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Hospital Readmissions after Pediatric Trauma

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Abstract

Objective—To determine the rate, etiology, and timing of unplanned and planned hospital readmissions and to identify risk factors for unplanned readmission in children who survive a hospitalization for trauma.

Design—Multicenter retrospective cohort study of a probabilistically linked dataset from the National Trauma Data Bank and the Pediatric Health Information System database, 2007–2012.

Setting—29 U.S. children's hospitals.

Patients—51,591 children (<18 years at admission) who survived a ≥ 2-day hospitalization for trauma.

Measurements and Main Results—The primary outcome was unplanned readmission within 1 year of discharge from the injury hospitalization. Secondary outcomes included any readmission, reason for readmission, time to readmission, and number of readmissions within one year of discharge. The primary exposure groups were isolated traumatic brain injury (TBI), both TBI and other injury, or non-TBI injury only. We hypothesized *a priori* that any TBI would be associated with both planned and unplanned hospital readmission. We used All Patient Refined Diagnosis Related Groups (APR-DRG) codes to categorize readmissions by etiology and planned or unplanned. Overall, 4,301/49,982 (8.6%) of the patients with ≥ 1 year of observation time were readmitted to the same hospital within one year. Many readmissions were unplanned: 2,704/49,982 (5.4%) experienced an unplanned readmission in the first year. The most common reason for unplanned readmission was infection (22%), primarily post-operative or post-traumatic infection (38% of readmissions for infection). TBI was associated with lower odds of unplanned

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readmission in multivariable analyses. Seizure or red blood cell transfusion during the index hospitalization were the strongest predictors of unplanned, earlier, and multiple readmissions.

Conclusions—Many survivors of pediatric trauma experience unplanned, and potentially preventable, hospital readmissions in the year after discharge. Identification of those at highest risk of readmission can guide targeted in-hospital or post-discharge interventions.

Keywords

pediatric; wounds and injury; critical care; seizures; brain injuries; traumatic; patient readmission

Introduction

Pediatric trauma is a major public health problem and the leading cause of death in children between 1 and 14 years old.(1) Despite the significant number of deaths, more than 95% of children survive their episode of trauma.(2, 3) However, many survivors have ongoing morbidities including cognitive, physical, mental health, quality of life, and family functioning impairments.(4–11) Under-recognition of these morbidities may lead to unmet health care needs that result in unplanned hospital readmissions.(12) These unplanned health care visits and admissions are costly and disruptive to patients and their families.(13, 14) Although some visits are likely related to unmodifiable patient and injury characteristics, a proportion of these visits may be preventable.(5)

The one-year hospital readmission rate in adult trauma patients is 21–25%.(15–17) Higher injury severity, pre-injury comorbidities, and low socioeconomic status are associated with greater readmission risk in adults. (12, 15, 16, 18, 19) Adult and pediatric trauma differs in regard to mechanism, type of injury, and patient-specific factors.(12, 20, 21) Additionally, care networks and post-discharge resources differ significantly and are likely to influence readmission rates.(22)

With the exception of index PICU hospitalization, risk factors for hospital readmission have not previously been described in a large, multicenter cohort of pediatric trauma survivors. (23) Addressing this knowledge gap is a necessary step to shape interventions aimed at decreasing ongoing morbidity after pediatric trauma and reducing the post-injury burden this places on patients, their families, and the health care system. The goals of this study are to determine the rate, etiology, and timing of both planned and unplanned hospital readmissions and to identify risk factors for unplanned readmission in children who survive a hospitalization for trauma.

Materials and Methods

Index Cohort

Pediatric Health Information System—The Pediatric Health Information System (PHIS) database is a benchmarking and quality improvement database containing inpatient data from more than 45 U.S. children's hospitals and more than 500,000 discharges per year. (24) PHIS contains administrative data, diagnoses, and procedures as well as utilization information for pharmacy, imaging, laboratory, supply, nursing, and therapy services. (25)

PHIS data are subjected to extensive reliability and validity checks and data quality monitoring.(26, 27) The notable strengths of the PHIS database for this study are 1) information about utilization of medications and treatments and 2) a unique identifier for each patient at each hospital, making longitudinal identification of readmissions at the same hospital possible.(22)

National Trauma Data Bank—The National Trauma Data Bank (NTDB) contains standardized trauma registry data from more than 3 million admissions at 900 trauma centers in the United States.(28) The NTDB also has an extensive continuous data quality improvement process.(28) The NTDB contains no protected health information (PHI) but does contain the Glasgow Coma Scale (GCS), necessary to categorize the severity of TBI and other important injury severity measures such as the Abbreviated Injury Scale (AIS) scores and the Injury Severity Score (ISS).

Dataset Linkage—The linkage method has been reported in detail.(29) Briefly, we applied Markov chain Monte Carlo-augmented probabilistic linkage to records of injured children (< 18 years old at admission) in the PHIS and NTDB databases. We validated the accuracy of the linkage using identified data from a single center that submits to both databases. The original linkage was 2007–2010, and the same methods were applied to data from 2011–2012 to create the 2007–2012 cohort for this study.

