

## Fatal Abusive Head Trauma Among Children Aged <5 Years — United States, 1999–2014

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In the United States, abusive head trauma (AHT) is one of the leading causes of maltreatment fatalities among infants and children, accounting for approximately one third of these deaths (1). Monitoring trends in AHT and evaluating prevention strategies have historically been difficult because of differences in AHT definitions used in research and surveillance. CDC's case definition for AHT and data from the National Vital Statistics System were used to examine the trends in fatal AHT during 1999–2014 using Joinpoint trend analysis software. During this period, AHT resulted in nearly 2,250 deaths among U.S. resident children aged <5 years. Whereas rates were relatively stable during 1999–2009, there was a statistically significant average annual decline of 13.0% in fatal AHT rates during 2009–2014. The fatal AHT rates in 2013 and 2014 (0.41 and 0.43 per 100,000 children aged <5 years, respectively) were the lowest in the 16-year study period. Although this decline in AHT deaths is encouraging, more can be done to prevent AHT, including family-based interventions and policies that create safe, stable, nurturing relationships and environments for children.

Comprehensive mortality data from the National Vital Statistics System (2) were used to identify fatal AHT\* using the CDC case definition (3), and more broadly, to identify fatal assault-related traumatic brain injury (TBI)<sup>†</sup> among U.S. resident children aged <5 years during 1999–2014.

\* Fatal abusive head trauma is defined as a death caused by an injury to the skull or intracranial contents of an infant or child aged <5 years attributable to inflicted blunt impact and/or violent shaking, and excludes deaths from injuries resulting from neglectful supervision and deaths from gunshot or stab wounds and penetrating trauma. Definite/presumptive fatal AHT cases have an external cause of injury code indicating assault or maltreatment. Probable fatal AHT cases have an undetermined external cause of injury code.

<sup>†</sup> Fatal traumatic brain injury is defined as a death caused by a bump, blow or jolt to the head, or by a penetrating injury, that disrupts normal brain function, and includes intentional gunshot wounds and stab wounds. These deaths can be classified as assault-related or nonassault-related.

Cases were identified based on the *International Classification of Diseases, 10th revision* (ICD-10) external cause/intent and nature-of-injury (body region and type of injury) codes, in accordance with established case definitions for AHT and TBI (3,4) (Figure). Only TBI (4) cases with an underlying cause consistent with assault (i.e., death record indicates assault as the intent of injury) were included in this analysis (Figure). Fatal assault-related TBI cases were then further classified by injury codes. Injury codes indicating blunt impact or violent shaking were classified as AHT, while injury codes indicating neglectful supervision, gunshot or stab wounds, and penetrating trauma were classified as assault-related TBI without AHT. Fatal AHT cases were further classified as definite or presumptive if the external cause of injury codes indicated assault or

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maltreatment, or probable if the external cause of injury codes were listed as undetermined. These assault-related TBI cases were further classified according to whether or not AHT was simultaneously indicated, to examine whether the reported decline in AHT deaths was offset by an increase in deaths identified as assault-related TBI exclusive of AHT, which might suggest that the decline in AHT deaths could have resulted from a change in coding of cases from AHT to assault-related TBI exclusive of AHT.

Both definite or presumptive and probable fatal AHT cases were included in the trend analysis. To examine whether or not cases that would have been coded as AHT were later being coded as assault-related TBI exclusive of AHT, death records that included an underlying cause code indicating assault and any nature-of-injury code indicating TBI were classified as assault-related TBI. Death records that did not list an underlying cause that broadly indicated injury were excluded from the analysis.

Yearly incidence rates were calculated using annual case counts and U.S. Census Bureau population estimates for children aged <5 years. To evaluate an apparent downward trend in annual rates of fatal AHT during the latter part of the analysis period (2009–2014), a negative binomial rate regression model allowing for an arbitrary shift in trend was fit to the data. The modeling process followed the general framework to test for significant changes in trend employed in the National Cancer Institute Joinpoint Regression Program (5), extended to compensate for potential overdispersion in the annual case

counts. The method allows for the description of changing trends over successive segments of time, and the increase or decrease within each time segment.

