



Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: [www.elsevier.com/locate/jped surg](http://www.elsevier.com/locate/jped surg)

## Injury patterns of child abuse: Experience of two Level 1 pediatric trauma centers<sup>☆</sup>

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### ARTICLE INFO

#### Article history:

Received 21 January 2018

Accepted 1 February 2018

Available online xxxx

#### Key words:

Child abuse

Non-accidental trauma

Abusive head trauma

Epidemiology

Injury patterns

### ABSTRACT

**Purpose:** This study examines non-accidental trauma (NAT) fatalities as a percentage of all injury fatalities and identifies injury patterns in NAT admissions to two level 1 pediatric trauma centers.

**Methods:** We reviewed all children (<5 years old) treated for NAT from 2011 to 2015. Patient demographics, injury sites, and survival were obtained from both institutional trauma registries.

**Results:** Of 4623 trauma admissions, 557 (12%) were due to NAT. However, 43 (46%) of 93 overall trauma fatalities were due to NAT. Head injuries were the most common injuries sustained (60%) and led to the greatest increased risk of death (RR 5.1, 95% CI 2.0–12.7). Less common injuries that increased the risk of death were facial injuries (14%, RR 2.9, 95% CI 1.6–5.3), abdominal injuries (8%, RR 2.8, 95% CI 1.4–5.6), and spinal injuries (3%, RR 3.9, 95% CI 1.8–8.8). Although 76% of head injuries occurred in infants <1 year, children ages 1–4 years old with head injuries had a significantly higher case fatality rate (27% vs. 6%,  $p < 0.001$ ).

**Conclusion:** Child abuse accounts for a large proportion of trauma fatalities in children under 5 years of age. Intracranial injuries are common in child abuse and increase the risk of death substantially. Preventing NAT in infants and young children should be a public health priority.

**Type of study:** Retrospective Review.

**Level of evidence:** II

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### 1. Background

Child abuse and neglect are a considerable problem in the United States affecting approximately 9.2 victims in every 1000 children in the population [1]. Non-accidental trauma (NAT) victims often have significant injuries and account for a significant portion of pediatric trauma populations. Pediatric surgeons are often involved in their care [2]. Experts have estimated that 1670 children in the US died in 2015 as a result of abuse and neglect [1]. This is a 5.4% increase from 2014. Younger children are at particular risk. Three-quarters of child fatalities occur in children younger than 3 years of age. In response to the alarming incidence of child abuse, the Commission to Eliminate Child Abuse and Neglect Fatalities (CECANF) was established by the U.S.

federal government in 2012. The objective of the Commission was to develop a national strategy and provide recommendations for reducing child fatalities from abuse and neglect. It called for individual states to undertake retrospective reviews of child abuse and neglect fatalities in order to inform prevention strategies [3].

In Texas, the State Child Fatality Review Team, in concert with local Child Fatality Review Teams, provides annual aggregate child fatality data and recommendations to prevent child injuries and fatalities. In 2013, 28% of child homicides in Texas reviewed were determined to be caused by child abuse or neglect [4]. Texas Children's Hospital and Children's Memorial Hermann Hospital are the only two Level 1 pediatric trauma hospitals serving Houston and its surrounding region, the 5th largest metropolitan area in the United States with a population of over 6.5 million people, of which 480,000 are children under the age of five. The aim of this study was to perform a population-based analysis of injury patterns in NAT admissions to the two Level 1 pediatric trauma centers and to examine NAT fatalities as a percentage of all injury fatalities in children under the age of five. Understanding the extent of NAT in our pediatric trauma population and the injury patterns that increase risk of death will help guide prevention strategies.

<sup>☆</sup> Disclosures: The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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**Table 1**  
Demographics of NAT survivors and fatalities.

	Overall n = 557	Survivors n = 514	Fatalities n = 43	p-value
Age (median yrs., IQR)	0.7 (0.3–1.3)	0.6 (0.3–1.2)	1.2 (0.4–2.0)	<b>0.01</b>
Age under 1 year	382 (69%)	363 (71%)	19 (44%)	<b>&lt;0.001</b>
Male Gender, n (%)	328 (59%)	305 (59%)	23 (54%)	0.5
Race/Ethnicity				
Asian/Pacific Islander	14 (3%)	13 (3%)	1 (2%)	0.4
Black	185 (33%)	166 (32%)	19 (44%)	
White Hispanic	173 (31%)	164 (32%)	9 (21%)	
White Non-Hispanic	174 (31%)	161 (31%)	13 (30%)	
Other/Unknown	11 (2%)	10 (2%)	1 (2%)	
Injury Severity Score (median, IQR)	10 (5–17)	10 (5–17)	26 (18–29)	<b>&lt;0.001</b>
ICU stay (n, %)	195 (35%)	160 (31%)	35 (81%)	<b>&lt;0.001</b>
Hospital LOS (median days, IQR)	4 (2–8)	4 (2–8)	2 (1–3)	<b>&lt;0.001</b>
Median hospital charges (\$, IQR)	\$26,647 (\$12,981–\$59,537)	\$23,907 (\$12,575–\$50,190)	\$69,818 (\$46,155–\$97,790)	<b>&lt;0.001</b>

