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Epidemiology of abusive abdominal trauma hospitalizations in United States children★

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Abstract

Objectives—(1) To estimate the incidence of abusive abdominal trauma (AAT) hospitalizations among US children age 0–9 years. (2) To identify demographic characteristics of children at highest risk for AAT.

Design—Secondary data analysis of a cross-sectional, national hospitalization database.

Setting—Hospitalization data from the 2003 and 2006 Kids' Inpatient Database (KID).

Main exposure—Frequency and rate of hospitalizations for abusive abdominal trauma as identified by ICD-9CM codes for abdominal trauma and child abuse and E-codes for inflicted injury.

Outcome measures—Hospitalization rates by age, insurance status, and frequency of specific organ injury.

Results—AAT rates were higher for infants than for any other age group, with 17.7 (95% CI 11.7–23.9) cases per million in 2006. More than 25% of all abdominal trauma in children <1 year of age was abusive. For all age groups, rates were higher for males than females, and for children insured by Medicaid compared to those with private insurance. Organs most commonly injured were the liver (64% of hospitalizations), kidney (19%), and stomach/intestines (12%).

Conclusions—Although experts have considered toddlers to be at highest risk for AAT, infants have higher rates of AAT hospitalization. Similar to other abusive injuries, young age, male gender, and poverty are risk factors for AAT.

Keywords

Child abuse; Abdominal trauma; Injury; Epidemiology

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Introduction

Approximately 4 per 1,000 children are substantiated victims of physical abuse every year (United States Department of Health and Human Services, 2010). The actual rate of physical abuse may be as much as ten times higher (Sedlack, Mettenburg, et al., 2010; Theodore et al., 2005), as many victims are not identified or reported to child protective service agencies. Abusive abdominal trauma is a particularly severe form of child maltreatment, with injuries including hematomas and lacerations of the liver, spleen, kidneys, adrenal glands, and pancreas, as well as hematomas and perforations of the stomach, intestines, and bladder. Mortality rates of 13–45% make abusive abdominal trauma the second leading cause of child physical abuse mortality after abusive head trauma (Davis, Cohn, & Nance, 1976; Grisoni, Gauderer, Ferron, & Izant, 1984; Barnes et al., 2005).

Studies using convenience samples show abusive abdominal trauma representing anywhere from 0.5 to 11% of physical abuse injuries (Cooper et al., 1988; DiScala, Sege, Li, & Reece, 2000). Studies have also indicated that the estimated percentages of abusive abdominal trauma injuries are highest among toddlers (Cooper et al., 1988; Trokel, Discala, Terrin, & Sege, 2006). While one study in the UK identified an incidence of 2.3 cases per million children age 0–5 years (Barnes et al., 2005), the incidence of abusive abdominal trauma in the US has not been previously studied. The aim of this study was therefore to determine the incidence of abusive abdominal trauma hospitalizations for all US children age 9 and younger, as well as to examine the incidence by age, gender, and insurance status. Secondary aims were to examine the proportions of specific injuries, and the identity of perpetrators.

Methods

The Kids' Inpatient Database (KID) is a database of inpatient hospital stays developed by the Agency for Healthcare Research and Quality (AHRQ), as a part of its Healthcare Cost and Utilization Project (HCUP). It is the only all-payer inpatient care database for children in the United States, and has been developed to provide national estimates of hospital utilization for children <20 years of age. Data sets are released every 3 years, and each contains a full year of hospitalization data with nearly 3 million pediatric discharges. These include data from 36 states and 3,438 hospitals in 2003 and 38 states and 3,739 hospitals in 2006. Records are at the discharge level, not the patient level; therefore it is possible that the same child may be represented in more than one hospitalization. Systematic random sampling is used to select 80% of non-birth related hospitalizations from each participating hospital. Weights are provided to estimate hospitalization rates for the entire US pediatric population. These discharge weights are based on hospital geographic region, urban/rural location, teaching status, bed size, ownership, and type (e.g., children's or non-children's) (Agency for Healthcare Research and Quality, 2008).

