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Thirty- and 90-Day Readmissions After Treatment of Traumatic Subdural Hematoma: National Trend Analysis

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Abstract

OBJECTIVE: Subdural hematoma (SDH), a form of traumatic brain injury, is a common disease that requires extensive patient management and resource utilization; however, there remains a paucity of national studies examining the likelihood of readmission in this patient population. The aim of this study is to investigate differences in 30- and 90-day readmissions for treatment of traumatic SDH using a nationwide readmission database.

METHODS: The Nationwide Readmission Database years 2013–2015 were queried. Patients with a diagnosis of traumatic SDH and a primary procedure code for incision of cerebral meninges for drainage were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification coding system. Patients were grouped by no readmission (Non-R), readmission within 30 days (30-R), and readmission within 31–90 days (90-R).

RESULTS: We identified a total of 14,355 patients, with 3106 (21.6%) patients encountering a readmission (30-R: n = 2193 [15.3%]; 90-R: n = 913 [6.3%]; Non-R: n = 11,249). The most prevalent 30- and 90-day diagnoses seen among the readmitted cohorts were postoperative infection (30-R: 10.5%, 90-R: 13.0%) and epilepsy (30-R: 3.7%, 90-R: 1.1%). On multivariate logistic regression analysis, Medicare, Medicaid, hypertension, diabetes, renal failure, congestive heart failure, and coagulopathy were independently associated with 30-day readmission; Medicare and rheumatoid arthritis/collagen vascular disease were independently associated with 90-day readmission.

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CONCLUSIONS: In this study, we determine the relationship between readmission rates and complications associated with surgical intervention for traumatic subdural hematoma.

Keywords

Readmissions; Subdural hematoma; Trauma

INTRODUCTION

In the past decade, unplanned hospital readmissions have played a major role in the soaring health care expenditures in the United States. In fact, 30-day unplanned readmissions have been observed in 1 out of every 7 Medicare beneficiaries.[1] In the year 2011 alone, hospital readmissions within 30 days of discharge cost the United States roughly $40 billion in health care costs.[2] As a result, policies through Centers of Medicaid and Medicare have been implemented to financially penalize hospitals with significantly higher rates of readmission.[3] Unplanned readmissions are not only costly but also associated with inferior clinical outcomes, such as increased complication rates and extended length of hospital stay.[4–6] Therefore identifying drivers and patient risk factors for unplanned readmissions after neurosurgical procedures is necessary to create avenues of health care reform in hopes of improving overall patient care and decreasing health care costs.[3]

Traumatic subdural hematoma (SDH) is the most common form of trauma-related intracranial hemorrhage, with an estimated occurrence of 15% after any traumatic brain injury and 30% after a severe traumatic brain injury.[7–9] Commonly used surgical approaches for intervention include decompressive hemicraniectomy, craniotomy, or burr hole for evacuation.[7] Unfortunately, traumatic SDH remains one of the most impactful brain injuries, with mortality rates ranging from 40% 60%.[10,11] In the United States alone, there has been an estimated increase in health care expenditures of 40% in the management of SDH, with cumulative costs expanding twofold from 1998 at $2.2 billion to $4.9 billion in 2007.[10,12,13] In fact, Kalanithi et al[10] published one of the earliest national database studies exploring the overall impact that traumatic SDHs have on patient care and the U.S. health care system. The authors found a 154% increase in hospital admissions of traumatic SDH from 1993 to 2006, with an associated 67% increase in average hospital costs.[10]

Unplanned hospital readmissions after interventions for traumatic SDH are significant drivers to increased health care resource utilization, with reported rates ranging from 20% to 44.7%.[12,14–16] Few studies have attempted to identify patient risk factors associated with hospital readmissions in patients with traumatic SDHs.[12] In a retrospective cohort study of 221 adult patients treated at a single institution with a diagnosis of traumatic SDH, Ho et al[12] found that increased age, male gender, presence of comorbidities, and discharge disposition were significantly associated with readmission within 6 months in the adult population. However, there is a paucity of generalizable, multi-institutional studies identifying overall rates and risk factors for 30- and 90-day readmission after surgical intervention for traumatic SDH.

