

The primary outcome of interest is in-hospital mortality during 30-day readmission. Secondary outcome of interest included prolonged length of stay, discharge disposition other than routine home discharge, and systemic complications including any postoperative complications occurring in anatomical locations other than the surgical site, such as pneumonia, acute renal failure, or myocardial infarction.[28]

Statistical Analysis

Initially, estimates of national case volume were calculated for each of the six procedures along with the distribution of case volume based on hospital bed size, location, and teaching status. All reported sample size in this study represented national estimates, calculated using stratification, clustering, and survey weights in accordance with the NRD sampling design.[25]

Following identification of 30-day readmission, patients were classified as either undergoing original hospital or non-original hospital readmission based on their rehospitalization destination. Each of the patient- and hospital-level exposure variables and outcome measures during initial hospitalization was examined for univariate association with subsequent non-original hospital readmission. A mixed-effect, multilevel logistic regression model was constructed to identify risk factors independently associated with likelihood of subsequent non-original hospital readmission, using hospital as the random effect. The Hosmer-Lemeshow test was used to assess its goodness of fit.[29] A p value of greater than 0.05 was interpreted as the observed outcome matching the predicted outcome in subgroups of the model population; therefore, the prediction model was well calibrated. In addition, receiver-operator characteristics were calculated to give the probability that a randomly selected patient who experienced non-original hospital readmission would have a higher risk score than a patient who underwent original hospital readmission.[30]

The resulting model with reasonable goodness of fit was used to assign propensity scores accounting for baseline patient and initial outcome differences between the comparison groups. The application of propensity score model and weighting under the constraints of complex survey data was performed in accordance with methods described by DuGoff et al.[31] Subsequently, propensity score-weighted univariate logistic regressions were used to examine associations between non-original hospital readmission and in-hospital mortality during readmission among the entire cohort and stratified by readmission hospital case volume quartiles. All tests were two-sided, with the significance level set at $\alpha = .05$. All statistical analyses were performed using Stata version 13 (StataCorp). This work was deemed exempt from review by the Institutional Review Board at the University of California, Los Angeles.

Results

During the study period, an estimated 1,660,034 UAO were performed in the USA (tabulated in eTable 2), most occurring in hospitals with low case volume. The 30-day readmission rate ranged from 6.0% after appendectomies to 25.0% after procedures for bowel obstruction.

After application of exclusion criteria (see Fig. 1), 71,551 patients who experienced 30-day readmission remained. Rehospitalization destination characteristics and outcomes are shown in Table 1. Mortality and systemic complications occurred in 2.7% and 21.3% of patients during readmission, respectively. Among surviving patients, 68.5% were discharged home, while 17.4% required home healthcare, and 12.3% were transferred to skilled nursing facility, 9.0% were transferred to short-term hospital, and 8.3% were left against medical advice.

Patient demographics, operations, and original hospital characteristics for the rehospitalized cohort are shown in Table 1. Of all 30-day readmissions, 10,368 (14.5%) occurred in a non-original hospital and ranged from 13.0% after appendectomies to 18.7% after operations for incarcerated hernia. Non-original hospital readmissions occurred more frequently following operations at low-volume centers, ranging from 10.3% in patients who received operation at the highest volume quartile hospitals to 16.3% at the lowest volume quartile hospitals.

In order to identify risk factors associated with non-original hospital readmission, a mixed-effect multilevel logistic regression analysis was performed using original hospital readmission as the random effects variable (shown in Table 2). This model passed the Hosmer-Lemeshow test with a p value of 0.96 and was associated with a C-statistic of .69. A higher baseline Charlson comorbidity score, lower income, and limited insurance coverage (Medicare or Medicaid) were all risk factors for non-original hospital readmission. Patients were less likely to return to the original hospital if they experienced a systemic complication, experienced prolonged length of stay, or were discharged to any destination other than home after the initial hospitalization. After adjusting for other baseline differences, case volume of the initial hospital was no longer associated with odds of subsequent non-original hospital readmission.

Of the non-original hospital readmissions, 26.5% were to a hospital belonging to a higher case volume quartile than the original, and 22.6% to a lower case volume hospital. Without adjustment, non-original hospital readmissions were associated with a significantly higher mortality rate, systemic complications, prolonged length of stay, and non-home disposition (see Table 3).

All the significant factors associated with non-original hospital readmission also predisposed patients to mortality during rehospitalization. In order to adjust for the baseline differences in mortality risk during readmission, a propensity score was assigned for each patient, predicting the probability of non-original hospital readmission using the above-described logistic regression model (Table 2). Following propensity score weighing, univariate logistic regression of the entire cohort demonstrated that non-original hospital readmission remained a significant risk factor for mortality (OR 1.68, 95% CI 1.38–2.04) and systemic complications (OR 1.21, 95% CI 1.11–1.32).

