

Outcomes and factors associated with infant abusive head trauma in the US

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OBJECT Head trauma is the leading cause of death in abused children, particularly prior to the age of 2 years. An awareness of factors associated with this condition as well as with a higher risk of mortality is important to improve outcomes and prevent the occurrence of these events. The objective of this study was to evaluate outcomes and factors associated with poor outcomes in infants with diagnosed abusive head trauma (AHT). Patient characteristics, socioeconomic factors, and secondary conditions such as retinal bleeding, contusion, and fractures were considered.

METHODS Data were obtained from the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. From the Kids' Inpatient Database (KID) sample, the authors identified infants no older than 23 months who had been diagnosed with AHT in 2000, 2003, 2006, and 2009. All statistical analyses were conducted in SAS 9.2. Descriptive statistics were provided, and multivariate logistic regression models were applied to evaluate factors associated with mortality and nonroutine discharge.

RESULTS A total of 5195 infants were analyzed in this study. Most infants (85.5%) had ages ranging between 0 and 11 months and were male (61.6%). Overall mortality was 10.8%, with a rate of 9.8% in the 0- to 11-month-old cohort and 16.5% in the 12- to 23-month-olds ($p = 0.0003$). The overall nonroutine discharge rate of 25.6% increased significantly from 23.3% to 39.0% with increasing age (0–11 vs 12–23 months of age, $p < 0.0001$). Assuming a multivariate model that adjusted for multiple confounders, the authors found that older infants (12–23 vs 0–11 months, OR 1.81, 95% CI 1.18–2.77) with a secondary diagnosis of retinal bleeding (OR 2.85, 95% CI 2.02–4.00) or shaken baby syndrome (OR 2.09, 95% CI 1.48–2.94) had an increased risk of mortality; these factors were similarly associated with an increased odds of a nonroutine discharge. A higher income (\$30,001–\$35,000 vs \$1–\$24,999) was associated with a reduction in the odds of mortality (OR 0.46, 95% CI 0.29–0.72). In the subset of cases (1695 [32.6%]) that specified the perpetrator involved in infant injury, the authors found that the father, stepfather, or boyfriend was most frequently reported (67.4%). A trend for a higher AHT incidence was documented in the early ages (peak at 2 months) compared with older ages.

CONCLUSIONS Despite the higher incidence of AHT among infants during the earlier months of life, higher mortality was documented in the 12- to 23-month-olds. Retinal bleeding and shaken baby syndrome were secondary diagnoses associated with higher mortality and nonroutine discharge. Males (67.4%) were overwhelmingly documented as the perpetrators involved in the injury of these infants.

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KEY WORDS abusive head trauma; in-hospital mortality; non-routine discharge; fracture; contusion; hematoma; retina bleeding; shaken baby syndrome; perpetrator; confidence interval

ABBREVIATIONS AHT = abusive head trauma; CDC = Centers for Disease Control and Prevention; ICD = International Classification of Diseases; IQR = interquartile range; KID = Kids' Inpatient Database; NCANDS = National Child Abuse and Neglect Data System; SBS = shaken baby syndrome.

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ACCORDING to data from the National Child Abuse and Neglect Data System (NCANDS), 49 states reported 1598 fatalities with a national estimate of 1640 child deaths from abuse and neglect in 2012. These figures represent 322.222 per year and an average of 4 children dying every day from abuse and neglect.²⁹ The NCANDS also concluded that children younger than 1 year accounted for 44.3% of fatalities. The majority of child maltreatment deaths resulted from injuries to the head, otherwise known as abusive head trauma (AHT).

A policy statement issued by the American Academy of Pediatrics in 2009 supports the term “abusive head trauma” resulting from violent shaking, blunt impact, or a combination of both.⁶ The Centers for Disease Control and Prevention⁷ defines abusive head trauma as “extracranial or intracranial contents of an infant or young child (< 5 years of age) resulting from neglectful supervision and gunshot wounds, stab wounds, and penetrating trauma.”¹⁰ This terminology replaces the former denotation of “shaken baby syndrome” (SBS), as the former described only one mechanism of head injury.