Large-scale, national databases that track overall health care outcomes at the individual patient level across a variety of hospital settings are a powerful research tool for examining the overall impact that preoperative, intraoperative, and postoperative patient characteristics have on unplanned readmissions. In this large, retrospective study we used data from the Nationwide Readmission Database (NRD)[17] to investigate differences in 30- and 90-day readmissions for treatment of traumatic SDH.

METHODS

Data Source and Patient Population

We used the Healthcare Cost and Utilization Project (HCUP) NRD, a nationally representative sample of all-payer discharges from U.S. nonfederal hospitals sponsored by the Agency for Healthcare Research and Quality. It includes discharge data with >100 clinical and nonclinical variables including patient demographics, diagnoses, procedures performed, source of payment, total hospital charges, treating hospital characteristics, and readmission information. Each year represents approximately 15 million discharges (≈35 million discharges, weighted). NRD 2013 is constructed from 21 HCUP partner states, representing 2006 hospitals, 49.3% of the total U.S. resident population, and 49.1% of all U.S. hospitalizations. NRD 2014 is constructed from 22 HCUP partner states, representing 2048 hospitals, 51.2% of the total U.S. resident population, and 49.3% of all U.S. hospitalizations. NRD 2015 is constructed from 27 HCUP partner states, representing 2367 hospitals, 57.8% of the total U.S. resident population, and 56.6% of all U.S. hospitalizations. A retrospective study was performed using years 2013–2015 of the NRD for all patients undergoing incision of cerebral meninges for drainage of traumatic subdural hematoma (similar to the methodology used by Kalanithi et al[10] in their analysis of traumatic subdural hematoma using the Nationwide Inpatient Sample).

The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedural coding system was used to query the NRD for all hospital admissions containing a diagnosis of traumatic SDH (852.20–852.39) with a primary procedure code for incision of cerebral meninges for drainage (01.31). On 1 October, 2015 the United States made a transition from using the ICD-9-CM coding system to ICD-10-CM sets for reporting clinical diagnoses and inpatient procedures. For consistency, we assessed only the months containing ICD-9-CM coding up until this transition. Unique patient linkage numbers were used to follow patients and identify 30- and 31- to 90-day readmission rates after intervention. Because patient linkage numbers do not track the same person from year to year, patients with insufficient time for 30- or 31- to 90-day accrual of readmissions were excluded. A patient’s first admission after the index surgery was considered a readmission, but all subsequent readmissions were excluded.

Data Collection

Patient demographics, comorbidities, and treating hospital characteristics were collected. Demographic information included age, gender, median household income percentile, and primary expected payer (Medicare, Medicaid, private insurer, other). Medicare is a federal program that provides health coverage for elderly patients 65+ or younger than 65 and have a disability, while Medicaid is a state and federal program that provides health coverage for low-income people, families and children, pregnant women, the elderly, and people with disabilities. Hospital characteristics included teaching status (metropolitan teaching, metropolitan nonteaching, and nonmetropolitan); bed size (small, medium, and large); and number of annual hospital discharges. Preexisting comorbidities were scored using the Elixhauser Comorbidity Index as computed by Agency for Healthcare Research and Quality. We included hypertension, diabetes, obesity, chronic pulmonary disease, depression, hypothyroidism, deficiency anemia, renal failure, other neurologic disorders, congestive heart failure, rheumatoid arthritis/collagen vascular diseases, peripheral vascular disease, coagulopathy, liver disease, and alcohol use. Smoking status was also identified (305.1, 649, 989.84, V15.82).

Complications associated with the index hospital encounter and at 30- and 31- to 90-days after discharge were tabulated by identifying the primary diagnosis code associated with each patient at the time of indexed unplanned readmission. The complications included seizures, perioperative stroke, postoperative neurologic complications, sepsis, deep vein thrombosis, pulmonary embolism, gastrointestinal complication, cardiac complication, genitourinary complication (i.e., urinary complication and/or acute kidney failure), and postoperative infection. The primary outcome investigated in this study was the difference in 30- and 31- to 90-day readmission rates after surgical drainage of traumatic SDH. Furthermore, we sought to identify the patient- and hospital-level factors associated with 30- and 31- to 90-day readmission rates.

