Journal of Pediatric Surgery 55 (2020) 1579–1584

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Trauma

National Estimates and Factors Influencing Trauma Recidivism in Children Leading to Hospital Readmission☆

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ARTICLE INFO

Article history:
Received 18 May 2019
Received in revised form 26 July 2019
Accepted 2 October 2019

Key words:
Trauma
Recidivism
Pediatrics
Outcomes
Predictors
Readmissions

ABSTRACT

Introduction: Trauma is the leading cause of mortality in children. Factors influencing recidivism after major trauma have not been well documented in children. The objective of this study is to determine the burden of pediatric trauma recidivism and to identify predisposing factors in the United States.
Methods: The 2010–2015 National Readmissions Database was queried for pediatric patients (≤18 years) with a diagnosis of major traumatic injuries. Patients readmitted for major trauma were subsequently identified. Patients that did not survive their index-hospitalization were excluded. Information on mechanism, intent, nature and injury severity including Abbreviated Injury Scale (AIS) and Injury Severity Scores (ISS) was obtained. Multivariable-regression analyses were performed adjusting for demographic, hospital-level and injury characteristics.
Results: Of 286,508 pediatric trauma records analyzed, trauma recidivists represented 2.9% of the total population. Recidivists had a higher proportion of severe (AIS ≥ 3) head injury (11.3%). Recidivists were more likely to have public-insurance (OR [95% CI]:1.30[1.25–1.37]), and belong to lower income families (OR [95% CI]:1.22 [1.15–1.31]). Recidivism was more common amongst patients with penetrating injuries (OR [95% CI]:2.12 [1.96–2.28]). The risk adjusted cost of readmission for trauma was $8401[95% CI: 6748-10,053] higher compared to the index hospitalization with a total increased cost of 11.5 million USD annually.
Conclusion: Although not common, recidivism after major trauma remains a significant public-health concern. This study gauges the previously unquantified burden of recidivism amongst children and identifies factors predisposing to recurrent trauma.
Level of Evidence: III
Type of Evidence: Case control study

Traumatic injuries are the leading cause of mortality in children. [1] Each year 9.2 million children and adolescents are treated in emergency rooms across the United States for various injuries. [2] A fraction of these patients present later in life with subsequent traumatic injuries, a phenomenon known as trauma recidivism. [3] Previous studies analyzing adult populations has estimated the burden of trauma recidivism at anywhere between 6% and 52% with significant regional variations. [4] However, there is scarce literature examining pediatric trauma recidivists. Davis and colleagues in their study of pediatric trauma patients presenting to a single urban pediatric center found a recidivism rate of 1.5%. [5] Recurrent exposure to injurious stimuli is shown to be associated with future violence and mortality. These adverse childhood experiences (ACEs) are now measured and are correlated not only with violence but also structural DNA changes [6–8]. Children can readily, either willingly or unwillingly, fall into a vicious cycle of exposure to violence. As a result, it is a promising target for health-policy initiatives geared towards prevention of recidivism.

While different factors have been identified in the adult literature, including male gender [9], socioeconomic status, [10] African-American race [9] previous incarceration [11] substance and alcohol use [12] there is scarce literature regarding pediatric trauma patients. One study analyzing pediatric patients with penetrating injuries found males and the age of 16–18 years to be predisposed towards demonstrating recidivistic behavior [13]. While trauma recidivism in children is of significant public health concern, efforts to address it mandate a more robust estimation of its incidence, risk factors and overall impact on outcomes.

Abbreviations: AIS, Abbreviated Injury Scale; ISS, Injury Severity Score; OR, Odds Ratio; CI, Confidence Interval; USD, United States Dollar.

☆ The paper has been accepted for presentation at the 2019 American College of Surgeons (ACS), Clinical Congress in San Francisco, CA.

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https://doi.org/10.1016/j.jpedsurg.2019.10.001
0022-3468/

To the best of our knowledge, no previous study has used a population-based cohort to study trauma recidivism amongst children in the US. This study aims to gauge the burden of trauma recidivism leading to in-hospital management, to identify factors influencing trauma recidivism, and to determine the cost of recidivism on national healthcare spending.