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CDC established guidelines for AHT in 2008 using the
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nonfatal AHT and more recently the ICD-10 codes for
fatal cases.²⁰ Additional limitations in documenting these
cases include underreporting, lack of consistent standards
for child autopsies or death investigations, uncoordinated
nonmultidisciplinary investigations, and medical examin-
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missed according to Jenny et al.¹² Thus, it is important to
ensure that any patient with AHT is appropriately evalu-
ated, documented, and coded. Despite the inaccuracies
that may be involved in coding AHT cases, previous stud-
ies have reported potential risk factors for AHT in young
children, including demographic, socioeconomic, and
clinical.^{3,6,8,14} According to several studies, infants young-
er than 1 year and with a lower socioeconomic status are
at higher risk for AHT.^{6,14} Additionally, a higher risk of
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ethnic minorities.^{3,8} Clinical entities associated with AHT
include retinal hemorrhages and subdural hematomas.^{9,28}
Although pertinent information has been obtained from
studies published to date, most of these studies have sig-
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In the present study we aimed to evaluate outcomes and risk factors associated with AHT among infants of ages 18 months to 4 years. We hypothesized that risk factors such as age, income, and secondary conditions may be associated with prognosis. Although there has been

limited reporting of the perpetrators involved in documented AHT cases, we provide a detailed description of the persons involved in these injuries. Overall, we hope that this study helps solidify and validate existing data on this patient population as reported in smaller studies. More importantly, however, we hope that these data help

Methods

Data Source and Patient Selection

Data were obtained from the Healthcare Cost and Utilization Project's Kids' Inpatient Database (KID) at the University of Washington Medical Center.¹³ Using the Kids' Inpatient Database (KID), we identified patients who had been diagnosed with AHT in 2000, 2003, 2006, and 2009. The KID is a nationally representative database that samples 80% of pediatric discharges and 10% of uncomplicated births to increase the statistical power to detect differences between groups.¹⁴ Discharges are weighted based on the sampling scheme to permit inferences for a nationally representative population. In 2009, the most recent year for which the KID was available at the time of this study, the KID contained demographic information on age, sex, race, and ethnicity for all patients. We used the International Classification of Diseases (ICD-9-CM) diagnosis codes developed by an AHT expert panel convened by the CDC (Table 1).²⁰ Given our interest in the outcomes of patients with CJD, we identified patients who had been diagnosed with CJD in 2000, 2003, 2006, and 2009. We included patients younger than 24 months were included in this analysis.

Data Variables

A patient's age in months, along with sex, race, type of payment (private, self-pay), and median household income was documented. Note that a 1-month-old infant has an age ranging from 28 to 61 days.

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sus nonteaching, children's versus nonchildren's hospital,
and hospital region (Northeast, Midwest, South, West)
were noted. Year of discharge and perpetrator involved in
the AHT assault were documented. A detailed description
of secondary diagnoses was made.

Outcome Variables

In-hospital mortality was the main outcome of interest. Secondarily, we explored nonroutine discharge events, which we denoted as a discharge other than a routine discharge (for example, transfers and home health care). Length of hospital stay and total charges accumulated

Statistical Analysis

A detailed description of the data is provided in terms

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TABLE 1. Algorithm for capturing definite or presumptive AHT cases using the narrow definition*

ICD-9-CM Diagnosis Codes	ICD-9-CM External Cause of Injury or Abuse Code	Fall & Accident Codes
781.0-781.4, 781.8, 800.1-800.4, 800.6-800.9, 801.1-801.4, 801.6-801.9, 803.1-803.4, 803.6-803.9, 804.1-804.4, 804.6-804.9, 850.0-850.9, 851.0-851.99, 852.0-852.59, 853.0-853.19, 854.0-854.19, 950.0-950.3, 995.55a	E960.0, E967, E968.1, E968.2, E968.8, E968.9, 995.50A, 995.54, 995.59A	E800-807, E810-819, E820-825, E826-829, E830-838, E840-845, E846-848, E880-888, E890-899, E900-909, E910-915, E916-928

* See Parker et al., 2012, for the CDC recommendations for capturing AHT in children.

A Excluded case in the presence of a fall or accident code.

a Did not require a cause code.

using a univariate logistic regression model. Factors associated with mortality and nonroutine discharge at the univariate level (alpha 0.2) were considered in the adjusted multivariate logistic models. A *p* value ≤ 0.05 was considered significant. Analyses were conducted in SAS 9.2 (SAS Institute Inc.).

