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Fragmentation of Care after Surgical Discharge: Non-Index Readmission after Major Cancer Surgery

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Abstract

BACKGROUND—Despite national emphasis on care coordination, little is known about how fragmentation affects cancer surgery outcomes. Our study examines a specific form of fragmentation in post-discharge care—readmission to a hospital different from the location of the operation—and evaluates its causes and consequences among patients readmitted after major cancer surgery.

STUDY DESIGN—We used the State Inpatient Database of California (2004 to 2011) to identify patients who had major cancer surgery and their subsequent readmissions. Logistic models were used to examine correlates of non-index readmissions and to assess associations between location of readmission and outcomes, measured by in-hospital mortality and repeated readmission.

RESULTS—Of 9,233 readmissions within 30 days of discharge after major cancer surgery, 20.0% occurred in non-index hospitals. Non-index readmissions were associated with emergency readmission (odds ratio [OR] = 2.63; 95% CI, 2.26–3.06), rural residence (OR = 1.81; 95% CI, 1.61–2.04), and extensive procedures (eg hepatectomy vs proctectomy; OR = 2.77; CI, 2.08–3.70). Mortality was higher during non-index readmissions than index readmissions independent of patient, procedure, and hospital factors (OR = 1.31; 95% CI, 1.03–1.66), but was mitigated by adjusting for conditions present at readmission (OR = 1.24; 95% CI, 0.98–1.58). Non-index

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readmission predicted higher odds of repeated readmission within 60 days of discharge from the first readmission (OR = 1.16; 95% CI, 1.02–1.32), independent of all covariates.

CONCLUSIONS—Non-index readmissions constitute a substantial proportion of all readmissions after major cancer surgery. They are associated with more repeated readmissions and can be caused by severe surgical complications and increased travel burden. Overcoming disadvantages of non-index readmissions represents an opportunity to improve outcomes for patients having major cancer surgery.

Readmissions after cancer surgery are common and costly. An estimated 13% to 30% of patients who have had major cancer surgery are readmitted within 30 days of discharge.^{1–7} Recent studies have also shown that these readmissions raise the total cost of care substantially.^{1,4} Although it is imperative to reduce the burden of readmissions,^{8,9} they still serve the crucial function of rescuing patients from surgical complications in the postoperative period.^{4,10} Given the widespread, critical, and expensive nature of postoperative readmissions, factors that impact their outcomes warrant close examination.

National emphasis has been placed on improving care coordination in the postdischarge period.^{11,12} Postsurgical coordination across multiple settings has proven to be difficult and affects patients' clinical outcomes.¹³ It was reported that among those readmitted after major cancer surgery, 22% to 79% are readmitted to a hospital other than that where the index cancer surgery was performed.^{1,7,14–18} Such non-index readmissions constitute a form of care fragmentation and challenge care coordination between index and readmitting hospitals.¹⁸ Despite the ponderous evidence from medical research that associates provider continuity with better patient outcomes and provider fragmentation with lower quality of care and higher costs,^{19–22} this hypothesis has not been sufficiently tested in postoperative settings. In the case of major cancer surgery, readmissions are known to be strongly driven by surgical complications,^{2,4–6,10,17,23,24} making provider and information continuity particularly relevant in such scenarios. However, the relationship between location and outcomes of readmission remains largely unexplored among cancer patients, with the exception of gastrectomy and radical cystectomy.^{15,25}

Owing to today's landscape of drastic regionalization in major cancer surgery, it is even more challenging to keep postdischarge care continuous and coordinated. An increasing proportion of patients might be readmitted to non-index hospitals as a result of the growing burden for patients to travel to the operative index hospital.^{26,27} It is therefore critical to evaluate causes and consequences of non-index readmission to inform clinical practice and policies on postdischarge patient management. To close this gap, our study sought to answer 3 central questions about this issue. First, what is the prevalence of non-index hospital readmissions after major cancer surgery? Second, what are the potential demographic and clinical drivers behind these readmissions to non-index hospitals? Third, is non-index readmission associated with worse outcomes, such as mortality and repeated readmissions?