During 1999–2014, a total of 2,018 (90%) of 2,247 AHT deaths were classified as definite or presumptive, ranging from a high of 97% in 2001 to 81% in 2013. Nearly all definite or presumptive AHT deaths were simultaneously identified as assault-related TBI deaths (four deaths involving maltreatment, one each in 2003, 2004, 2005, and 2010, were not classified as assault-related). No probable AHT deaths were identified as assault-related TBI deaths (because the “probable” component of the AHT case definition excludes assault). During 1999–2009, annual rates of fatal AHT ranged from 0.68 per 100,000 children aged <5 years in 2001 to 0.88 per 100,000 in 2000 and 2009 (Table), with a modeled trend indicating a nonsignificant average annual increase of 0.04% ( $p = 0.96$ ). During 2009–2014, annual rates of fatal AHT declined, with a modeled trend indicating a statistically significant average annual decrease of 13.0% ( $p < 0.01$ ). Notably, the decline in deaths identified as AHT during this later period was not offset by an increase in deaths identified as assault-related TBI exclusive of AHT (Table), suggesting a real decline in AHT. During 2008–2014, the annual rate of fatal assault-related TBI (total) declined 28% from 2.25 to 1.62 per 100,000 children aged <5 years; from 2009 to 2014, this decline was almost entirely because of the decline in fatal AHT, as the rate of fatal assault-related TBI without AHT remained relatively stable during this period.

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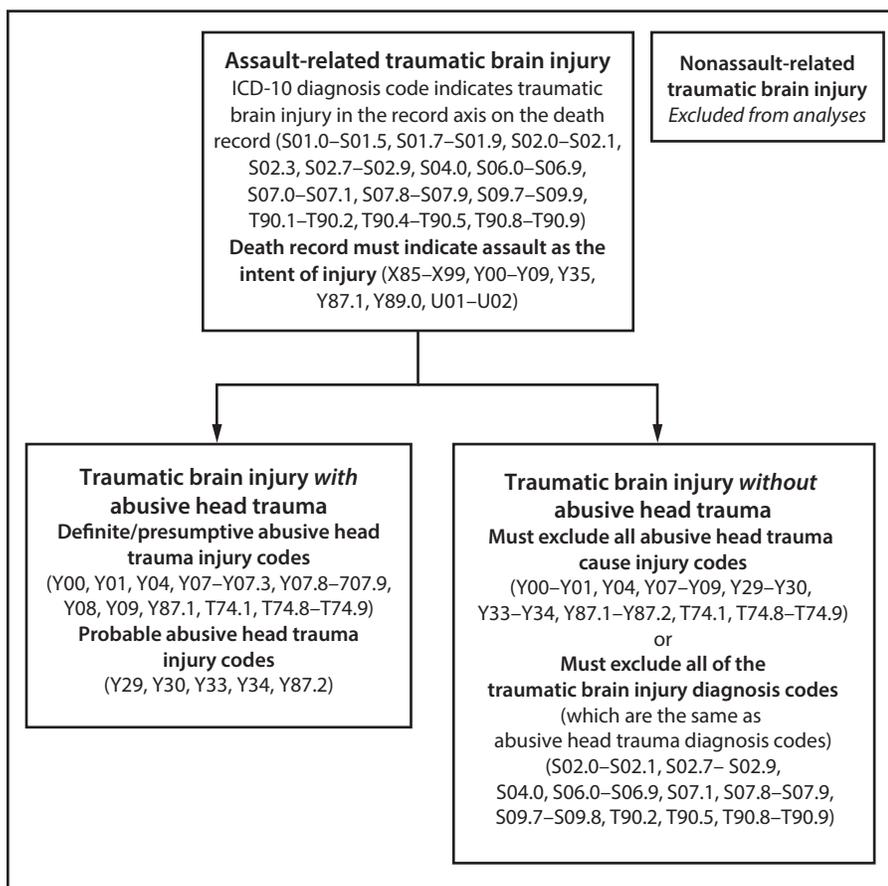
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**FIGURE. Classification of fatal assault-related traumatic brain injury\* with and without abusive head trauma† among children aged <5 years — United States, 1999–2014**

**Abbreviation:** ICD = *International Classification of Diseases*.

\* Fatal traumatic brain injury is defined as a death caused by a bump, blow, or jolt to the head, or by a penetrating injury that disrupts normal brain function, and includes intentional gunshot wounds and stab wounds. These deaths can be classified as assault-related or nonassault-related.