Results

Demographics

A total of 5195 infants ages 0–23 months were diagnosed with AHT according to the KID (Table 2). The average age was 11 months (range 0–23 months), and 49.6% of all patients were documented as white. Most patients were discharged from the hospital within 7 days (median 5 days, range 0–49 days). Fewer patients were diagnosed in northeastern hospitals (1.1%) compared with other regions (1.1%). A large fraction of patients were discharged from the hospital within 7 days (median 5 days, range 0–49 days). Fewer patients were diagnosed in northeastern hospitals (1.1%) compared with other regions (1.1%). A large fraction of patients were discharged from the hospital within 7 days (median 5 days, range 0–49 days). Fewer patients were diagnosed in northeastern hospitals (1.1%) compared with other regions (1.1%).

Age and Perpetrator Distribution

A detailed plotting of the number of AHT cases by patient age in months reveals an increase in documented cases with age (Fig. 2). Considering only cases with a documented perpetrator, the majority of cases were perpetrated by parents (88.8%), followed by other family members (11.2%). The majority of cases were perpetrated by parents (88.8%), followed by other family members (11.2%). The majority of cases were perpetrated by parents (88.8%), followed by other family members (11.2%).

Outcomes

Overall mortality rate was 10.8%, with a rate of 9.8%

in the 0- to 11-month-old cohort and 16.5% in the 12- to 23-month-olds ($p = 0.0003$). The overall nonroutine discharge rate was 39.0% with increasing age (0–11 vs 12–23 months of age, $p < 0.0001$; Table 4). The average hospital stay was 9.9 days (median 7 days, range 0–49 days). A list of secondary diagnoses that have been described in association with AHT is provided in Table 4. The most

TABLE 2. Characteristics of 5195 infants diagnosed with AHT in US hospitals in 2000, 2003, 2006, and 2009

Variable	No.
Age in mos*	
0-11	4440
12-23	755
Average age in mos [†]	
Mean (SEM)	5.9 (0.14)
Median (IQR)	3.5 (1.5-7.4)
No. of males (%)	3198 (61.6)
Race (%) [‡]	
White	1988 (49.6)
Black	828 (20.7)
Hispanic	796 (19.9)
Other	393 (9.8)
Admission type (%) [‡]	
Emergent/urgent	4154 (92.7)
Elective	325 (7.2)
Primary payer (%) [‡]	
Private	3679 (71.0)
Self-pay	1124 (21.7)
Other	382 (7.4)
Median income in zip code (%) [‡]	
\$1-\$24,999	1467 (28.9)
\$25,001-\$30,000	1493 (29.4)
\$30,001-\$35,000	1278 (25.2)
\$35,001 & above	840 (16.5)

* In patients without a precise age in months, an age-year of 0 corresponded to an age of 0-11 months and an age-year of 1 corresponded to an age of 12-23 months.

[†] Data available in 4249 (81.8%) of cases.

[‡] Missing data (%): sex (0.06), race (22.9), admission type (13.8%), payer (0.2), and income (2.2).

§ Medicare is included in other.

TABLE 3. Hospital-specific characteristics of 5195 infants diagnosed with AHT in US hospitals in 2000, 2003, 2006, and 2009

Variable	No. (%)
Children's hospital*	3777 (79.7)
Teaching hospital*	4367 (90.2)
Hospital region	
Northeast	642 (12.4)
Midwest	1424 (27.4)
South	1749 (33.7)
West	1380 (26.6)
Year of discharge	
2000	1212 (23.3)
2003	1370 (26.4)
2006	1299 (25.0)
2009	1314 (25.3)

* Missing data (%): children's hospital (8.8), teaching hospital (6.8).

common co-occurring diagnosis was subdural hematoma (60.1%), followed by retinal hemorrhage (51.0%), fracture (40.8%). Infants with a diagnosed hematoma, 61.0% also had retinal hemorrhage. The predicted probability of mortality increased by an average of 0.006% with an increasing age in months ($T^2 = 0.43$; Fig. 3). A 1-sided Cochran-Armitage trend test also supported an increasing mortality trend with increasing age in months ($p < 0.0001$).

In-hospital mortality and nonroutine discharge were evaluated while adjusting for multiple confounder factors (Table 5). We found that older infants (12–23 vs 0–11 months), a lower income, and additional diagnoses such as

retinal hemorrhage and SBS were strongly associated with greater odds of mortality. The odds of mortality nearly doubled for infants with a diagnosed hematoma compared with infants from the lowest-income group. The odds of mortality increased for infants with a diagnosed fracture compared with infants from the lowest-income group. The odds of mortality increased for infants with a diagnosed retinal hemorrhage compared with infants from the lowest-income group. The odds of mortality increased for infants with a diagnosed SBS compared with infants from the lowest-income group. The odds of mortality increased for infants with a diagnosed fracture compared with infants from the lowest-income group. The odds of mortality increased for infants with a diagnosed retinal hemorrhage compared with infants from the lowest-income group. The odds of mortality increased for infants with a diagnosed SBS compared with infants from the lowest-income group.