METHODS

Data source

We chose to include the following 6 major cancer surgery procedures, all of which are complex oncologic resections performed in inpatient settings involving relatively high risk: esophagectomy, gastrectomy, pancreatectomy, hepatectomy, proctectomy, and lung resections.^{28,29} We identified 69,128 adult patients who underwent 1 of these 6 major cancer operations as the primary inpatient procedure between January 1, 2004 and September 30, 2011 from State Inpatient Database (SID) of California using ICD-9-CM procedure codes (Appendix 1; available online).

We chose to focus specifically on cancer procedures because cancer care requires a multidisciplinary team where care coordination is particularly crucial, and readmission after surgery has been known to affect cancer patients by delaying life-saving adjuvant therapies.³⁰ In addition, cancer operations will likely be included in the target procedures of Affordable Care Act readmission penalties. This has been implied as part of the growing emphasis on bundle payment for oncology care, which has underestimated the impact of surgical treatment in cancer therapy outcomes.

The SID discharge database is a part of the AHRQ Healthcare Cost and Utilization Project.³¹ To appropriately track individual patients and their readmission, we restricted our sample to discharge records with a nonmissing person ID (visitLink³²) and the first complex cancer surgery on record for each patient. Our analytical dataset consists of 9,233 patients who were readmitted to a hospital in California within 30 days of index discharge. Patients transferred to other short-term hospitals at the end of index admission (n = 49) were excluded from the analysis.

To include hospital factors in the analyses, we linked the SID database to the 2009 American Hospital Association Annual Survey Database, a census of hospitals with detailed information on hospital structure and resources.

Variables

The variable of primary interest was the location of the first unplanned readmission within 30 days of the index admission. Location of readmission was dichotomized as index (where the index major cancer surgery was performed) hospital or non-index hospital. To qualify as an unplanned readmission, the hospitalization must be unscheduled and not a transfer (which does not constitute a new episode of hospitalization).

Patient characteristics included age, sex, race, insurance type, and location of residence (metropolitan vs micropolitan/rural). Patient's level of comorbidity was captured using Charlson's algorithm with Deyo's adaptations.³³ Hospital characteristics included region, teaching status, hospital control, bed size, system membership, and presence of cancer program. Year of admission was used as a categorical variable to adjust for possible fluctuations in yearly data collection. Dispositions from index admission were classified as routine, transfer to other facilities (excluding short-term hospitals, including skilled nursing facility, intermediate care facility, etc), home health care, and other. Counties in California

were combined into 2 categories: Los Angeles/Bay Area and other.³⁴ It should be noted that only the county of hospitals, but not of patient residence, was available from SID.

Readmission diagnoses were classified using Clinical Classification Software developed by Healthcare Cost and Utilization Project.³⁵ The first 5 diagnoses on the discharge record from a readmission were used to determine whether the patient had digestive, respiratory, circulatory, endocrine or nutritional, infectious, or genitourinary conditions, each defined as a binary variable. Only conditions present at admission were included in the analysis.

To assess both the immediate and delayed outcomes of non-index readmission, we evaluated 2 distinct quality measures. In-hospital mortality during readmission was an immediate result of treatment during readmission and presumably directly related to the condition that led to readmission. The other result was repeated readmission, defined as a separate episode of hospitalization within 60 days of discharge from the first readmission among those who survived the first readmission. Repeated readmission is a delayed result of readmission that reflects the medium-term course of postoperative care seeking.

Hospital characteristics included hospital ownership, bed size, membership, teaching status, whether the hospital has an American College of Surgeons-approved cancer program, and fill rate. Hospital fill rate was defined as the yearly mean of proportion of beds occupied, and was calculated by dividing total facility inpatient days by 365 then by total facility beds; this rate was then dichotomized into 2 levels: <80% and ≥80%. Six of 333 operative hospitals had fill rates slightly higher than 100%.

