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A Population-Based Study of Inflicted Traumatic Brain Injury in Young Children

Heather T. Keenan, MDCM, MPH
Desmond K. Runyan, MD, DrPH
Stephen W. Marshall, PhD
Mary Alice Nocera, RN, MSN
David F. Merten, MD
Sara H. Sinal, MD

Context Physical abuse is a leading cause of serious head injury and death in children aged 2 years or younger. The incidence of inflicted traumatic brain injury (TBI) in US children is unknown.

Objective To determine the incidence of serious or fatal inflicted TBI in a defined US population of approximately 230000 children aged 2 years or younger.

Design, Setting, and Subjects All North Carolina children aged 2 years or younger who were admitted to a pediatric intensive care unit or who died with a TBI in 2000 and 2001 were identified prospectively. Injuries were considered inflicted if accompanied by a confession or a medical and social service agency determination of abuse.

Main Outcome Measure Incidence of inflicted TBI. Multivariate logistic regression models were used to compare children with inflicted injuries with those with noninflicted injuries and with the general state population aged 2 years or younger.

Results A total of 152 cases of serious or fatal TBI were identified, with 80 (53%) incurring inflicted TBI. The incidence of inflicted traumatic brain injury in the first 2 years of life was 17.0 (95% confidence interval [CI], 13.3-20.7) per 100000 person-years. Infants had a higher incidence than children in the second year of life (29.7 [95% CI, 22.9-36.7] vs 3.8 [95% CI, 1.3-6.4] per 100000 person-years). Boys had a higher incidence than girls (21.0 [95% CI, 15.1-26.6] vs 13.0 [95% CI, 8.4-17.7] per 100000 person-years). Relative to the general population, children who incurred an increased risk of inflicted injury were born to young mothers (≤21 years), non–European American, or products of multiple births.

Conclusions In this population of North Carolina children, the incidence of inflicted TBI varied by characteristics of the injured children and their mothers. These data may be helpful for informing preventive interventions.

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CHILD MALTREATMENT INVOLVING physical abuse is the leading cause of infant death from injury[1] and serious head injury in children.[2] Most inflicted traumatic brain injury (TBI) occurs in children younger than 2 years. Bruce and Zimmerman[3] found in a clinical series that 80% of deaths from head trauma in infants and children younger than 2 years were from inflicted injuries. Developmental outcomes of children who survive inflicted TBI may be worse than those of children with noninflicted TBI.[4] Mortality rate estimates for inflicted TBI range from 15%[5] to 38%,[6] and neurologic morbidity for surviving children can be severe.[7,8]

One prospective, population-based study of inflicted TBI has been reported in the literature.[9] The study identified 19 cases in Scotland during an 18-month period and calculated the incidence of inflicted TBI to be 24.6 per 100000 infants.

The current study reports the first population-based estimates and demographics of serious inflicted TBI in children aged 2 years or younger in the United States. In a statewide population, we compared cases of inflicted TBI with noninflicted TBI to assess the differences in risk factors between these 2 groups; we also compared prenatal risk factors for inflicted TBI with population aggregates from the North Carolina vital statistics registry.

See also Patient Page.

METHODS

Subject Ascertainment

Hospitalization With TBI. We prospectively collected data from all 9 hospitals in North Carolina with a pediatric intensive care unit (PICU) or a monitored step-down unit. The study identified all North Carolina resident children aged 2 years or younger in whom a serious or fatal TBI occurred between January 1, 2000, and December 31, 2001. Subjects were identified prospectively by contacting each PICU's charge nurse 3 times weekly during the study period. Additionally, medical records at each center were searched every 6 months by *International Classification of Diseases, Ninth Revision, Clinical Modification*[10] code and

Author Affiliations: Departments of Social Medicine (Drs Keenan and Runyan), Pediatrics (Dr Runyan), Epidemiology (Dr Marshall), Orthopedics (Dr Marshall), and Radiology (Dr Merten), University of North Carolina at Chapel Hill, and University of North Carolina Injury Prevention Research Center (Drs Keenan, Runyan, and Marshall and Ms Nocera), Chapel Hill; Department of Pediatrics, Brenner Children's Hospital, Wake Forest University School of Medicine, Winston-Salem, NC (Dr Sinal).
Corresponding Author and Reprints: Heather T. Keenan, MDCM, MPH, Department of Social Medicine, Wing D, Medical School, CB7240, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7240 (e-mail: hkeenan@med.unc.edu).

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matched to PICU admission logbooks to ensure that no eligible child had been missed. Children were required to have been admitted to a PICU or monitored step-down unit and have evidence of a nonpenetrating TBI on computed tomography, magnetic resonance imaging, or pathologic findings. Most seriously injured children in North Carolina would likely be transported to a North Carolina PICU because of insurance or geography. However, to ensure complete case ascertainment, the 3 closest out-of-state hospitals with PICUs to which children might be transported (1 in Virginia and 2 in Georgia) were queried during the study period about PICU admissions of North Carolina residents who were injured in North Carolina with head trauma. This study was reviewed and approved by the institutional review boards of all participating hospitals.