The current cohort included children who 1) were < 18 years old at discharge from the index hospitalization, 2) had index length of stay ≥ 2 days, and 3) had non-missing GCS and index hospitalization disposition. Traumatic injury was defined using standard International Classification of Diseases, 9th edition, Clinical Modification (ICD-9-CM) diagnosis codes (any of 800–959.99 or 995.5× except 905–909, 910–924, and 930–939). We excluded children who were transferred to another acute care facility, left against medical advice, or were discharged to hospice. Using that approach, 83% of eligible children in the NTDB linked accurately. The study was approved by the Colorado Multiple Institutional Review Board.

Exposure Groups—Index hospitalization injury type was categorized as isolated TBI (only TBI), both TBI and other injury (TBI+other), or non-TBI injury only (non-TBI). This categorization was based on body region AIS scores. In this way, we followed Centers for Disease Control recommendations that the appropriate control group for children hospitalized after TBI is not children hospitalized for non-injury reasons, but rather children hospitalized after trauma that does not include TBI.(30)

Statistical Analyses

The primary outcome was unplanned readmission within one year of discharge from index hospitalization. Secondary outcomes included any readmission (unplanned or planned) within one year of discharge, reason for readmission, time to readmission, and number of readmissions within one year of discharge. We used All Patient Refined Diagnosis Related Groups (APR-DRG) codes (present in the PHIS database) to categorize the readmissions as likely planned or unplanned and to categorize the primary etiologies of each readmission

(Supplemental Digital Content, eTable1). For time to readmission analyses, subjects without an unplanned readmission were censored on the earlier of their eighteenth birthday or September 30th, 2015.

We used the chi-square test to compare categorical variables, the two-sided t-test for continuous variables, and the Wilcoxon rank-sum test to compare durations.

Models—We evaluated unplanned and any 1-year readmission using multivariable logistic regression models. These models also allowed us to identify index hospitalization patient, injury, and treatment characteristics that were predictors of readmission. We used accelerated failure time (AFT) models to evaluate time to readmission and Poisson regression models to evaluate the number of readmissions within one year of discharge. The models evaluating the odds of any readmission (logistic) and counts of readmissions (Poisson) within one year were based on those patients who had at least one full year of observation after the index discharge. The "time to readmission" AFT models used the whole cohort with an observation period until the earlier of the subject's 18th birthday or September 30th, 2015. Planned and unplanned readmissions were not evaluated as competing risk events when we analyzed unplanned and planned readmissions, respectively. As sensitivity analyses, we fit separate logistic models for unplanned and any 1-year readmission among the three injury subgroups.

Candidate Predictors—The following index hospitalization variables were *a priori* selected for inclusion in every model: age, sex, exposure group (only TBI, non-TBI, TBI + other), injury mechanism, head/neck AIS score, ISS, ICP monitor placement, craniotomy/ craniectomy, seizure, cardiac arrest, packed red blood cell (pRBC) transfusion, days of exposure to benzodiazepines, narcotics, neuromuscular blockade, and inotropes/ vasopressors, ICU admission, hospital length of stay (LOS), and discharge disposition.(31)

Software

Statistical analysis was performed using R version 3.4.1 (2017-06-30). Statistical significance was defined as $P < 0.05$.

Results

Index Cohort

The index cohort included 51,591 children admitted to 29 hospitals in 19 states who survived their hospitalization after trauma. The median (IQR) age of the cohort was 9 (4, 13) years (Table 1). As is typical of trauma cohorts, 64% were male. Patient and injury characteristics by exposure group (only TBI, non-TBI, TBI + other) are shown in Table 2. The cohort included 16,181 (31.4%) children with TBI, which represents approximately 10% of U.S. pediatric hospitalizations after TBI during 2007–2012. In our cohort, 26.6% of subjects had TBI only, 4.8% had both TBI and other injuries, and 68.6% had non-TBI injuries.

Readmissions

Overall, 49,982 (96.9%) of the patients had at least one year of observation time. Of those, 4,301/49,982 (8.6%) had ≥ 1 readmission, planned or unplanned, within one year of discharge from their index hospitalization.

Unplanned readmission within one year—Many readmissions were unplanned: 2,704/49,982 (5.4%) experienced an unplanned readmission in the first year after discharge. Those readmitted tended to be younger, $P < 0.001$ (Table 1). The primary outcome did not vary with gender, $P = 1.000$. Readmission within one year was more likely among children with inflicted injury, higher injury severity, and longer hospital LOS, all $P < 0.001$. In univariable analyses, children with any TBI were more likely than children with other trauma to have an unplanned readmission within one year, $P < 0.001$. Unplanned readmission within 1 year of discharge accounted for 2,704 (62.9%) of all readmissions.

Reasons for Readmission—Overall, the most common etiologies for each patient's first unplanned readmission were 1) infection (22.3%), 2) abdominal, gastrointestinal, or genitourinary diagnoses (12.9%), and 3) mental health or substance use problems (9.4%) (Figure 1). Interestingly, seizures were the second most common etiology for both the non-TBI and TBI + other exposure groups.

