

Characteristics of fatal abusive head trauma among children in the USA: 2003–2007: an application of the CDC operational case definition to national vital statistics data

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ABSTRACT

Objective In March of 2008, an expert panel was convened at the Centers for Disease Control and Prevention to develop code-based case definitions for abusive head trauma (AHT) in children under 5 years of age based on the *International Classification of Diseases, 10th Revision (ICD-10)* nature and cause of injury codes. This study presents the operational case definition and applies it to US death data.

Methods National Center for Health Statistics National Vital Statistics System data on multiple cause-of-death from 2003 to 2007 were examined.

Results Inspection of records with at least one *ICD-10* injury/disease code and at least one *ICD-10* cause code from the AHT case definition resulted in the identification of 780 fatal AHT cases, with 699 classified as definite/presumptive AHT and 81 classified as probable AHT. The fatal AHT rate was highest among children age <1 year with a peak in incidence that occurred at 1–2 months of age. Fatal AHT incidence rates were higher for men than women and were higher for non-Hispanic African-Americans compared to other racial/ethnic groups. Fatal AHT incidence was relatively constant across seasons.

Conclusions This report demonstrates that the definition can help to identify population subgroups at higher risk for AHT defined by year and month of death, age, sex and race/ethnicity. This type of definition may be useful for various epidemiological applications including research and surveillance. These activities can in turn inform further development of prevention activities, including educating parents about the dangers of shaking and strategies for managing infant crying.

INTRODUCTION

Abusive head trauma (AHT) is a phenomenon known by many different names depending upon the discipline and setting. These include shaken baby or shaken infant syndrome; shaken impact syndrome; infant whiplash-shake injury syndrome; inflicted traumatic brain injury (TBI) and inflicted, non-accidental or intentional head injury. Each of these terms refers to conditions resulting from assaults on infants or young children that include but are not always limited to violent shaking and/or blunt impact. However, depending upon the term used and how it is operationalised, the corresponding measures of incidence, prevalence and clinical picture can be quite different. In April 2009, the American Academy of Pediatrics officially

recommended adopting the term ‘abusive head trauma’ to describe inflicted injuries to the head and its contents among children.¹

AHT is one of the leading causes of child maltreatment fatalities in the USA.^{2–3} Among head trauma-related deaths in infants and children under 2 years old, between 50% and 80% have been estimated to result from abuse.^{4–5} Population-based rates for serious inflicted head injury have been previously estimated to fall between 15 and 19 cases per 100 000 person-years for children under 2 years of age.^{5–8} The majority of victims are under 2 years of age, with the peak in incidence typically found at 3 months; however, injuries consistent with AHT have been found in children as old as 5 years of age.^{4–9–10}

The public health significance is compounded by the adverse health consequences for victims. Though most AHT victims do survive, the mortality rate in clinical studies has ranged from 13% to 35%.^{11–14} The majority of AHT survivors have physical disabilities and neurologic impairment. AHT survivors are typically affected by numerous, long-term cognitive and neurologic sequelae, including motor and visual deficits; epilepsy and speech, language and behavioural problems.^{15–17} Good outcomes, with little to no impairment or disability, are only seen in 10%–15% of AHT survivors.^{17–20}

Despite the numerous studies that have been published on the epidemiology, clinical manifestations and sequelae of AHT, routine surveillance (eg, measuring incidence, examining temporal trends and demographic patterns) has been limited by the lack of standard case definitions. Thus, in March of 2008, a panel of pediatricians, child maltreatment experts, AHT experts, coding experts and experienced state health department personnel was convened at the Centers for Disease Control and Prevention (CDC) to develop *International Classification of Diseases, 10th Revision (ICD-10)* code-based case definitions for both non-fatal AHT (applicable primarily to hospital discharge data) and fatal AHT (applicable primarily to death certificate data) in children under 5 years of age (see online appendix 1 for list of expert panel members). The panel reached consensus on both broad and narrow operational case definitions, with the former emphasising sensitivity of case ascertainment and recommended for general population-based surveillance, and the latter emphasising specificity and recommended for more focused assessments.²¹ This study presents

the panel's broad operational case definition for fatal AHT and applies it to US death data to characterise fatal AHT incidence in children under 5 years old.

METHODS

For fatal AHT, the panel's broad and narrow operational case definitions are based on *ICD-10* nature and cause of injury codes and are applicable to children under 5 years of age.²² The recommended set of *ICD-10* codes for the broad case definition and the segmentation of cases into two AHT categories are shown in table 1. In each category, a case must have at least one injury/disease code and at least one cause code.