Statistical Analysis

National estimates were calculated by applying discharge weights developed for the NRD before analysis. Descriptive statistics were summarized for patient demographic information, hospital characteristics, and comorbidities of the study cohort grouped by those with unplanned 30-day readmission, 31- to 90-day readmission, and no readmission (Non-R) after decompression and/or stabilization surgery. Parametric data were expressed by readmission groups as mean ± standard deviation. Nonparametric data were expressed as median (interquartile range). Categorical variables were described using percentages. For the most common principal diagnoses among the readmission cohorts, proportions of 30- and 31- to 90-day readmission were described using percentages. For our primary hypothesis, weighted univariate and multivariate logistic regressions were fitted with 30- and 90-day readmission as the dependent variables. Backward stepwise logistic regression was used to select a subset of variables in the final model, using 0.1 as entry and stay criteria. We forced 3 variables of interest including age, female sex, and any complication during admission into the model based on the joint biological association between these covariates and in view of the plausibility for confounding. Odds ratios with 95% confidence intervals (CIs) were calculated. A P value <0.05 was determined to be statistically significant. We used R Studio, Version 1.1.383 (RStudio Inc., Boston, Massachusetts, USA) for all statistical analyses.

RESULTS

Patient Demographics and Hospital Characteristics

There was a total of 14,355 patients included in this study with 3106 (21.6%) readmissions —15.3% for 30-R and 6.3% for 90-R (30-R: n = 2193 vs. 90-R: n = 913 vs. Non-R: n =

11,249) (Table 1). The average age of patients with 30-day readmissions trended to be higher than those with 90-day readmissions, and both were higher than those with no readmissions (30-R: *n* = 72.7 ± 14.4 years vs. 90-R: 72.3 ± 15.0 years vs. Non-R: 70.3 ± 16.0 years) (see Table 1). There trended to be more females in the 30-day and no readmission cohorts (30-R: 32.2% vs. 90-R: 30.8% vs. Non-R: 33.5%) (see Table 1). Overall, the median household income percentiles were evenly distributed, with the 51st 75th income percentile trending to be the largest in the readmitted cohorts (30-R: 26.9% vs. 90-R: 29.4% vs. Non-R: 25.5%), and 76th 100th income percentile trending to be largest in the nonreadmitted cohort (30-R: 25.3% vs. 90-R: 23.1% vs. Non-R: 27.7%) (see Table 1. Medicare trended to be in the largest percent of primary payor for the readmitted cohorts (30-R: 76.5% vs. 90-R: 76.9% vs. Non-R: 66.7%), while private insurers were greater in the nonreadmission group (30-R: 13.9% vs. 90-R: 13.1% vs. Non-R: 18.8%) (see Table 1). Most patients in all cohorts received care at a metropolitan teaching hospital (30-R: 75.6% vs. 90-R: 75.9% vs. Non-R: 77.0%), which was a large bed sized hospitals (30-R: 72.9% vs. 90-R: 71.1% vs. Non-R: 74.4%) (see Table 1).

Admission and Patient Comorbidities

The most common patient comorbidities were hypertension (30-R: 74.7% vs. 90-R: 64.3% vs. Non-R: 66.9%), smoking (30-R: 23.2% vs. 90-R: 21.6% vs. Non-R: 24.7%), and diabetes (30-R: 25.0% vs. 90-R: 21.6% vs. Non-R: 19.1%). Other common comorbidities included deficiency anemia (30-R: 17.9% vs. 90-R: 20.1% vs. Non-R: 13.8%), hypothyroidism (30-R: 13.3% vs. 90-R: 13.6% vs. Non-R: 13.2%), and chronic pulmonary disease (30-R: 14.1% vs. 90-R: 14.1% vs. Non-R: 11.7%) (Table 2).

Complications for Index Admissions

The rates of any complication were greater in the readmission cohorts compared with the nonreadmitted cohort (30-R: 21.5% vs. 90-R: 23.3% vs. Non-R: 17.6%). The most common inpatient complications were postoperative infection (30-R: 13.3% vs. 90-R: 14.9% vs. Non-R: 9.7%), epilepsy (30-R: 8.3% vs. 90-R: 9.1% vs. Non-R: 5.0%), seizures (30-R: 4.9% vs. 90-R: 5.2% vs. Non-R: 5.1%), and genitourinary complication (30-R: 4.7% vs. 90-R: 5.1% vs. Non-R: 3.8%) (Table 3).