1. Methods

1.1. Dataset

The National Readmissions Database (NRD) is a publicly available dataset developed as part of the Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency of Healthcare and Quality (AHRQ). It captures approximately 36 million weighted discharges each year as well as readmission rates for all insured and uninsured patients. Information is drawn from state inpatient databases containing verified patient linkages that can be used to track subsequent healthcare encounters within states. As of 2016, 27 states have contributed data to the NRD in partnership with HCUP and account for 57.8% of the total US population and 56.6% of all US hospitalizations. The advent of NRD addresses and solves the issue of lack of nationally representative data on hospital readmissions across all ages. Discharges with missing or unverified linkages are reportedly excluded from the NRD. Information available in the database includes patient characteristics (such as age, gender, insurance status, year of admission and income quartile), hospital characteristics (such as geographical location, rurality, teaching status, ownership and bed size), disease severity (as determined by All Patients Refined Diagnosis Related Groups risk of mortality), outcomes (mortality and length of stay), and International Classification of Disease 9th edition (ICD-9) diagnosis and procedure codes. The NRD, however, is only able to capture readmissions within the same calendar year, precluding assessment of readmissions past the year of admission.

1.2. Study population

This study utilized the 2010–2015 NRD to query for pediatric patients (≤18 years) with a primary diagnosis of a major traumatic injury using International Classification of Diseases 9th Edition (ICD-9-CM) diagnosis codes 800 through 959 inclusive. Patients with late effects of injury (905) were excluded. All patients had at least 90 days of follow up time. Upon plotting frequency distributions of trauma by age, an inflection point was seen at 11 years of age which corresponded to a significant increase in traumatic injuries (Fig. 1). Therefore, a subset of the patient population between ages 11 and 18 was further generated for analysis.

1.3. Covariates and outcome measures

The outcome measure of interest was recidivism after an index hospitalization for major trauma and cost of recidivism. Recidivism was defined as a repeat admission for major trauma after a previous admission for the same. Patients that did not survive the index hospitalization and those that did not meet hospital admission criteria were excluded. Information was available on patient demographics (age, race/ethnicity, sex, median household income quartile for a patient's residential zip code, and insurance status), hospital characteristics (urban vs. rural location, teaching status, geographical region, and hospital bed size), weekend vs. weekday admission, ICD-9-CM diagnostic codes, total charges, hospital-specific all-payer cost-to-charge ratios (developed using standardized hospital information on all-payer inpatient cost and charge reported by hospitals to the Center for Medicare and Medicaid Services), and lengths of stay. Information on injury severity scores (ISS) and the mechanism of injury was obtained from ICD-9-CM diagnosis and e-codes. Severe injury to body regions was defined by an Abbreviated Injury Scale (AIS) ≥3.

Costs from 2010 to 2015 were adjusted for inflation per year and converted to 2018 dollars using appropriate Consumer Price Indices. Median household income quartile for a patient's residential zip code is categorized by NRD according to annual income percentiles such that quartile 1 (Q1) corresponds to percentiles 0–25, quartile 2 (Q2) to percentiles 26–50, quartile 3 (Q3) to percentiles 51–75, and quartile 4 (Q4) to percentiles 76–100 within a given year. Insurance status was categorized as private primary payer, government primary payer, uninsured, and unknown. ISS was subcategorized into (i) <9, (ii) 9–15, (iii) 16–24, and (iv) 25–75. Using the Elixhauser Comorbidity Index, information was obtained pertaining to alcohol use, prevalence of depression and psychosis, and prevalence of drug abuse.

1.4. Statistical analysis

Multivariable models adjusted for age, race/ethnicity, gender, insurance-status, income, injury severity score, year, children's hospital designation, hospital-volume, teaching status, location, and geographical region. Multivariable regression analyses, also assessed for differences in total predicted mean costs per-rehospitalization (gamma distribution, postestimation calculation of average marginal effects). We found a sudden uptick in the incidence of traumatic injuries beyond the age of 10 years as demonstrated by the inflection point shown in

