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Mental health outcomes in pediatric trauma patients: A 10 year real world analysis using a large database approach



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ABSTRACT

Introduction: Traumatic injury is the leading cause of morbidity and mortality among children in the United States. Single institution studies suggest an increased risk of poor mental health outcomes among these patients, but there are few population-based studies assessing this risk.

Methods: The IBM® MarketScan® private insurance claims database was used to identify children (6–17yo) with traumatic injuries between 2007 and 2016. Time-to-event analysis was performed to compare rates of PTSD, depression, anxiety, and adjustment disorder among children admitted to the hospital compared to children treated in the emergency department (ED), urgent care (UC), or in the outpatient setting, and to children admitted with uncomplicated appendicitis.

Results: Among children admitted for traumatic injury, 3.3% developed a subsequent mental health diagnosis, and 1.6% developed PTSD. Children admitted for traumatic injury were at increased risk of developing a mental health condition (HR 1.34, $p < 0.001$) compared to those admitted for appendicitis. Children treated in the ED or UC for traumatic injury and those treated in the outpatient setting were also at increased risk (HR 1.20 and 1.18, $p = 0.006$ and $p = 0.012$, respectively). Among those admitted to the hospital, the risk of subsequent mental health diagnosis increased by 1.5% per day; in the first 31 days of hospitalization, the risk of PTSD diagnosis increased by 13% per day.

Conclusion: Children who sustain a traumatic injury are at increased risk of developing a mental health condition. PTSD rates found in our real world analysis are lower than those found in prospective studies, raising the possibility of under-recognition of PTSD in this population.

Level of evidence: Level II

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1. Introduction

Traumatic injury is the leading cause of morbidity and mortality among children in the United States, accounting for more than 9 million emergency room visits per year and more than 12,000 deaths [1,2]. Treatment typically focuses on the immediate care of physical injuries, often aided by national or international consensus guidelines for management and quality metrics [3,4]. These guidelines have been credited with improving trauma systems and reducing the number of preventable deaths among trauma victims [5,6]. However, trauma systems have been limited in addressing the longer term outcomes of traumatic injury, including patterns of functional and socio-emotional recovery.

Increasing attention is being given to mental health outcomes after traumatic injury. Studies suggest that nearly half of children experience symptoms of post-traumatic stress in the first month after injury. Aaron et al. found that 23% of pediatric patients ad-

mitted for traumatic injury met criteria for post-traumatic stress disorder when interviewed one month after hospitalization and 48% met 2/3 of the symptom clusters [7]. The challenges with emotional recovery extend to children's families as well. In interviews with parents of children who were injured in traffic accidents, Kassam-Adams et al. found that 12% of parents met criteria for acute stress disorder and 25% met partial criteria [8]. Up to one third of those with acute stress symptoms subsequently develop post-traumatic stress disorder (PTSD) with significant effects on emotional and functional recovery.

Despite this large burden of disease, little is known about the population-wide incidence and primary risk factors for pediatric mental health disorders after traumatic injury. Prior studies, including those cited above, have been conducted almost exclusively as single-institution studies with follow-up typically limited to 6 months. Only two studies have provided data on outcomes longer than 6 months [9,10] and only one study on outcomes longer than 1 year [11].

Healthcare administrative claims databases allow for large scale longitudinal analyses of patient cohorts, beyond the limitations of

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clinical trials or prospective studies with typically limited follow-up periods and subject to study observation or confirmation biases. Claims databases provide for the longitudinal tracking of enrollees, with information about hospital admissions, outpatient visits, and prescriptions for the duration of enrollment in the insurance plan, thus reflecting real world data collected outside the context of highly structured observational or interventional studies. This study uses an administrative claims database to assess the risk for mental health disorders among pediatric patients following traumatic injury.