National Center for Health Statistics National Vital Statistics System data on multiple cause-of-death were examined to identify all records meeting the criteria for any category in this operational case definition. Because fatal AHT cases are relatively uncommon, this study relied on data for the combined period 2003–2007.²³

Each record on multiple cause-of-death provides information on the age, sex and race/ethnicity of the decedent, the calendar month of death, one *ICD-10* code specifying the underlying cause of death and up to 20 accompanying *ICD-10* record axis codes. Record axis codes are derived from the direct and contributory causes appearing on death certificates and provide the accepted basis for multiple-cause mortality tabulations.²⁴ Only those records representing deaths among US residents under 5 years old and indicating an injury-related underlying cause of death (*ICD-10* codes U01–U03, V01–Y36, Y85–Y87, Y89) were included in the analysis. Qualifying records were further inspected to determine whether the *ICD-10* underlying cause and record axis codes indicated AHT under the broad operational case definition; underlying cause and record axis codes were treated equivalently for this purpose. For a record to be counted as a case in a given category in the operational definition, an AHT disease/injury (nature of injury) code and an AHT cause code listed for that category were both required. Records simultaneously satisfying the conditions for both categories were counted as cases in the higher category.

Qualifying records were also inspected to determine if the record axis codes indicated TBI, using the CDC case definition for fatal TBI.²⁵ The *ICD-10* code set for the CDC fatal TBI case definition fully subsumes the code set for the operational definition of fatal AHT; any case qualifying as AHT therefore also qualifies as TBI-related. Fatal TBI cases not already assigned to one of the fatal AHT categories were assigned to the comparison group 'TBI without AHT'. The TBI (without AHT) cases were further classified (using the underlying cause code) as assault related (*ICD-10* codes X85–Y09, Y87.1, U01–U02), unintentional (*ICD-10* codes V01–X59, Y85–Y86) or as undetermined intent

(*ICD-10* codes Y10–Y34, Y87.2, Y89.9). (See online appendix 3 for list of unintentional injury codes and descriptions.)

Case counts for the combined period 2003–2007 were tabulated by age, sex, race/ethnicity and calendar month of death. Population-based rates by age, sex and race/ethnicity were calculated by dividing the tabulated case counts by corresponding midyear population estimates combined across this same 5-year period; all rates are expressed in terms of cases per 100 000 person-years.²⁶

RESULTS

Inspection of the data on multiple cause-of-death for 2003–2007 resulted in the identification of records representing 17 995 injury-related deaths among US residents under 5 years old. Of these, 2057 records included at least one of the injury/disease codes in the AHT case definition, and 2806 records included at least one of the cause codes in the definition. The intersection of these records code resulted in the identification of 780 fatal AHT cases (table 2).

Of these 780 cases, three simultaneously meet the criteria for both definite/presumptive AHT and probable AHT; these cases were assigned to the higher of these categories (definite/presumptive AHT). An additional 81 cases meet the criteria for probable AHT only. A total of 4299 records not assigned to a fatal AHT category were identified as meeting the fatal TBI case definition and were assigned to the category 'TBI without AHT'. Within this category, 1212 cases were further classified as assault-related; 3018 cases were classified as unintentional; 69 cases were classified as undetermined intent and were excluded from further analysis. Table 3 shows the distribution of each type of case by calendar year of occurrence. No temporal trend is apparent for the fatal AHT cases, while there is a modest drop in the incidence of fatal TBI (without AHT) near the end of the analysis period.

The distribution of fatal AHT cases by single year of age shows a significant concentration among infants (children under 1 year-old) (table 4). The corresponding population-based rates (per 100 000 person-years for each year of age; definite/presumptive AHT and probable AHT combined) ranged from 2.14 per 100 000 for infants to 0.20 for children 4 years old. The distribution of fatal TBI (without AHT) cases that were assault-related also shows the highest concentration among infants; while cases that were unintentional also show the highest concentration among infants, a much more substantial proportion of such cases extends into the years following infancy. Among children <2 years old, the rates for fatal AHT and fatal TBI (without AHT) were 1.45 and 5.38, respectively. Examples of assault-related fatal TBI (without AHT) cases included, but were not limited to, unspecified injuries to the face and head (S09.9) and open wounds to an unspecified part of the head (S01.9) accompanied by underlying codes including, but not limited to, assault by unspecified means (Y09) and assault by other specified means (Y08).

Referring exclusively to the underlying cause of death, nearly 100% of cases identified as definite/presumptive AHT were coded as assault related; by definition, none of the cases

Table 1 The CDC operational case definition for fatal AHT in children under 5 years old*

AHT classification	AHT injury/disease code (<i>ICD-10</i>)	AHT cause code (<i>ICD-10</i>)
Definite or presumptive abusive head trauma	S02, S02.0–S02.1, S02.7–S02.9, S04.0, S06.0–S06.9, S07.1, S07.8–S07.9, S09.7–S09.8, T90.2, T90.5, T90.8–T90.9	Y00, Y01, Y04, Y07.0–Y07.3, Y07.8–Y07.9, Y08, Y09, Y87.1, T74.1, T74.8–T74.9
Probable abusive head trauma	All of those above	Y29, Y30, Y33, Y34, Y87.2

*See online appendix 2 for description of codes.

AHT, abusive head trauma; CDC, Centers for Disease Control and Prevention.