In addition, we investigated whether the survival advantage of readmission to the original hospital was present after taking the original hospital case volume into consideration. Non-original hospital readmissions were associated with higher readmission mortality only in patients who received operations at centers with case volume below the 25th percentile (OR 1.63, 95% CI 1.28–2.08, $p < .001$) and 25–50th percentiles (OR 1.98, 95% CI 1.39–2.83, $p < .001$). On the other hand, no significant mortality difference was observed among the small number of patients who received operation at hospitals with case volume at the 50–75th percentiles (OR 1.62, 95% CI 0.52–5.10, $p = 0.40$) or above the 75th percentile (OR 0.59, 95% CI 0.17–2.05, $p = 0.40$). In other words, the mortality difference between original and non-original hospital readmissions was only present if the initial operation was performed at a low-volume center.

Discussion

Rates of unplanned rehospitalizations after major operations are now routinely utilized as quality metrics and have major clinical and financial implications.[8,32] Despite identification of risk factors for readmission in the existing literature,[8,32] few have examined the association between readmission destination volume and clinical outcomes.[33] In the present analysis of the Nationwide Readmissions Database, non-original hospital readmissions constituted approximately 14.5% of the 30-day readmissions following UAO. Patients who experienced non-original hospital readmissions frequently exhibited more comorbidities and socioeconomic risk factors that predisposed them to higher mortality. However, after adjusting for these baseline differences, non-original hospital readmissions continued to be associated with elevated in-hospital mortality during readmission. This association was particularly pronounced among patients who received operations at low-volume hospitals.

While previous studies have shown a positive correlation between postoperative outcome and surgical volume on a hospital level,[23,24] we found that most UAO in the USA were performed at hospitals with very low institutional volume. For instance, hospitals at the 75th percentile case volume only performed 57 appendectomies, 24 operations for incarcerated

Table 1 Patient and hospital characteristics during initial admission (percentage by row)

	Original hospital readmission, $n = 61{,}183$ (85.5%)	Non-original hospital readmission, $n = 10{,}368$ (14.5%)	*p* value
Operations			
Appendectomy	22,601 (36.9%)	3364 (32.4%)	< 0.001
Operation for bowel obstruction	12,621 (20.6%)	1894 (18.3%)	
Operation for incarcerated hernia	9991 (16.3%)	1915 (18.5%)	
Cholecystectomy	7921 (12.9%)	1822 (17.6%)	
Colectomy	6562 (10.7%)	1067 (10.3%)	
Operation for perforated peptic ulcer	1488 (2.4%)	306 (2.9%)	
Patient characteristics			
Age group			
18–65 years	40,102 (65.5%)	6769 (65.3%)	0.68
65–80 years	13,332 (21.8%)	2227 (21.5%)	
> 80 years	7749 (12.7%)	1371 (13.2%)	
Gender			
Male	28,912 (47.3%)	4934 (47.6%)	0.73
Female	32,271 (52.7%)	5,4345 (52.4%)	
Charlson comorbidity index			
0	34,498 (56.4%)	5276 (50.9%)	< 0.001
1–4	23,507 (38.4%)	4412 (42.6%)	
> 4	3178 (5.2%)	681 (6.6%)	
Median household income quartile			
0–25th percentile	16,934 (28.1%)	3134 (30.8%)	< 0.001
25–50th percentile	15,185 (25.2%)	2665 (26.2%)	
50–75th percentile	14,614 (24.2%)	2368 (23.3%)	
75–100th percentile	13,556 (22.5%)	2005 (19.7%)	
Insurance status			
Medicare	23,492 (38.4%)	4397 (42.4%)	< 0.001
Medicaid	7906 (12.9%)	1549 (14.9%)	
Private insurance	21,675 (35.4%)	3139 (30.3%)	
Others or missing	8110 (13.3%)	1284 (12.4%)	
Patient residence county*			
"Central" metropolitan w/ population ≥ 1 million	5734 (26.4%)	1008 (27.0%)	< 0.001
"Fringe" metropolitan w/ population ≥ 1 million	5731 (26.4%)	911 (24.4%)	
Population 250K–999K	4626 (21.3%)	711 (19.0%)	
Population 50K–249K	2188 (10.1%)	271 (7.2%)	
Population 10–50L	2046 (9.4%)	444 (11.9%)	
Others	1411 (6.5%)	393 (10.5%)	
Original hospital characteristics			
Hospital case volume quartile			
1–25th percentile	34,599 (56.6%)	6747 (65.2%)	< 0.001
25–50th percentile	18,643 (30.5%)	2641 (25.5%)	
50–75th percentile	4944 (8.1%)	623 (6.0%)	
75–100th percentile	2979 (4.9%)	343 (3.3%)	
Initial surgery outcome			
Systemic complications	11,216 (18.3%)	2286 (22.0%)	< 0.001
Surgical complications	9365 (15.3%)	1496 (14.4%)	0.90
Prolonged LOS > 12 days	7125 (11.6%)	1436 (13.8%)	< 0.001
Discharge disposition			
Routine home	45,795 (74.8%)	7358 (71.0%)	< 0.001
Home healthcare	7967 (13.0%)	1195 (11.5%)	
Other, including SNF and ICF	7162 (11.7%)	1611 (15.5%)	
Against medical advice	276 (0.5%)	201 (1.9%)	