Statistical analyses

We first estimated rates of 30-day readmission to index and non-index hospitals for each procedure. We then compared distributions of patient characteristics between those readmitted to index and non-index hospitals using chi-square tests. Next, we used binary logistic regression to model probability of being readmitted to a non-index hospital among all patients who were readmitted by postdischarge day 30. All variables with $p < 0.2$ in the bivariate chi-square tests were entered into the model; stepwise selection of effects was used with criteria of both entry and removal set at a significance level 0.1. Due to the possibility that the location of readmission can affect how a given condition is coded by the readmitting hospital, these diagnoses were not used to model the location of readmission. A sensitivity analysis was conducted where all patients who were discharged from the index admission alive were included, and those that were not readmitted within 30 days constituted the third category in a 3-level response variable. A multinomial logistic model was used in which all applicable covariates were included. Outputs from this model were compared with its readmitted patients only binary model counterpart.

We subsequently used location of readmission as an explanatory variable to model readmission in-hospital mortality and rate of repeated readmission. Because we were primarily interested in unbiased estimate of the effect of non-index readmission, all patient and hospital factors were included as covariates. We compared estimates from regular logistic models and hierarchical logistic models with hospital random effect and robust estimator of standard error; the odds ratios associated with location of readmission were

similar between the 2 methods (within 5% of each other). Therefore, we decided to present results from regular logistic models to ease the calculation of model validity measures. Three models were constructed sequentially for each of the outcomes: a base model adjusting for patient and basic clinical factors, an extended model adding hospital characteristics, and a third model adding readmission diagnoses. Another sensitivity analysis was performed by substituting same-hospital readmission with same-system readmission, that is, whether the operative and readmission hospitals belonged to the same health care system, to predict outcomes of the readmission.

Validity of all models was assessed via c-statistic and Hosmer-Lemeshow tests. All analyses were conducted using SAS software, version 9.4 (SAS Institute Inc). All statistical tests were 2-sided and used a 0.05 significance level.

RESULTS

Rates of readmission

Rates of 30-day readmission ranged from 9.9% after lung resections to 19.18% after pancreatectomy, with an overall rate of 13.4% among all 6 procedures (Table 1). Among those, readmissions to non-index hospitals accounted for an overall 20.0%, ranging from 14.3% in proctectomy to 29.6% in esophagectomy.

Patient and hospital characteristics by location of readmission after major cancer surgery

Overall, patients readmitted to non-index hospitals were slightly older (median age 68 years vs 66 years), more likely to be non-Hispanic white (70.5% vs 63.8%), Medicare beneficiaries (61.4% vs 52.3%), live in rural/micropolitan area (31.6% vs 21.4%), and have higher comorbidity level (proportion with Charlson Comorbidity Index ≥ 2 was 20.8% vs 16.9%) than those readmitted to index hospital (Table 2). The vast majority of readmissions to both index and non-index hospitals were through the emergency department, although non-index hospitals observed a higher proportion of emergency readmissions (87.5% vs 74.1%). The time interval between discharge and readmission was longer for non-index than index readmissions (median 10 vs 8 days). Patients readmitted back at the index hospital were slightly less likely to have been operated at a high fill rate hospital (fill rate $\geq 80\%$) than those readmitted elsewhere (28.4% vs 31.5%; $p = 0.008$).

When comparing structural characteristics of readmitting hospitals by index status (Table 2), the non-index hospitals had fewer beds (proportion with ≥ 400 beds: 13.2% vs 31.5%), were more likely to be for profit (15.6% vs 6.5%), not a member of a hospital system (29.9% vs 26.7%), nonteaching (78.9% vs 51.5%), and lack a cancer program approved by the American College of Surgeons (57.3% vs 40.9%) than index readmission hospitals. Among all readmitted patients, 55.5% had their index surgery in the Los Angeles/Bay Area, but only 52.0% were readmitted to a hospital there (Supplementary Table 1; available online). Of the Los Angeles/Bay Area index patients, 7.1% were readmitted in other areas of California. In contrast, only 0.9% of patients whose index surgery was performed outside of Los Angeles/Bay Area were readmitted to a hospital in Los Angeles/Bay Area.