Table 2 Fatal AHT cases identified using the CDC operational case definition for children under 5 years old, USA, 2003–2007

Case classification	Cases identified
Definite or presumptive abusive head trauma	699
Probable abusive head trauma	81

Table 3 Distribution of fatal AHT/fatal TBI cases for children under 5 years old, by calendar year of death, USA, 2003–2007

Case classification	Year of occurrence					Total
	2003	2004	2005	2006	2007	
AHT—definite or presumptive	154	122	134	140	149	699
AHT—probable	10	16	22	14	19	81
Total AHT	164	138	156	154	168	780
TBI without AHT—assault-related	242	239	213	265	253	1212
TBI without AHT—unintentional	640	620	663	555	540	3018
Total TBI without AHT*	882	859	876	820	793	4230

*Excludes 69 TBI cases with undetermined intent.
AHT, abusive head trauma, TBI, traumatic brain injury.

identified as probable AHT were coded as assault related. Among cases identified as TBI (without AHT), the fraction coded as assault related gradually declined with age, from 48% among infants to 14% among 4-year-olds.

For infant cases, the data on multiple cause-of-death include month of age (at time of death). The distribution of fatal AHT among infants shows a prominent peak at 1–2 months (approximately 30–89 days) of age; thereafter, incidence declines noticeably (figure 1). The distribution of fatal assault-related TBI (without AHT) cases among infants has a similar profile, with peak incidence at 1–2 months. In contrast, fatal TBI (without AHT) cases that were unintentional show a peak incidence at 4 months of age.

For both definite/presumptive AHT and probable AHT, male children accounted for a substantially higher percentage of cases (table 5). The corresponding population-based rates (for definite/presumptive and probable AHT combined) by sex are significantly different; with sex = female as the referent, the rate ratio is 1.30 (0.86/0.66=1.30; 95% CI 1.13 to 1.50). Fatal TBI cases (without AHT) show a similar distribution by sex. For both male and female children, the peak number of AHT cases (combined) and the peak number of assault-related TBI (without AHT) cases occurred at 1–2 months of age, while the peak number of TBI (without AHT) cases that were unintentional occurred at about 4 months of age (not shown).

Table 6 shows the distribution of cases by ethnicity and race. The corresponding population-based rates exhibit significant variation. With ethnicity/race = non-Hispanic Caucasian as the referent, the rate ratios for AHT are 1.24 for Hispanics (95% CI

1.03 to 1.50); 3.14 for non-Hispanic African-Americans (95% CI 2.66 to 3.70); 0.73 for non-Hispanic Asians/Pacific Islanders (A/PI) (95% CI 0.46 to 1.14) and 2.46 for non-Hispanic American Indians/Alaska Natives (AI/AN) (95% CI 1.44 to 4.20). For TBI (without AHT) cases with non-Hispanic Caucasians as the referent, the rate ratios are 1.19 for Hispanics (95% CI 1.10 to 1.28), 1.85 for non-Hispanic African-Americans (95% CI 1.72 to 2.00), 0.52 for non-Hispanic A/Pis (95% CI 0.42 to 0.64) and 3.11 for non-Hispanic AI/ANs (95% CI 2.57 to 3.75). It should be noted that due to small case counts, the estimated rates of AHT for non-Hispanic A/Pis and non-Hispanic AI/ANs may be statistically unstable.

The distributions of fatal AHT cases and fatal TBI (without AHT) cases by calendar month of death are shown in figure 2. Fatal TBI cases classified as unintentional show a clear seasonal pattern, peaking from late spring through summer. By comparison, the incidence of fatal AHT and fatal assault-related TBI (without AHT) was relatively consistent across seasons.

DISCUSSION

By examining the application of CDC's operational fatal AHT case definition to data on multiple cause-of-death from the National Vital Statistics System, this report demonstrates the use of the definition for public health surveillance activities. The standard fatal AHT case definition can help to identify population subgroups at higher risk for AHT defined by year and month of death, age, sex and race/ethnicity. The results also demonstrate the importance of a standard fatal AHT case

Table 4 Distribution of fatal AHT/fatal TBI cases for children under 5 years old, by year of age, USA, 2003–2007

Case classification	Age in years					Total
	<1	1	2	3	4	
AHT—definite or presumptive	393	140	85	45	36	699
AHT—probable	51	13	8	4	5	81
Total AHT	444	153	93	49	41	780
Percentages by year of age*	57%	20%	12%	6%	5%	
Rates (per 100 000 person-years) by year of age	2.14	0.75	0.45	0.24	0.20	0.76
TBI without AHT—assault-related	596	248	175	115	78	1212
TBI without AHT—unintentional	642	735	620	560	461	3018
Total TBI without AHT †	1238	983	795	675	539	4230
Percentages by year of age*	29%	23%	19%	16%	13%	
Rates (per 100 000 person-years) by year of age	5.97	4.79	3.88	3.32	2.68	4.14

*Percentages are calculated across cases 0–4 years old.