In a subset analysis of mortality according to the perpetrator involved in the injury, we found that infants cared for by nonrelative caregivers had the highest mortality rate (16.1%), followed by father, stepfather, or boyfriend (12.4%), and mother, stepmother, or girlfriend (8.9%).

Discussion

Using a national database, we were able to validate the number of reported cases, where younger infants (0–11 months) were more commonly AHT victims than 12- to 23-month-olds. As in previous studies, we found that fathers, stepfathers, and boyfriends were most frequently involved in AHT cases. A possible explanation for the differing rates in reported cases by state may be the varying levels of AHT awareness. Kesler et al. and Altman et al. reported a greater concentration of AHT prevention programs in the northern states. As noted in Shanahan et al., it is also possible that differences in ICD-9-CM coding practices affect the rates reported by authors using administrative databases. In a preliminary exploration of the KID database, we found that northern states were much more likely to document SBS than western states (54.8% vs 35.0%, $p = 0.004$). Other possible explanations for the differences in

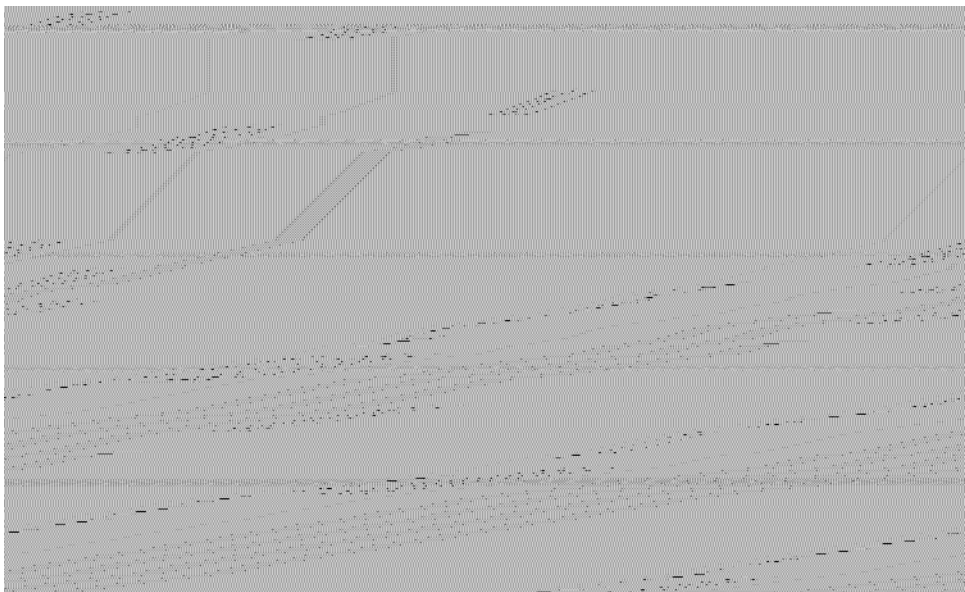


FIG. 1. Distribution of AHT cases diagnosed in US hospitals (2000, 2003, 2006, and 2009) by patient age in months, based on a total of 4249 patients with available data.