2. Methods

2.1. Study design

We performed a 10 year retrospective analysis using an administrative claims database to evaluate the risk for subsequent development of mental health disorders after traumatic injury among pediatric patients. We identified children admitted for traumatic injury who had no history of a mental health disorder and searched their subsequent records for a new diagnosis of PTSD, anxiety, depression, or adjustment disorder. We chose these mental health disorders because of overlapping symptom criteria with PTSD. Since hospitalization has also been shown to be a risk factor for mental health disorders, we sought to create a control group of children who were also generally healthy and hospitalized for an acute issue: acute, uncomplicated appendicitis. Since many patients are treated for traumatic injuries in the emergency department (ED) or urgent care (UC), and outpatient settings, we also constructed cohorts of these children and compared them to our hospitalized groups. The database was queried for all cases from 2007 to 2016.

This study was approved under the Stanford University Institutional Review Board's PHS-40,974 umbrella protocol for use of de-identified data from the Center for Population Health Sciences. Initial database cleaning and merging was completed in Redivis, our institution's online data management system. Further data cleaning and analysis was conducted in Python 3 (Netherlands) and Stata Statistical Software: Release 16 (College Station, TX) [12].

2.2. Data set

The IBM® MarketScan® Research Database (formerly Truven), a large private insurance claims database, was used to analyze the mental health trajectory of children with traumatic injuries. MarketScan® includes aggregated claims from 350 payers and has more than 20 billion service records available from both inpatient and outpatient settings between the years 2007 and 2016 [13].

For demographic data, MarketScan® includes only the metropolitan/micropolitan statistical area (MSA) of the enrollee. The MSA is a delineation of geographic regions provided by the Office of Management and Budget. This was used to link each enrollee with County Level Data from Area Health Resource Files released by the Health Resources and Services Administration in 2019.

For injury severity data, MarketScan® includes only ICD codes which were mapped to abbreviated injury scale (AIS) scores and body regions using the ICDPIC Stata module [14]. AIS scores from the three most severely injured body regions were then combined to calculate the ISS for each patient [15].

2.3. Cohort construction

Using ICD-9 and ICD-10 codes, the database was queried for children 6–17 years of age with an inpatient hospital admission

for traumatic injury or for uncomplicated appendicitis. Uncomplicated appendicitis (ICD9 540–543; ICD10 K35, K36, K37, K38) was defined by hospital length of stay less than or equal to 3 days, with a procedure code for appendectomy (ICD9 47.01, 47.09; ICD10 0DTJ, 0DBJ, 0DQJ), and no diagnosis indicating abscess, perforation, or gangrene (excluded ICD9 540.1; ICD10 K35.21, K35.31, K35.33, K35.891). The database was also queried for children with traumatic injury treated in the ED/UC, or outpatient setting (ICD9 800–929, 940–959; ICD10 S00–S99, T07, T14, T20–T28, T30–T32, T79). After identification of our patient cohort, records following their index event (appendicitis or traumatic injury) were searched for subsequent diagnoses of PTSD (ICD9 309.81, ICD10 F43.1), depression (ICD9 296.2, 309.1, 311; ICD10 F32.0–F32.5, F32.8–F32.9), anxiety (ICD9 300; ICD10 F41.9), or adjustment disorder (ICD9 309.0, 309.2–309.4, 309.82, 309.83, 309.89, 309.9; ICD10 F43.0, F43.2). Exclusion criteria included those with a mental health diagnosis documented within 6 months preceding the index event, those with a mental health services carve-out from their insurance plan, and those whose coverage was terminated less than 6 months after their inciting event.

2.4. Statistical analysis

Within Stata, the proportional hazards assumption was tested; age was found to be a time-dependent covariate and so was treated as such in further analyses [16].

Univariate and multivariate Cox regression survival estimates were generated for the cohort, with start time defined as the date of service for treatment of the traumatic injury or the date of admission for appendicitis. A “mental health event” was defined as the inpatient or outpatient diagnosis of a new mental health condition at least six months after the index event to minimize prior mental health conditions identified because of patients presenting to care for their trauma. Patients were censored at the time of their insurance coverage end date. Successive models included covariates for patient characteristics (sex, age, number of previous outpatient exposures, number of previous hospitalizations, and estimated ISS), for socioeconomic status at the MSA level (median household income, percent below poverty level, percent with less than a high school education, and percent with four or more years of college), and for hospital admission (length of stay and indicator for ICU admission and intubation).