†Excludes 69 TBI cases with undetermined intent.
AHT, abusive head trauma; TBI, traumatic brain injury.

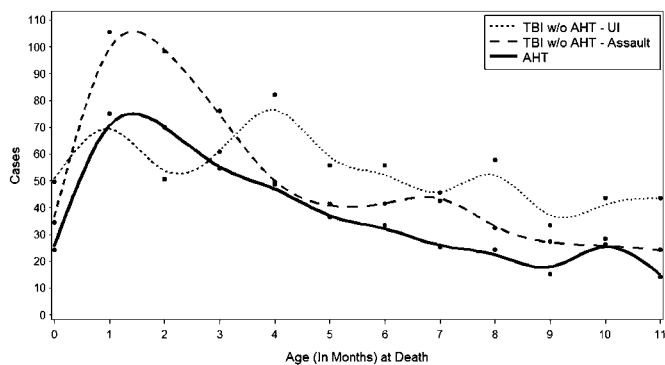


Figure 1 Distribution of fatal AHT/fatal TBI cases for children under 1 year old, by month of age, USA, 2003–2007.

definition for young children by presenting comparisons of numbers and rates of fatal AHT cases with those of fatal paediatric TBI (without AHT) cases by selected characteristics. By definition, AHT is a subset of TBI, differentiated by age, nature of injury and cause of injury. Thus, it is expected that the epidemiology of AHT would in many ways mirror that of TBI, particularly assault-related TBI.

This is one of a few studies that have examined the demographic and seasonal characteristics of AHT fatalities with direct comparisons to non-AHT TBI. As expected, there were significantly more cases of TBI (without AHT) than AHT for each year of data analysed. Also, the incidence of AHT was relatively constant over the study period from 2003 to 2007. This finding is consistent with several other studies. In their examination of Pennsylvania child abuse registry data from 1996 to 2004, Kesler *et al* found that the rates of both AHT deaths and injuries were steady over the study period.⁸ Analyses of California hospital inpatient data also revealed steady rates in AHT in children less than 2 years of age during 1998–2004.²⁷ These consistent findings may reflect a lack of progress toward better detection and classification of fatal AHT cases but may also indicate a truly steady incidence over time.

As was expected, we found that AHT and assault-related TBI (without AHT) deaths occurred most frequently among children less than 1 year of age. Our results also coincide with findings of other studies that demonstrate a peak incidence of AHT early in the first year of life.^{28 29} However, our study revealed a peak in deaths at 1–2 months of age, while the aforementioned studies found peaks in AHT incidence between 10 and 16 weeks of age.

Table 5 Distribution of fatal AHT/fatal TBI cases for children under 5 years old, by sex, USA, 2003–2007

Case classification	Sex		Total
	M	F	
AHT—definite or presumptive	402	297	699
AHT—probable	48	33	81
Total AHT	450	330	780
Percentages by sex	58%	42%	
Rates (per 100 000 person-years) by sex	0.86	0.66	
TBI without AHT—assault-related	681	531	1212
TBI without AHT—unintentional	1739	1279	3018
Total TBI without AHT*	2420	1810	4230
Percentages by sex	57%	43%	
Rates (per 100 000 person-years) by sex	4.63	3.62	

*Excludes 69 TBI cases with undetermined intent. AHT, abusive head trauma; TBI, traumatic brain injury.

The difference in our findings may represent differences in physiologic vulnerability in early infancy. The youngest infants exposed to AHT (eg, 1–2 months of age) are most likely to die from their injuries, while those who have assault-related head injuries at around 3–4 months of age may be more resilient and more likely to survive their injuries and be represented in hospital-based studies of injuries associated with child abuse.

The age-specific incidence curve for fatal AHT found in this study is similar to that for levels of crying among infants. Studies of crying, a primary stimulus underlying shaking and other behaviours that cause AHT, have found that it increases in the first month after birth, peaks in the second month and decreases thereafter.^{29–33} This suggests that preventive efforts that help parents deal with the frustration caused by crying infants may be helpful in decreasing fatal AHT.

A consistent finding in the literature on AHT and TBI is the significantly higher incidence among boys.^{5 8 34 35} This was upheld in the current analysis as well. These findings suggest that boys are not only more frequently AHT victims but also are more likely to be victims of severe AHT that leads to death.