Specific data elements include up to 15 discharge diagnoses per hospitalization, up to 4 external cause of injury codes (E-codes), patient demographics (age, sex, race, median income of families in the zip code of residence), length of stay, procedures, and discharge disposition, among others. The database has been used by other researchers to examine the incidence of abusive head trauma; rates from the KID were comparable to those of several prospective studies leading the authors to conclude that KID data could be used to estimate the incidence of at least one form of abusive injury (Ellingson, Leventhal, & Weiss, 2008). Our analyses include KID data from 2003 and 2006. This study was approved by our Institutional Review Board.

Hospitalizations for child abuse, abdominal trauma, and abusive abdominal trauma in children age 0–9 years were included in our analyses. We limited our data to children 9 years of age and under as it becomes increasingly difficult in older children to determine whether the injury was inflicted by a caregiver or a peer. Hospitalizations for abdominal trauma were identified by International Classification of Disease, 9th Edition, Clinical Modification (ICD-9 CM) codes 863.0–869.16 (abdominal organ injury) and 902.0–902.9 (abdominal vascular injury). Abdominal trauma was considered to be present if any of the 15 diagnosis codes contained an abdominal trauma ICD-9 CM code. Injuries to specific organs were determined by individual ICD-9 CM codes. Child abuse hospitalizations were identified by either an ICD-9 code for child abuse (995.5 – child maltreatment syndrome, 995.50 – child abuse unspecified, 995.54 – physical abuse, 995.59 – other child abuse and neglect) or E-code for inflicted injury (E-960–969). Inclusion was not limited to hospitalizations for isolated abdominal trauma; children with extra-abdominal injuries (e.g., abusive head trauma), in addition to their abdominal injuries, were included.

Estimates of the total number of US hospitalizations and 95% confidence intervals for child abuse, abdominal trauma, and abusive abdominal trauma were extracted from KID data, using the weighting incorporated in the database design. Numbers by age, race, and insurance status were also determined. Incidence rates and 95% confidence intervals were calculated using US census data estimates for 2003 and 2006 (US Census Bureau, 2008, 2009). Overall incidence rates were determined for all child abuse, all abdominal trauma, and all abusive abdominal trauma hospitalizations; incidence rates of hospitalization by age, sex, and insurance status were also calculated for abusive abdominal trauma hospitalizations. Medicaid insurance status was used as a proxy for poverty, as the KID does not contain any direct measures of family income, and Medicaid eligibility requires income below a state-specific threshold. While the KID does provide data on uninsured children, these are not reported because there were few such children in this sample, resulting in wide confidence intervals for incidence estimates. The number and percentage of injuries to each abdominal organ were calculated based on the total (unweighted) number of children with abusive abdominal trauma in the two years of data ($n = 234$).

Data on race were missing for approximately one third of the sample, primarily because 10 states do not report race data to HCUP. Given the large proportion of missing data, we opted not to examine incidence rates by race.

Results

Based on our weighted estimates (Table 1), among children age 9 years and younger, abusive abdominal trauma accounted for approximately 3.8% (183/4,785) of all child abuse hospitalizations in 2003 and 4.3% (211/4,901) in 2006 (Table 1). Abusive abdominal trauma accounted for 4.8% (183/3,823) and 5.9% (211/3,563) of all abdominal trauma admissions during these years. Abusive injury represented more than one quarter of all abdominal trauma hospitalizations among children <1 year of age (60/216, 27.8% in 2003 and 71/281, 25.3% in 2006). For children between the ages of 1 and 2 years, abusive injury was responsible for 11% (2003) and 18% (2006) of all abdominal trauma hospitalizations.

For all children age 0–9 years, the incidence of hospitalization for abusive abdominal trauma was 4.6 per million children (95% CI 3.5–5.7) in 2003 and 5.3 per million children (95% CI 4.1–6.5) in 2006 (Table 2). The incidence of hospitalization for abusive abdominal trauma was higher among infants than among any other age group, with 14.9 hospitalizations per million infants (95% CI 9.7–20.4) in 2003 and 17.7 per million infants (95% CI 11.7–23.9) in 2006 (Table 2). Among children age 0–4 years, rates were 7.8 per million children (95% CI 5.7–9.8) in 2003, and 9.1 (95% CI 6.9–11.3) in 2006.