## 2. Methods

### 2.1. Study design

Following IRB- approval (H-39155, HSC-MS-16-0561), we queried each institution's trauma database for children under the age of five who were diagnosed with NAT or suspected NAT during the period of 2011–2015. Both Texas Children's Hospital and Children's Memorial Hermann Hospital are level 1 pediatric trauma centers verified by the American College of Surgeons. Children designated as NAT victims in the trauma registry or who had ICD-9 external cause code E967.0–E967.9 identifying a perpetrator of child abuse were included. Additionally, suspected NAT victims were defined as any child with:

1. Suspected abuse reported to law enforcement and/or child protective services (CPS)
2. Investigation of physical abuse initiated due to suspicious circumstances or
3. Caregiver at discharge different from caregiver at admissions due to suspected physical abuse.

Demographic data collected included age, gender, and race/ethnicity. Hospital data obtained from each trauma registry included year of admission, external cause code, CPS or law enforcement involvement, disposition from the emergency department (death, hospital floor, operating room, intensive care unit [ICU], etc.), ICD-9/ICD-10 injury diagnoses, Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), hospital length of stay, and hospital disposition. We also obtained hospital charges for each NAT admission. All de-identified data were recorded on a standardized case report form.

The Abbreviated Injury Scale (AIS) was used to assign a body region and mortality risk for each injury. The AIS is a 7 digit code that describes the type, location, and severity of an injury [5]. The first digit signifies the body region injured with a value from 1 to 9 to representing head, face, neck, thorax, abdomen, spine, upper extremity, lower extremity, and unspecified respectively. The third and fourth digits in the AIS describe the specific anatomic structure. Values of 02, 04, 06 and 08 in this position when followed by a 1 in

the AIS second digit (whole area) represent skin abrasion, contusion, laceration, and avulsion, respectively, and were used to create a soft tissue category separate from the first digit designation of body region for the injury. For example, AIS of 410,202 is defined as abrasion (02) of the thorax (4). This AIS was counted as a soft tissue injury and not counted in the thorax injury group. A value of 20 in the third and fourth digit position of the AIS signifies burn injury. These codes were also extracted to create a separate burn category. Our final analysis of injury patterns included the following 9 body region categories: head, thoracic, abdominal, extremity, burn, spinal, face, soft tissue, and genital. The last digit of the AIS represents severity on a scale of 1–6. A value of 1 represents a minor injury with 0% probability of death while a value of 6 represents a maximal (untreatable) injury with 100% probability of death. This value was used to determine the maximal severity of head injuries sustained by each patient admitted for NAT.

The Injury Severity Score (ISS) is a global severity score computed by summing the squares of the maximum AIS severity score for the three body regions of greatest injury [ $ISS = (AIS \text{ body region } 1)^2 + (AIS \text{ body region } 2)^2 + (AIS \text{ body region } 3)^2$ ]. The ISS is used to assess trauma severity; a score of 15 or greater defines major trauma [6].

Additionally, we used the trauma registry to determine the total number of all children under 5 years of age admitted for trauma between 2011 and 2015 at either institution. The final disposition of these patients was also collected in order to establish the overall trauma fatality rate.

### 2.2. Statistical analysis

Statistical analysis was performed using SPSS (version 24, IBM SPSS). Descriptive analysis was performed using counts and proportions for categorical variables and medians with interquartile [IQR] ranges for continuous variables. Two age groupings were used for analysis: age less than 1 year and age between 1 year and 4 years [7]. Demographics and injury patterns of NAT fatalities were compared to NAT survivors. Comparative analysis was performed using Student's t-test for parametric and Mann Whitney U for nonparametric continuous variables.

**Table 2**  
Comparison of NAT admissions as a proportion of all trauma admissions by age.

Year	Age < 1 year		Age 1–4 years		All patients age < 5 years	
	NAT admissions (% All trauma admissions)	All trauma admissions	NAT admissions (% All trauma admissions)	All trauma admissions	NAT admissions (% All trauma admissions)	All trauma admissions
2011	69 (24%)	292	34 (5%)	752	103 (10%)	1044
2012	80 (27%)	293	37 (6%)	671	117 (12%)	964
2013	65 (30%)	220	32 (4%)	717	97 (10%)	937
2014	106 (42%)	251	36 (6%)	598	142 (17%)	849
2015	62 (28%)	220	36 (6%)	609	98 (12%)	829
<b>Total</b>	<b>382 (30%)</b>	<b>1276</b>	<b>175 (5%)</b>	<b>3347</b>	<b>557 (12%)</b>	<b>4623</b>

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