Postoperative Inpatient Outcomes for Index Admissions

Both average length of stay (30-R: 7.8 ± 6.8 days vs. 90-R: 9.0 ± 8.5 days vs. Non-R: 7.7 ± 7.0 days) and total cost (30-R: $20,472 ± $14,655 vs. 90-R: $23,997 ± $23,813 vs. Non-R: $20,164 ± $17,852) for index admissions were greater in the readmitted cohorts than the nonreadmitted cohorts. The nonreadmitted cohort had the highest percentage of routine discharges (30-R: 35.8% vs. 90-R: 34.6% vs. Non-R: 48.0%), while the 90-day readmission cohort had more discharges to skilled nursing, intermediate, or other facility (30-R: 42.7% vs. 90-R: 48.6% vs. Non-R: 32.4%) (Table 4).

Thirty- and 90-Day Readmissions: Primary Diagnoses

The most prevalent 30- and 90-day complications seen among the readmitted cohorts were postoperative infection (30-R: 10.5% vs. 90-R: 13.0%) and epilepsy (30-R: 3.7% vs. 90-R:

1.1%), followed by genitourinary complication (30-R: 1.6% vs. 90-R: 2.1%) and cerebral infarct (30-R: 2.1% vs. 90-R: 1.3%) (Table 5). Seizures (30-R: 3.3% vs. 90-R: $n < 10$), altered mental status (30-R: 1.6% vs. 90-R: 1.5%), deformity of head (30-R: $n < 10$ vs. 90-R: 1.7%), and pulmonary embolism (30-R: 1.3% vs. 90-R: $n < 10$) were all less common (Table 5).

Multivariate Logistic Regression Predicting 30-Day Readmission

On multivariate regression analysis, Medicare insurance [OR: 1.98, 95% CI: (1.33, 2.97), $P < 0.001$]; Medicaid insurance [OR: 1.78, 95% CI: (1.11, 2.84), $P = 0.016$], hypertension [OR: 1.27, 95% CI: (1.05, 1.53), $P = 0.013$], diabetes [OR: 1.24, 95% CI: (1.05, 1.47), $P = 0.013$], renal failure [OR: 1.56, 95% CI: (1.16, 2.08), $P = 0.003$], congestive heart failure [OR: 1.32, 95% CI: (1.01, 1.73), $P = 0.044$], and coagulopathy [OR: 1.43, 95% CI: (1.04, 1.96), $P = 0.027$] during index admission were independently associated with increased 30-day unplanned hospital readmission (Table 6). Age ($P = 0.685$), female sex ($P = 0.481$), private insurance ($P = 0.067$), rheumatoid arthritis/collagen vascular diseases ($P = 0.080$), and the presence of any complication ($P = 0.290$) were hospital not found to have a significant association with 30-day readmissions (see Table 6).

Multivariate Logistic Regression Predicting 31- to 90-Day Readmission

On multivariate regression analysis, Medicare insurance [OR: 2.14, 95% CI: (1.21, 3.81), $P = 0.009$] and rheumatoid arthritis/collagen vascular diseases [OR: 2.99, 95% CI: (1.26, 7.11), $P = 0.013$] during index admission were independently associated with increased 31- to 90-day unplanned hospital readmission (Table 7). Age ($P = 0.797$), female sex ($P = 0.098$), Medicaid insurance ($P = 0.076$), private insurance ($P = 0.246$), deficiency anemia ($P = 0.051$), coagulopathy ($P = 0.089$), and the presence of any complication ($P = 0.059$) were not found to have a significant independent association with 31- to 90-day hospital readmissions (see Table 7).

DISCUSSION

In this retrospective study of 14,355 patients undergoing surgical intervention for traumatic SDH, we found unplanned readmission rate to be 21.6%. The most common 30- and 90-day complications were postoperative infection, sepsis, and epilepsy. Patient factors such as Medicaid insurance, Medicare insurance, hypertension, and diabetes were independently associated with unplanned readmissions.