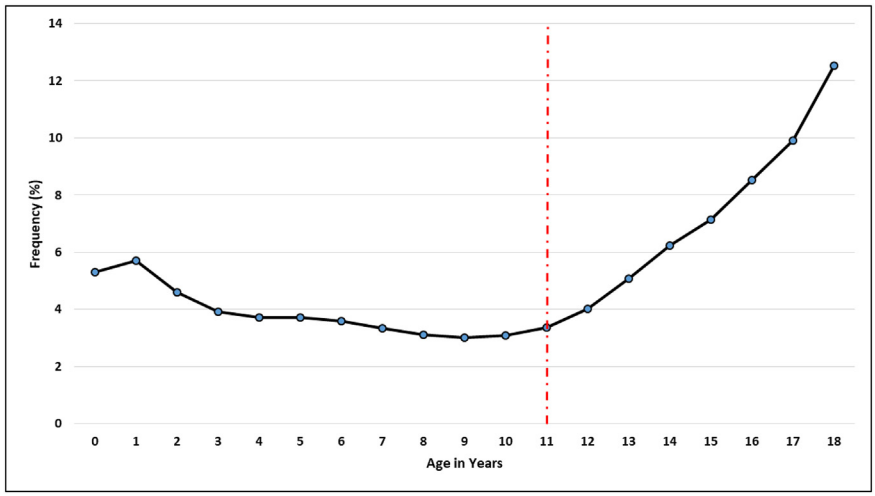

Fig. 1. Frequency distribution of major trauma by age amongst children. Increase in frequency of major trauma was observed beyond 11 years of age (indicated by the red dotted line).

Fig. 1. As a result we performed a subset multivariable analyses on the group of children aged >10 years as well. All statistical analyses were conducted using Stata Statistical Software: Release 13 (StataCorp LP, College Station, TX). Two-sided p-values <0.05 were considered statistically significant.

2. Results

Of 285,508 records analyzed, pediatric trauma recidivists represented 2.9% of the total trauma population. Approximately, 1.7% readmissions occurred within 30 days of initial admission. Median time to readmission was 21 [IQR: 8–6] days. Mean age of recidivists was 11.8 years (5.9) and these were predominantly male (61.0%). Table 1 offers a comparison of the baseline demographic parameters of recidivists and nonrecidivists. A higher proportion of recidivists had public insurance and belonged to the lowest income quartile ($p < 0.005$). The great majority of recidivists (85.6%) presented to the hospital of index admission upon their return. Sixteen percent were readmitted two or more times to the hospital. Interestingly, recidivists had higher rates of underage alcohol use, drug abuse, and depression/psychosis ($p < 0.05$).

Table 2 describes the injury characteristics of the overall population and compares injury characteristics of recidivists and nonrecidivists. A high proportion of recidivists presented with penetrating trauma during their index admission when compared to nonrecidivists (28.1% vs 15.6%, $p < 0.05$). A higher proportion of these recidivists were victims of stabbings or firearm injuries. A high proportion of recidivists also presented with assault related injuries (8.8% vs. 6.9%, $p < 0.05$). A majority of severe injuries amongst recidivists were sustained to the head and neck (11.3%), followed by superficial external injuries (10.5%), and injuries to the extremities (9.6%). Table 3 demonstrates overall outcomes for the study populations. Recidivists had a longer median hospital stay as well as cost of index hospitalization, compared to nonrecidivists ($p < 0.05$).

The incidence of traumatic injuries appears to increase in frequency in children aged 11 and up as demonstrated in Fig. 1. The incidence continues to steadily increase with increasing age up to the age of 18. For this reason, the analysis was repeated on a subset of the population aged 11–18 years. The rate of recidivism was found to be 3.3% for this subset of the population. Tables 4, 5 and 6 describe the demographic/hospital parameters, injury characteristics and outcomes, respectively.

Table 7 shows factors influencing recidivism after major trauma. Increasing age was found to be associated with an increasing likelihood of recidivism. Recidivists were more likely to be female (OR [95% CI]:1.12 [1.07–1.17]), have public insurance (OR [95% CI]:1.30[1.25–1.37]), and

Table 1
Demographic and hospital-level characteristics of the overall study population, including differences between recidivists and nonrecidivists.