Our findings regarding fatal AHT incidence by race were similar to those of some previous studies. In our study of AHT deaths for the USA, a higher incidence was observed among both non-Hispanic African-American and non-Hispanic AI/AN children; rate estimates for AI/ANs should be interpreted with caution due to small case counts. In analyses of data from Pennsylvania, the highest incidence was observed among African-Americans.⁸ In another study conducted using California shaken baby syndrome surveillance data, the incidence was highest among Hispanics of any race.²⁷ A higher incidence of AHT in non-Caucasian children has been reported in several studies conducted in North Carolina.^{5 35}

During the study period, seasonal differences were not observed for the incidence of fatal AHT or assault-related fatal TBI without AHT. This finding contributes to mixed results in the existing literature regarding seasonal fluctuation in AHT incidence. One previous study demonstrated significant seasonal fluctuation in incidence of AHT⁸ with peaks in the winter months (October through December). At least one other study has shown decreases in the incidence of overall physical child abuse during Child Abuse Prevention Month in April.³⁶

There are several limitations in applying the panel's operational case definition for fatal AHT to the National Vital Statistics System mortality data. First, these data are based on death certificates only, which likely resulted in an undercount of cases. Evaluation studies indicate that death certificate data alone underestimate national and state incidence of child maltreatment fatalities.^{37–39} However, assault-related cases are more likely to be ascertained from death certificate data than cases involving less physical forms of abuse. Crume *et al*³⁷ found that maltreatment was ascertained in 93 of 109 (85%) cases when the mechanism of death was bodily force or a blunt object, compared to an overall ascertainment rate for maltreatment deaths of 50%. Furthermore, given the similarity in the epidemiology of AHT and assault-related TBI (without AHT), it is possible that some cases in the latter category are misclassified due to incorrect, incomplete and/or non-specific coding of information on the death certificate. However, even if reliance on death certificate data results in underestimation of the incidence of AHT (and assault-related TBI), our study suggests that the operational case definition can be useful for public health surveillance activities, such as monitoring temporal trends and demographic patterns. The AHT cases identified in our study show demographic characteristics similar in distribution to

Table 6 Distribution of fatal AHT/fatal TBI cases for children under 5 years old, by ethnicity/race, USA, 2003–2007

Case classification	Ethnicity/race						Total
	Hispanic All races	Non-Hispanic				Unknown	
		Caucasian	African-American	A/PI	AI/AN		
AHT—definite or presumptive	143	286	239	15	12	4	699
AHT—probable	22	32	20	5	2	0	81
Total AHT	165	318	259	20	14	4	780
Percentages by race	21%	41%	33%	3%	2%	<1%	
Rates (per 100 000 person-years) by ethnicity/race	0.69	0.55	1.74	0.40*	1.36*		
TBI without AHT—assault-related	267	513	374	20	33	5	1212
TBI without AHT—unintentional	736	1517	603	72	80	10	3018
Total TBI without AHT†	1003	2030	977	92	113	15	4230
Percentages by race	24%	48%	23%	2%	3%	<1%	
Rates (per 100 000 person-years) by ethnicity/race	4.19	3.54	6.56	1.85	10.99		

*Rate may be unstable because it is based on 20 or fewer deaths.

†Excludes 69 TBI cases with undetermined intent.

AHT, abusive head trauma; TBI, traumatic brain injury.

those of other population-based studies of child maltreatment fatalities. Despite the similarities between AHT and assault-related TBI, because AHT is associated with a specific type of behaviour, that is, shaking, and has distinct, long-term consequences and prevention activities that may differ from other assault-related TBIs, we recommend considering the two conditions separately.

A second potential limitation is that some AHT cases may not be identifiable due to medical examiners and coroners lacking sufficient information to confirm and code child maltreatment. A majority of the definite/presumptive AHT cases (64.8%) identified had no *ICD-10* maltreatment syndrome codes (T74 or Y07) recorded in their multiple cause listing. Among AHT case records showing Y07 as either the underlying cause code or among the record axis codes, most (93%) did not include information on the specific perpetrator type. This may have resulted from a lack of information about the specific circumstances of the injury event at the time the death certificate was completed. The completeness and specificity of cause of death data, especially pertaining to assignment of abuse/maltreatment codes, could be improved if information from law enforcement records and state and local child death review systems was made available to the medical examiner or coroner prior to when they certify the causes of death on the death certificate.^{39 40} This would provide additional information (specification of abuse, battering, beating or maltreatment) on the death certificate for

mortality coding specialists to assign *ICD-10* abuse/maltreatment codes (T74 and/or Y07) to electronic death records for children and teenagers under 18 years of age.⁴¹ Also, *ICD-10* abuse/maltreatment codes are very limited in specificity. Expanded maltreatment code sets are needed to capture the circumstances surrounding child assault, abuse and maltreatment and to further specify the types of perpetrators. The *ICD-11* coding system is currently under development, which could provide an opportunity to develop and implement such code sets for future use.⁴²

Because our study involved national data and explored seasonal trends using death data combined across 5 years, the incidence counts would not likely reflect targeted prevention efforts. Our study data suggest that efforts to prevent assault-related fatal head injuries should be ongoing. On the other hand, our findings suggest that fatal TBI incidence from unintentional causes occur more often in the late spring and summer months when young children are more active outdoors. Similar patterns of peak TBI incidence between April and September have been previously reported.⁴³ This suggests efforts to prevent unintentional fatal TBI, and its sequelae should be most intensive immediately before and during spring and summer months.