3. Results

From 2007–2016, there were 153 million patients available through the MarketScan® Database. Of these, 30.9 million were between the ages of 6 and 17 years, and 8.2 million children within this age group had a qualifying event diagnosis. There were 4345,852 children identified with traumatic injury and 10,164 children identified with admission for uncomplicated appendicitis who met final inclusion criteria. Of children with traumatic injury, 37,897 were admitted to the hospital, 1571,932 were seen in the emergency department or urgent care, and 2736,023 were seen in the outpatient setting (Fig. 1). Basic demographic data were compiled for each of these four sub-cohorts, and they were found to have similar demographic characteristics (Table 1). Among admitted children, trauma patients were less likely to be female (29.5 vs. 41.8%), had slightly longer lengths of stay, and were more likely to require ICU care compared to patients in the uncomplicated appendicitis group (2.7 days vs. 1.4 days, and 18.1% vs. 1.2%, respectively). Mean duration of follow up within the insurance claims database was similar across all groups.

Over the time studied, 121,082 children, or 2.8% of the cohort, developed a new diagnosis of PTSD, depression, anxiety, or adjustment disorder (Table 2). Anxiety was the most prevalent disorder

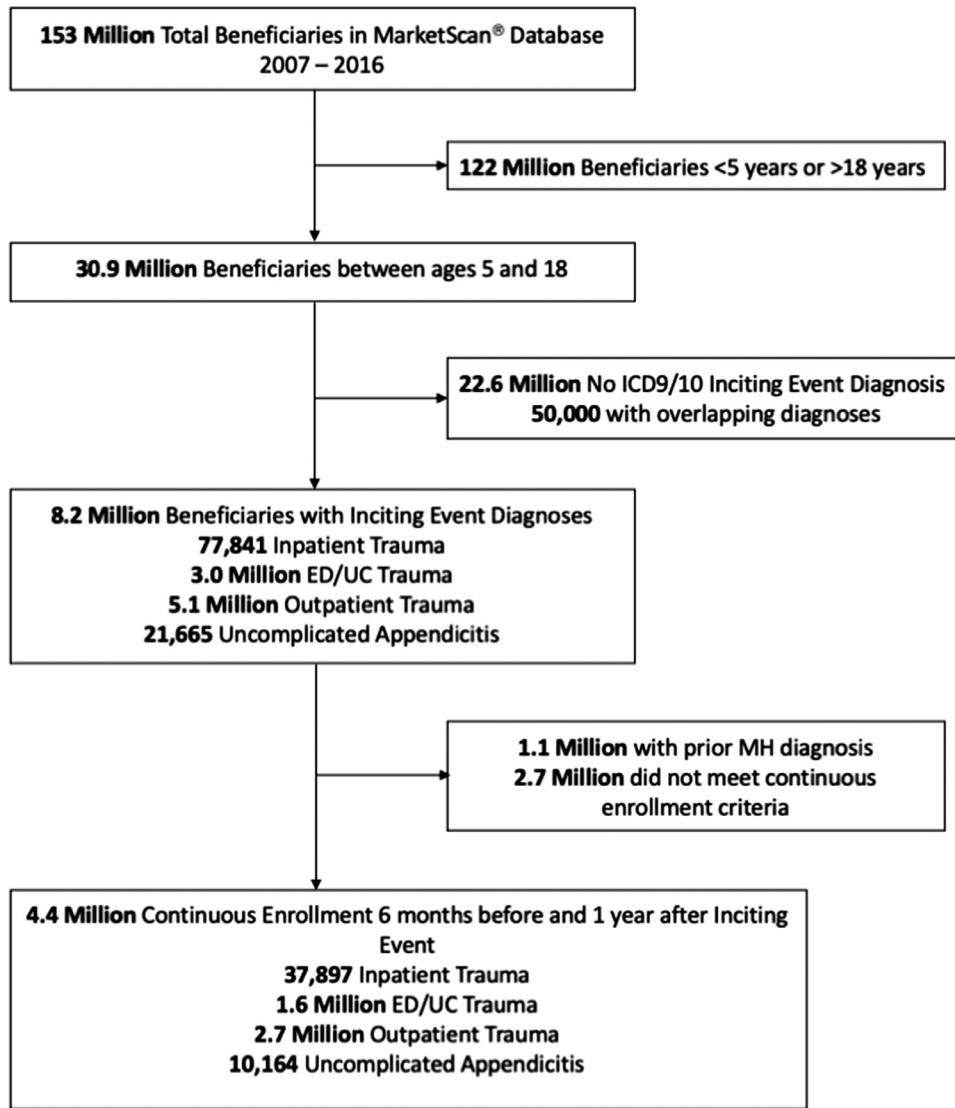


Fig. 1. Cohort enrollment criteria.

Table 1
Demographic characteristics.

	Trauma Admission (n = 37,897)	Trauma ED/UC (n = 1571,932)	Trauma Outpatient (n = 2736,023)	Appendicitis Admission (n = 10,164)
Age, mean	12.6	11.4	11.8	12.4
Female,%	29.5%	40.5%	45.5%	41.8%
MSA Characteristics				
Median Household Income	\$61,429	\$61,489	\$62,583	\$60,991
Percent Below Poverty Level, mean	12.8%	12.6%	12.4%	13.0%
Percent Less than High School, mean	11.8%	11.3%	11.4%	12.3%
Percent More than College, mean	27.7%	27.9%	28.5%	27.2%
Length of Stay, mean (days)	2.7	–	–	1.4
ICU,%	18.1%	–	–	1.2%
Months Follow Up, mean	31.3	29.9	31.0	27.5

Notes: Abbreviations: MSA = Metropolitan Statistical Area, ICU = Intensive Care Unit, ED = Emergency Department, UC = Urgent Care.

Table 2
Mental health outcomes in pediatric trauma patients.