	Overall	Recidivists	Nonrecidivists	p-value
	(n = 285,508)	(n = 8231)	(n = 278,277)	
Age, mean (SD)	10.6 (6.1)	11.8 (5.9)	10.6 (6.1)	<0.001
Female, (%)	36.3	39.0	36.3	<0.001
Insurance status, (%)				<0.001
•Private	41.8	36.3	41.9	
•Government	53.5	60.5	53.3	
•Uninsured	4.4	1.0	4.5	
•Unknown	0.3	0.2	0.3	
Income Quartile, (%)				<0.001
•0–25th percentile	33.5	35.8	33.4	
•26–50th percentile	24.2	25.3	24.2	
•51–75th percentile	22.2	21.0	22.2	
•76–100th percentile	18.5	16.2	18.6	
•Unknown	1.6	1.7	1.6	
Weekend Admission, (%)	29.3	26.2	29.4	<0.001
Alcohol Use, (%)	2.1	2.5	2.1	0.015
Drug Abuse, (%)	4.3	5.9	4.2	<0.001
Depression/Psychosis, (%)	4.2	8.2	4.1	<0.001
Teaching Status, (%)				<0.001
•Metropolitan nonteaching	16.9	18.1	16.9	
•Metropolitan teaching	78.8	72.3	78.8	
•Nonmetropolitan hospital	4.2	2.6	4.3	
Hospital Bed size, (%)				<0.001
•Small	6.33	7.4	6.3	
•Medium	19.6	20.5	19.6	
•Large	74.0	72.1	74.1	
Readmission to Index Hospital, (%)	-	85.6	-	

Table 2
Injury characteristics of the overall study population, including differences between recidivists and nonrecidivists.

	Overall	Recidivists	Nonrecidivists	p-value
	(n = 285,508)	(n = 8231)	(n = 278,277)	
Mechanism, (%)				<0.001
•Stab	6.3	8.5	6.3	
•Fall	19.2	9.1	19.5	
•Firearm	7.7	11.0	7.6	
•MVC	16.9	14.4	16.9	
•Struck-by	6.7	4.2	6.8	
•Machinery	0.3	0.5	0.3	
•Pedestrian	2.4	1.2	2.4	
•Natural/Environmental	3.5	1.5	3.6	
•Poisoning	0.8	0.7	0.8	
•Suffocation	1.2	1.5	1.2	
•Others	10.5	20.7	10.2	
•Unspecified	4.5	4.7	4.5	
•Adverse Effects	2.5	5.5	2.4	
•Unknown/Missing	17.4	16.3	17.5	
Intent, (%)				<0.001
•Unintentional	76.7	64.8	77.0	
•Self-Inflicted	5.1	10.2	4.9	
•Assault	7.0	8.8	6.9	
•Undetermined	0.9	1.6	0.9	
•Other	2.6	5.8	2.5	
•Unknown/Missing	7.8	8.8	7.8	
Penetrating, (%)	15.9	28.1	15.6	<0.001
Injury Severity Score Categories, (%)				<0.001
•<9	64.6	63.9	64.6	
•9–15	20.2	10.2	20.4	
•16–24	6.4	8.8	6.4	
•25–75	2.2	1.6	2.2	
•Missing	6.6	5.8	6.5	
Body Region with AIS ≥ 3, (%)				
•Head/Neck	10.8	11.3	10.7	0.083
•Face	0.2	0.3	0.2	0.033
•Chest	6.7	7.3	6.6	0.024
•Abdomen and Pelvis Contents	3.2	3.7	3.2	0.007
•Extremities or Pelvic Girdle	11.1	9.6	11.2	<0.001
•External/Burns	6.7	10.5	6.6	<0.001

AIS: Abbreviated Injury Scale.

Table 3
Outcome for the overall study population, and differences between recidivists and nonrecidivists.