Examination of abusive abdominal trauma hospitalization incidence by gender demonstrated higher rates for males versus females among all age groups (Table 3). Male infants had the highest incidence, with 16.6 hospitalizations per million male infants (95% CI 8.3–24.8) in 2003, and 20 hospitalizations per million (95% CI 10.7–29.2) in 2006.

Marked differences were seen in hospitalization rates by insurance status (Table 4). The incidence of abusive abdominal trauma hospitalizations was up to 10-times higher among those receiving Medicaid compared to those covered by private insurance. Hospitalization rates for infants with Medicaid were 40.8 per million children (95% CI 24.1–57.3) in 2003 and 38.1 per million children (95% CI 23.3–52.2) in 2006. In contrast, privately insured infants were hospitalized at a rate of 2.5 per million (95% CI 0–5.9) in 2003 and 3.5 per million (95% CI 0.4–7.1) in 2006.

Liver injuries were the most common injuries (Table 5). Nearly 2/3 of all abusive abdominal trauma hospitalizations involved the liver. Injuries to the kidneys were also common, identified in 19% of hospitalizations. Injuries to the stomach and/or intestines were seen in 12% of hospitalizations.

Discussion

Approximately 5 of every million US children age 0–9 years are hospitalized for abusive abdominal trauma each year. These numbers include about 15 hospitalizations per million infants (age <1 year) and 10 per million toddlers (age 1–3 years). As the confidence intervals for 2003 and 2006 incidence rates overlap, there is no clear change in incidence during this time period. While these hospitalizations account for a small percentage (~4%) of all child abuse hospitalizations, they represent a significant proportion of hospitalizations for abdominal trauma among infants and toddlers. Therefore, abuse should be strongly considered when infants and toddlers present with abdominal injuries, unless high velocity trauma, such as a motor vehicle crash, is clearly involved or the event is witnessed by a reliable observer.

Only 1 other study, by Barnes et al. (2005) in the UK, has examined the incidence of abusive abdominal trauma, but not in hospitalized children only. The incidence among children ages 0–4 from the KID data is much higher (~8 per million) than Barnes' calculation of 2.3 cases per million children (95% CI 1.43–3.78). Our data suggest that US children in this age group are much more likely to be victims of abusive abdominal trauma than their British counterparts. The difference in rates between the 2 studies might, however, be due to methodological differences. The Barnes study used an ongoing surveillance program for rare disorders, in which pediatricians returned cards each month noting whether they had identified any children with the listed disorders. Over 2 years, 92% of all cards were returned, suggesting very good ascertainment. However, surgeons were not part of the surveillance program, and the authors do not make clear whether pediatricians were involved in caring for all children with trauma, or only those identified by surgeons as having been abused. If the latter is true, than any instance of abuse that surgeons missed would not be counted. Barnes' data included all children with abusive abdominal trauma, not just hospitalized children, yet still had lower rates than those seen in our US hospitalization data. In addition, our rates are more likely to be underestimates than overestimates, given the known reluctance of physicians to acknowledge and report the possibility of abuse (Flaherty et al., 2006, 2008; Gunn, Hickson, & Cooper, 2005; Jones et al., 2008; Sege & Flaherty, 2008). Differences in these rates do not necessarily reflect overall differences in violence between the 2 countries. While the US has a fourfold higher homicide rate, national statistics indicate that the incidence rates of assault and intimate partner violence are higher in the UK, although, here too, these may involve methodological differences (Coleman, Jansson,

Kaiza, & Reed, 2007; Heron et al., 2009; MMWR, 2008a, 2008b; Rand, 2008; Tjaden & Thoennes, 2000; Walker, Flatley, Kershaw, & Moon, 2008).

