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Readmission after neurosurgical intervention in epilepsy: A nationwide cohort analysis

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Abstract

Objective—Hospital readmissions result in increased health care costs and are associated with worse outcomes after neurosurgical intervention. Understanding factors associated with readmissions will inform future studies aimed at improving quality of care in those with epilepsy.

Methods—Patients of all ages with epilepsy who underwent a neurosurgical intervention were identified in the 2014 Nationwide Readmissions Database, a nationally representative dataset containing data from roughly 17 million US hospital discharges. Diagnosis of epilepsy was based on International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)–based case definitions. Neurosurgical interventions for epilepsy: resective/disconnective surgery, responsive neurostimulation/deep brain stimulation, vagus nerve stimulation, radiosurgery, and intracranial electroencephalography were identified using ICD-9-CM procedure codes. Primary outcome was all-cause 30-day readmission following discharge from the index hospitalization.

Results—There were a total of 2284 index surgical admissions. Overall, 10.83% ($n = 251$) of patients following an index epilepsy surgery admission were readmitted within 30 days. Factors independently associated with 30-day readmission for all epilepsy surgery admissions were: Medicare insurance ($P < .01$), discharge disposition that was not home ($P < .01$), higher Elixhauser comorbidity indexes ($P < .01$), longer length of stay ($P < .01$), and adverse events of surgical and medical care during index stay ($P = .04$). In the multivariate model, Medicare insurance (hazard ratio [HR] 1.81 [1.29–2.53], $P < .01$) and length of stay (HR 1.02 [1.01–1.04], $P < .01$) remained significant independent predictors for 30-day readmission. The most common primary reason for readmissions was epilepsy/convulsions accounting for 22.85%.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

Significance—Our results suggest that careful management of postoperative seizures and discharge planning after epilepsy surgery may be important to optimize outcomes and reduce the risk of readmission, particularly for patients on Medicare.

Keywords

epilepsy; national readmission database; population-based; surgery

1 | INTRODUCTION

Recent standards established by the Centers for Medicare & Medicaid Services (CMS) have initiated programs to reduce the economic burden of hospital readmission by penalizing hospitals with higher than expected readmission rates.¹ Readmissions contribute to higher operating costs for healthcare systems as seen with unplanned 30-day readmissions costing Medicare \$17.4 billion in the year of 2004.²

Epilepsy surgery is highly effective in appropriately selected candidates with drug-resistant epilepsy.^{3,4} A nationwide study examining 30-day readmissions after surgical resection for drug-resistant epilepsy noted an 11.5% readmission rate.⁵ Other studies using the Agency for Healthcare Research Quality (AHRQ) State Inpatient Database (SID) reported readmission rates of up to 14% for seizures after resective epilepsy surgery.^{6,7}

Identifying modifiable risk factors and higher-risk patients for unplanned readmission after neurosurgical intervention in patients with epilepsy is paramount to improve postoperative outcomes. Using a nationally representative dataset capturing around 17 million US hospital discharges annually, we investigated causes and predictors of 30-day readmissions after neurosurgery in both adult and pediatric epilepsy populations. Understanding causes for readmission and their associated factors is important in order to implement future quality improvement initiatives aimed at reducing readmission after surgery in persons with epilepsy.

2 | METHODS

2.1 | Study design

A retrospective cohort study was conducted to examine factors and causes of 30-day readmissions among patients with epilepsy who underwent any of the following neurosurgical procedures: (a) resective/disconnective surgery, (b) responsive neurostimulation (RNS)/deep brain stimulation (DBS), (c) vagus nerve stimulation (VNS), (d) radiosurgery, and (e) intracranial electroencephalography (iEEG).

2.2 | Data source

The 2014 National Readmission Database (NRD), which is part of the Healthcare Cost and Utilization Project (HCUP) and sponsored by the AHRQ, was used for this study. The NRD is a nationally representative database on approximately 17 million hospital discharges. This database allows for the evaluation of readmission analyses across hospital types for all payers and the uninsured. It includes data from 22 geographically dispersed states and

accounts for 51% of the total US population and 49% of all hospitalizations. The patient information is collected from hospitals excluding rehabilitation or long-term acute hospitals.