† Fatal abusive head trauma is defined as a death caused by an injury to the skull or intracranial contents of an infant or child aged <5 years attributable to inflicted blunt impact and/or violent shaking, and excludes deaths from injuries resulting from neglectful supervision and deaths from gunshot or stab wounds and penetrating trauma.

## Discussion

Based on CDC's recommended definition for AHT for public health surveillance (3), the rates of fatal AHT remained relatively stable during 1999–2009, followed by a significant decline during 2009–2014. The fatal AHT rates in 2013 and 2014 (0.41 and 0.43 per 100,000 children aged <5 years, respectively) were the lowest rates reported during the 16-year study period. This is the first documentation of a decline in AHT rates after 2009. These encouraging results are consistent with downward trends in other indices of child maltreatment and data systems, such as the recent analysis by the Children's Bureau of the National Data Archive on Child Abuse and Neglect, which found that the number of children experiencing maltreatment decreased 3.8 percent during 2009–2013 (6).

Examining both definite or presumptive and probable fatal AHT cases illustrates that although definite or presumptive cases declined, probable cases did not increase, suggesting that the observed decline in definite or presumptive cases does not represent a change in case classification. In addition, data on fatal assault-related TBI (with and exclusive of AHT) similarly illustrate that classification of cases did not change over time from AHT to assault-related TBI exclusive of AHT. Sensitivity of clinical ascertainment of signs and symptoms associated with AHT might have systematically decreased or the coding of death data might have systematically changed over time. However, the nearly consistent annual number of injury-related death records listing an AHT-related cause code and constant annual rates of assault-related TBI exclusive of AHT during 2009–2014 suggest that such systematic changes are unlikely.

The findings in this report are subject to at least two limitations. First, the mortality data are based on coding of death certificates, which could result in undercounting AHT cases. However, any recent potential undercounting might be offset by enactment of the Child and Family Services Improvement and Innovation Act in 2011, which requires states to describe the data sources used to compile information on deaths attributable to child abuse or neglect. Because of this law, many states reported increased counts of child fatalities caused by abuse or neglect, and implemented child death reviews or expanded their scope. By 2012, all 50 states, the District of Columbia, and Guam had implemented child death reviews. Child death reviews have been identified as a key source of information for case identification and embody a process in which teams representing multiple disciplines, including medical examiners and juvenile justice experts, meet to share and discuss case information on child deaths to understand how and why they occur and how they might be prevented.<sup>§</sup> Second, this analysis cannot definitively determine the reasons for the decline in fatal AHT.

<sup>§</sup> <https://www.childdeathreview.org>.

TABLE. Annual rates of fatal AHT and fatal assault-related TBI per 100,000 children aged &lt;5 years — United States, 1999–2014