Previous studies have assessed the rate and drivers of unplanned hospital readmission after admission for traumatic SDH. In a retrospective study of 221 adults with a diagnosis of traumatic SDH, Wasfie et al[18] found a readmission rate of 26.7% within the first 6 months. While in a retrospective cohort study of 112 patients who had traumatic SDH due to falls, Teo et al[19] found that 40.2% of patients experienced readmission within 1 year. Similarly, in a retrospective cohort study of 167 traumatic SDH patients treated at a single care center, Ho et al[12] found that 44.7% of patients experienced an unplanned readmission. In another retrospective cohort study of 200 subdural hematoma patients admitted to the ICU at a single academic institution, Franko et al[20] found a rate of readmission of 26.0% within 30 days, with the most common cause driver for readmission being headache, followed by new focal neurologic deficit. Analogous to the aforementioned studies, our study identified an unplanned readmission rate of 21.6%. Moreover, we found the most common reasons for readmission after management of traumatic SDH to be postoperative infection, sepsis, and epilepsy. Identifying modifiable targets such as antibiotic protocols and prophylactic use of antiepileptic medications may provide avenues to reduce posthospital complications and lower readmission rates.

Few reported studies have attempted to identify associations between patient demographics and increased hospital readmissions after traumatic SDH. A clear consensus on the most important risk factors is yet to emerge. Ho et al[12] demonstrated that, in a univariate analysis, increased age (defined as age >60 years old) was associated with higher rates of readmission within 6 months with no difference based on gender of patients. In contrast, a study based on a multivariate logistic regression model found that age did not play a significant role, while male sex was independently and significantly associated with readmission.[12] Furthermore, Franko et al[20] demonstrated that female sex was associated with higher rates of readmission within 30 days of discharge, while increased age did not play a significant role. Finally, Teo et al[19] showed that neither female sex nor increased age were independent predictors of readmission within 12 months of injury. In a larger, retrospective study of 15,277 patients with an index admission diagnosis of traumatic brain injury (with subdural hematoma being the most common condition), Brito et al[21] found that increased age had a significant association with increased rates of readmission while female gender was not found to have a statistically significant role. Moreover, the association of increased age and increased risk of readmission remained upon multivariate regression analysis.[21] In addition, the authors demonstrated that Medicare insurance status was associated with increased rates of readmission, private insurance status was associated with decreased rates of readmission, and Medicaid insurance had no statistically significant impact.[21] Overall, our study found that neither increased age nor female sex was a significant independent predictor of 30- or 90-day readmissions after management of traumatic SDH. However, we found that Medicaid and Medicare insurance status were independent predictors of readmission, while private insurance status did not have a statistically significant role.

Along with patient demographics, previous studies have looked at patient comorbidities that may predispose patients to unplanned readmissions. In the Ho et al[12] study, the authors found that having greater than 4 comorbidities was significantly associated with increased likelihood of readmission while coagulopathy was not. Similarly, Franko et al[20] demonstrated that neither congestive heart failure, coronary artery disease, nor coagulopathy played a significant role in predicting readmission. In a retrospective study of 10,158 patients with an acute subdural hematoma, Schmidt et al[22] demonstrated that diabetes was a significant independent predictor of recurrence of subdural hematoma necessitating rehospitalization. Moreover, the authors found that chronic liver disease, coagulopathy, hypertension, and renal insufficiency were not significantly associated with recurrence.[22] Similarly, in a retrospective study of 226 patients with chronic subdural hematoma, You et al[23] found that neither hypertension, diabetes mellitus, nor heart disease was significantly associated with increased recurrence. Analogous to the aforementioned studies, we demonstrated that hypertension, diabetes, renal failure, congestive heart failure, and coagulopathy were all significant independent predictors of unplanned hospital readmission.

Furthermore, there is a paucity of studies that have investigated the impact discharge disposition has on unplanned readmission rates, which may shed light into potential postdischarge risk factors for readmissions. In the Ho et al[12] study, the group found that the majority of readmitted patients were initially discharged to a health care facility, while in contrast, a majority of patients who were not readmitted were discharged home. Similarly, in the Brito et al[21] study, the authors found that discharge to a skilled nursing facility as compared with discharge home was significantly associated with both readmission within 30 days and any unplanned hospital readmission. Moreover, this association was found to persist upon multivariate regression analysis.[21] In a retrospective study of 301 elderly patients with chronic subdural hematoma, Dumont et al[24] found that 9% of patients who were discharged home were readmitted while 14% of patients who were discharged to an acute rehabilitation facility experienced readmission. Analogously, we found higher rates of routine discharge in the nonreadmitted cohort and higher rates of discharge to skilled nursing facilities among the readmitted cohort. Identifying strategies to improve transitions of care may help reduce unplanned readmissions.