Table 3 provides a summary of conditions present at readmission abstracted from each readmitted patient's first 5 readmission diagnoses. Compared with patients readmitted back at the index hospital, non-index readmitted patients present at readmission with more respiratory (31.5% vs 23.4%; $p = 0.001$), circulatory (47.1% vs 43.5%; $p = 0.0046$), endocrine or nutritional (49.3% vs 42.9%; $p = 0.001$), infectious (18.2% vs 16.2%; $p = 0.0042$), and genitourinary conditions (18.2% vs 16.2%; $p = 0.0036$), but less digestive conditions (39.0% vs 44.4%; $p = 0.001$). The most frequent 15 primary diagnoses were presented by location of readmission in Supplementary Table 2 (available online).

Correlates of non-index readmissions after major cancer surgery

Table 4 shows the adjusted odds ratios (ORs) of different patient characteristics for non-index readmission. Clinical factors, such as route of readmission (OR of emergency vs routine readmission = 2.63; 95% CI, 2.26–3.06) and type of cancer procedure were associated with non-index readmissions. The more complex/extensive oncologic resection exhibited higher odds for non-index readmission than proctectomy (eg hepatectomy OR = 2.77; 95% CI, 2.08–3.70; esophagectomy OR = 2.46; 95% CI, 1.90–3.19). Patients with higher comorbidities were slightly more likely to be readmitted at a non-index hospital (OR of having a Charlson Comorbidity index 2 vs 0 was 1.19; 95% CI, 1.03–1.37). Meanwhile, later readmissions were slightly more likely to happen at a non-index hospital than earlier ones (OR of readmissions 15 to 30 days vs 1 to 7 days from discharge = 1.30; 95% CI, 1.15–1.47). Receiving operation at a hospital with higher fill rate (> 80%) was associated with 28% higher odds of being readmitted at a non-index hospital (OR = 1.28; 95% CI, 1.14–1.45).

Patients who live in non-metropolitan areas were 81% more likely than their metropolitan counterparts to be readmitted at a non-index hospital (OR = 1.81; 95% CI, 1.61–2.04). Patients discharged to non-hospital care facilities after index admission also had higher chance of being readmitted to non-index hospitals (OR = 1.25; 95% CI, 1.07–1.46). Major racial minority groups (Hispanic, Asian/Pacific Islander, and non-Hispanic blacks) all had about 23% lower odds of non-index readmission than non-Hispanic whites (OR = 0.76 to 0.77; all $p < 0.05$). Patient's age had a non-linear relationship with non-index readmission. Compared with patients 75 years or older, those 18 to 49 years were more likely (OR of non-index readmission = 0.80; 95% CI, 0.66–0.97), and those 65 to 74 years were less likely to be readmitted at index hospital (OR = 1.20; 95% CI, 1.04–1.37).

The model reported in Table 4 achieved a c-statistic of 0.658; Hosmer-Lemeshow test accepted the model.

Association between non-index readmissions after major cancer surgery with in-hospital mortality and repeated readmissions

In-hospital mortality during readmission was higher among readmissions at non-index hospitals than index hospitals after adjusting for patient- and index admission-related characteristics (OR = 1.36; 95% CI, 1.08–1.71; Table 5). This association was slightly attenuated by adjustment for characteristics of the readmission hospital (OR = 1.32; 95% CI, 1.03–1.66) and further attenuated by additional adjustment for readmission diagnoses (OR =

1.26; 95% CI, 0.99–1.61). Infectious (OR = 3.03; 95% CI, 2.43–3.78) and respiratory conditions (OR = 2.27; 95% CI, 1.81–2.84) at readmission were both moderately associated with increase in mortality. The three models had c-statistics of 0.720, 0.722 and 0.772, respectively. All models were accepted by Hosmer-Lemeshow tests.