Of the 1,075 children whose first unplanned readmission was due to an infection, the "post-operative/post-traumatic infection" APR-DRG category was the most common etiology and accounted for 38.0% of infectious readmissions (Supplemental Digital Content, eFigure1). That was also true in the TBI+other (32.8%) and non-TBI (44.5%) exposure groups. Among children with isolated TBI, respiratory viral illness was the most common etiology (29.7%) with post-operative/post-traumatic infection the second most common (24.7%).

Time to Readmission—For the 7,008 subjects who had a readmission, the median (IQR) time to any readmission was 178 (28, 652) days. The median (IQR) time to unplanned readmission was 208 (29, 737) days.

Figure 2 shows the cumulative probability of any readmission, planned readmission, and unplanned readmission over the first year after discharge, stratified by exposure group (non-TBI, only TBI, or TBI+other). Children in the TBI+other exposure group were readmitted earlier than the TBI only and non-TBI groups (median 103 versus 175 versus 189 days, $P < 0.001$).

Multiple Readmissions—Of those with a full year of observation time, 715/49,982 (1.4%) had > 1 unplanned readmissions in the first year. Similarly, 1,118/49,982 (2.2%) experienced two or more readmissions for any reason, planned or unplanned.

Multivariable Models

Logistic model of unplanned readmission within one year—In a multivariable logistic model, the independent index hospitalization predictors of 1-year unplanned readmission were older age, inflicted injury, more severe head injury, seizure, pRBC transfusion, ICU admission, longer hospital LOS, and disposition to home with services or to a long-term care facility (Table 3). Seizure and pRBC transfusion were the two strongest individual predictors of 1-year unplanned readmission. Interestingly, in this multivariable model, TBI was associated with lower odds of unplanned readmission and neurosurgical procedures (ICP monitoring, craniotomy/craniectomy) were not associated with unplanned readmission. Multivariable logistic models by exposure group (non-TBI, only TBI, TBI +other) for unplanned and any readmission within 1 year of discharge are reported in the Supplement (eTables 3–5).

Logistic model of any readmission within one year—In the logistic model for any 1-year readmission, the independent predictors were similar to those from the 1-year unplanned readmission model (Table 3). Notably, craniotomy/craniectomy was associated with readmission in the any readmission model. This is not unexpected because some children who receive cranial surgery may require a planned readmission for bone flap and/or a plate insertion.

Accelerated failure time model for time to first unplanned readmission—We used a multivariable AFT model to estimate the time to first unplanned readmission (Table 3). Larger acceleration factor point estimates indicate a longer time to first unplanned readmission. Independent predictors of earlier unplanned readmission were older age, inflicted injury, more severe head injury, seizure, pRBC transfusion, fewer days of benzodiazepines and narcotics, ICU admission, longer hospital LOS, and discharge disposition other than home without services. Again, seizure and pRBC transfusion were the two strongest independent predictors of earlier unplanned readmission. Children who had seizures have an expected median time to unplanned readmission of 0.14 (0.11, 0.18) times as long as those who did not seize during the index admission. Compared to the logistic models, exposure group was not as strong of a predictor and benzodiazepine and narcotic exposure variables were significant in this model.

Accelerated failure time model of time to first overall readmission—Using a similar approach, we estimated predictors of earlier overall readmission (Table 3). Key differences from the unplanned readmission AFT model included associations between TBI (exposure group), craniotomy/craniectomy, and more neuromuscular blockade exposure with earlier readmission.

Poisson model of multiple unplanned readmissions—Overall, 715 (1.4%) patients experienced more than one unplanned readmission in the first year after hospital discharge. In a multivariable Poisson model, seizure, pRBC transfusion, and discharge disposition other than home without services were the strongest predictors of multiple unplanned readmissions (Supplemental Digital Content, eTable2). Using mean ratios, we estimated the number of unplanned readmissions within one year for children with various characteristics (Supplemental Digital Content, eTable2). Those who had a seizure during the index hospitalization, for example, were estimated to have 2.65 times as many readmissions in the first year as those who did not.

Sensitivity Analyses—In logistic multivariable models for 1-year unplanned and any readmission among the three injury subgroups (rather than models including the injury group variable), we found similar results (eTables 3–5). Seizure, pRBC transfusion, and discharge disposition were the strongest predictors of readmission.

Poisson model of multiple overall readmissions—We also estimated predictors of multiple overall readmissions. The overall Poisson model was largely similar to its unplanned readmission counterpart. As expected, craniotomy/craniectomy was associated with multiple overall readmissions. Interestingly, compared to other types of trauma, TBI was associated with a lower likelihood of multiple readmissions in this multivariable model.

Discussion

In this multicenter retrospective cohort study, we found that 8.6% of children who survive a 2-day hospitalization for trauma are readmitted in the first year after discharge and 5.4% have an unplanned readmission. Contrary to our hypothesis, after controlling for patient, injury, and clinical course characteristics, TBI was associated with lower odds of readmission. We report a striking association between seizures during the index hospitalization and readmission, more frequent readmissions, and earlier readmission. Additionally, we found a strong association between pRBC transfusion during the index hospitalization and an increased risk of readmission that was independent of injury severity and hospital length of stay.