One particular aspect of tSDH that has been gaining traction has been rate and implications of recurrent SDHs after initial hemorrhage. In the Ho et al[12] study, the authors found that 32.2% of patients were readmitted for recurrence of SDH. Similarly, in a retrospective study of 27,502 patients treated for SDH, Morris et al. demonstrate that roughly half of readmissions were due to recurrence of the subdural hematoma.[25] In fact, in the Schmidt et al[22] study, the authors showed that 9% of patients had a recurrence of the bleed within 4 weeks of initial bleeding and 14% had recurrence within a year. These recurrent bleeds have a major impact on clinical outcomes after treatment. In a retrospective study of 114 patients treated at a single institution for chronic subdural hematoma, Konig et al[26] demonstrated that recurrence was significantly associated with inferior patient outcomes. Similarly, in a retrospective cohort study of 97 patients operated on for chronic SDH, Song et al[27] reported that reoperations for recurrent bleeds have increased morbidity and mortality. In another retrospective study of 218 patients treated at a single institution, Mellergard et al[28] demonstrated that over 25% of patients experiencing reoperation for recurrence of the SDH required a third operation for recurrence, 12% required 4 operations, and 6% developed subdural empyemas after the recurrences, further exacerbating the poor clinical course. Interestingly, in a retrospective study of 500 chronic SDH patients treated at a single institution, Mori et al[29] demonstrated that poor reexpansion of the brain was highly correlated with recurrence of the subdural hematoma. In addition, the authors found that poor reexpansion correlated with a number of other factors traditionally associated with poor outcomes after surgery, such as increased age, presence of air in the subdural space after surgery, and preexisting cerebral infarction.[29] Overall, recurrent SDHs have garnered enough interest that there have been preliminary attempts to proactively prevent a recurrent SDH from forming. One particular procedure that is increasing in popularity is middle meningeal artery embolization (MMAE) for chronic SDH. In a recent systematic review of 190 patients who underwent MMAE for chronic SDH, Court et al[30] reported no procedural complications and a 96.8% resolution of the chronic SDH. Further studies are necessary to better understand the role of MMAE in the management of traumatic SDH (including chronic SDH).

There are inherent limitations to this study that have implications on its interpretation. First, the analysis is retrospective, with data only available by ICD-9-CM codes, which may contain reporting biases for both diagnosis and procedural coding. Second, there is a possibility of misclassified or incomplete data. We are also unable to comment on the choice of intervention, severity of complications, or the care of patients treated outside the United States. Thirdly, identifying the sole driver of readmission is not well characterized in the NRD database; therefore using prevalent complications codes associated with the indexed hospital readmission has interpretation bias and may not be the true reason for the hospital readmission. Furthermore, as the patient visit links do not track patients across consecutive years, we are limited by a potential seasonal bias for patients admitted in the latter part of the year. Finally, while the study was performed using the same coding algorithm as previously published,[10] it is subject to the same inherent limitations, which include being unable to distinguish between the mechanism and acuity of presentation of chronic versus acute traumatic SDH due to lack of ICD-9 coding variables. Specifically, the mechanism of injury most common in the younger patient population is high-velocity impact (i.e., motor vehicle accidents) resulting in presentation with acute SDH. In contradistinction, the elderly patient population more commonly suffers low-velocity trauma resulting in presentation with chronic SDH.[10] However, despite these limitations, this study identifies on a national level a large and specific cohort of patients who are predisposed to readmission after all ICD-9 recorded traumatic SDH.

CONCLUSION

In this study, we identify an unplanned readmission rate to be 21.6% after treatment of traumatic SDH, with the most common drivers being postoperative infection, sepsis, and epilepsy-related complications. Furthermore, multiple patient-specific variables were independently associated with hospital readmission. Knowledge of these factors may help reduce the burden of unplanned hospital readmissions for traumatic SDH.

Abbreviations and Acronyms

30-R	Readmission within 30 days
90-R	Readmission within 31 to 90 days
CI	Confidence interval
HCUP	Healthcare Cost and Utilization Project
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification coding system
Non-R	No readmission
NRD	Nationwide Readmission Database

SDH Subdural hematoma

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Table 1.