Odds of repeated readmission within 60 days of discharge from first readmission were 15% higher for non-index than index readmissions (OR = 1.15; 95% CI, 1.02–1.30) in the base model, and robust against additional adjustment for hospital characteristics (OR = 1.17; 95% CI, 1.03–1.34) and readmission diagnoses (OR = 1.16; 95% CI, 1.02–1.32). No significant association was seen between diagnoses at first readmission and repeated readmission with the exception of genitourinary conditions (OR = 1.21; 95% CI, 1.07–1.38). The 3 models had c-statistics of 0.595, 0.597, and 0.601, respectively. All models were accepted by Hosmer-Lemeshow tests.

Sensitivity analysis

In the first sensitivity analysis, the estimated odds ratios for non-index vs index readmission were very close between the 3-level multinomial model and the binary model (all change in OR <8%). This suggests that including the un-readmitted patients in the analysis does not affect identification of associates of non-index readmissions. We chose to present estimates from the main analysis.

Among all non-index readmissions, 18.3% happened at a hospital within the same health care system as the index hospital; 59.6% of such cases occurred within the Kaiser system. In the second sensitivity analysis after adjusting for all covariates, different-system readmissions had a nonsignificant 16% higher mortality (OR = 1.16; 95% CI, 0.89–1.51) and a significant 22% higher odds of repeated readmission (OR = 1.22; 95% CI, 1.06–1.41) than same-system readmissions. The conclusions of this sensitivity analysis remain unchanged from the main analysis.

DISCUSSION

Our study aimed to analyze the widespread phenomenon of readmission to non-index hospitals after major cancer surgery by examining its causes and consequences. To our knowledge, this is the first systematic report on this topic. Our results suggest that 1 in every 5 thirty-day readmission after major cancer surgery occur in non-index hospitals; non-index readmission is a multifactorial phenomenon associated with a wide range of clinical and demographic factors and patients who had their first readmission at a non-index hospital after surgery are 16% more likely to experience additional episodes of hospitalization after discharge from first readmission.

We found that reasons for non-index readmission might stem from multiple domains. Notably, emergency readmission, extensive procedures, and rural residence of patients were all moderately associated with non-index readmissions. Our finding that rural residence of patients predicted non-index readmissions is in line with previous reports that rural patients bear greater burden to travel to the index hospital,²⁶ which in turn leads to higher non-index readmissions.^{16,18} Our data also showed that hospitals in Los Angeles or the Bay Area saw

more index admission than readmission, indicating that some patients of non-index readmissions likely traveled to Los Angeles or the Bay Area from other parts of California for the index surgery. On the other hand, in contrast to a previous report that concluded Medicare surgical patients were diverted to non-index hospitals for readmissions for primarily nonmedical reasons,³⁶ our findings that emergency readmission, extensive procedures, and comorbidity were all associated with non-index readmissions suggest non-index readmissions might be caused, at least in part, by severe and urgent complications.

Although research on medical patients has shown robust association between provider continuity and improved outcomes, evidence about the effects of provider continuity among surgical patients is sparse and sometimes contradictory.^{14–16,18,25,37} Our study suggests that although non-index readmission is associated with higher in-hospital mortality, this increase might be attributable to varying clinical conditions leading to readmissions at different locations. Similarly, a hospital-level analysis from New York state also found that although the aggregate 30-day mortality rate was higher at non-index hospitals than index hospitals after radical cystectomy, this elevation was mitigated by adjustment of covariates, including severity of illness and risk of mortality, which both captured all patient refined diagnosis-related group and diagnoses at readmission.¹⁵ Additional examination is warranted to evaluate whether non-index readmissions contribute to higher mortality outside of hospitals independent of reasons for readmission.