	Overall	Recidivists	Nonrecidivists	p-value
	(n = 285,508)	(n = 8231)	(n = 278,277)	
Length of Stay, median	2	4	2	<0.001
[IQR]	[1–4]	[2–8]	[1–4]	
Cost in 2018 USD, median	6893	9649	6833	<0.001
[IQR]	[3790–13,534]	[4735–23,935]	[3768–13,344]	

belong to lower income families (OR [95% CI]:1.22[1.15–1.31]). Uninsured patients however, had a 23% lower likelihood of recidivism (OR [95% CI]:0.77[0.69–0.89]). Alcohol use was associated with a 19% increased likelihood of recidivism (OR [95% CI]: 1.19 [1.03–1.37]); however this was not statistically significant when the analysis was restricted to patients >10 years of age (OR [95% CI]: 1.02 [0.88–1.18]). Drug use was associated with a 42% increased likelihood of recidivism (OR [95% CI]: 1.42 [1.29–1.56]) and patients with depression/psychosis had a 2-fold increased likelihood of recidivism (OR [95% CI]: 2.07 [1.91–2.25]). Recidivism was more common among patient with higher ISS on initial presentation (OR [95% CI]:1.85 [1.65–2.08]) with penetrating injuries (OR [95% CI]:2.12 [1.96–2.28]). Those with a history of leaving against medical advice had 80% higher likelihood of being readmitted (OR [95% CI]:1.80 [1.30–2.49]). After risk-adjustment, there was no decrease in the likelihood of recidivism observed for the years studied ($p > 0.05$). Interestingly, weekend admissions were associated with a lower likelihood of recidivism ($p < 0.05$). This phenomenon even though statistically significant harbors questionable clinical relevance. Additional risk factors that appear to be correlated with recidivism include income and hospital teaching status (Table 7).

Table 8 demonstrates the risk-adjusted mean costs for hospitalization for recidivists and nonrecidivists. Median cost for index hospitalization was $6893 [IQR: 3790–13,534]. The risk adjusted cost of readmission for trauma was $8386 [95% CI: 6893–9879] higher compared to the index hospitalization. Admission to the nonindex hospital was associated with a $2294 [95% CI: 739–3849] higher cost of hospitalization ($p < 0.05$); however, this was not statistically significant in pediatric trauma patients aged >10 years $888 [95% CI: −823 to 2599]. There was a steady increase in the risk adjusted cost of recidivism over the years ($p < 0.05$).

Table 4
Demographic and hospital-level characteristics of children aged >10 years, including differences between recidivists and nonrecidivists.

	Ages > 10	Recidivists	Nonrecidivists	p-value
	(n = 162,859)	(n = 5412)	(n = 157,447)	
Age, mean (SD)	15.4 (2.1)	15.6 (2.1)	15.4 (2.2)	<0.001
Female, (%)	33.2	38.7	33.0	<0.001
Insurance status, (%)				<0.001
•Private	45.6	41.0	47.8	
•Government	47.1	55.5	46.8	
•Uninsured	5.0	3.3	5.2	
•Unknown	0.3	0.2	0.3	
Income Quartile, (%)				<0.001
•0–25th percentile	31.7	33.3	31.7	
•26–50th percentile	23.9	24.7	23.9	
•51–75th percentile	22.8	22.0	22.9	
•76–100th percentile	19.9	18.4	19.9	
•Unknown	1.6	1.6	1.6	
Weekend Admission, (%)	29.8	26.8	29.9	<0.001
Alcohol Use, (%)	3.7	3.8	3.7	0.751
Drug Abuse, (%)	7.4	8.6	7.3	0.001
Depression/Psychosis, (%)	7.1	12.0	6.9	<0.001
Teaching Status, (%)				<0.001
•Metropolitan nonteaching	20.4	19.9	20.4	
•Metropolitan teaching	74.8	76.9	74.8	
•Nonmetropolitan hospital	4.7	3.2	4.8	
Hospital Bed size, (%)				0.427
•Small	6.4	6.7	6.4	
•Medium	21.0	21.3	21.0	
•Large	72.6	72.0	72.6	
Readmission to Index Hospital, (%)	-	82.7	-	

Table 5
Injury characteristics of children aged >10 years, including differences between recidivists and nonrecidivists.