	Overall (n = 4356,016)	Trauma Admission (n = 37,897)	Trauma ED/UC (n = 1571,932)	Trauma Outpatient (n = 2736,023)	Appendicitis Admission (n = 10,164)
PTSD	1363 (0.03%)	34 (0.09%)	574 (0.04%)	753 (0.03%)	2 (0.02%)
Depression	32,176 (0.74%)	381 (1.01%)	11,629 (0.74%)	20,087 (0.73%)	79 (0.78%)
Anxiety	63,291 (1.45%)	592 (1.56%)	21,675 (1.38%)	40,898 (1.49%)	126 (1.24%)
Adjustment	24,252 (0.56%)	244 (0.64%)	8609 (0.55%)	15,358 (0.56%)	41 (0.40%)
Total	121,082 (2.78%)	1251 (3.30%)	42,487 (2.70%)	77,096 (2.82%)	248 (2.44%)

Table 3
Risk of mental health outcomes after traumatic injury in children, hazard ratio.

	Unadjusted (<i>p</i> value)	Adjusted for Personal Characteristics (<i>p</i> value)	Adjusted for PC & SES (<i>p</i> value)	Adjusted for PC & Admission Characteristics (AC) (<i>p</i> value)	Adjusted for PC, AC & SES (<i>p</i> value)
All Mental Health					
Trauma Outpatient	0.995 (0.940)	1.178 (0.012)	1.104 (0.254)	1.170 (0.016)	1.086 (0.342)
Trauma ED/UC	0.999 (0.982)	1.196 (0.006)	1.129 (0.162)	1.188 (0.008)	1.111 (0.227)
Trauma Admit	1.152 (0.046)	1.340 (< 0.001)	1.246 (0.021)	1.289 (< 0.001)	1.206 (0.054)
PTSD					
Trauma Outpatient	1.210 (0.788)	1.442 (0.605)	1.537 (0.668)	1.468 (0.588)	1.470 (0.701)
Trauma ED/UC	1.678 (0.465)	2.08 (0.301)	2.259 (0.416)	2.120 (0.289)	2.161 (0.442)
Trauma Admit	3.930 (0.060)	4.623 (0.036)	4.876 (0.123)	4.133 (0.054)	4.616 (0.140)
Depression					
Trauma Outpatient	0.805 (0.054)	1.028 (0.804)	0.902 (0.483)	1.035 (0.758)	0.915 (0.544)
Trauma ED/UC	0.852 (0.156)	1.133 (0.268)	1.022 (0.881)	1.141 (0.244)	1.036 (0.809)
Trauma Admit	1.100 (0.442)	1.309 (0.030)	1.185 (0.295)	1.178 (0.198)	1.035 (0.836)
Anxiety					
Trauma Outpatient	1.023 (0.798)	1.180 (0.064)	1.056 (0.638)	1.152 (0.117)	1.020 (0.867)
Trauma ED/UC	0.993 (0.936)	1.173 (0.074)	1.053 (0.657)	1.145 (0.133)	1.017 (0.889)
Trauma Admit	1.068 (0.504)	1.251 (0.023)	1.068 (0.611)	1.250 (0.026)	1.082 (0.551)
Adjustment Disorder					
Trauma Outpatient	1.234 (0.179)	1.475 (0.013)	1.708 (0.020)	1.446 (0.019)	1.632 (0.034)
Trauma ED/UC	1.250 (0.154)	1.408 (0.029)	1.628 (0.034)	1.380 (0.041)	1.555 (0.056)
Trauma Admit	1.394 (0.049)	1.609 (0.005)	1.915 (0.008)	1.560 (0.009)	1.936 (0.008)