Our study also looked into the question of whether non-index readmissions predicted subsequent risk for repeated readmissions. Repeated readmissions occur in about 30% of all readmitted cancer surgery patients, but have not been well explored in the literature for patient outcomes. We showed that non-index readmission was associated with a 16% increase in odds of repeated readmission among patients of major cancer surgery. This might be caused by a combination of negative treatment effects of fragmented care and the need of patients to revisit the index hospital to seek specialty care and resolve problems associated with the operation.⁴ This trend agrees with the prevailing hypothesis in medical research that provider discontinuity is correlated with increased health care use.²⁰ Particularly, a study on patients of medical or surgical hospitalizations found that following up with the discharge hospital rather than community physicians was associated with lower rates of death or nonelective readmission.¹⁹

Our study is not free from limitations. First, due to lack of information on patients' residences, we were not able to measure the burden of travel to the index hospital. Although it is likely that patients who live far away from the index hospital are more likely to be readmitted at a non-index hospital,^{18,37} the literature has shown mixed results on the association between travel burden and surgical outcomes.^{38–40} It is therefore difficult to gauge how the lack of adjustment for travel distance might have confounded our estimates. Second, the administrative database used for the study lacks the granularity for precise determination of clinical condition. Despite our best efforts, we acknowledge that the ICD-9 coding of a condition might be influenced by the location of readmission. Third, we were also confined by the scope of our data source in that readmissions to hospitals outside of California and mortal events outside of hospitals were not captured in the California SID. The lack of mortality data outside of inpatient setting might present a potential for survival

bias that could be relevant to the analysis on non-index readmission's effect on repeated readmission. However, if the pattern of mortality by location of readmission was similar before and after discharge (ie mortality was higher after non-index than index readmissions), the survival bias would shift the estimated ORs closer to null. In that case, this particular type of bias is unlikely to have affected our conclusions.

Despite of these limitations, we believe our study fills an important gap in the literature. Strengths of our study include the following: we systematically investigated the causes and consequences of non-index readmissions after major cancer surgery, a phenomenon that is increasingly noteworthy due to fast centralization of surgical procedures; our analysis paid special attention to controlling the confounding among the causes, location, and outcomes of readmissions; multiple sensitivity analysis was performed; and our results should be applicable to the general population of major cancer surgery because we used a population-based database that is rich in diversity and inclusive of all payment methods and age groups.

Our study was designed as a first step to understanding the phenomenon of non-index readmissions among patients of major cancer surgery. Recent studies have found that travel burden and the need for reoperation can modify the effect of readmission location on its outcomes among Medicaid patients of general surgery.^{18,37} Whether such a phenomenon also exists among cancer surgery patients should be explored by future studies. The financial implication of non-index readmissions also warrants examination.

Given the considerable proportion of patients readmitted to a non-index hospital and the movement toward regionalization of care for certain complex procedures, our findings support continued efforts toward care coordination for patients traveling between hospitals or hospital systems. Strategies such as the medical home model and early discharge planning should be considered to reduce non-index readmissions. In the mean time, developing health information technology to enhance data sharing and facilitating communications between the index hospital and readmitting non-index hospitals might be viable approaches toward minimizing the negative consequences of fragmentation.

CONCLUSIONS

This report scrutinized a specific form of care fragmentation in postdischarge care—readmission to non-index hospitals after major cancer surgery. We found that non-index readmissions account for 1 in 5 readmissions within 30 days after discharge from index surgery. They occur more frequently in rural patients and might be caused by severe and urgent complications. Patients readmitted at non-index hospitals are at higher risk for repeated readmission. Results from our study shed light on an important aspect of postdischarge care coordination. Future research is needed to help understand this phenomenon and develop intervention strategies. These findings suggest that mitigating provider fragmentation with information continuity provides an opportunity to reduce overall costs and improve outcomes among patients of major cancer surgery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix 1. ICD-9 Procedure Codes Used for Identifying Major Cancer Surgery

Type of cancer resection	ICD-9 procedure codes
Esophagus	42.40–42.42
Gastrectomy	43.5, 43.6, 43.7, 43.91
Liver	50.3, 50.4
Pancreas	52.5–52.7
Rectal	48.5, 48.6
Lung	32.3–32.5

Rates of 30-Day Readmission after Major Cancer Surgery, State Inpatient Database of California 2004 to 2011 (N = 9,233)