The 1-year readmission rate (8.6%) in this pediatric cohort is lower than the 21–25% reported in the adult literature.(15–17) We hypothesized that children experiencing TBI, alone or in conjunction with other injuries, would be at highest risk of readmission in the year after discharge. However, the presence or absence of TBI only modestly affected the child’s risk of readmission in multivariable analyses. This finding is contrary to reports of older adult trauma victims in whom one of the strongest predictors of readmission is severe head injury.(17) We speculate that the differing impact of TBI on readmission could be due to a higher proportion of non-severe head injury in our cohort. Alternatively, it may be reflective of differences in post-discharge support structures or the maturation-associated response to injury.

We also evaluated the reason for readmission. We found infection to be the most frequent cause of unplanned readmission for both the TBI and non-TBI exposure groups. The proportion of pediatric readmissions caused by infection (22.3%) exceeds that reported in the adult literature (1.5–14%).(12, 16, 32) This is not unexpected given that infection, most often respiratory, is the most frequent reason for hospitalization in childhood.(33) Additionally, the subset of children within our cohort who develop neurologic (such as seizures) or neuromuscular chronic conditions as a result of their trauma may be at higher risk of hospitalization and complications from respiratory infections due to impaired airway protective reflexes, restrictive lung disease due to ineffective chest expansion, chronic pulmonary injury due to microaspiration, or lung injury incurred during their injury or during mechanical ventilation post-injury. We also found that post-operative and post-traumatic infections cause 33–45% of unplanned readmissions for infection. Importantly, we found that a particularly high proportion of the non-TBI injury group (14.3%) experienced an unplanned readmission for post-operative and post-traumatic infection. These infectious readmissions may be preventable with improved in-hospital or post-discharge infection prevention interventions (e.g. immunizations to reduce vaccine-preventable diseases) or education (e.g. hand hygiene).

The third most common etiology for readmission in our cohort was mental health and substance abuse. This is not unexpected given the high rate of admission for psychiatric illness in children and the known association between injury and subsequent mental health disorders.(34) However, hospitalization after trauma may serve as a first exposure to the health care system. When the mental health disorder may have preceded or even caused the injury, the trauma hospitalization is an opportunity to diagnose these illnesses and ensure adequate access to mental and home health services as a way to prevent future hospitalizations.(33)

In every model we tested, we found a strong association between seizures during the index hospitalization and unplanned, early, and frequent readmissions. Particularly in young children, brain injury often manifests clinically as seizure activity. Our group recently characterized the frequency of seizure diagnosis in children admitted with severe TBI and reported that 36% of children younger than 2 years old have seizures during their hospitalization for severe TBI.(35) This young age group is known to have the highest burden of non-accidental trauma. Inflicted injury is an independent predictor of 1-year unplanned readmission and most commonly occurs in the TBI only subset of the population. (Supplemental Digital Content, eTable4)

Our current findings suggest that seizures during the index hospitalization are associated with an increased health burden that extends after discharge. We hypothesize that the seizure diagnosis may be a proxy for development of a chronic neurological condition resulting from their injury. Chronic neurologic injury has been identified separately as a primary predictor of readmission in hospitalized children using the Complex Chronic Condition (CCC) rubric.(22) While the CCC rubric may allow for identification of children with chronic neurologic injury during subsequent health care visits, the characteristics identified in our study provide a way to identify these children earlier in their hospital stay, allowing for more directed interventions during their hospitalization and discharge planning. The strong association between seizure diagnosis and readmission suggests that providers should be alert for seizures in children after trauma and consider a low threshold for EEG monitoring.(36)

The independent and strong association we found between pRBC transfusion and readmission suggests that blood transfusion may have negative effects on injured children that can persist after hospital discharge. Muszynski et al have described clinical evidence of transfusion-related immune modulation in injured children.(37) We hypothesize that this phenomenon could function to place these injured children at increased risk of severe infection or impaired healing, resulting in a higher risk of readmission.

Our analysis has several important limitations. We examined each individual APR-DRG code to classify readmissions as planned or unplanned. However, we are unable to validate the true planning status of each readmission. Therefore, the percentage of unplanned readmissions may be over- or underestimated. Additionally, we grouped the codes into diagnosis categories in order to describe and interpret the results. However, while the overall etiology categories are unlikely to change significantly, variations in groupings may have yielded alterations in the findings. We are also limited in our ability to interpret a more specific etiology of the infectious readmissions due to the lack of speciation data within our dataset. Additionally, we can only track readmissions at the same hospital. Therefore, our rate estimates are likely to be conservative. It is known that 86% of all U.S. pediatric readmissions occur at the original admission hospital.(38) In addition, children with injury diagnoses and those cared for at urban teaching hospitals (as nearly all of the 29 linked hospitals are) have among the lowest rate of different-hospital readmission.(38)