Notes: Hazard Ratios (*p*-value), all compared to appendicitis control group.

Personal Characteristics (PC): Age, sex, number of healthcare exposures, number of hospitalizations.

Admission Characteristics (AC): ICU, intubation, length of stay.

Socioeconomic Status (SES): Median household income, percent below poverty level, percent less than high school education, percent less than college.

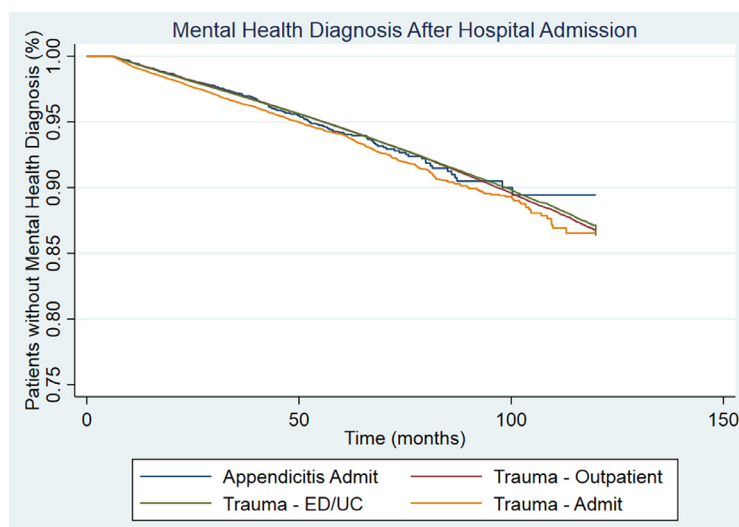


Fig. 2. Composite mental health disorders.

(1.5%), and PTSD was the least prevalent disorder (0.03%). Among patients admitted to the hospital for traumatic injury, the composite rate of mental health disorder was 3.3%, with 0.1% of patients developing PTSD.

When adjusted for age, sex, number of hospitalizations, and number of healthcare exposures, children admitted to the hospital for traumatic injury had significantly increased risk of developing a mental health diagnosis (HR 1.34, $p < 0.001$), compared to those admitted for appendicitis (Table 3). Children treated in the emergency department or urgent care for traumatic injury and those treated in the outpatient setting were also at increased risk of developing a mental health condition relative to appendicitis patients, although not to the same degree as admitted patients (HR 1.20 and 1.18, $p = 0.006$ and $p = 0.012$, respectively).

Children admitted to the hospital for traumatic injury were at the highest risk of developing a diagnosis of PTSD (HR 4.62, $p = 0.036$) when adjusted for age, sex, number of hospitalizations, and number of healthcare exposures. Trauma patients managed in

the outpatient, ED or UC setting did not demonstrate similarly increased risk (Fig. 2).