Year	Fatal AHT rates (No. deaths)			Fatal assault-related TBI rates (No. deaths)		
	Definite or presumptive*	Probable†	Total	TBI and AHT	TBI without AHT	Total
1999	0.75 (143)	§ (11)	<b>0.80 (154)</b>	0.75 (143)	0.84 (161)	<b>1.59 (304)</b>
2000	0.83 (159)	§ (9)	<b>0.88 (168)</b>	0.83 (159)	1.09 (209)	<b>1.92 (368)</b>
2001	0.66 (128)	§ (4)	<b>0.68 (132)</b>	0.66 (128)	1.28 (247)	<b>1.94 (375)</b>
2002	0.77 (149)	§ (7)	<b>0.80 (156)</b>	0.77 (149)	1.14 (221)	<b>1.90 (370)</b>
2003	0.79 (154)	§ (10)	<b>0.84 (164)</b>	0.78 (153)	1.24 (242)	<b>2.02 (395)</b>
2004	0.62 (122)	§ (16)	<b>0.70 (138)</b>	0.61 (121)	1.21 (239)	<b>1.82 (360)</b>
2005	0.67 (134)	0.11 (22)	<b>0.78 (156)</b>	0.67 (133)	1.07 (213)	<b>1.74 (346)</b>
2006	0.70 (140)	§ (14)	<b>0.77 (154)</b>	0.70 (140)	1.33 (265)	<b>2.03 (405)</b>
2007	0.74 (149)	§ (19)	<b>0.83 (168)</b>	0.74 (149)	1.26 (253)	<b>2.00 (402)</b>
2008	0.65 (132)	0.12 (25)	<b>0.77 (157)</b>	0.65 (132)	1.60 (325)	<b>2.25 (457)</b>
2009	0.77 (155)	0.12 (24)	<b>0.88 (179)</b>	0.77 (155)	1.32 (267)	<b>2.08 (422)</b>
2010	0.52 (106)	§ (13)	<b>0.59 (119)</b>	0.52 (105)	1.25 (252)	<b>1.77 (357)</b>
2011	0.59 (119)	§ (11)	<b>0.65 (130)</b>	0.59 (119)	1.28 (258)	<b>1.87 (377)</b>
2012	0.44 (87)	§ (18)	<b>0.53 (105)</b>	0.44 (87)	1.27 (254)	<b>1.71 (341)</b>
2013	0.33 (66)	§ (15)	<b>0.41 (81)</b>	0.33 (66)	1.30 (258)	<b>1.63 (324)</b>
2014	0.38 (75)	§ (11)	<b>0.43 (86)</b>	0.38 (75)	1.24 (247)	<b>1.62 (322)</b>

**Abbreviations:** AHT = abusive head trauma; TBI = traumatic brain injury.

\* Definite or presumptive fatal AHT cases are classified as death caused by an injury to the skull of an infant or child aged <5 years attributable to inflicted blunt impact and/or violent shaking, with an external cause of injury code indicating assault or maltreatment.

† Probable fatal AHT cases are classified as death caused by an injury to the skull of an infant or child aged <5 years attributable to inflicted blunt impact and/or violent shaking with an undetermined external cause of injury code.

§ Incidence rates based on counts <20 are not considered statistically stable and are not presented.

Fatal abusive head trauma, like all forms of child maltreatment, is preventable. An important step in the prevention of AHT and child maltreatment is the ongoing, systematic collection of data that help guide and monitor prevention approaches. Using CDC's uniform definitions of AHT and child maltreatment are important steps in strengthening surveillance. Data collected from surveillance systems, in combination with information on the implementation and results of interventions and policies, can help shape continuing public health efforts to prevent AHT.

Although the decrease in fatal AHT during 2009–2014 is encouraging, additional efforts are needed to prevent AHT. Prevention of child maltreatment requires understanding and addressing behavioral and environmental characteristics that increase and reduce the risk for child maltreatment. There is growing evidence that child maltreatment prevention strategies, such as those that change interactions, including those between parents and children, parents and other caregivers, and parents and health care providers are effective interventions (7). CDC's *Essentials for Parenting Toddlers and Preschoolers* (<http://www.cdc.gov/parents/essentials/index.html>) is an evidence-informed online resource based on decades of research about effectively promoting positive parenting and preventing child maltreatment, using various approaches, including videos and interactive practice exercises, to help caregivers build healthy relationships with their children aged >3 years. Community-level strategies offer additional critical components of preventing child maltreatment by modifying social and economic factors that put infants and young children at

risk for violence. Promising community-level strategies include strengthening economic supports for families and improving family-friendly work policies, such as the availability of paid parental leave (8). Societal level strategies aim to shift cultural norms surrounding parenting through public engagement and education campaigns to reframe thinking about child abuse. Communities can use CDC's *Preventing Child Abuse and Neglect: A Technical Package for Policy, Norm, and Programmatic Activities* (<http://www.cdc.gov/violenceprevention/pdf/can-prevention-technical-package.pdf>) and CDC's *Essentials for Childhood Framework: Steps to Create Safe, Stable, Nurturing Relationships and Environments for All Children* (<http://www.cdc.gov/violenceprevention/childmaltreatment/essentials.html>) to promote safe, stable, nurturing relationships and environments to prevent child maltreatment and assure that all children reach their full potential. This framework encourages communities to consider building and coordinating relationships between traditional and nontraditional partners (e.g., public health and business), collaboratively identify and implement child maltreatment prevention strategies, and monitor impact on morbidity and mortality.