National estimates can be obtained from the NRD as it includes discharge weights. Discharge weights are defined by dividing the number of hospital discharges nationally by the number of hospital discharges in the sampling frame. The sampling frame includes discharges in community hospitals that were poststratified by patient (gender, age) and hospital (census region, urban/rural location, teaching status, size of the hospital defined by the number of beds, and hospital control) characteristics.⁸

The NRD includes the following files: (a) hospital-level data—including type of hospital; (b) core data—patient data on admission/discharge, clinical information, demographics, readmission, and healthcare resource use; (c) severity data—ie, patient data on comorbidities; and (d) diagnosis and procedure groups. All four files were linked together using NRD unique record, hospital identifier, and patient linkage number. These numbers and identifiers are created by HCUP and all data are deidentified. The NRD allows analysis of readmissions with the use of an anonymized, verified linkage identifier for each patient. The study was approved by the Mount Sinai program for the protection of human subjects under IRB-IF2356842 and all analyses comply with the HCUP data-use agreement.

2.3 | Cohort identification

Patients were selected if they had a primary or secondary diagnosis of epilepsy based on 345.x ICD-9-CM diagnosis codes and had an epilepsy-related neurosurgical intervention based on ICD-9-CM procedure code (Table S1). The epilepsy case definition was based on previously published epilepsy validation studies.⁹ The index admission was defined between January 2014 and November 2014 as the first admission when a patient had any of the above-defined neurosurgical intervention and had non-missing length of stay as well as NRD days to event (count from “start date” to admission date) data.⁸ Exclusion criteria included: (a) diagnosis of status epilepticus without a concurrent epilepsy diagnosis; (b) all admissions before index surgical admission so as to only include likely first admissions for epilepsy surgery; (c) transfers; and (d) nonelective surgery.

3 | MEASURES

3.1 | Dependent variables

The primary outcome of interest was time to readmission within a 30-day period. The first readmission was defined following an index neurosurgical admission in a person with epilepsy within 30 days. Readmissions were defined using patient linkage number and time between admissions.⁸ All subsequent readmissions were excluded from the analysis. The secondary outcomes of interest were reasons for 30-day readmissions defined using clinical classifications software categories for diagnoses. The top reasons for readmissions were examined.

3.2 | Independent variables

Patient demographic, clinical, and hospital-level factors were examined. Patient demographic factors included age, sex, primary payer (Medicare, Medicaid, private insurance/other/ self-pay/no charge), median household income quartile for patient's zip code (\$0-\$39 999, \$40 000-\$50 999, \$51 000-\$65 999, and \$66 000). Clinical factors included: patient disposition (routine/home health care, transfer/against medical advice/destination unknown), AHRQ Elixhauser comorbidity index, length of stay (LOS), adverse events due to surgical and medical care, and adverse events due to medical drugs. Hospital-level factors included: control/ownership of hospital (public, private) and hospital size based on the number of beds (small/medium, large). Previous studies have mostly used comorbidity indexes (eg, Charlson and Elixhauser comorbidity indexes) that were developed to predict mortality; however, recently an index was developed to predict hospital readmissions and utilized for this study, the AHRQ Elixhauser comorbidity index.¹⁰ We have used this specific index developed on the Elixhauser comorbidity index to predict hospital readmissions for this study. The calculated models were adjusted for these comorbidities.

For the purpose of the current study, all health conditions were based on clinical classification codes or International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes unless otherwise specified. Reasons for readmission were identified using the AHRQ Clinical Classification Software (CCS) codes. Primary diagnosis position CCS codes were investigated to elucidate the primary reason for readmission. As according to the HCUP data agreement, cell sizes <10 are expressed as not reportable (NR).

3.3 | Statistical analysis

Baseline characteristics were defined at the index admissions with percentages and frequencies described for categorical variables and means and standard errors computed for continuous variables. Chi-square and *t* test were conducted to examine subgroup differences between patients who were readmitted within 30-days postsurgery as compared to those who were not readmitted. Ranked frequencies were assessed to identify the most common reasons for 30-day readmissions among patients who were readmitted within 30-days postsurgery. Unadjusted and adjusted cox regression analyses were performed to identify the factors associated with 30-day readmissions risk following any neurosurgical procedure. Hazard ratio and 95% confidence intervals were reported. The model was adjusted for all patient-, clinical-, and hospital-level factors, as defined above. All analyses were performed using Statistical Analysis Software version 9.4 (SAS Institute Inc, Cary, NC, USA) and accounted for sample design using stratum, cluster, and discharge weights to describe national estimates.