The highest hospitalization rates in our study were seen among infants, males, and children with Medicaid. Data from earlier studies have suggested that toddlers are the most frequent victims of abusive abdominal trauma (Cooper et al., 1988; Trokel et al., 2006). While the *percentage* of child abuse injuries caused by abdominal trauma is highest among toddlers, our data indicate that the highest *rates* of abusive abdominal trauma are seen among infants. The incidence among toddlers is intermediate between that of infants and older children. Therefore, it is important for clinicians to consider the possibility of abuse when evaluating infants with abdominal injuries.

Approximately 25% of abdominal trauma hospitalizations in infants were the result of abuse, according to KID data. While this is a large proportion, it is smaller than the 50% that Trokel et al. (2006) found in their evaluation of data from the National Pediatric Trauma Registry (NPTR). This difference could be from better diagnosis of child abuse at pediatric trauma centers (usually located within children's hospitals) compared to community hospitals. Another possibility is that because the KID includes both trauma and non-trauma centers, children with more minor injuries are included; these may be more likely the result of injuries other than child abuse.

By far, the most common injury seen in our data was liver trauma (64% of cases). Wood, Rubin, Nance, and Christian (2005), in a 10 year single-institution retrospective review of abdominal trauma hospitalizations also noted liver injuries to be the most common (92% of cases). However, Barnes et al. (2005) identified liver injuries less often (35%). While 12% of our hospitalizations had injuries to the stomach and/or intestines, these injuries were seen more often in other studies (35–65% of cases) (Barnes et al., 2005; Ledbetter, Hatch, Feldman, Fligner, & Tapper, 1988; Trokel et al., 2006; Wood et al., 2005). Intestinal injuries were, in fact the most common finding in Barnes' et al. (2005) data. These differences may be explained, in part, by differences in data sources. Inclusion of children who died before they could be hospitalized (Barnes et al., 2005) and restricting data to trauma centers (Trokel et al., 2006) would increase the proportion of more severe injuries in the sample. In contrast, data from Wood and the KID database did not include injuries severe enough to result in pre-hospital death, and they included injury hospitalizations that might not necessitate trauma center referral. Because intestinal perforations are more likely to require surgical repair and may more often be fatal; they may be overrepresented in trauma center and mortality data, and underrepresented in general hospitalization data.

Risk factors for abusive abdominal trauma are similar to those seen in other forms of inflicted injury (Keenan et al., 2003; United States Department of Health and Human Services, 2010). These risks include young age, poverty, and male gender. Poverty was a particularly pronounced risk factor in our data, with approximately 10-fold higher incidence rates for Medicaid beneficiaries compared to those with private insurance. It is possible that biases in identification of abuse by socioeconomic status account for at least some of the difference in rates by insurance status, as suggested by previous studies (Lane & Dubowitz, 2007; Hampton & Newberger, 1985; Jason, Andreck, Marks, & Tyler, 1982). However, poverty has also been clearly demonstrated as an independent risk factor for maltreatment (Kotch, Browne, Dufort, & Winsor, 1999).

Several limitations to our findings should be noted. First, because the number of abusive abdominal injuries was relatively small, some of our rate estimates were imprecise, particularly for smaller age groupings and older age groups. As with any child abuse data, it is highly likely that cases of abuse were misclassified as accidental injury. Likewise, some

cases of accidental injury may have been misclassified as abuse, particularly in minority children. In addition, it is possible that some inflicted injuries in the older children were the result of assault by a peer or non-caregiving adult, and not abuse by a caregiver.

Because race data were missing for 1/3 of the sample, we opted not to include incidence rates by race. While CPS data demonstrate higher rates of minority children in the child welfare system (United States Department of Health and Human Services, 2010), other data suggest that rates of maltreatment are no different for Black than for White children, or that differences that do exist are the result of confounding by poverty (Sedlack & Broadhurst, 1996; Sedlack, McPherson, & Das, 2010). We therefore felt that including rates of abusive abdominal trauma by insurance status was far more valuable than including rates by race.