Conclusion

Both planned and unplanned readmissions significantly disrupt family functioning and incur a burden on the health care system. While we are unlikely to be able to prevent planned readmissions, we can identify subjects at highest risk of unplanned, and potentially preventable, readmission for targeted in-hospital or post-discharge interventions. Discharge and follow-up care interventions are effective in decreasing hospital readmission rates in pediatric and adult populations and may prove to be similarly effective in pediatric trauma. (39, 40) Further studies are needed to evaluate patient-level interventions and additional readmission characteristics in children at high-risk of readmission. The mechanisms that link seizures and blood transfusion to readmission are important to further investigate.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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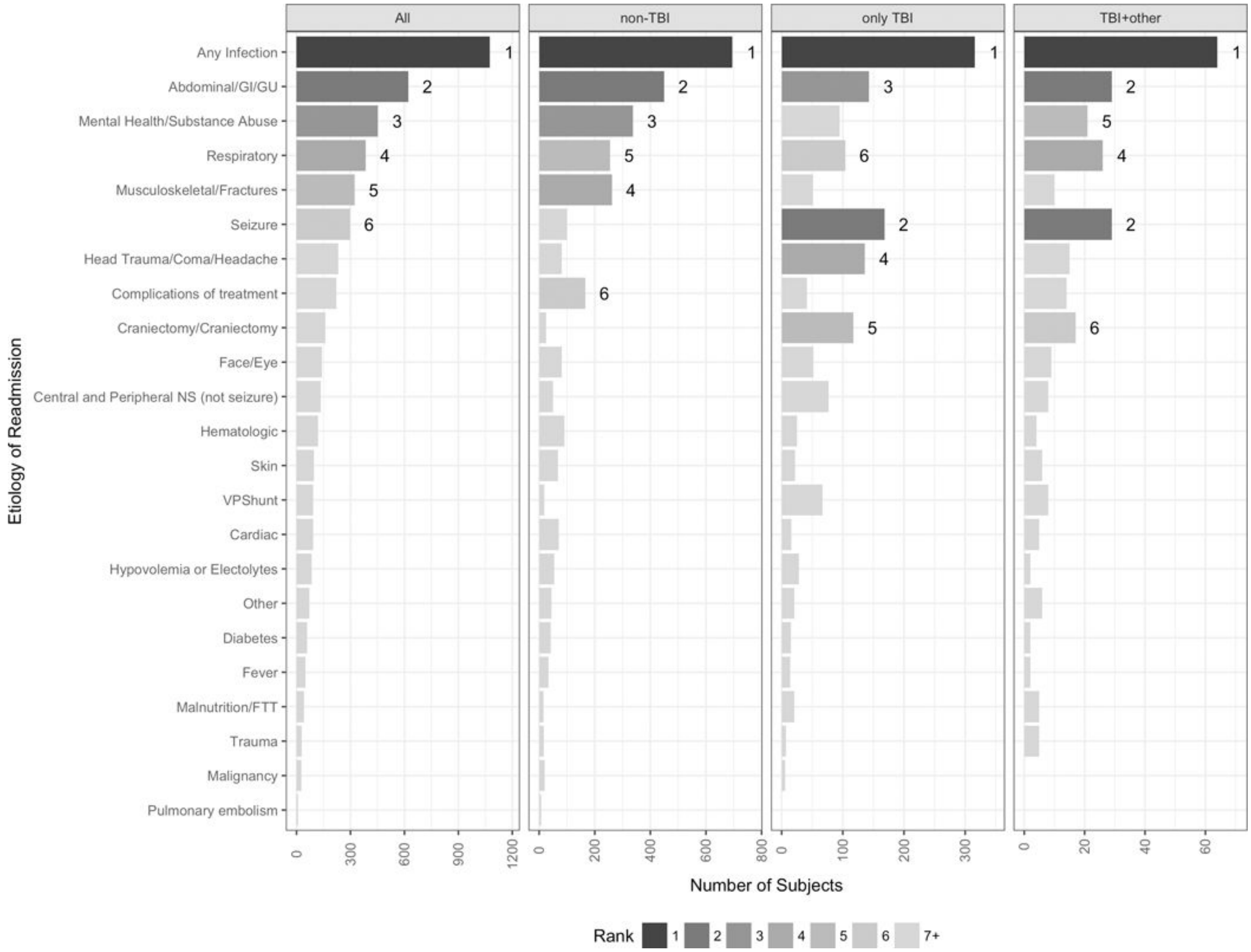

Figure 1. Etiology of First Unplanned Readmission

Infection was the primary reason for unplanned readmission overall and across all injury groups. Abdominal/Gastrointestinal (GI)/Genitourinary (GU), seizure, mental health/ substance abuse categories also accounted for a significant proportion of unplanned readmissions across all groups. TBI = traumatic brain injury, NS = nervous system, VP = ventriculoperitoneal, FTT = failure to thrive.