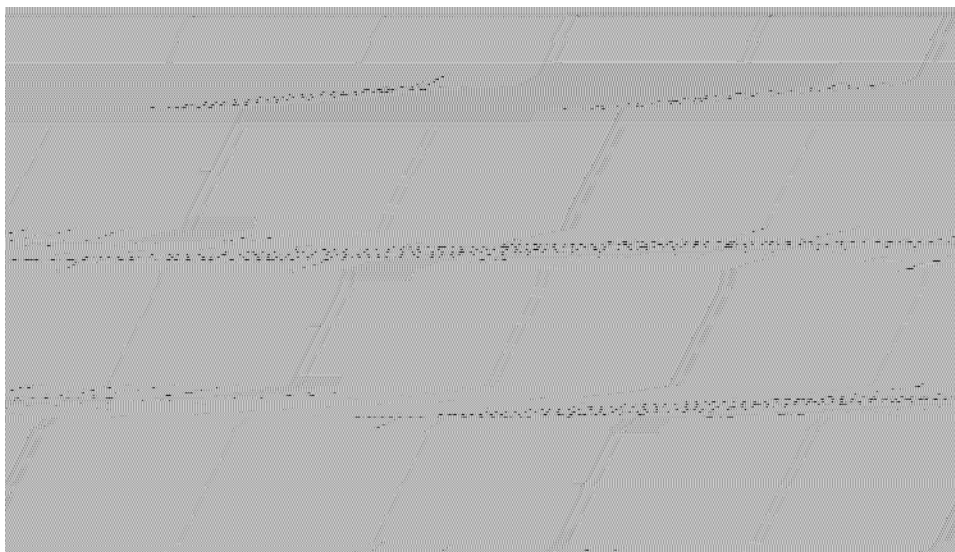


FIG. 2. Frequency of perpetrators involved in the 4818 documented AHT cases diagnosed in US hospitals in 2000, 2003, 2006, and 2009. [†]Other refers to cases in which the perpetrator was indicated as other, unspecified. ^{*}Relative includes related child/sibling/grandparent.

reported cases may be other external factors such as economy or unemployment, which can vary across regions. Also in this study we determined that the odds of mortality were higher in infants secondarily diagnosed with retinal hemorrhage and SBS and in patients from lower socioeconomic status, which is consistent with trends previously reported trends.^{6,9,14,28} The reporting of secondary diagnoses such as SBS and retinal hemorrhage provides some insight, although limited, on the mechanism of injury and clinical features, respectively.

Infants older than 12 months. A possible explanation for this observation may be the fact that older children have smaller or closed fontanelles, as well as sutures that are less mobile (sutures do not really close until age 18 years or so when the skull stops increasing in size).²⁹ The reporting of secondary diagnoses such as SBS and retinal hemorrhage provides some insight, although limited, on the mechanism of injury and clinical features, respectively. Further, the end of their normal range lead to alterations in cerebral blood flow. This phenomenon may lead to worse outcomes for the older infants who could potentially have risk of mortality captured in the older cohort may be the cumulative effects of AHT that are more likely to be reported in older infants. According to Levin et al. and others, retinal hemorrhage was more common in children who died of AHT than in neurologically intact survivors because of their nonsuperficial retinal hemorrhages. The shaking of a child is usually described by perpetrators as an attempt to stop an infant's excessive crying, but

reports of excessive crying at approximately 2 months of age coincide with documented cases of SBS.^{5,16,20,26}

Data in this study corroborate results in other studies indicating a majority of socioeconomically disadvantaged families among cases of AHT.^{2,6,14} Potential theories for increased risk of mortality in patients on Medicaid and a higher proportion of children on Medicaid having abusive injuries rather than accidental injuries.¹⁹ Limited or delayed access to health care may also partially explain the increased risk of mortality

TABLE 4. Outcomes of infants diagnosed with AHT in US hospitals in 2000, 2003, 2006, and 2009

Outcomes	No. (%)
Mortality	560 (10.8)
Nonroutine discharge*	1328 (25.6)
Length of stay in days	
Mean (SE)	9.9 (0.31)
Median (IQR)	5.6 (2.4–11.7)
Total charges (\$)	
Mean (SE)	\$56,494 (\$2825)
Median (IQR)	\$28,917 (\$13,454–\$67,986)
Secondary diagnoses	
Fracture	2214 (42.6)
Contusion	905 (17.4)
Hematoma	3122 (60.1)
Retinal bleeding	2652 (51.0)
SBS	2186 (42.1)

* Nonroutine discharge includes transfers/home health care.