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## References

## Summary

## What is already known about this topic?

In the United States, abusive head trauma (AHT) is one of the leading causes of child maltreatment fatalities, accounting for approximately one third of these deaths. CDC developed a formal case definition for fatal AHT to facilitate consistent tracking over time and evaluation of interventions focused on prevention.

## What is added by this report?

During 1999–2014, AHT resulted in nearly 2,250 deaths among U.S. resident children aged <5 years. During 2009–2014, annual rates of fatal AHT declined significantly, with an average annual decrease of 13.0%, and there was no evidence that cases were simply being classified differently during this time. This is the first report of a decline in AHT rates after 2009. The fatal AHT rates in 2013 and 2014 were 0.41 per 100,000 children aged <5 years and 0.43 per 100,000, respectively, the lowest rates in the 16-year study period.

## What are the implications for public health practice?

Communities can use evidence-based approaches, such as family-based interventions, and CDC's *Essentials for Childhood Framework: Steps to Create Safe, Stable, Nurturing Relationships and Environments for All Children and Preventing Child Abuse and Neglect: A Technical Package for Policy, Norm and Programmatic Activities* to promote safe, stable, nurturing relationships and environments for children. Ongoing surveillance for AHT, in combination with information on the implementation and results of interventions and policies, can help shape prevention.

1. Palusci VJ, Covington TM. Child maltreatment deaths in the US national child death review case reporting system. *Child Abuse Negl* 2014;38:25–36. <http://dx.doi.org/10.1016/j.chiabu.2013.08.014>
2. Murphy SL, Xu J, Kochanek KD. Deaths: final data for 2010. *Natl Vital Stat Rep* 2013;61:1–117. [http://www.cdc.gov/nchs/data/nvsr/nvsr61/nvsr61\\_04.pdf](http://www.cdc.gov/nchs/data/nvsr/nvsr61/nvsr61_04.pdf)
3. Parks SE, Annest JL, Hill HA, Karch DL. Pediatric abusive head trauma: recommended definitions for public health surveillance and research. Atlanta GA: US Department of Health and Human Services, CDC; 2012. <http://www.cdc.gov/ViolencePrevention/pdf/PedHeadTrauma-a.pdf>
4. Coronado VG, Xu L, Basavaraju SV, et al. Surveillance for traumatic brain injury-related deaths—United States, 1997–2007. *MMWR Surveill Summ* 2011;60:1–32.
5. National Cancer Institute. Joinpoint regression program. Version 4.1.1.–August 2014. Bethesda, MD: US Department of Health and Human Services, National Cancer Institute, Statistical Methodology and Applications Branch; 2014. <http://surveillance.cancer.gov/joinpoint/>
6. US Department of Health and Human Services; Administration for Children and Families; Administration on Children, Youth and Families, Children's Bureau. *Child maltreatment 2013*. Washington, DC: Administration for Children and Families, US Department of Health and Human Services; 2013. <http://www.acf.hhs.gov/sites/default/files/cb/cm2013.pdf>
7. Macmillan HL, Wathen CN, Barlow J, Fergusson DM, Leventhal JM, Taussig HN. Interventions to prevent child maltreatment and associated impairment. *Lancet* 2009;373:250–66. [http://dx.doi.org/10.1016/S0140-6736\(08\)61708-0](http://dx.doi.org/10.1016/S0140-6736(08)61708-0)
8. Klevens J, Luo F, Xu L, Peterson C, Lutzman NE. Paid family leave's effect on hospital admissions for pediatric abusive head trauma. *Inj Prev* 2016. Epub February 11, 2016.