Patient Demographics and Hospital Characteristics

Variables	30-Day Readmission (n = 2193)	31- to 90-Day Readmission (n = 913)	Non-R (n = 11,249)
Age (years)			
Mean ± SD	72.7 ± 14.4	72.3 ± 15.0	70.3 ± 16.0
Median [IQR]	76 [66–83]	75 [66–83]	74 [62–82]
Female (%)	32.2	30.8	33.5
Median household income percentile (%)			
0–25th	25.1	25.5	23.3
26–50th	25.3	23.1	27.7
51–75th	26.9	29.4	25.5
76–100th	22.2	21.1	22.7
Primary expected payer (%)			
Medicare	76.5	76.9	66.7
Medicaid	5.4	6.1	6.1
Private insurance	13.9	13.1	18.8
Other	4.1	3.9	8.4
Teaching status of hospitals (%)			
Metropolitan nonteaching	22.7	22.4	21.2
Metropolitan teaching	75.6	75.9	77.0
Nonmetropolitan hospital	1.6	1.7	1.8
Hospital bed size (%)			
Small	4.8	4.7	5.7
Medium	22.3	24.2	22.9
Large	72.9	71.1	71.4

SD, standard deviation; IQR, interquartile range.

Signifies that the count number is <10 and cannot be reported.

Table 2.

Admission and Patient Comorbidities

Variables (%)	30-Day Readmission (n = 2193)	31- to 90-Day Readmission (n = 913)	Non-R (n = 11,249)
Hypertension	74.7	64.3	66.9
Diabetes	25.0	21.6	19.1
Obesity	4.5	5.1	4.8
Chronic pulmonary disease	14.1	14.1	11.7
Depression	11.0	12.1	10.7
Hypothyroidism	13.3	13.6	13.2
Deficiency anemia	17.9	20.1	13.8
Renal failure	13.2	8.6	7.4
Other neurologic disorders	2.5	2.4	2.2
Congestive heart failure	8.7	7.9	5.4
Rheumatoid arthritis/collagen vascular diseases	3.8	6.4	1.9
Peripheral vascular disease	5.3	5.5	4.4
Coagulopathy	7.3	8.4	4.6
Liver disease	2.3	2.3	1.8
Alcohol abuse	10.3	13.7	10.0
Smoking	23.2	21.6	24.7

Table 3.

Complications for Index Admissions

Variables	30-Day Readmission (n = 2193)	31- to 90-Day Readmission (n = 913)	Non-R (n = 11,249)
Complications (%)			
Postoperative infection	13.3	14.9	9.7
Sepsis	0.9	2.1	0.4
Central nervous system	0.2	0.4	0.2
Wound	0.0	0.0	0.0
Respiratory	1.3	1.3	1.1
Genitourinary	10.3	9.6	7.5
Gastrointestinal	0.5	1.5	0.3
Other postoperative infection	0.1	0.0	0.2
Epilepsy	8.3	9.1	5.0
Seizures	4.9	5.2	5.1
Perioperative stroke	0.5	$n < 10^{*}$	0.4
Postoperative neurologic complication	0.7	1.6	0.5
Deep vein thrombosis	0.5	$n < 10^{*}$	0.3
Pulmonary embolism	0	$n < 10^{*}$	0.1
Gastrointestinal complication	$n < 10^{*}$	0	$n < 10^{*}$
Cardiac complication	$n < 10^{*}$	$n < 10^{*}$	0.3
Genitourinary complication	4.7	5.1	3.8
Any complication	21.5	23.3	17.6

*Signifies that the count number is <10 and cannot be reported.

Table 4.

Postoperative Inpatient Outcomes for Index Admissions

Variables	30-Day Readmission (n = 2193)	31- to 90-Day Readmission (n = 913)	Non-R (n = 11,249)
Length of stay (days)			
Mean ± SD	7.8 ± 6.8	9.0 ± 8.5	7.7 ± 7.0
Median [IQR]	6 [4–9]	6 [4–10]	5 [4–9]
Total cost of admission ($)			
Mean ± SD	20,472 ± 14,655	23,997 ± 23,813	20,164 ± 17,852
Median [IQR]	16,650 [12,051–24,610]	17,630 [12,767–26,581]	15,940 [11,291–23,776]
Disposition (%)			
Routine	35.8	34.6	48.0
Short-term hospital	1.9	1.5	1.1
Skilled nursing, intermediate, or other facility	42.7	48.6	32.4
Home health care	19.4	15.0	18.2

SD, standard deviation; IQR, interquartile range.