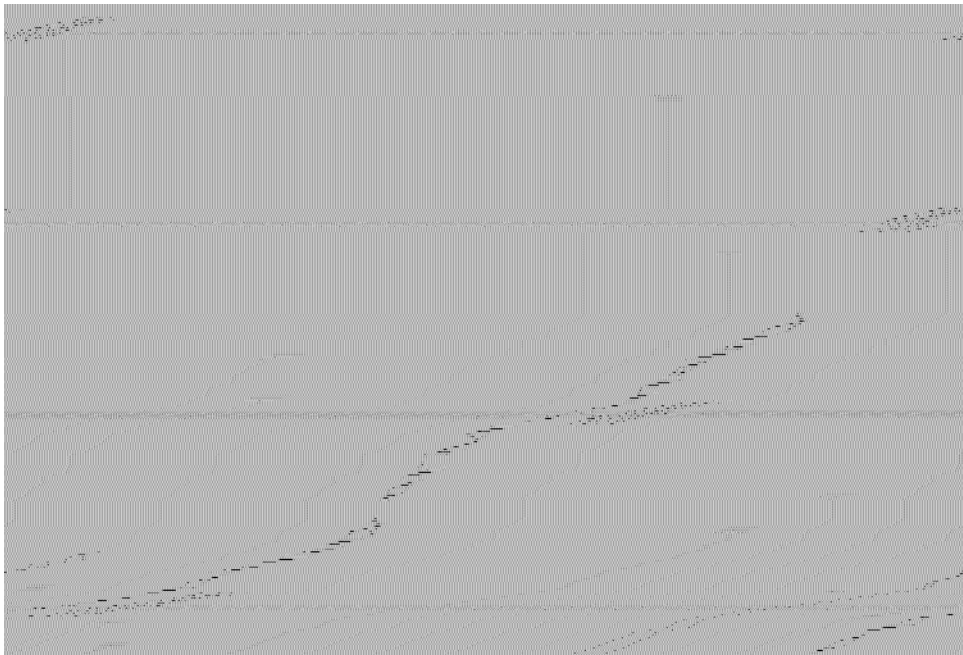


FIG. 3. Predicted probability of mortality and 95% confidence intervals by age in months for cases diagnosed in US hospitals (2000, 2003, 2006, and 2009). Trend line for a linear fit resulted in $y = 0.006x + 0.0546$ ($R^2 = 0.4305$).

documented in socioeconomically disadvantaged patients. In addition to this study, previous research has included discussions on the prevalence of a nonparental perpetrator^{45,49} However, in the rate of abuse attributed to nonparental perpetrators

Yet the fact that these perpetrators seem to be associated with a lack of further investigation. A possible explanation for this increased mortality risk is that nonparental caregivers doctor examinations and less aware of pertinent information delivered by clinicians.⁴⁹ Thus, fathers may not have information on how to manage behavioral problems in

TABLE 5. Adjusted odds ratios for mortality and nonroutine discharge

Variables*	In-Hospital Mortality			Nonroutine Discharge		
	OR	95% CI	p Value	OR	95% CI	p Value
Age in mos						
12m vs 0m	1.81	1.18-2.77	0.006	2.24	1.58-3.16	<0.0001
Race (ref: white)			0.61			0.04
Black	1.10	0.72-1.58		1.61	1.15-2.24	
Hispanic	1.08	0.72-1.64		1.17	0.82-1.67	
Other	1.36	0.86-2.14		1.14	0.78-1.69	
Insurance (ref: non-private)			0.18			0.42
Private	0.71	0.43-1.17		0.88	0.65-1.19	
Admission (ref: non-elective)			0.23			0.45
Elective	0.65	0.33-1.31		0.86	0.57-1.29	
Income (ref: \$1-\$24,999)			0.006			0.45
\$25,001-\$30,000	0.69	0.48-1.00		0.82	0.61-1.11	
\$30,001-\$35,000	0.46	0.29-0.72		0.82	0.60-1.13	
\$35,001 & above	0.76	0.46-1.26		0.99	0.69-1.44	
Additional conditions						
Retinal bleeding	2.85	2.02-4.00	<0.0001	1.70	1.34-2.17	<0.0001
SBS	2.09	1.48-2.94	<0.0001	1.98	1.58-2.48	<0.0001

* Factors significant at the 0.2 level in the univariate model were included.

children, leading them to engage in acting out behaviors and ultimately impulsive physical abuse resulting in AHT.

While some of the strengths of this study relate to the national trends and hospital-level characteristics, there are several limitations that are inherent to administrative databases. The most important limitation is the accuracy of ICD-9 codes for the diagnosis of physical abuse; for example, there is a lack of detailed documentation on the severity of retinal hemorrhage, which has been shown to be associated with an increased likelihood of child abuse.⁴ The high rate of missing documentation on the perpetrators of injury in the cases discussed in this study is a limitation and is possibly found in small cohort studies given the sensitivity and implications of these data.