Given the similarity in the epidemiology of fatal and nonfatal AHT, potential avenues for prevention are likely to follow similar directions. Current thinking about prevention of AHT is based on the assumption that violent shaking of infants results, at least in part, from lack of information and skills about how to manage prolonged, inconsolable and unpredictable episodes of infant crying.^{44 45} These periods of crying are a normal feature of child development; however, this is not widely known nor is it appropriately addressed in parental advice literature.^{7 44} These understandings have led to the development of educational interventions to educate parents about the dangers of shaking, strategies for managing infant crying and the sharing of preventive information with peers.⁴⁶ Prominent examples of these types of educational programs include a hospital-based shaken baby syndrome education program for parents and the Period of PURPLE Crying.^{46 47} The hospital-based shaken baby syndrome education program for parents was tested in hospitals in western New York State and found to reduce the incidence of AHT by 47% from the pre- to post-evaluation period, with no comparable decrease found in the comparison site

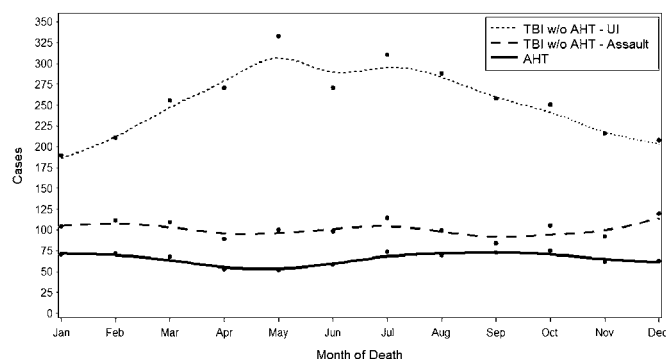


Figure 2 Distribution of fatal AHT/fatal TBI cases for children under 5 years old, by calendar month of death, USA, 2003–2007.

What is already known on the subject

- ▶ AHT is the leading cause of physical child maltreatment fatalities. Good outcomes, with little to no impairment or disability, are only seen in 10%–15% of survivors
- ▶ Surveillance (eg, measuring incidence, examining temporal trends and demographic patterns) of AHT has been limited by the lack of standard case definitions

What this study adds

- ▶ The code-based case definitions for fatal AHT in children under 5 years of age, which was developed by a CDC-convened expert panel has been successfully operationalised and applied to US death data
- ▶ The proposed fatal AHT definition can be a useful tool for future public health surveillance activities
- ▶ The proposed fatal AHT definition can also be integrated into evaluations of current and ongoing prevention efforts

(Pennsylvania).⁷ Randomised controlled trials of the Period of PURPLE Crying program materials have found them to lead to positive differences in the crying-related knowledge and behaviours of mothers of newborns.^{44–48} A case control study evaluating the use of an educational video highlighting the dangers of AHT in a level-one trauma center in Utah found that exposure to the video was associated with non-statistically significant reductions in AHT.⁴⁹ Despite the lack of definitive evidence for the effectiveness of educational programs in preventing AHT, they are being widely used across the USA.⁵⁰ Currently the Period of PURPLE Crying and the hospital-based shaken baby syndrome education program for parents are being evaluated in North Carolina and Pennsylvania, respectively, with funding support from CDC. Guidance on preventing AHT has been fully described elsewhere.⁵¹

In summary, this study demonstrates the use of the standard AHT definition for public health research and surveillance and suggests its utility for evaluation of current and ongoing prevention efforts. Also, several methodological issues that need to be addressed in order to improve those efforts are discussed. Despite the indicated limitations, including lack of specificity of ICD abuse/maltreatment codes and paucity of effective prevention programs, the establishment of a standardised AHT definition has implications as a useful surveillance tool for examining trends and patterns of AHT in the US population.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