4 | RESULTS

A total of 2284 epilepsy patients underwent elective neurosurgery in 2014. Table 1 presents the baseline demographics of the total surgical sample and comparison for those who were readmitted within 30 days of surgery compared to those who were not. The mean age of all patients who had epilepsy and underwent any type of epilepsy surgical intervention was 36.5

years (range >0–90). Males represented 50.42% of the population. The majority of the cohort had the following: a routine postoperative discharge (ie, discharged home; 91.60%); had no adverse surgical and medical care events (92.16%); had no adverse events due to medical drugs (95.68%); were admitted to private, not-for-profit/private investment owned hospitals (88.04%); and were admitted to a hospital with large bed size (76.96%). More than half had private/other type of insurance/self-pay/no-charge (58.36%) and resided in an area with median household income greater than \$51 000 (54.09%). The mean Elixhauser comorbidity index was 5.46 (range –4–66) and patients stayed in hospital for on average 5.40 days (range 0–87). The patients had the following Elixhauser comorbidities: paralysis (9.66%), chronic pulmonary disease (9.48%), uncomplicated diabetes (5.68%), hypothyroidism (7.31%), metastatic cancer (1.84%), solid tumor without metastasis (3.00%), fluid and electrolyte disorders (10.82%), anemia (6.20%), psychosis (3.37%), depression (12.42%), hypertension (21.95%), and obesity (9.94%) (Table S2).

Of the 2284 patients who had epilepsy and underwent surgery, 251 (10.83%) were readmitted within 30 days of surgery. Thirty-day readmission proportions for each type of surgery were as follows: (a) resective/disconnective surgery 11.18%; (b) RNS/DBS 13.57%; (c) VNS 6.37%; (d) radiosurgery 10.15%; and (e) iEEG 11.15%. All were unique surgeries other than four patients who had iEEG and were readmitted for resective surgery within 30 days. As compared to those who did not have a readmission within 30 days of surgery, the readmitted population had a significantly higher proportion of patients with Medicare insurance (31.15% vs 18.93%; $P < .01$); adverse events due to surgery and medical care (11.45% vs 7.41%, $P = .04$); and the following comorbidities—paralysis (14.01% vs 9.13%; $P = .03$), uncomplicated diabetes (9.89% vs 5.16%, $P < .01$), metastatic cancer (3.32% vs 1.66%, $P = .02$), anemia (9.58% vs 5.79%; $P = .04$), and hypertension (29.61% vs 21.02%, $P < .01$) (Table 1 and Table S2). A significantly lower proportion of patients who had a readmission within 30 days were discharged home as compared to those without any readmission within 30 days (84.96% vs 92.40%; $P < .01$). Patients with a readmission within 30 days had a significantly higher mean Elixhauser comorbidity index (6.84 vs 5.30; $P = .01$) and LOS at the time of surgery (7.21 days vs 5.15 days; $P < .01$) as compared to those who did not have a readmission with 30-days postsurgery.

The top reasons for readmissions postsurgery included epilepsy/convulsions (22.85%); complications of surgical procedures or medical care (18.67%); and infections that included septicemia, pneumonia, and fever of unknown origin (7.77%). Top reasons for readmissions by surgery type were the following: (a) resective/disconnective surgery—epilepsy/convulsions, complications of surgical procedures or medical care; (b) RNS/DBS—epilepsy/convulsions, complications of device/implant/graft; (c) VNS—fluid and electrolyte disorders, residual codes; (d) radiosurgery—epilepsy/convulsions, cancer of brain and nervous system; (e) iEEG—epilepsy/convulsions, complications of surgical procedures or medical care.