Yg fguetkdgf uqog f pfpkiu vjcv ecp dg wugf vq ko prove the practice of neurosurgeons caring for infants at risk for AHT. In addition to validating the trends in mortality according to age, income, and secondary diagnoses, yg jki jnki jvgf rvcgpp cpf jqukvnc/urgek f hcevqtu cuuqekated with an increased risk of AHT.

Qwt fcvv ujyqgf vjcv ocngru hcvjgtlvgrhcvjgtldq(-friend) were the main perpetrators of injury in the report-gf ecugul Yg urgewncvg vjcv nk o kygf C J V c yctgpguu cpflqt differences in socioeconomic factors in the southern states may be associated with higher rates of AHT. While we were unable to document any delays in the diagnosis or treatment of reported AHT cases, previous studies have pqvgf ukipk fcpv tcvgu qh o kuencuuk fcvkqp *53 ' + qh vjgug cases.¹² Cnv j qwi j rvcgppv ygtg xgppwcn { encuuk f gf eqtrectly, there was certainly a delay in documentation and appropriate treatment. Given the described trends in inci-fgpeg cpf tkum. yg ctg eqp f fgp vjcv pgwtquwti gppu ecting for infants with injuries resembling the conditions described herein (AHT, SBS, retinal hemorrhage, fractures, and hematomas) could take an active role in documenting data that are typically missing. Furthermore, efforts to increase awareness in the clinic through the discussion of factors associated with AHT (age, perpetrator, socioeconomic factors) among family members of patients who may be at risk could play a critical role in improving outcomes in this patient population.

Conclusions

In infants diagnosed with AHT, an older age, lower income, and secondary diagnoses such as retinal hemor-tjcig cpf UDU ygtg ukipk fcpv { cuuqekcvgf ykvj cp kpcreased risk of mortality. Abusive head trauma cases were most often reported in infants in the early months of life, peaking at 2 months. In the cases with documented perpetrators, we found that infants attended by non-relative caregivers had the greatest risk of mortality, followed by fathers, stepfathers, and boyfriends.

References

- 30 Cnv ocp TN. Ecpvgf L. Rcvtkem RC. Fcng { P. Dww PM. Dtepf DA: Parent education by maternity nurses and prevention of abusive head trauma. *Pediatrics* 128:g33866g3394. 4233
2. Bechtel K, Stoessel K, Leventhal JM, Ogle E, Teague B, Laviates S, et al: Characteristics that distinguish accidental