	Ages > 10	Recidivists	Nonrecidivists	p-value
	(n = 162,859)	(n = 5412)	(n = 157,447)	
Mechanism, (%)				<0.001
•Stab	9.5	12.4	9.4	
•Fall	13.1	7.6	13.2	
•Firearm	6.1	1.8	6.0	
•MVC	22.6	18.6	22.7	
•Struck-by	8.4	4.9	8.5	
•Machinery	0.3	0.3	0.3	
•Pedestrian	2.4	1.2	2.4	
•Natural/Environmental	1.8	1.8	1.9	
•Poisoning	1.1	0.9	1.1	
•Suffocation	0.6	0.8	0.6	
•Others (not classified)	8.8	18.2	8.4	
•Unspecified	4.1	4.1	4.1	
•Adverse Effects	2.3	5.3	2.2	
•Unknown/Missing	19.0	17.0	19.1	
Intent, (%)				<0.001
•Unintentional	69.9	59.8	70.2	
•Self-Inflicted	8.8	15.2	8.5	
•Assault	9.4	8.8	9.4	
•Undetermined	0.8	1.3	0.8	
•Other	2.5	5.6	2.4	
•Unknown/Missing	8.6	9.2	8.6	
Penetrating, (%)	22.2	33.9	21.9	<0.001
Injury Severity Score Categories, (%)				<0.001
•<9	65.1	68.2	65.0	
•9–15	21.8	15.0	22.0	
•16–24	7.4	7.5	7.4	
•25–75	3.0	4.9	2.9	
•Unknown/Missing	2.7	4.4	2.7	
Body Region with AIS ≥ 3, (%)				
•Head/Neck	11.1	11.1	11.1	0.879
•Face	0.2	0.2	0.2	0.880
•Chest	9.4	9.5	9.4	0.696
•Abdomen and Pelvis Contents	4.4	4.7	4.4	0.20
•Extremities or Pelvic Girdle	11.2	9.4	11.2	<0.001
•External/Burns	2.9	4.6	2.9	<0.001

AIS: Abbreviated Injury Scale.

3. Discussion

This is the first study to evaluate trauma recidivism in children nationally in the US using a population sample representative of the patient population. We demonstrated a recidivism rate of 3.3%. Recidivists were more likely to belong to the lowest socioeconomic strata of society and were more likely to engage in risky behavior predisposing to violent exposure such as underage alcohol use and drug abuse. Psychological illnesses were associated with a 2-fold risk of indulging in violent behavior and subsequent recidivism. A higher proportion of recidivists had initially presented with penetrating trauma. Recidivism was also associated with a higher cost of total hospitalization cost.

Table 6
Outcome for children aged >10 years, and differences between recidivists and nonrecidivists.

	Ages > 10	Recidivists	Nonrecidivists	p-value
	(n = 162,859)	(n = 5412)	(n = 157,447)	
Length of Stay, median	2	4	2	<0.001
[IQR]	[1–5]	[2–9]	[1–5]	
Cost in 2018 USD, median	8260	9790	8222	<0.001
[IQR]	[4476–15,583]	[4747–24,538]	[4468–25,386]	

Table 7
Factors predictive of recidivism in (a) all pediatric trauma patients, and (b) in children aged >10 years.