- Christian CW, Block R. Abusive head trauma in infants and children. *Pediatrics* 2009;**123**:1409–11.
- Administration for Children & Families. *Child Abuse and Neglect Fatalities: Statistics and Interventions*. <http://www.childwelfare.gov/pubs/factsheets/fatality.cfm> (accessed 28 Apr 2011).
- National MCH Center for Child Death Review. *Child Abuse and Neglect Fact Sheet*. <http://www.childdeathreview.org/causesCAN.htm> (accessed 28 Apr 2011).
- Bruce DA, Zimmerman RA. Shaken impact syndrome. *Pediatr Ann* 1989;**18**:482–4, 486–489, 492–494.
- Keenan HT, Runyan DK, Marshall SW, et al. A population-based study of inflicted traumatic brain injury in young children. *JAMA* 2003;**290**:621–6.
- Barlow KM, Minns RA. Annual incidence of shaken impact syndrome in young children. *Lancet* 2000;**356**:1571–2.
- Dias MS, Smith K, DeGuehery K, et al. Preventing abusive head trauma among infants and young children: a hospital-based, parent education program. *Pediatrics* 2005;**115**:e470–7.
- Kesler H, Dias MS, Shaffer M, et al. Demographics of abusive head trauma in the Commonwealth of Pennsylvania. *J Neurosurg Pediatr* 2008;**1**:351–6.
- Pounder DJ. Shaken adult syndrome. *Am J Forensic Med Pathol* 1997;**18**:321–4.
- Ludwig S, Warman M. Shaken baby syndrome: a review of 20 cases. *Ann Emerg Med* 1984;**13**:104–7.
- Dias MS, Backstrom J, Falk M, et al. Serial radiography in the infant shaken impact syndrome. *Pediatr Neurosurg* 1998;**29**:77–85.
- Hadley MN, Sonntag VK, Rekeate HL, et al. The infant whiplash-shake injury syndrome: a clinical and pathological study. *Neurosurgery* 1989;**24**:536–40.
- Sinal SH, Ball MR. Head trauma due to child abuse: serial computerized tomography in diagnosis and management. *South Med J* 1987;**80**:1505–12.
- Zimmerman RA, Bilaniuk LT, Gennarelli T, et al. Cranial computed tomography in diagnosis and management of acute head trauma. *AJR Am J Roentgenol* 1978;**131**:27–34.
- Barlow KM, Thomson E, Johnson D, et al. Late neurologic and cognitive sequelae of inflicted traumatic brain injury in infancy. *Pediatrics* 2005;**116**:e174–85.
- Duhaime AC, Christian C, Moss E, et al. Long-term outcome in infants with the shaking-impact syndrome. *Pediatr Neurosurg* 1996;**24**:292–8.
- Goldstein B, Kelly MM, Bruton D, et al. Inflicted versus accidental head injury in critically injured children. *Crit Care Med* 1993;**21**:1328–32.
- Ewing-Cobbs L, Kramer L, Prasad M, et al. Neuroimaging, physical, and developmental findings after inflicted and noninflicted traumatic brain injury in young children. *Pediatrics* 1998;**102**:300–7.
- Kivlin JD, Simons KB, Lazoritz S, et al. Shaken baby syndrome. *Ophthalmology* 2000;**107**:1246–54.
- Starling SP, Holden JR, Jenny C. Abusive head trauma: the relationship of perpetrators to their victims. *Pediatrics* 1995;**95**:259–62.
- Injury Surveillance Workgroup. Pediatric Abuse Head Trauma Surveillance-Recommended Definitions Using International Classification of Disease (ICD) and External Cause of Injury Codes. In process.
- International Classification of Diseases. *10th Revision (ICD-10)*. Geneva, Switzerland: World Health Organization, 2001.
- Xu JQ, Kochanek KD, Murphy SL, et al. Deaths: final data for 2007. *Natl Vital Stat Rep*. 2010;**58**:1–119.
- National Center for Health Statistics. *Documentation for the Mortality Public Use Data Set, 1999*. Hyattsville, MD: National Center for Health Statistics, 2002.
- Faul M, Xu L, Wald MM, et al. *Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths, 2002–2006*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 2010.
- National Center for Health Statistics. *Postcensal Estimates of the Resident Population of the United States for July 1, 2000–July 1, 2009, by Year, County, Age, Bridge Race, Hispanic Origin, and Sex (Vintage 2009)*. Hyattsville, MD: National Center for Health Statistics, 2010.
- Wirtz SJ, Trent RB. Passive surveillance of shaken baby syndrome using hospital inpatient data. *Am J Prev Med* 2008;**34**(4 Suppl):S134–9.
- Agran PF, Anderson C, Winn D, et al. Rates of pediatric injuries by 3-month intervals for children 0 to 3 years of age. *Pediatrics* 2003;**111**:e683–92.
- Barr RG, Trent RB, Cross J. Age-related incidence curve of hospitalized Shaken Baby Syndrome cases: convergent evidence for crying as a trigger to shaking. *Child Abuse Negl* 2006;**30**:7–16.
- Barr RG. The normal crying curve: what do we really know? *Dev Med Child Neurol* 1990;**32**:356–62.
- Barr RG. Excessive crying. In: Sameroff AJ, Lewis M, Miller SM, eds. *Handbook of Developmental Psychopathology*. 2nd edn. New York: NY Kluwer Academic/Plenum Press, 2000:327–50.
- Barr RG. Crying behavior and its importance for psychosocial development in children. In: Tremblay RE, Barr RG, Peters RD, eds. *Encyclopedia on Early Childhood Development*. Montreal, QC: Centre of Excellence for Early Childhood Development, 2006:1–10.
- Lee C, Barr RG, Catherine N, et al. Age-related incidence of publicly reported shaken baby syndrome cases: is crying a trigger for shaking? *J Dev Behav Pediatr* 2007;**28**:288–93.
- Graupman P, Winston KR. Nonaccidental head trauma as a cause of childhood death. *J Neurosurg* 2006;**104**(4 Suppl):245–50.
- Keenan HT. Practical aspects of conducting a prospective statewide incidence study: the incidence of serious inflicted traumatic brain injury in North Carolina. *Am J Prev Med* 2008;**34**(4 Suppl):S120–5.
- Thomas NJ, Shaffer ML, Rzcuidlo S, et al. Temporal factors and the incidence of physical abuse in young children: decreased nonaccidental trauma during Child Abuse Prevention Month. *J Pediatr Surg* 2007;**42**:1735–9.
- Crume TL, DiGuseppi C, Byers T, et al. Underascertainment of child maltreatment fatalities by death certificates, 1990–1998. *Pediatrics* 2002;**110**:e18.
- Herman-Giddens ME, Brown G, Verbiest S, et al. Underascertainment of child abuse mortality in the United States. *JAMA* 1999;**282**:463–7.
- Schnitzer PG, Covington TM, Wirtz SJ, et al. Public health surveillance of fatal child maltreatment: analysis of 3 state programs. *Am J Public Health* 2008;**98**:296–303.