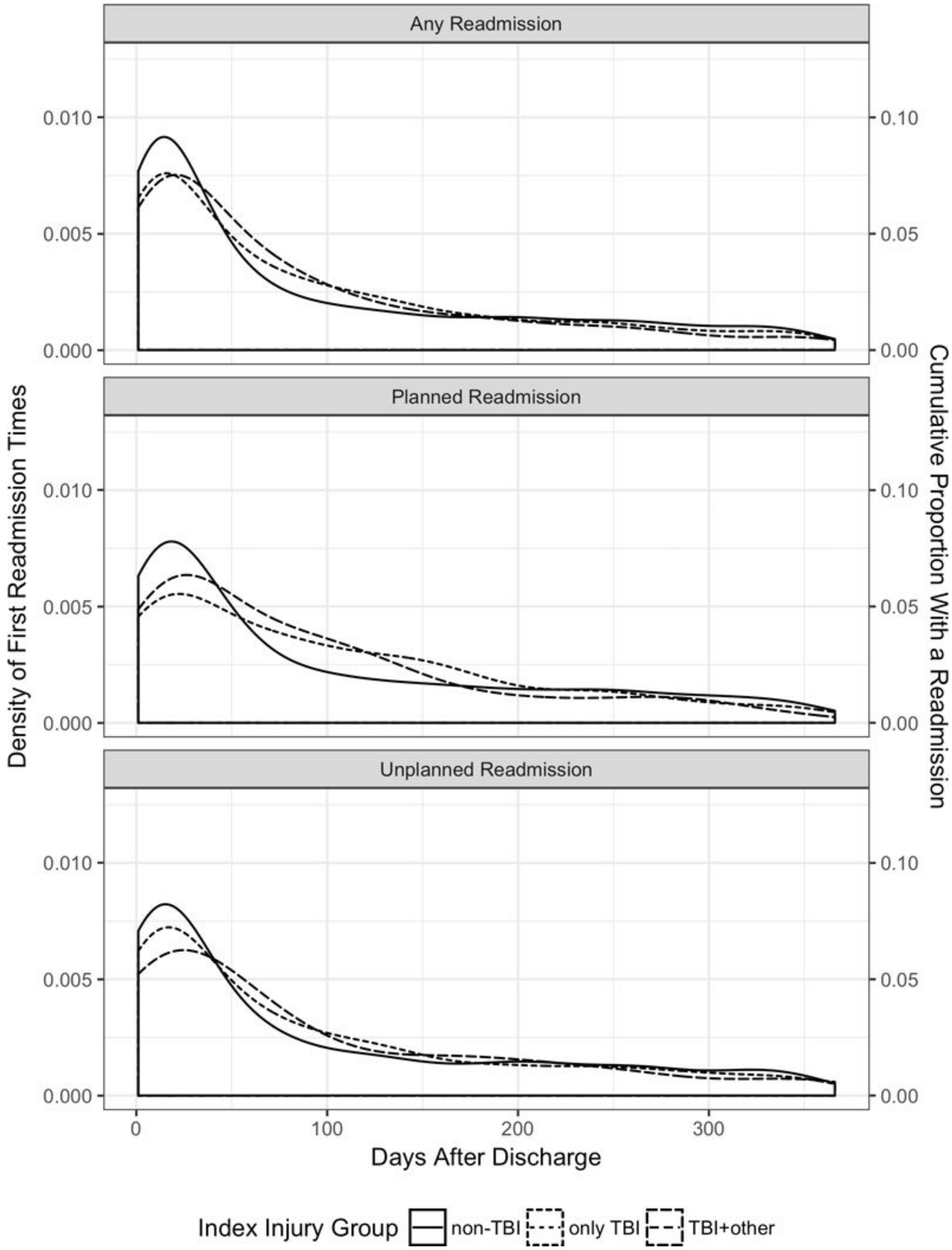

Figure 2. Timing of First Readmission

Cumulative probability of readmission and density plot. Proportion of patients with readmission (any, planned, unplanned) and cumulative probability of readmission (any, planned, unplanned) based on exposure group (only TBI, non-TBI trauma only, TBI + other injury). Censored events have been omitted from the graphic for clarity. TBI = traumatic brain injury.

Table 1

Patient, injury, and index admission characteristics by number of 1-year unplanned readmissions status

Characteristic	All Subjects (n = 51,591)	None (n = 48,887)	≥ 1 (n = 2,704)
Age (months)			
median (IQR)	104 (49, 160)	105 (50, 160)	82 (18, 159)
Sex			
Male, n (%)	33,068 (64)	31,338 (64)	1,730 (64)
Female, n (%)	18,454 (36)	17,489 (36)	965 (36)
Missing, n (%)	69 (0)	60 (0)	9 (0)
Injury Mechanism			
Inflicted, n (%)	8,653 (17)	8,031 (16)	622 (23)
Fall, n (%)	17,745 (34)	16,979 (35)	766 (28)
Motor Vehicle, n (%)	10,727 (21)	10,252 (21)	475 (18)
Other, n (%)	14,466 (28)	13,625 (28)	841 (31)
Any Burn			
Yes, n (%)	1,863 (4)	1,764 (4)	99 (4)
TBI/Other Trauma			
only TBI, n (%)	13,699 (27)	12,791 (26)	908 (34)
non-TBI, n (%)	35,410 (69)	33,797 (69)	1,613 (60)
TBI+other, n (%)	2,482 (5)	2,299 (5)	183 (7)
Injury Severity			
ED GCS, median (IQR)	15 (15, 15)	15 (15, 15)	15 (15, 15)
ED GCS 13–15, n (%)	47,381 (92)	45,153 (92)	2,228 (82)
ED GCS 9–12, n (%)	1,147 (2)	1,049 (2)	98 (4)
ED GCS <= 8, n (%)	3,063 (6)	2,685 (5)	378 (14)
ISS, median (IQR)	5 (4, 10)	5 (4, 10)	9 (4, 16)
Intensive Care Unit			
Admission, n (%)	12,321 (24)	11,280 (23)	1,041 (38)
LOS (days), median (IQR)	2 (1, 4)	2 (1, 4)	3 (2, 10)
Hospital LOS (days)			
median (IQR)	2 (1, 4)	2 (1, 4)	4 (2, 10)