Signifies that the count number is <10 and cannot be reported.

Table 5.

Thirty- and 90-Day Readmissions: Primary Diagnoses

	Frequency (percent of admissions)[*]	
Diagnosis (%)	**30 Days**	**31–90 Days**
Postoperative infection	10.5	13.0
Sepsis	4.1	6.9
Central nervous system	0.7	0.2
Wound	0.0	0.0
Respiratory	1.1	1.9
Genitourinary	1.9	1.7
Gastrointestinal	$n < 10$[*]	$n < 10$[†]
Other postoperative infection	2.4	2.1
Epilepsy	3.7	1.1
Seizures	3.3	$n < 10$[†]
Genitourinary complication	1.6	2.1
Cerebral infarct	2.1	1.3
Altered mental status or encephalopathy	1.6	1.5
Deformity of head	$n < 10$[*]	1.7
Pulmonary embolism	1.3	$n < 10$[†]
Transient cerebral ischemia	1.0	$n < 10$[†]
Volume depletion	0.7	$n < 10$[†]

[*] Weighted frequencies for common readmission diagnoses within 30 and 31–90 days.

[†] Signifies that the count number is <10 and cannot be reported.

Table 6.

Multivariate Logistic Regression Predicting 30-Day Readmission

	Univariate Model	Multivariate Model	*P* Value
Age	1.01 (1.00, 1.02)	1.00 (0.99, 1.01)	0.685
Female sex	0.95 (0.79, 1.15)	0.93 (0.77, 1.13)	0.481
Insurance status			
Medicare	2.21 (1.52, 3.22)	1.98 (1.33, 2.97)	<0.001
Medicaid	1.76 (1.10, 2.80)	1.78 (1.11, 2.84)	0.016
Private insurance	1.48 (0.99, 2.21)	1.46 (0.97, 2.18)	0.067
Other	REFERENCE		
Comorbidity			
Hypertension	1.47 (1.23, 1.76)	1.27 (1.05, 1.53)	0.013
Diabetes	1.40 (1.18, 1.65)	1.24 (1.05, 1.47)	0.013
Deficiency anemia	1.31 (1.04, 1.64)	*Removed*	
Renal failure	1.89 (1.44, 2.49)	1.56 (1.16, 2.08)	0.003
Congestive heart failure	1.61 (1.24, 2.10)	1.32 (1.01, 1.73)	0.044
Rheumatoid arthritis/collagen vascular diseases	1.71 (1.00, 2.92)	1.60 (0.95, 2.72)	0.080
Coagulopathy	1.52 (1.11, 2.08)	1.43 (1.04, 1.96)	0.027
Any complication	1.24 (1.01, 1.52)	1.12 (0.91, 1.39)	0.290

Table 7.

Multivariate Logistic Regression Predicting 31- to 90-Day Readmission

	Univariate Model	Multivariate Model	*P* Value
Age	1.01 (0.99, 1.02)	0.99 (0.99,1.01)	0.797
Female sex	0.89 (0.69, 1.15)	0.81 (0.62,1.04)	0.098
Insurance status			
Medicare	2.23 (1.32, 3.75)	2.14 (1.21, 3.81)	0.009
Medicaid	2.01 (0.99, 4.11)	1.92 (0.93, 3.96)	0.076
Private insurance	1.44 (0.78, 2.64)	1.43 (0.78, 2.60)	0.246
Other	REFERENCE		
Comorbidity			
Deficiency anemia	1.49 (1.11, 1.99)	1.34 (0.99, 1.81)	0.051
Rheumatoid arthritis/collagen vascular diseases	2.98 (1.27, 7.00)	2.99 (1.26, 7.11)	0.013
Coagulopathy	1.72 (1.05, 2.82)	1.52 (0.94, 2.45)	0.089
Any complication	1.36 (1.04, 1.79)	1.30 (0.99, 1.72)	0.059