While we anticipate that most children with symptomatic abusive abdominal trauma will be hospitalized for their injuries, the KID data do not include children who died prior to reaching a hospital, or who died in a hospital emergency department. Further, abused children may have abdominal injuries that are asymptomatic or associated with minor or vague complaints (Lindberg et al., 2009; Coant, Kornberg, Brody, & Edwards-Holmes, 1992; Lane, Dubowitz, & Langenberg, 2009). Because screening for occult abdominal trauma is not routine practice in all hospitals, it is likely that many cases of occult abdominal trauma are not identified, and therefore not reflected in KID data (Lane et al., 2009).

Despite these limitations, our study is important in that it is the first effort to examine the incidence of abusive abdominal trauma in children in the US. Further, we have demonstrated that infants are at highest risk for abusive abdominal trauma hospitalization, challenging previously held assumptions that toddlers were at greatest risk. Although the incidence of abusive abdominal trauma is lower than in many other maltreatment-related injuries, (e.g., the incidence of abusive head trauma is tenfold higher), it represents a significant proportion of all abdominal trauma injuries. It is therefore important that clinicians consider the possibility of child abuse unless there is a clear history of non-inflicted abdominal injury; missed cases of abuse and failure to protect may lead to escalating trauma and even death (Jenny, Hymel, Ritzen, Reinert, & Hay, 1999).

Abdominal injuries may require long hospitalizations, and result in significant costs to the health care system (Trokel, DiScala, Terrin, & Sege, 2004). The high mortality from abusive abdominal trauma is a substantial problem. Therefore there is a strong need to identify better methods of prevention of abusive abdominal trauma, as well as other forms of maltreatment.

Conclusions

Although experts have considered toddlers to be at highest risk for AAT, infants have higher rates of AAT hospitalization in the US. The possibility of abuse should be strongly considered in infants as well as toddlers with abdominal injuries. In addition, the high proportion of abuse among infants and toddlers hospitalized for abdominal trauma should alert clinicians to suspect abuse in these populations. The high rate of male perpetrators points to the need for child abuse prevention efforts that include male caregivers.

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Table 1

Estimated total hospitalizations for child abuse, abdominal trauma, and abusive abdominal trauma by age – 2003 and 2006.

Age (years) ^a	Child abuse weighted N ^b (95% CI)		Abusive abdominal trauma weighted N ^b (95% CI)		Abdominal trauma weighted N ^b (95% CI)	
	2003	2006	2003	2006	2003	2006
<1	2,712 (2,633–3,062)	2,679 (2,293–3,065)	60 (39–82)	71 (47–96)	216 (169–263)	281 (224–337)
1–2	1,117 (977–1,256)	1,274 (1,085–1,464)	71 (41–100)	104 (74–134)	647 (512–783)	578 (457–699)
3–4	340 (279–402)	345 (286–404)	22 (10–35)	11 (2–21)	544 (451–638)	539 (441–637)
0–4	4,159 (3,679–4,661)	4,299 (3,724–4,873)	154 (113–194)	187 (141–232)	1,408 (1,195–1,621)	1,398 (1,187–1,608)
5–9	616 (529–702)	603 (511–695)	30 (16–43)	24 (11–38)	2,414 (2,140–2,689)	2,165 (1,887–2,443)
0–9	4,785 (4,256–5,315)	4,901 (4,284–5,519)	183 (140–226)	211 (162–260)	3,823 (3,366–4,279)	3,563 (3,098–4,029)

^aAges are inclusive of all children in that age group, e.g. age 1–2 includes children up to their third birthday, age 3–4 includes children up to their 5th birthday.

^bHospitalization numbers were calculated using Kids' Inpatient Database (KID) discharge weights.

Table 2

Abusive abdominal trauma hospitalizations – number and rates by age, 2003 and 2006.

Age (years) ^a	2003	2006
	Rate per million ^b (95% CI)	Rate per million ^b (95% CI)
<1	14.9 (9.7–20.4)	17.7 (11.7–23.9)
1–2	8.8 (5.1–12.4)	12.9 (9.2–16.6)
3–4	2.8 (1.3–4.5)	1.4 (0.2–2.7)
0–4	7.8 (5.7–9.8)	9.1 (6.9–11.3)
5–9	1.5 (0.8–2.2)	1.2 (0.5–1.9)
0–9	4.6 (3.5–5.7)	5.3 (4.1–6.5)

^a Ages are inclusive of all children in that age group, e.g. age 1–2 includes children up to their third birthday, age 3–4 includes children up to their 5th birthday.