IQR = interquartile range, TBI = traumatic brain injury, ED GCS = Emergency Department Glasgow Coma Scale, ISS = Injury Severity Score, LOS = length of stay.

Table 2

Patient, injury, and index admission characteristics by exposure group

Characteristic	non-TBI (n = 35,410)	only TBI (n = 13,699)	TBI+other (n = 2,482)
Age (months)			
median (IQR)	111 (60, 162)	77 (17, 146)	125 (60, 169)
Sex			
Male, n (%)	22,947 (65)	8,551 (63)	1,570 (63)
Female, n (%)	12,425 (35)	5,121 (37)	908 (37)
Missing, n (%)	38 (0)	27 (0)	4 (0)
Injury Mechanism			
Inflicted, n (%):	5,488 (15)	2,977 (22)	188 (8)
Fall, n (%):	12,692 (36)	4,815 (35)	238 (10)
Motor Vehicle, n (%):	6,044 (17)	3,135 (23)	1,548 (62)
Other, n (%):	11,186 (32)	2,772 (20)	508 (20)
Any Burn			
n (%)	1,805 (5)	32 (0)	26 (1)
Injury Severity			
ED GCS, median (IQR)	15 (15, 15)	15 (14, 15)	14 (6, 15)
ED GCS 13–15, n (%)	34,713 (98)	11,191 (82)	1,477 (60)
ED GCS 9–12, n (%)	227 (1)	721 (5)	199 (8)
ED GCS <= 8, n (%)	470 (1)	1,787 (13)	806 (32)
ISS, median (IQR)	4 (4, 9)	10 (8, 16)	22 (17, 29)
Abbreviated Injury Scale score			
Head/Neck	0 (0, 0)	3 (2, 4)	3 (2, 4)
Chest	0 (0, 0)	0 (0, 0)	3 (0, 3)
Abdomen	0 (0, 0)	0 (0, 0)	0 (0, 2)
Extremity	2 (1, 2)	0 (0, 1)	2 (0, 3)
Intensive Care Unit			
Admission, n (%)	4,339 (12)	6,286 (46)	1,696 (68)
LOS (days), median (IQR)	2 (1, 3)	2 (1, 3)	3 (2, 9)
Hospital LOS (days)			
median (IQR)	2 (1, 3)	2 (1, 4)	6 (3, 14)
Index Hospitalization Events			
ICP Monitoring, n (%)	12 (0)	609 (4)	280 (11)
Craniectomy/Craniotomy, n (%)	23 (0)	950 (7)	134 (5)
Seizures, n (%)	340 (1)	1,280 (9)	175 (7)
Cardiac Arrest, n (%)	38 (0)	35 (0)	15 (1)
Index Hospitalization Treatments			
pRBC Transfusion, n (%)	1,069 (3)	717 (5)	492 (20)
Benzodiazepines (days), median (IQR)	0 (0, 1)	0 (0, 0)	1 (0, 3)
Narcotics (days), median (IQR)	2 (0, 3)	0 (0, 2)	3 (1, 7)
NM Blockade (days), median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 1)

Characteristic	non-TBI (n = 35,410)	only TBI (n = 13,699)	TBI+other (n = 2,482)
Vasoactives (days), median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)
Discharge Disposition, n (%)			
Home with services	176 (0)	73 (1)	41 (2)
Home without services	34,723 (98)	12,856 (94)	1,968 (79)
Transfer to Care Facility	154 (0)	203 (1)	113 (5)
Transfer to Rehab	357 (1)	567 (4)	360 (15)

IQR = interquartile range, TBI = traumatic brain injury, ED GCS = Emergency Department Glasgow Coma Scale, ISS = Injury Severity Score, LOS = length of stay, ICP = intracranial pressure, pRBC = packed Red Blood Cell, NM = neuromuscular.