	Overall (n = 285,508)	Ages > 10 (n = 162,859)
	Odds Ratio [95% Confidence Interval]	
Age (years)	1.03 [1.03–1.04]	1.05 [1.04–1.07]
Female	1.12 [1.07–1.17]	1.28 [1.21–1.35]
Insurance Type		
(reference: Private)		
•Government	1.30 [1.25–1.37]	1.38 [1.30–1.46]
•Uninsured	0.77 [0.69–0.89]	0.75 [0.65–0.88]
Income Quartile		
(reference: 0–25th percentile)		
•26–50th percentile	0.97 [0.92–1.03]	0.98 [0.92–1.06]
•51–75th percentile	0.88 [0.82–0.93]	0.92 [0.85–0.99]
•76–100th percentile	0.81 [0.76–0.87]	0.88 [0.81–0.95]
Weekend Admission	0.85 [0.81–0.90]	0.85 [0.80–0.91]
Alcohol Use	1.19 [1.03–1.37]	1.02 [0.88–1.18]
Drug Abuse	1.42 [1.29–1.56]	1.19 [1.08–1.31]
Depression/Psychosis	2.07 [1.91–2.25]	1.84 [1.68–1.99]
Teaching Status		
(reference: Metropolitan non teaching)		
•Metropolitan teaching	0.94 [0.88–0.99]	1.05 [0.98–1.13]
•Nonmetropolitan hospital	0.57 [0.50–0.66]	0.69 [0.58–0.81]
Hospital Bed size		
(reference: Small)		
•Medium	0.89 [0.81–0.97]	0.96 [0.85–1.08]
•Large	0.82 [0.76–0.90]	0.94 [0.84–1.04]
Intent		
(reference: Unintentional)		
•Self-Inflicted	2.47 [2.30–2.67]	2.10 [1.68–1.98]
•Assault	1.52 [1.40–1.64]	1.10 [1.00–1.22]
•Undetermined	2.20 [1.84–2.62]	1.97 [1.55–2.5]
•Other	2.72 [2.47–2.99]	2.69 [2.38–3.04]
Penetrating	2.12 [1.96–2.29]	1.82 [1.68–1.98]
Injury Severity Score Categories		
(reference: ISS < 9)		
•9–15	0.73 [0.68–0.77]	0.65 [0.60–0.70]
•16–24	1.16 [1.07–1.27]	0.97 [0.87–1.07]
•25–75	1.85 [1.65–2.08]	1.59 [1.40–1.81]
Body Region with AIS ≥ 3		
•Head/Neck	1.06 [0.99–1.13]	1.01 [0.92–1.10]
•Face	1.56 [1.03–2.34]	1.04 [0.58–1.86]
•Chest	1.10 [1.01–1.19]	1.02 [0.93–1.12]
•Abdomen and Pelvis Contents	1.18 [1.04–1.32]	1.09 [0.96–1.23]
• Extremities or Pelvic Girdle	0.84 [0.78–0.91]	0.82 [0.75–0.90]
•External/Burns	1.65 [1.53–1.77]	1.64 [1.43–1.86]

AIS: Abbreviated Injury Scale.

While we found that the majority of patients admitted to hospitals for trauma related episodes were male (61%), females were more likely to be trauma recidivists. While data from the CDC have suggested that males are more likely to be victims of both fatal and nonfatal injuries [2], previous work in adults [9,14–16] and children [5,13] has shown male gender rather than female to be a risk factor for recidivism. It most certainly highlights the need for further studies and added focus in this population. We also found that recidivists were more likely to have public insurance and belong to lower income families, findings that are consistent with adult population [10,17,18]. A higher ISS was a predictor for recidivism. This contrasts with adult literature that has shown no correlation [19,20] to injury severity. In addition, penetrating trauma strongly correlated with trauma recidivism, a finding that is again consistent with previous adult [9] and pediatric [5] reports. Another interesting finding was that leaving against medical advice was a predictor of recidivism. While Davis et al. noted a statistical difference in their population group aged 0–19 years, and found no difference in the age group of 0–16 years, we found a statistically significant difference in our population, highlighting the need for further work in this area [5].

A more critical analysis of our patients' social factors demonstrated additional findings that concur with adult literature. We found that patients with alcohol (OR 1.19 [95% CI: 1.03–1.37]) and drug abuse (OR: 1.42 [1.29–1.56]) were more likely to re-present as recidivists. A systematic review in adult populations by Nunn demonstrated a consistent relation between alcohol use and recidivism with an estimate of 41%. [12]. Cordovilla-Guardia and colleagues demonstrated this relationship also noting the effect of drug use on recidivism in adults. [21]. In addition to the neurologic disinhibition produced by substance abuse and the resultant clouded judgment induced, it is also likely that such individuals partake in behaviors that place them at an increased risk of injury. Similarly clouding of cognition produced by the effects of mental illness was also noted to be heavily predictive of trauma recidivism (OR: 2.07 [1.91–2.25]). This phenomenon has been well documented in the adult trauma literature [14]. The stress response to trauma has been described to be unique in children compared to adults, and it may be longer lasting. Its correlation with recidivism in the pediatric population remains less well studied. A study by Ardino and colleagues demonstrated that 30% of prisoners with PTSD were at risk of a repeat offense [22], whereas Sadeh and colleagues showed that PTSD was associated with an increased likelihood of violence and recidivism in their analysis of 771 patients [23]. The results of this study present a unique opportunity to identify children at risk for recidivistic behavior, and to intervene early after their initial exposure to violent stimuli.