Table 1

Type of procedure	Total procedures, n	Patients readmitted within 30 days		Patients readmitted within 30 days to non-index hospitals	
		n	% of Total procedures	n	% of 30-Day readmissions
Esophageal	2,251	375	16.7	111	29.6
Gastric	10,965	1,795	16.4	328	18.3
Liver	2,188	312	14.3	85	27.2
Pancreatic	8,940	1,774	19.8	379	21.4
Rectal	20,679	2,595	12.5	372	14.3
Lung	24,105	2,382	9.9	571	24.0
All	69,128	9,233	13.4	1,846	20.0

Table 2

Distribution of Characteristics of Patient and Readmitting Hospital by Location of First 30-Day Readmission after Major Cancer Surgery, State Inpatient Database of California 2004 to 2011 (N = 9,233)

Characteristic	Location of first readmission		p Value
	Index hospital (n = 7,387), %	Non-index hospital (n = 1,846), %	
Age			<0.0001
18–49 y	14.6	10.8	
50–64 y	31.0	26.3	
65–74 y	27.1	33.4	
75+ y	27.3	29.5	
Sex			0.41
Male	53.3	54.2	
Race/ethnicity			<0.0001
Non-Hispanic white	63.8	70.5	
Non-Hispanic black	6.3	5.0	
Hispanic	15.8	13.1	
Asian/Pacific Islander	11.4	8.5	
Other	2.7	3.0	
Median household income state quartile for patient ZIP code			0.21
First quartile	17.8	19.0	
Second quartile	20.6	22.2	
Third quartile	24.1	23.0	
Fourth quartile	24.3	24.2	
Primary payer			<0.0001
Medicare	52.3	61.4	
Medicaid	9.5	7.9	
Private	35.0	28.1	
Other	3.2	2.7	
Location			<0.0001
Rural/micropolitan	21.5	31.8	
Metropolitan	78.5	68.2	
Charlson Comorbidity Index			<0.0001
0	53.0	46.4	
1	30.1	32.8	
2+	16.9	20.8	
Procedure type			<0.0001
Esophageal	3.6	6.0	
Gastric	19.9	17.8	
Liver	3.1	4.6	

Characteristic	Location of first readmission		p Value
	Index hospital (n = 7,387), %	Non-index hospital (n = 1,846), %	
Pancreatic	18.9	20.5	
Rectal	30.1	20.2	
Lung	24.5	30.9	
Index disposition			<0.0001
Routine	57.0	52.1	
Non-hospital facilities	14.7	19.7	
Home care	28.0	27.8	
Route of readmission			<0.0001
Emergency	74.1	87.5	
Index hospital: fill rate			
80%	28.4	31.5	0.0078
Readmission hospital: ownership			<0.0001
Governmental, non-federal	17.8	14.5	
Not for profit	73.4	67.1	
For profit	6.5	15.6	
Readmission hospital: bed size			<0.0001
1–99	3.0	12.7	
100–399	63.2	71.2	
400	31.5	13.2	
Readmission hospital: member of a system	73.3	70.1	0.014
Readmission hospital: teaching hospital	48.5	21.1	<0.0001
Readmission hospital: has American College of Surgeons approved cancer program	59.1	42.7	<0.0001

ZIP, zone improvement plan.

Table 3

Conditions Present at First 30-Day Readmissions after Major Cancer Surgery by Location of Readmission, State Inpatient Database of California 2004 to 2011 (N = 9,233)

Condition* present at readmission	Location of first readmission		p Value
	Index hospital (n = 7,387), %	Non-index hospital (n = 1,846), %	
Digestive	44.4	39	<0.0001
Respiratory	23.4	31.5	<0.0001
Circulatory	43.5	47.1	0.0046
Endocrine or nutritional	42.9	49.3	<0.0001
Infectious	16.2	18.2	0.042
Genitourinary	16.2	18.2	0.036

* The first 5 ICD-9 diagnosis codes of each readmission record were used to identify conditions present at readmission; therefore, a patient might be represented in more than one row. The diagnosis codes were classified using the Clinical Classification System. Level 1 classification was used for this table.