- htqo "cdwukxg" kplwt { "kp" jqukvnc | gf { qwp i "ej knftgp" ykvj "jgc f" trauma. *Pediatrics* 114:165–168, 2004
- 50 Dgppgv O F Lt. J cmn L. Htc | kgf N Lt. Rcvgn P. Dctmgt N. Ujcy M. J q o kekfg qh ej knftgp c ig f 266 { gct u. 4225/26 Tguwnvu htqo vjg Pcvkqpcn Xkqngpv Fgc vj Tgrqtkpi U { uvgo *Inj Prev* 12 (Suppl 2):ii39–ii43, 2006
- 60 Dkpgpdcw o I. Okt | c / I ggt i g P. E j tkuvkcp E Y. Hqtdgu DL. Odds of abuse associated with retinal hemorrhages in children suspected of child abuse. *J AAPOS* 13:48: 6494. 422;
5. Blumenthal I: Shaken baby syndrome. *Postgrad Med J* 78:9546957. 4224
- 80 E j tkuvkcp E Y. Dnqem T. Cdwukxg jgc f vtcw o c kp kphcpvu cpf children. *Pediatrics* 123:1409–1411, 2009
- 90 Fkcu OU. U o kvj M. Fg I wjgt { M. Oc | wt R. Nk X. Ujchgt ML: Preventing abusive head trauma among infants and young children: a hospital-based, parent education program. *Pediatrics* 115:g6926g699. 4227
- 0 F tcmg D. Lqngg { L O. Ncpkgt R. Hnwmg L. Dctvj TR. Lqpuqp Tgkf O Tcekc n dkc u kp ej knf rtqvgvkkp A C eq o rctkuqp qh eq o r g v i n g explanations using national data. *Pediatrics* 127:6936 69: . 4233
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10. Gordy C, Kuns B: Pediatric abusive head trauma. *Nurs Clin North Am* 48:193–201, 2013
- 330 J c f n g { O P. Uqppvci X M. Tgmcvg J N. Owtr j { C V j g kphcpv whiplash-shake injury syndrome: a clinical and pathological study. *Neurosurgery* 24:536–540, 1989
- 340 Lgpp { E. J { o g n MR. Tkv | gp C. Tgkpgtv UG. J c { VE C C p n { u k u of missed cases of abusive head trauma. *JAMA* 281:621–626, 1999
13. Johnson DL, Braun D, Friendly D: Accidental head trauma and retinal hemorrhage. *Neurosurgery* 33:231–235, 1993
- 360 Mggppcp J V. Twp { cp FM. Octujcmn U Y. Pqegtc O C. Ogtvgp FH. Ukpen U J < C r q r w n c v k p / d c u g f u v w f { q h k p E k e v g f v t c w o c v i c brain injury in young children. *JAMA* 290:621–626, 2003
- 370 Mgungt J. Fkcu OU. Ujchgt O. Tqvw owpf E. Ecrrqu M. Thomas NJ: Demographics of abusive head trauma in the Commonwealth of Pennsylvania. *J Neurosurg Pediatr* 1: 351–356, 2008
16. Kivlin JD: Manifestations of the shaken baby syndrome. *Curr Opin Ophthalmol* 12:158–163, 2001
- 390 Ngxgpvcn L O. I c k v j g t L T k p e k f g p e g q h u g t k q w u k p l w t k g u f w g v q r j { u k e c n c d w u g k p v j g W p k v g f U v c v g u k 3 ; 9 v q 422; 0 *Pediatrics* 130:g: 696g: 74. 4234
- 3: 0 Ngxkp CX. Tgkpcn j g o q t t j c i g k p c d w u k x g j g c f v t c w o c *Pediatrics* 126:; 836; 92. 4232
19. Palusci VJ, Covington TM: Child maltreatment deaths in the WOU Pcvkqpcn E j knf Fgc vj Tgkgy Ecug Tgrqtkpi U { uvgo *Child Abuse Negl* 38:25–36, 2014
- 420 Rctmu UG. Mgingt UT. Cppguv LN. Ogte { LC < E j c t c e v g t k u v k e u of fatal abusive head trauma among children in the USA: 4225/4229 cp c r n k e c v k p q h v j g E F E q r g t c v k p c n e c u g f g i n i t i o n to national vital statistics data. *Inj Prev* 18:193–199, 2012
- 430 Tkupg UT. Uwumcwg UL. Fg o cvv GL. Unq o kpg DU. Ucnqtqk EH. Functional outcomes in children with abusive head trauma receiving inpatient rehabilitation compared with children with nonabusive head trauma. *J Pediatr* 164:613–619, 2014
22. Schloff S, Mullaney PB, Armstrong DC, Simantirakis G. J w o r j t g { u TR O { u g t q u LU. g v c n T g v k p c n f p f k p i u k p children with intracranial hemorrhage. *Ophthalmology* 109:369463698. 4224
- 450 Uetkdcqp RX. Ocmqtqhh MN. Hgnf ocp M Y. Dgtigt TR < Cu-sociation of perpetrator relationship to abusive head trauma clinical outcomes. *Child Abuse Negl* 37:9936999. 4235
- 460 Ugncuukg CY. Dgti M. Dwuej E. Twuugn Y U C d w u k x g j g c f

- trauma in young children: a population-based study. **Pediatr Emerg Care** 29:283–291, 2013
- 470" Ujcpcjcp"OG." \qmqvt"CL."Rcttkuj"LY."Dett"TI."Twp{cp" DK: National, regional, and state abusive head trauma: application of the CDC algorithm. **Pediatrics** 132:e1546–e1553, 2013
 - 480" Urckfg"TH."Uygpign"TO."Uejcttg"FY."Ogkp"EG<"Ujcmgp" baby syndrome. **Am Fam Physician** 41:1145–1152, 1990
 - 490" Uvctnkp i"UR." Jqnfgp"LT."Lgpp{"E<"Cdwukxg"jgc f"vtcw o c<" the relationship of perpetrators to their victims. **Pediatrics** 95:259–262, 1995
 28. Talvik I, Metsvaht T, Leito K, Pöder H, Kool P, Väli M, et al: KpEkevgf"vtcw o cvke"dtckp"klplwt {"*KVDK+"qt"ujcmgp"dcd{"u{p-drome (SBS) in Estonia. **Acta Paediatr** 95:9; ; ô:26."4228
 29. US Department of Health and Human Services: **Child Maltreatment 2013**. Washington, DC: US Dept of Health and Human Services, 2015

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