Table 3

Multivariable 1-year readmission models

Characteristic	Logistic 1-yr Unplanned	Logistic 1-yr Any	AFT Unplanned	AFT Any
Demographics				
Age, per year	**0.98 (0.97, 0.99)**	1.00 (1.00, 1.01)	**0.99 (0.97, 1.00)**	**0.96 (0.94, 0.97)**
Male	1.00 (0.92, 1.09)	1.04 (0.97, 1.11)	1.04 (0.91, 1.20)	0.96 (0.85, 1.09)
Injury Group				
non-TBI	Reference	Reference	Reference	Reference
only TBI	**0.82 (0.69, 0.98)**	**0.69 (0.60, 0.80)**	1.31 (0.98, 1.75)	**1.88 (1.45, 2.43)**
TBI+other	**0.72 (0.57, 0.91)**	**0.60 (0.49, 0.73)**	**1.51 (1.02, 2.23)**	**2.08 (1.48, 2.93)**
Injury Mechanism				
Fall	Reference	Reference	Reference	Reference
Inflicted	**1.37 (1.22, 1.53)**	**1.27 (1.15, 1.40)**	**0.57 (0.47, 0.69)**	**0.63 (0.53, 0.75)**
Motor Vehicle	**0.83 (0.73, 0.94)**	0.97 (0.88, 1.08)	**1.59 (1.29, 1.97)**	**1.30 (1.09, 1.55)**
Other	**1.28 (1.15, 1.42)**	**1.24 (1.14, 1.36)**	**0.76 (0.63, 0.90)**	**0.77 (0.66, 0.90)**
Any Burn				
Yes	**0.80 (0.64, 1.00)**	1.04 (0.88, 1.23)	1.11 (0.77, 1.59)	0.81 (0.60, 1.10)
Injury Severity				
ISS, per point	0.99 (0.99, 1.00)	1.00 (1.00, 1.00)	**1.02 (1.01, 1.03)**	1.00 (1.00, 1.01)
Head/Neck AIS, per point	**1.09 (1.03, 1.15)**	**1.05 (1.00, 1.10)**	**0.86 (0.78, 0.94)**	**0.90 (0.82, 0.97)**
Index Hospitalization Stay				
Admitted to ICU	**1.19 (1.07, 1.33)**	**1.13 (1.03, 1.24)**	**0.80 (0.66, 0.96)**	**0.80 (0.67, 0.94)**
Length of stay, per day	**1.03 (1.03, 1.03)**	**1.03 (1.03, 1.04)**	**0.96 (0.96, 0.96)**	**0.96 (0.96, 0.97)**
Index Hospitalization Events				
ICP Monitor	1.04 (0.82, 1.32)	1.22 (0.99, 1.50)	0.95 (0.63, 1.43)	0.79 (0.55, 1.14)
Craniotomy/Craniectomy	1.21 (0.96, 1.51)	**1.48 (1.22, 1.79)**	0.74 (0.51, 1.08)	**0.52 (0.38, 0.73)**
Seizure	**2.35 (2.03, 2.74)**	**2.01 (1.75, 2.32)**	**0.14 (0.11, 0.18)**	**0.19 (0.15, 0.25)**
Cardiac Arrest	1.03 (0.58, 1.84)	0.95 (0.55, 1.65)	0.72 (0.30, 1.73)	0.80 (0.36, 1.81)
Index Hospitalization Treatments				
pRBC Transfusion	**1.72 (1.48, 2.01)**	**1.80 (1.58, 2.05)**	**0.30 (0.23, 0.39)**	**0.23 (0.18, 0.29)**
Benzodiazepines, per day	1.00 (0.99, 1.02)	1.01 (1.00, 1.03)	**1.01 (1.00, 1.02)**	1.01 (1.00, 1.02)
Narcotics, per day	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	**1.01 (1.01, 1.02)**	**1.01 (1.00, 1.02)**
NM Blockade, per day	0.98 (0.95, 1.02)	0.99 (0.96, 1.03)	0.96 (0.91, 1.02)	**0.93 (0.89, 0.97)**
Vasoactives, per day	1.00 (0.97, 1.04)	0.99 (0.96, 1.03)	0.97 (0.92, 1.03)	0.98 (0.94, 1.03)
Disposition				
Home without services	Reference	Reference	Reference	Reference
Home with services	**1.74 (1.21, 2.49)**	**2.06 (1.53, 2.78)**	**0.31 (0.17, 0.58)**	**0.24 (0.14, 0.40)**
Transfer to Care Facility	**1.62 (1.21, 2.16)**	**1.76 (1.37, 2.25)**	**0.33 (0.21, 0.54)**	**0.30 (0.20, 0.46)**
Transfer to Rehab	1.20 (0.98, 1.47)	1.07 (0.89, 1.27)	**0.50 (0.36, 0.70)**	**0.52 (0.39, 0.71)**

We used logistic regression with reported odds ratios (95% confidence intervals) and accelerated failure time (AFT) with reported acceleration factors (95% confidence intervals) models to determine variables independently associated with 1-year unplanned readmission and shorter time to readmission, respectively. Acceleration factor point estimates <1 indicate a shorter time to first readmission as compared to the reference group. For example, the median time to first unplanned readmission in subjects who had a seizure was 0.14 times the median time to unplanned readmission in those who did not have a seizure. Bolded entries indicate significance at the 0.05 level. TBI = traumatic brain injury, ISS = injury severity score, AIS = abbreviated injury scale, ICU = Intensive Care Unit, ICP = intracranial pressure, pRBC = packed Red Blood Cell, NM = neuromuscular.

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