Increased length of stay during hospital admission for traumatic injury was associated with an increased risk of developing a mental health diagnosis (Table 4). For each additional hospital day for the first 31 days of admission, there was a 1.5% increased risk of developing a mental health diagnosis ($p < 0.001$). The risk of developing PTSD was increased by 13% per hospital day for the first 31 days of admission ($p < 0.001$). There was no significantly increased risk of developing a mental health condition with increased length of stay in appendectomy patients.

Injury Severity Scores (ISS) were stratified by mild (1–8), moderate (9–15), serious (16–24), and severe (25+) for all pediatric trauma patients (Table 4). For patients with severe injuries, there was a significant increased risk of developing a mental health diagnosis (HR 1.79, $p < 0.001$), and the relationship was strongest for the development of PTSD (HR 4.44, $p = 0.035$). ISS was not significantly associated with developing adjustment disorder.

Table 4
Risk factors for mental health diagnosis.

	All Mental Health	PTSD	Depression	Anxiety	Adjustment
Length of Stay (Coefficient for each additional day, p value)					
Appendicitis					
LOS ≤ 31 days	−0.060 (0.480)	−2.220 (0.086)	−0.012 (0.937)	−0.020 (0.864)	−0.236 (0.261)
All LOS	−0.060 (0.480)	−2.220 (0.086)	−0.012 (0.937)	−0.020 (0.864)	−0.236 (0.261)
Trauma Admit					
LOS ≤ 31 days	0.022 (0.018)	0.130 (< 0.001)	0.031 (0.034)	0.002 (0.891)	0.022 (0.286)
All LOS	0.015 (< 0.001)	0.022 (0.008)	0.020 (< 0.001)	0.000 (0.981)	0.015 (0.012)
Injury Severity Score (Hazard Ratio, p value)					
Mild (1–8)	1	1	1	1	1
Moderate (9–15)	1.062 (0.050)	1.274 (0.352)	1.112 (0.063)	1.038 (0.381)	1.032 (0.640)
Serious (16–24)	1.224 (0.002)	1.865 (0.213)	1.636 (< 0.001)	1.168 (0.095)	0.945 (0.730)
Severe (25+)	1.786 (< 0.001)	4.437 (0.035)	2.064 (0.001)	1.761 (0.001)	1.124 (0.726)

Notes: LOS = length of stay.

4. Discussion

In this time-to-event analysis using a large insurance claims database, children admitted to the hospital for traumatic injury were found to be at increased risk of developing a mental health disorder compared to a control group of children admitted for appendicitis. This risk was most pronounced for the development of PTSD. Children seen in the ED, urgent care, and in the outpatient setting for traumatic injury were also found to be at increased risk, although not to the same degree.

In constructing the statistical model, it was necessary to identify an appropriate group of children to which to compare the patients admitted for traumatic injury. Children admitted for uncomplicated appendicitis were thought to be an appropriate group because of the similarity of being admitted to the hospital for a one-time, unexpected event. Only one other population-based study has looked at mental health outcomes after traumatic injury in children; Zatzik et al. [19] used data from a group health plan in Oregon to compare children with ICD-9 coded traumatic injury to those without a traumatic injury. This study found children with traumatic injury in 2001 had significantly greater odds of being diagnosed with PTSD more than the three years following injury (2002 OR 2.78, 2003 OR 1.90, 2004 OR 2.43) [19].

Hospital admission, and particularly admission to the ICU, is thought to be a risk factor for medical traumatic stress, underscoring the importance of using a control group that had also experienced a hospital admission [20,21]. As further comparison, children treated for traumatic injury in the emergency room, urgent care, and other outpatient settings were included. The increased risk of mental health diagnoses in all pediatric trauma patients, although to a lesser degree in those not requiring admission, suggests that trauma as an indication for seeking medical care is a risk factor for developing a mental health diagnosis beyond hospital admission.