SNF, skilled nursing facility; *ICF*, intermediate care facility

*Information regarding patient residence county is missing in 18,990 patients, representing 62.4% of the data

Table 2 Propensity score model identifying factors predicting non-original hospital readmission

Variables	Odds ratio (95% confidence interval)	*p* value
Operations		
Colectomy	1 (baseline)	
Operation for bowel obstruction	1.03 (0.90–1.17)	0.66
Appendectomy	1.10 (0.96–1.26)	0.15
Operation for perforated peptic ulcer	1.32 (1.05–1.67)	0.02
Operation for incarcerated hernia	1.27 (1.11–1.46)	< 0.001
Cholecystectomy	1.56 (1.35–1.80)	< 0.001
Age group		
18–65 years	1 (baseline)	
65–80 years	1.55 (1.35–1.77)	< 0.001
> 80 years	1.16 (1.03–1.30)	0.02
Gender		
Male	1 (baseline)	
Female	0.96 (0.90–1.03)	0.23
Charlson comorbidity index		
0	1 (baseline)	
1–4	1.11 (1.03–1.20)	0.03
> 4	1.24 (1.07–1.44)	0.004
Median household income quartile		
0–25th percentile	1.15 (1.04–1.27)	0.007
25–50th percentile	1.09 (0.99–1.20)	0.09
50–75th percentile	1.07 (0.97–1.18)	0.20
75–100th percentile	1 (baseline)	
Insurance status		
Medicare	1.35 (1.21–1.51)	< 0.001
Medicaid	1.22 (1.10–1.36)	< 0.001
Private insurance	1 (baseline)	
Others or missing	1.03 (0.92–1.16)	0.57
Hospital case volume quartile		
1–25th percentile	1.17 (0.95–1.44)	0.13
25–50th percentile	1.08 (0.88–1.32)	0.46
50–75th percentile	1.04 (0.83–1.30)	0.75
75–100th percentile	1 (baseline)	
Systemic complications	1.15 (1.06–1.25)	< 0.001
Surgical complications	.95 (0.87–1.04)	0.30
Prolonged LOS > 12 days	1.22 (1.08–1.37)	0.001
Discharge disposition		
Routine home	1 (baseline)	
Home healthcare	1.01 (0.92–1.11)	0.81
Other, including SNF and ICF	1.43 (1.29–1.60)	< 0.001
Against medical advice	1.94 (1.45–2.60)	< 0.001

SNF, skilled nursing facility; *ICF*, intermediate care facility

hernia, 11 cholecystectomies, 12 operations for bowel obstructions, 8 colectomies, and 2 operations for perforated ulcer, annually. For certain procedures, previous literature has shown that patients who received surgery at low-volume hospitals were associated with a higher readmission rate,[34] which was manifest in our observation that discharges from hospitals with the lowest case volume quartile made up 57.8% of the 30-day readmissions. Our findings suggested that despite evidence for improved postoperative outcomes at high-volume centers, the urgency of UAO diagnoses as well as geographic and accessibility issues may present barriers to choosing the optimal facility for such operations.