Table 2 and Table S2 present results of the unadjusted and adjusted cox regression model to examine the factors associated with readmissions within 30-days postsurgery. In the unadjusted model, the following factors were associated with a higher risk of 30-day readmissions: patients insured through Medicare (hazard ratio [HR] = 1.89, 95% confidence

interval [CI] = 1.42, 2.50); those who had adverse events due to medical and surgical care (HR = 1.51, 95% CI = 0.99, 2.30); and those with the following comorbidities: paralysis (HR = 1.54, 95% CI = 1.02, 2.31), uncomplicated diabetes (HR = 1.86, 95% CI = 1.24, 2.80), metastatic cancer (HR = 1.88 95% CI = 1.10, 3.22), anemia (HR = 1.64, 95% CI = 1.02, 2.64), and hypertension (HR = 1.53, 95% CI = 1.15, 2.03). Patients with routine discharge had a lower risk of 30-day readmissions as compared to those discharged to a facility (HR = 0.50, 95% CI = 0.34, 0.73). Increased risk for 30-day readmissions were estimated with increasing Elixhauser comorbidity index (HR = 1.02, 95% CI = 1.01, 1.03) and increasing LOS (HR = 1.03, 95% CI = 1.02, 1.04).

In the adjusted model, patients who had Medicare insurance had a higher risk of readmission within 30-days postsurgery as compared to patients who had private/other insurance/did self-pay/had no-charge (HR = 1.81, 95% CI = 1.23, 2.53). Those who had higher LOS at the time of the index surgery also had a higher risk of readmission (HR = 1.02, 95% CI = 1.01, 1.04). In those who were readmitted within 30 days, as compared to other insurance plans, Medicare patients were less likely to be discharged home (71.08% vs 92.22%, $P < .0001$), were more likely to live in lower median household income areas (50.93% vs 44.10%, $P = .03$), were older (median age 55.60 vs 31.08, $P < .0001$), and had a higher median number of comorbidities (5.99 vs 2.06, $P = .01$).

Subgroup regression analysis to look at specific-risk factors for readmission was only feasible for resective surgery due to lack of power. Cox regression models for resective surgery found that the following factors were associated with a higher risk of 30-day readmissions: Medicare insurance (HR = 1.92, 95% CI = 1.33, 2.79) and higher length of stay (HR = 1.02, 95% CI = 1.00, 1.04).

5 | DISCUSSION

There is a growing body of literature about 30-day readmission rates after neurosurgical interventions.^{5,7,11–13} Single neurosurgical centers have found overall readmission rates nearing 10%, with most predictors of readmissions seen secondary to postoperative care complications.^{11,13} Larger studies have looked at 30-day readmissions according to neurosurgical specialties such as post cranial tumor resection, spine surgery, or stroke-related surgery using statewide or nationwide databases with varying 30-day readmission rates.^{14–16} However, within this body of literature, those related to surgery in persons with epilepsy remain limited. A study using California SID investigating 30-day readmissions post VNS reported 4% readmission rates, with <2% of patients having postoperative complications and an overall reduced postoperative incidence of seizure-related emergency room visits.¹⁷ Another study using the New York SID in their cohort of 154 patients undergoing cranial resective epilepsy surgery reported 30-day readmission rates of 7.1%.¹⁸ In a study using multiple SIDs (California, Florida, New York), 30-day readmission rates were 13.9% in those who had resective epilepsy surgery (2.8% of total craniotomy surgeries).⁷ Predictors of readmission included male sex and initial admission via the emergency department.⁷ More recently, a nationwide study examining 30-day readmissions after surgical resection for drug-resistant epilepsy noted 11.5% readmission rates with predictors of 30-day readmission being Medicare insurance, lowest quartile of income,

depression, hemispherectomy, postoperative complications, and small bed size hospital.¹⁵ This latter study, however, used 2013 NRD data adjusting for comorbidities using indexes that were developed to predict mortality rather than readmissions. Our current study utilized the 2014 NRD with indexes specifically developed to predict hospital readmissions looking at all types of surgical interventions for epilepsy.¹⁰

In this current large nationally representative study, patients with epilepsy undergoing neurosurgery beyond just surgical resection had an 11.0% frequency of readmission within 30 days, which is similar to previously reported values (4%–13.9%) and lower than the reported all-cause readmission rate in the overall NRD cohort (13.9%).¹⁹ We determined that a longer LOS after neurosurgery in those with epilepsy and being on Medicare insurance were the two variables associated with increased hospital readmissions within 30 days of surgery (Table 2). The LOS was on average 2 days longer in those who were readmitted within 30 days compared to those who were not (7.21 ± 0.98 days vs 5.15 ± 0.22 days) (Table 1). Those with Medicare had an 80% increased risk of readmission as compared to those on other insurance plans (HR 1.81 (1.29–2.53), $P < .01$).