40. **Covington T**, Foster V, Rich S, eds. *A Program Manual for Child Death Review*. Okemos, MI: The National Center for Child Death Review, 2005.
41. **National Center for Health Statistics**. *ICD-10 Mortality Coding Guidelines*. Hyattsville, MD: National Center for Health Statistics, US Health and Human Services, 2011:266–7. <http://www.cdc.gov/nchs/data/dvs/2b2011.pdf>.
42. **McKenzie K**, Fingerhut L. *Restructuring External Causes in ICD-11: Implications for Mortality Data*. <http://www.nchirt.qut.edu.au/consultancy/amdig/workshops/documents/27McKenzieICD-11.pdf>.
43. **Kraus JF**, Fife D, Cox P, et al. Incidence, severity, and external causes of pediatric brain injury. *Am J Dis Child* 1986;**140**:687–93.
44. **Barr RG**, Barr M, Fujiwara T, et al. Do educational materials change knowledge and behavior about crying and shaken baby syndrome? A randomized controlled trial. *CMAJ* 2009;**180**:727–33.
45. **Catherine N**, Ko JJ, Barr RG. Getting the word out: advice on crying and colic in popular parenting magazines. *J Dev Behav Pediatr* 2008;**29**:508–11.
46. **Klevens J**. Prevention of inflicted neurotrauma: what we know, what we don't know, and what we need to know. In: Reece RM, Nicholson CE, eds. *Inflicted Childhood Neurotrauma*. Elk Grove Village, IL: American Academy of Pediatrics, 2003:269–79.
47. **Committee on Child Abuse and Neglect of the American Academy of Pediatrics**. Shaken baby syndrome: rotational cranial injuries: technical report. *Pediatrics* 2001;**108**:206–10.
48. **Barr RG**, Rivara FP, Barr M, et al. Effectiveness of educational materials designed to change knowledge and behaviors regarding crying and shaken-baby syndrome in mothers of newborns: a randomized, controlled trial. *Pediatrics* 2009;**123**:972–80.
49. **Keenan HT**, Leventhal JM. A case-control study to evaluate Utah's shaken baby prevention program. *Acad Pediatr* 2010;**10**:389–94.
50. **National Center on Shaken Baby Syndrome**. *Map of PURPLE Implementation*. <http://www.dontshake.org/index.php> (accessed 26 Apr 2011).
51. **Centers for Disease Control and Prevention**. *Preventing Shaken Baby Syndrome: A Guide for Health Departments and Community-based Organizations*. http://www.cdc.gov/Concussion/pdf/Preventing_SBS_508-a.pdf (accessed 26 Apr 2011).

Bus companies in Jakarta require safety audit

To reduce deaths from road crashes in Jakarta, the Transportation Ministry is planning to audit bus service companies. The audit is to be prioritised in provinces such as East Java that have many crashes. According to the National Police, in January to mid-February more than 35 people died every day in traffic accidents throughout the country. The types of vehicles mostly involved were motorcycles (9555), passenger cars (1357) and buses (207). <http://www.thejakartaglobe.com/news/transportation-ministry-to-audit-bus-companies-for-safety/499463>

Toilets cause thousands of deaths on Indian railways

A surprising cause of death on Indian railways is human excrement. It has corroded much of the 70 000 miles of tracks. Toilets discharge waste directly onto tracks, which causes corrosion and instability and a significant proportion of deaths. A related problem is that maintenance workers often refuse to service the undercarriage of the trains because of the discharge from toilets. <http://www.tntmagazine.com/travel/news/toilets-cause-thousands-of-deaths-on-indian-railways-every-year>

A bizarre, possibly unpreventable event

A surgeon in Montreal was killed in a bizarre traffic accident while driving home in a snowstorm at around 23:00. A snowplough ahead of him hit a light pole in the median. The sectioned pole then toppled over against a large overhead road sign, which in turn fell on a transport truck, causing it to strike the median. According to police, the victim's sport utility vehicle was struck by debris from that collision, killing him instantly.



Characteristics of fatal abusive head trauma among children in the USA: 2003 –2007: an application of the CDC operational case definition to national vital statistics data

Sharyn E Parks, Scott R Kegler, Joseph L Annest, et al.

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