Table 3 Outcomes following 30-day readmission (percentage by column)

	Original hospital readmission, *n* = 61,183 (85.5%)	Non-original hospital readmission, *n* = 10,368 (14.5%)	*p* value
In-hospital mortality	1462 (2.4%)	471 (4.5%)	< 0.001
Systemic complications	12,520 (20.5%)	2717 (26.2%)	< 0.001
Surgical complications	22,115 (36.1%)	2380 (23.0%)	< 0.001
Prolonged LOS > 12 days	4903 (8.0%)	1191 (11.5%)	< 0.001
Discharge disposition			
Routine home	41,929 (68.5%)	6690 (64.5%)	< 0.001
Home healthcare	10,971 (17.9%)	1681 (16.2%)	
Other, including SNF and ICF	7843 (12.8%)	1853 (17.9%)	
Against medical advice	438 (0.7%)	142 (1.4%)	

SNF, skilled nursing facility; *ICF*, intermediate care facility

In a practical sense, patients and referring providers were limited in their hospital choice due to the urgent nature of these cases. However, patients may have a choice in the readmission process. Should patients opt for a non-original hospital with better quality of care or should they return to the original hospital in order to preserve continuity of care? While considerable controversy existed regarding the optimal benchmarking parameter for quality of care, we used case volume due to its established correlation with lower failure-to-rescue rate.[3,23,24] Besides institutional quality of care, the second factor to consider when choosing readmission destination was continuity of care. In our study, we defined non-original hospital readmission as a marker for fragmented care. After adjusting for all baseline differences in mortality risk, we found that non-original hospital readmission was associated with a higher in-hospital mortality compared to rehospitalization at the original hospital. Furthermore, this association persisted following stratification by hospital volume, especially among lower case volume hospitals. The overwhelming significance of care fragmentation on surgical outcomes was corroborated by several existing reports in the literature.[9,15,35,36] Unlike previous publications which have focused on complex specialized operations routinely performed at high-volume facilities, the present study examined the impact of care fragmentation in UAO, which was ubiquitously performed across all hospital types.[14,37–40] It is worthwhile to note that a few investigators have reported no association between non-original hospital readmission and outcomes.[41,42] However, these were mostly reports of institutional case series with considerably lower statistical power and none have accounted for the case volume and quality of care at the readmission facility. Taken together, our results suggested that the impact of care fragmentation exceeds that of failure-to-rescue at low-volume facilities and should be considered in future policies addressing value-based delivery of healthcare.

The overwhelming consensus of superiority of original hospital readmission leads one to wonder, why would patients opt for a non-original hospital readmission facility? If such decisions were voluntary, it was reasonable to hypothesize that patients turning to a non-original facility may have been unsatisfied with their care during the initial hospitalization, as evident by the significantly higher proportion of patients having been discharged against medical advice in the non-original hospital readmission group than in the original hospital readmission group. However, patients may also have been readmitted to a non-original hospital involuntarily. We, along with several previous reports, have found that patients who underwent non-original hospital readmissions were socioeconomically disadvantaged, were living in rural residences, and had more baseline comorbidities and complex pre-existing conditions,[15,35] leading one to hypothesize that their readmission destination choice may have been limited due to insurance restriction, accessibility issues, or inability to make decisions for their own care.

Several considerations should be noted when interpreting the results of the current study. Due to the retrospective nature of our data source, readmission destination was inevitably subject to selection bias and unmeasured confounding, including factors such as time to presentation and geographic access to healthcare. Being aware that the potential for poor care coordination and the consequences of fragmented care are compounded by patient complexity may guide future initiatives to identify cohorts at elevated risk for care fragmentation. Second, hospital volume may or may not be the best summary statistic for quantifying hospital's quality of care and competence in managing complications. Future research should focus on designing objective measures of hospital quality of care for different applications and purposes. In addition, due to the lack of physician-level variable in the current database, it is difficult to discern patients who have undergone non-original hospital readmissions but were cared for by the same surgeon if the surgeon provided healthcare services across different hospitals.

Conclusions

Our study highlights the outcomes benefit of returning to the original hospital for postoperative complication, especially if the original hospital was associated with low surgical volume. Whether this observation stemmed from an optimized continuity of care in small hospitals or their poor cross-institutional medical record hand-off remains to be clarified with higher-granularity clinical data. While it is not realistic nor desired to have all urgent abdominal operations performed at centers of excellence, changes in the hospital compensatory structure and performance measures may facilitate cross-organizational post-discharge coordination of care and be a likely candidate strategy to reduce mortality during readmissions.

Author Contribution Substantial contribution to the conception or design of the work: Juo, Sanaiha, Tillou, Dutson, Benharash

Acquisition, analysis or interpretation of data: Juo, Sanaiha, Khrucharoen

Drafting the work or critical revision: Juo, Sanaiha, Khrucharoen, Tillou, Dutson, Benharash

Final approval of the version to be submitted: Juo, Sanaiha, Khrucharoen, Tillou, Dutson, Benharash

Agreement to be accountable for all aspects of the work: Juo, Sanaiha, Khrucharoen, Tillou, Dutson, Benharash

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