Understanding the factors that extend LOS has the potential to reduce hospital costs as well as decrease hospital-acquired complications.²⁰ In this study, complications of surgical procedures or medical care were the second most common reason for readmission (18.67%). Patients who had adverse events of surgical and medical care during their inpatient stay and were readmitted within 30 days also had significantly longer mean LOS as compared to those who were not readmitted (13.82 days vs 8.71 days, $P = .04$). Univariate analyses showed that patients who were readmitted had a significantly higher mean number of comorbidities, adverse events of surgical or medical nature during inpatient stay, and were discharged elsewhere other than home, all which point to a sicker patient population. Similarly, another study about 30-day readmissions after resective surgery for epilepsy using New York statewide data found that the most common causes for unplanned readmission were infection (29.52%) and medical complications (19.22%).¹⁸ Other studies related to readmission after seizure-related hospitalizations also quoted multiple comorbidities and inpatient hospital adverse events as associated with increased odds of readmission, with seizures being the common primary reason.^{7,21} In our study, the AHRQ Elixhauser comorbidity index accounted for only a certain number of comorbidities, which may reflect why the multivariable model did not show significance. Delays in discharge are also often seen due to difficulties in coordinating proper discharge planning to skilled nursing or rehabilitation centers. In fact, it has been noted that patients who are discharged home are more likely to leave the hospital when medically fit as compared to those being discharged to a facility.²²

In our multivariable cox regression model, Medicare patients were more likely to be readmitted within 30 days after discharge. Those with Medicare had an 80% increased risk of readmission as compared to those on other insurance packages. Medicare patients are generally older, and in this study were more likely to have larger numbers of comorbidities and lower median income compared to those without Medicare. The high risk of readmission in Medicare epilepsy patients in our study is greater than the overall Medicare numbers where 30-day readmission rates are close to 20%, with an associated annual cost

greater than \$24 billion if VA hospitals are included.^{2,23,24} Cost of readmission for neurosurgery is nearly \$30 000 for each readmission vs an average of \$2200 across hospital readmissions.^{23–25} Medicare data have shown that cranial neurosurgery represents one of the higher readmission rates among surgical specialties.²⁶ Of concern is the minimal decline in readmission rates over time as compared to other surgical specialties such as orthopedics, otolaryngology, plastic, cardiothoracic, and peripheral vascular surgery.^{26,27} A part of this may be explained by readmissions related to comorbidities that are not immediately modifiable such as brain tumors, central nervous system infections, and associated neuropsychiatric disorders. Although factors such as medical comorbidities and payer status are not modifiable, these will aid physicians in improving identification of higher-risk patients and implement necessary actions to diminish avoidable readmissions.

The most common primary reason for readmission overall was epilepsy/convulsions accounting for 22.85% of all readmissions, with the second most common reason being complications from surgical procedures accounting for 18.67% of readmissions, and the third being infections accounting for 7.77% of readmissions. Previous studies looking at resective epilepsy surgery–related 30-day readmissions have shown that postoperative seizures account for 5.9% to 15.8% of readmissions.^{5,18} These values are lower than our study and may be due to the smaller cohorts being studied and coding uncertainties. Although particular readmissions may not be planned or preventable, it has often been noted that a significant fraction of unplanned readmission can be avoided.^{28–30} The Centers for Medicare & Medicaid Services (CMS) brought in the Hospital Readmissions Reduction Program (HRRP) via the Affordable Care Act in 2010, which is currently directed toward readmissions following acute myocardial infarction, chronic obstructive pulmonary disease, heart failure, pneumonia, coronary artery bypass graft surgery, elective primary total hip arthroplasty, and/or total knee arthroplasty.³¹ Although epilepsy/seizures are not in the current list of diseases being penalized for 30-day readmissions, this will certainly change, with many defining it is an ambulatory care condition.³² A proportion of these seizure-related readmissions should be preventable if quality care or good-follow-up occurs in the outpatient setting. Postoperatively there may also be issues regarding adherence to antiseizure medications, incorrect antiseizure medication prescription at the time of discharge, cognitive deficits, and loss of a care partner; thus proper allied health services (eg, social services, home care services) and discharge care planning with medication reconciliation should be considered after neurosurgery in those with epilepsy. It is also worth mentioning that not all readmissions can be addressed, and that some causes may be permanent due to risks from underlying effects despite optimal care and discharge planning.