Table 4

Adjusted Odds Ratios of Being Readmitted at Non-index Hospital among All Major Cancer Surgery Patients Readmitted Within 30 Days of Index Discharge, State Inpatient Database of California 2004 to 2011 (N = 9,233)

Effect	Odds ratio (95% CI)	p Value
Age (Ref = 75 y or older)		
18–49 y	0.80 (0.66–0.97)	0.026
50–64 y	0.88 (0.76–1.02)	0.089
65–74 y	1.20 (1.04–1.37)	0.011
Race (Ref = non-Hispanic white)		
Non-Hispanic black	0.76 (0.60–0.97)	0.028
Hispanic	0.77 (0.66–0.90)	0.0014
Asian/Pacific Islander	0.76 (0.63–0.92)	0.0054
Other	1.17 (0.85–1.60)	0.34
Patient residence (Ref = metropolitan)		
Rural/micropolitan	1.81 (1.61–2.04)	<0.0001
Fill rate of index hospital (Ref = <80%)		
80%	1.28 (1.14–1.45)	<0.0001
Type of resection (Ref = rectal)		
Esophageal	2.46 (1.90–3.19)	<0.0001
Gastric	1.32 (1.12–1.56)	0.0011
Liver	2.77 (2.08–3.70)	<0.0001
Pancreatic	2.77 (2.08–3.70)	<0.0001
Lung	1.63 (1.40–1.90)	<0.0001
Source of readmission (Ref = routine)		
Emergency	2.63 (2.26–3.06)	<0.0001
Time from discharge to readmission, d (Ref = 1–7 d)		
8–14 d	1.16 (1.02–1.33)	0.026
15–30 d	1.30 (1.15–1.48)	<0.0001
Charlson Comorbidity Index (Ref = 0)		
1	1.06 (0.94–1.21)	0.32
2+	1.19 (1.03–1.37)	0.020
Index disposition (Ref = routine)		
Other facilities	1.25 (1.07–1.46)	0.0043
Home care	1.05 (0.92–1.19)	0.49
Other	1.39 (0.61–3.19)	0.43

Ref, reference.

Table 5

Association Between the Location and Outcomes of Readmissions after Major Cancer Surgery, State Inpatient Database of California 2004 to 2011 (N = 9,233)

Variable	Readmission mortality		Repeated readmission [†]	
	Odds ratio (95% CI)	p Value	Odds ratio (95% CI)	p Value
Model 1 [‡]				
Non-index vs index readmission	1.36 (1.08–1.71)	0.008	1.15 (1.02–1.30)	0.025
Model 2 [§]				
Non-index vs index readmission	1.32 (1.03–1.67)	0.026	1.17 (1.03–1.34)	0.015
Model 3 [*]				
Non-index vs index readmission	1.26 (0.99–1.61)	0.065	1.16 (1.02–1.32)	0.023
Condition at readmission: present vs not				
Digestive	0.95 (0.75–1.19)	0.63	0.97 (0.88–1.08)	0.61
Respiratory	2.27 (1.81–2.84)	<0.0001	1.11 (0.98–1.25)	0.11
Circulatory	0.80 (0.65–1.00)	0.048	1.03 (0.93–1.14)	0.59
Endocrine or nutritional	0.67 (0.54–0.82)	0.0002	1.03 (0.93–1.13)	0.60
Infectious	3.03 (2.43–3.78)	<0.0001	1.12 (0.98–1.28)	0.090
Genitourinary	1.14 (0.88–1.49)	0.33	1.21 (1.07–1.38)	0.0034

* Adjusted for covariates in Model 1 and 2 and the conditions present at readmission, identified from the first 5 ICD-9 diagnosis codes. The diagnosis codes were classified using the Clinical Classification System.

[†] For repeated readmission, additional adjustment was made for destination of disposition from first readmission in all models.

[‡] Adjusted for characteristics of patient (age, sex, race, type of insurance, comorbidity, emergency status, procedure, and patient residence) and of the index admission (destination of disposition, hospital fill rate, and year of admission).

[§] Adjusted for covariates in Model 1 and characteristics of readmission hospital included region, control, bed size, membership, teaching status (approved by ACGME), and cancer program (approved by American College of Surgeons).