Given the complexity of trauma recidivism and its large public burden, we also attempted to gauge its fiscal impact on healthcare. To the best of our knowledge, this is the first study to have attempted such an undertaking. We found that the cost of readmission was $8386 higher than the cost of the index hospitalization with an estimated excess cost of 1.2 million USD per annum. Most of these patients (85.6%) re-presented to their hospital of index admission. Those that did not, had a $2294 increased cost of hospital stay, however, this was not significant in ages 11 and up. When considering that most of these patients rely on public insurance, the burden placed on US healthcare expenditure over a small 5-year period is immense. This is higher than the cost reported in the adult literature. [4]

Given the large fiscal impact of these injuries, there is an obvious need for interventions that are targeted and effective to help reduce

Table 8
Risk adjusted total cost of hospitalization for (a) recidivists and nonrecidivists, and (b) total cost of readmission to hospital of index hospitalization vs readmission to nonindex hospital

	Overall (n = 285,508)	Ages >10 (n = 162,859)
	Cost in 2018 USD ($ [95% Confidence Interval])	
Recidivists	21,704 [20,083–23,325]	24,443 [22,645–26,241]
Nonrecidivists	13,318 [13,190–13,446]	15,286 [15,120–15,451]
Absolute Cost Difference	+8386 [6893–9879]	+9s157 [7525–10,790]
	Recidivists (n = 8,231)	**Recidivists Ages >10 (n = 5,412)**
	Cost in 2018 USD ($ [95% Confidence Interval])	
Admission to Nonindex Hospital	15,748 [14,065–17,431]	16,401 [14,526–18,277]
Admission to Index Hospital	13,454 [13,326–13,582]	15,513 [15,349–15,678]
Absolute Cost Difference	+2294 [739–3849]	+888 [−823 to 2599]

these devastating events from recurring. A few successful examples include violence intervention programs led by case managers that reduced reinjury rates from 8% to 4% with particular success in women and African American trauma patients [24]. Intervention and education at the outset in the emergency department via electronic sessions or through a therapist also resulted in reduced exposure to violence at 6 months in adults [25]. Hospital based violence prevention programs have also demonstrated benefits in reducing health care costs and improving patient outcomes [26]. Additionally, the need to similarly educate parents and guardians cannot be understated. Even though much work and study are needed in this regard, adapting and tailoring such programs for pediatric patients and their parents and/or guardians have the potential for widespread reduction in experiencing recurrent injury, and substantial healthcare savings at a population level.

We recognize several limitations in our study given the retrospective nature of the analysis and the administrative nature of the dataset. The NRD is only able to capture readmissions within the same calendar year; therefore, we were unable to determine if readmissions for recidivism in subsequent years occurred. Furthermore, the NRD by nature only captures inpatient encounters and therefore visits and discharges to the ED and outpatient clinics after subsequent exposure to injurious stimuli were unavailable. Inability to capture encounters outside of the inpatient setting also greatly underestimates the true incidence of trauma recidivism in children. The NRD, while designed to study readmissions, is derived from administrative data. It does not contain important clinical information relevant to hospital resource utilization. Additionally, we do not have information on other factors that may affect a patient's decision to be admitted to an index versus nonindex hospital such as travel distance, hospital accreditation, or patient functional status. Also, the NRD only picks up readmissions within the same state; thus, we do not identify patients that were readmitted to out of state hospitals. However, these patients are expected to be too few in number to influence our results. Furthermore, since the NRD does not carry information on self-reported race/ethnicity as other HCUP dataset, a race-based correlation between exposure and outcome could not be obtained.

4. Conclusion

Recidivism after major trauma is a significant public health concern. Exposure to injurious stimuli repetitively has the potential to negatively impact a child's developmental potential. Therefore, even though, children represent a small population of recidivists, the implications of exposure to recurrent injury can be severe and far-reaching. This also places a significant burden on healthcare spending. This study gauges the previously unquantified burden of recidivism in children and describes factors predisposing to recurrent injury. Targeted interventions aimed specifically at children possess the ability to have widespread benefits and further study characterizing the effect of injury prevention programs on trauma and recidivism are needed. Given the current limitations in elucidating its complete burden, which is likely significant, pediatric trauma recidivism should remain the focus of further investigations.

Conflicts of interest

The authors have no conflicts of interest relevant to this article to disclose.

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