Depending on the methodologic approach and data available, readmission rates can differ between studies and in the current climate of health informatics and use of big data, there will always be a balance needed between using smaller data sets with more detailed clinical information and large population-based nationwide datasets. The utility of larger datasets such as the NRD has its limitations. Miscoding of epilepsy within administrative databases can be an issue and although validated in various datasets, epilepsy has not, to our knowledge, been validated within the NRD.³³ Another limitation is that the accuracy of surgical codes has not been validated. However, using validated epilepsy diagnosis codes we have defined index admissions as the first admission when a patient had a diagnosis of

epilepsy with an epilepsy-related neurosurgical intervention based on ICD9-CM procedure codes. It is also not possible to break down whether the elective surgeries were therapeutic or diagnostic or look specifically into brain locations. Epilepsy severity is also difficult to assess within such databases. It was not feasible to determine whether there was an association between 30-day readmission and surgical volume or type of center (ie, specialized program with an epilepsy center or not, pediatric vs nonpediatric center). These databases also lack information related to patient education level, marital status, availability of a care partner, data regarding social services, and adherence to antiseizure medications, which can all affect readmission in this cohort of patients. Although hospital type and size are considered, information regarding whether the surgeon was trained formally in epilepsy surgery and whether the surgical/presurgical work-up occurred in a comprehensive epilepsy center is not included within this dataset. These are important data that should be captured in large datasets such as electronic medical records to guide future quality improvement initiatives to improve processes and outcomes, and to inform the best service delivery models. The generalizability of our results may account for only the US population or for health systems with similar characteristics. Certainly, data outside the US are lacking and future studies are needed to determine whether the findings are similar in other regions of the world.

Thirty-day readmission metrics are now commonly studied as they can represent an indicator of quality of care and cost-effective management. Monetary incentives are distributed by healthcare regulations targeting quality improvement in inpatient management that is also cost-saving. Our results suggest that, particularly in Medicare recipients who tend to have more comorbid conditions, careful postoperative discharge planning that involves allied health services after neurosurgery and follow-up soon after discharge to minimize seizures or any signs of post-op complications may be important to enhance outcomes and reduce the risk of readmission and its associated consequences in epilepsy. Research regarding postoperative seizure management and readmissions is scarce. Future studies addressing the potential need for increased antiseizure medications directly postoperation or other interventions (eg, self-management, medical therapies) to reduce postoperative seizures are needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

CONFLICT OF INTERESTS

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Key points

- In a nationally representative dataset, 11% of patients following an index epilepsy surgery admission were readmitted within 30 days.
- Patients on Medicare insurance and increased length of stay were significant independent predictors for 30-day readmission.
- The most common primary reason for readmissions was epilepsy/convulsions accounting for 23%.
- Careful management of post-operative seizure and discharge planning after epilepsy surgery is important particularly those on Medicare.

Baseline demographics of patients with epilepsy who underwent an epilepsy surgical procedure