Studies to date suggest that PTSD is relatively common after hospitalization for acute traumatic injury, with rates ranging from 12 to 25% in prospective studies with 6–12 month follow up [9,17,18]. This present analysis suggests a lower overall prevalence of diagnosis, with only 3.3% of admitted trauma patients developing any mental health diagnosis and only 0.1% developing a diagnosis of PTSD. One reason for the discrepancy in prevalence may be that prior studies are nearly all prospective studies assessing for the development of PTSD. However, studies designed to assess for a particular outcome may suffer from significant observation and confirmation bias. While the actual prevalence may be as high as suggested in these smaller studies, an insurance claims database may more accurately reflect the current state of practice. This suggests that PTSD may be routinely underdiagnosed in pediatric trauma patients and may represent a large practice gap in the management of injured patients.

Although there is significant potential for adverse mental health consequences following traumatic injury which can span the life course of injured children, there is limited formal training on the diagnosis and management of PTSD among surgeons. The American College of Surgeons (ACS) provides limited guidance on the management of mental health co-morbidities of traumatic injury. In 2018, ACS Committee on Trauma prepared two statements regarding post-traumatic stress disorder in children and adults encouraging the implementation of a screening and referral protocol into the care of trauma patients using an evidence-based tool [22,23]. Despite these statements, there is no universal standard of PTSD assessment for trauma centers.

Provider knowledge of PTSD has not been studied in surgeons, however in a study of pediatric emergency room providers, there were significant gaps in provider knowledge of PTSD. Ziegler et al. [24] found that 88% of respondents were unaware of available, validated PTSD assessment tools, and only 2% endorsed using such tools in their practice. Only half of participants in the study could identify department staff other than physicians who could help administer these tools, and few endorsed recommending their patients follow up with primary care providers regarding potential PTSD symptoms [24].

The underdiagnosis and undertreatment of PTSD among children with traumatic injury can have devastating ramifications. In an epidemiologic UK based study, Lewis et al. [25] found that children with PTSD are at increased risk of harm to themselves and others. Approximately half of children with PTSD reported self-harm and 20.1% reported suicide attempts. They were three times more likely than children without PTSD to have records of violent offenses. Children with PTSD were found to be three times less likely to be involved in education, employment, or vocational training. Despite the increased burden of mental health conditions in this population, only 30% of participants with PTSD were found to have accessed mental health services in the year prior to the study [25].

Insurance claims databases such as MarketScan® contain vast amounts of data and allow for extended follow-up periods not typically feasible in clinical research studies. In this study, the average duration of health insurance enrollment was 2.5 years after traumatic injury, and some patients showed continuous enrollment for as long as 10 years. By comparison, much of the existing literature, composed primarily of prospective studies, has follow-up often limited to 6 months [7,17,18,26–28].

The limitations of this study primarily relate to the challenges of working with an insurance claims database to answer a clinical question. Other studies using insurance claims have found that their results vary depending on the specific set of ICD codes used to identify clinical conditions [29,30]. In the case of this study, inconsistent inclusion of external cause-of-injury codes (“E codes”)

made it difficult to identify specific mechanisms of injury thought to be higher risk for the development of PTSD.

A second limitation is the lack of clinical granularity afforded by insurance claims databases. In the setting of trauma, there are clinical variables that would have been useful to include in the model but are not readily accessible with the available data. The analysis relied on calculating ISS from the available ICD9/10 codes included in the claims database. It is also possible that mental health diagnoses are under-reported in this insurance claims database because of children seeking care for these disorders outside the formal medical system, or that these diagnoses are not recorded on the claims. While children with a mental health services carve-out in their insurance plan were excluded from this analysis, it is possible that children sought care with a school counselor, social worker, or other provider who would not bill insurance for their services. Finally, MarketScan® includes claims from private insurers and thus excludes the 42% of children covered by public insurance, limiting the generalizability of these results [31].

5. Conclusion

This large scale, longitudinal, population-based study demonstrates that children admitted to the hospital for a traumatic injury are at increased risk of a poor mental health outcome, including PTSD, depression, anxiety, and adjustment disorder. However, the rates of PTSD were substantially lower than those identified in prospective studies of smaller, more selected populations, suggesting underdiagnosis of PTSD in pediatric trauma patients in the broader population. More research is needed to understand underlying factors that may contribute to this discrepancy, including provider knowledge and duration of clinical follow-up.

Declaration of Competing Interest

None to Declare.

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