^b Hospitalization rates were calculated using HCUP–KID discharge weights and population estimates from 2003, and 2006 US Census data.

Table 3

Abusive abdominal trauma hospitalizations by gender and age – 2003 and 2006.

Age (years) ^a	2003				2006			
	Males		Females		Males		Females	
	Number of cases ^b	Rate per million ^c (95% CI)	Number of cases ^b	Rate per million ^c (95% CI)	Number of cases ^b	Rate per million ^c (95% CI)	Number of cases ^b	Rate per million ^c (95% CI)
<1	34	16.6 (8.3–24.8)	26	13.3 (6.6–19.9)	41	20.0 (10.7–29.2)	30	15.3 (8.1–22.4)
1–2	37	9.0 (4.4–13.9)	32	8.1 (3.8–12.2)	70	17.0 (11.4–22.7)	34	8.6 (4.3–13.2)
3–4	14	3.5 (1.0–6.0)	<10	2.1 (0–4.2)	<10	1.8 (0–3.5)	<10	1.3 (0–2.6)
5–9	14	1.4 (0.4–2.3)	12	1.2 (0.4–2.5)	13	1.6 (0.2–2.8)	<10	0.6 (0–1.3)
0–9	103	5.1 (3.6–6.5)	78	4.0 (2.8–5.3)	130	7.1 (5.2–9.1)	76	3.9 (2.5–5.3)

^a Ages are inclusive of all children in that age group, e.g. age 1–2 includes children up to their third birthday, age 3–4 includes children up to their 5th birthday.

^b Hospitalization numbers and rates were calculated using HCUP–KID discharge weights. HCUP does not permit reporting of numbers <10.

^c Rates were calculated using population estimates from 2003, and 2006 US Census data.

Table 4

Abusive abdominal trauma hospitalizations by insurance status and age, 2003 and 2006.

Age (years) ^a	2003				2006			
	Medicaid		Private		Medicaid		Private	
	N ^b	Rate per million ^c (95% CI)	N ^b	Rate per million ^c (95% CI)	N ^b	Rate per million ^c (95% CI)	N ^b	Rate per million ^c (95% CI)
<1	49	40.8 (24.1–57.5)	<10	2.5 (0–5.9)	54	38.1 (23.3–52.2)	<10	3.5 (0.4–7.1)
1–2	56	21.8 (12.1–32.0)	<10	1.8 (0–3.5)	79	29.3 (19.7–39.4)	11	2.2 (0.6–3.8)
3–4	14	5.3 (1.1–9.2)	<10	1.7 (0–2.9)	<10	2.7 (0–5.8)	0	0 (0–0)
5–9	20	3.7 (1.7–6.0)	<10	0.5 (0–0.9)	14	2.5 (0.5–4.3)	<10	0.5 (0.0)
0–9	139	11.8 (8.7–15.1)	30	1.2 (0.6–1.7)	154	12.5 (9.0–10.2)	25	1.0 (0.5–1.5)

^a Ages are inclusive of all children in that age group, e.g. age 1–2 includes children up to their third birthday, age 3–4 includes children up to their 5th birthday.

^b Hospitalization numbers and rates were calculated using HCUP–KID discharge weights.

^c Rates were calculated using population estimates from 2003 and 2006 US Census data.

Table 5

Abusive abdominal trauma–specific injuries $N = 234$ (unweighted data, 2003 and 2006).

Injury	Number ^a	Percent
Liver	150	64.1%
Kidney	45	19.2%
Stomach/Intestines	28	12.0%
Spleen	21	9.0%
Pancreas	17	7.3%
Pelvic Injury	10	4.3%

^aTotal number of injuries sums to more than 234 because some children had more than one injury.