TABLE 1

	30-day Readmissions			No 30-day Readmissions			Total		P-value
	N	Wt%	N	Wt%	N	Wt%	N	Wt%	
Total	251	10.83	2033	89.17	2284	100.00			
Age (mean, SE)	38.42 ± 1.87		36.21 ± 1.32		36.45 ± 1.31				.10
Age group									
0–25	62	29.70	572	34.69	634	34.15			.21
26–45	73	27.93	655	30.09	728	29.86			
46–64	80	30.90	593	26.49	673	26.97			
65	36	11.47	213	8.73	249	9.03			
Sex									
Male	127	47.22	1032	50.81	1159	50.42			.30
Female	124	52.78	1001	49.19	1125	49.58			
Insurance									
Medicare	83	31.15	415	18.93	498	20.25			.00
Medicaid	44	19.12	393	21.67	437	21.39			
Private/other	123	49.73	1224	59.40	1347	58.36			
Discharge disposition									
Routine	214	84.96	1872	92.40	2086	91.60			.00
Transfer	37	15.04	161	7.60	198	8.40			
Median household income for patient's zip code									
\$0–\$39 999	57	23.65	406	20.14	463	20.51			.50
\$40 000–\$50 999	57	25.52	468	25.39	525	25.40			
\$51 000–\$65 999	58	22.85	508	26.74	566	26.32			
\$66 000	71	27.98	609	27.74	680	27.77			
Elixhauser index									
Index (mean, SEM)	6.84 ± 0.69		5.29 ± 0.30		5.46 ± 0.03				.01
Length of stay (LOS)									
LOS (mean, SEM)	7.21 ± 0.98		5.15 ± 0.22		5.37 ± 0.24				.00
Adverse events of surgical and medical care									

	30-day Readmissions			No 30-day Readmissions			Total			P-value
	N	Wt%		N	Wt%		N	Wt%		
Yes	31	11.45		153	7.41		184	7.84		.04
No	220	88.55		1880	92.59		2100	92.16		
Adverse events of medical drugs										
Yes	13	5.30		96	11.45		109	4.32		.33
No	238	94.70		1937	88.55		2175	95.68		
Hospital type										
Public	26	10.31		272	12.16		298	11.96		.50
Private	225	89.69		1761	87.84		1986	88.04		
Hospital bed size										
Small or medium	54	21.41		466	23.24		520	23.04		.57
Large	197	78.59		1567	76.76		1764	76.96		

Abbreviations: SE, standard error; SEM, standard error mean.

TABLE 2
Results of cox regression model for any surgery—30-day readmissions vs no readmissions

	Unadjusted Models		Adjusted models	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Age				
0–25	0.68 (0.43, 1.07)	.09	1.16 (0.67, 1.99)	.60
26–45	0.73 (0.46, 1.17)	.19	1.09 (0.67, 1.76)	.74
46–64	0.91 (0.60, 1.39)	.67	1.37 (0.90, 2.09)	.14
65	ref		Ref	
Sex				
Male	0.87 (0.67, 1.13)	.30	0.88 (0.68, 1.14)	.34
Female	ref		Ref	
Insurance				
Medicare	1.89 (1.42, 2.50)	<.01	1.81 (1.29, 2.53)	<.01
Medicaid	1.04 (0.68, 1.60)	.84	1.03 (0.65, 1.61)	.91
Private/other	ref		Ref	
Discharge disposition				
Routine	0.50 (0.34, 0.73)	<.01	0.75 (0.50, 1.13)	.17
Transfer	ref			
Median household income for patient's zip code				
\$0–\$39 999	1.16 (0.79, 1.69)	.45	1.04 (0.71, 1.52)	.84
\$40 000–\$50 999	0.99 (0.70, 1.42)	.97	0.98 (0.69, 1.39)	.92
\$51 000–\$65 999	0.86 (0.62, 1.18)	.34	0.84 (0.61, 1.16)	.28
\$66 000	ref		ref	
Elixhauser index				
Index	1.02 (1.01, 1.03)	.01	1.00 (0.99, 1.02)	.60
Length of stay (LOS)				
LOS	1.03 (1.02, 1.04)	<.01	1.02 (1.01, 1.04)	<.01
Adverse events of surgical and medical care				
Yes	1.51 (0.99, 2.30)	.05	1.14 (0.76, 1.70)	.54
No	Ref		ref	

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	Unadjusted Models		Adjusted models	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Adverse events of medical drugs				
Yes	1.27 (0.79, 2.30)	.32	1.18 (0.72, 1.93)	.52
No	ref		ref	
Hospital type				
Public	0.84 (0.50, 1.41)	.52	0.83 (0.52, 1.32)	.42
Private	Ref		Ref	
Hospital bed size				
Small or Medium	0.90 (0.64, 1.27)	.54	0.93 (0.64, 1.34)	.69
Large	ref		ref	