Fatal TBIs. Children who died at a hospital without a PICU or prior to hospital admission were identified through the Office of the Chief Medical Examiner. North Carolina has a centralized medical examiner system that reviews all cases of unexpected or violent deaths. The North Carolina Office of the Chief Medical Examiner was queried to identify all deaths among children aged 2 years or younger. Charts were manually reviewed to identify children who died of head injuries. Data were abstracted, including pathologic evidence of brain injury and the results of the medical examiner's investigation of the cause of death. Autopsies are performed on all children who do not have a self-evident cause of death. Double counting of deaths was avoided by matching date of birth, date of death, race/ethnicity, sex, and place and manner of death to children who died in the hospital.

Definitions. The outcome definition of serious TBI included computed tomography, magnetic resonance imaging, or pathologic evidence of intracranial injury, including any type of intracranial hemorrhage, shear injury, lacerations, or contusions. Patients with skull fractures but no evidence of intracranial injury were excluded. The *International Classification of Diseases, Ninth Revision, Clinical Modification*[10] codes used to query medical records included the following: 800.1 to 801.49, 801.6 to 801.99, 803.1 to 803.49, 803.6 to 803.99, 804.1 to 804.99, 850.0 to 850.99, 851.0 to 851.99, 852.0 to 852.59, 853.0 to 853.19, 854.0 to 854.19, and brain injuries from 959.8 to 959.9.

Inflicted TBI required evidence of TBI as defined herein accompanied by a confession or a medical and child protective services determination that the injury was inflicted. The medical and social services evaluations were performed by the treating team at each hospital and reviewed by 2 of the authors (H.T.K., D.K.R.).

Children aged 12 months or younger were defined as infants. Other children were included up to and including their second birth date. Extended family living in the home was defined as adults related to the child who were not the child's parents, foster parents, or primary caretaker and spouse (if the child was in the legal custody of a family member other than the biological parents). Premature birth was defined as a birth occurring at 37 weeks or less of completed gestational age.

Procedures

Medical Record Abstraction and Data Collection. Two medical abstractors reviewed the complete medical chart or medical examiner record of each child. The patients' presentation, including details of the history as told by the parent or guardian, the physical examination, hospital course, and outcome, were abstracted. The results of all radiological, ophthalmologic, and electroencephalographic examinations were reviewed, as were all surgical procedures and discharge summaries. Involvement by the North Carolina Department of Social Services and the child's posthospitalization disposition were documented from the medical record. The Department of Social Services' involvement with a family is always documented in the medical record to ensure legal clarity. The initial head computed tomography and/or magnetic resonance imaging scan and subsequent radiological examination results of each patient were read by a single pediatric radiologist who was blinded to the mechanism of injury to ensure that each subject met uniform entrance criteria. Children born in North Carolina were matched to their birth records to ascertain data about mothers' prenatal care, age, number of prior births, and education.

Unknown Etiology Classification. For cases in which no social service or medical information was contained in the medical record about injury etiology, the project coordinator prepared an abstract of the case for review by 2 of the investigators (H.T.K., D.K.R.), adapting the methods of Stier et al.[11] Each abstract included a summary of each case, a description of the cause of injury as presented by the caretaker to the treating physicians, and a description of the injuries, including specific findings such as metaphyseal fractures, retinal hemorrhages, and old injuries found on long bone studies. Demographic information such as race/ethnicity, sex, referring hospital, and socioeconomic status was not included. Child age was included in the summary because the likelihood of certain reported events is developmentally linked. Each reviewer independently classified the case as inflicted or noninflicted TBI. If the 2 reviewers did not agree, an additional 3 reviewers, including pediatric intensivists and child abuse experts, were available to provide additional review and resolve disputes.

Statistical Analysis

Incidence in person-years was calculated for infants using the number of births in the state for each study year as the denominator. Incidence for children aged 12 months to 2 years was calculated using the number of live births minus the number of infant deaths for the preceding year as the denominator. These numbers were added to obtain the denominator for the entire study population. To assess a possible bias related to migration either in or out, population-

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based data were obtained for infants and 2-year-old children from the 2000 census and were found to be within 6% of the information from vital statistics records.[12] Information on the racial/ethnic makeup of the population was based on the North Carolina birth records for the comparable year.[12]

Three comparison groups were used for the analyses. The first comparison group was composed of the children in the prospectively collected TBI cohort who had noninflicted TBI. The second comparison group represented the population at risk and was composed of aggregate statistics for all North Carolina births in 2000. To perform multivariate logistic regression analyses of prenatal risk factors, a third comparison group of 300 births was randomly selected from the birth cohorts of 2000 and 2001 proportional to the number of injured children born in each year.

Simple frequencies and proportions were calculated to describe the demographics. *t* Tests were used to compare continuous variables. Odds ratios were calculated to compare children with inflicted injuries with children with noninflicted injuries and to compare children with inflicted TBI with the North Carolina aggregate data. Exact confidence intervals (CIs) were calculated for expected cell sizes of 5 or less.

Two multivariate logistic regression analyses were fit to the data. The first model estimated adjusted odds ratios comparing prenatal demographic features of children with inflicted TBI to the North Carolina birth certificate data. All variables available from both the vital statistics database and the inflicted injury group were entered into the model. Indicator variables were used to compare differences among racial/ethnic groups (European American, African American, and all other minorities) and 3 maternal age groups (≤21 years, 22-26 years, and >26 years). The second model was constructed using a forward model-building strategy. It compared demographic and family characteristics of children having an inflicted TBI with children having a noninflicted TBI. Analyses were computed with SAS software, version 8.2 (SAS Institute Inc, Cary, NC).

Table 1. Serious Traumatic Brain Injury in Children Aged 2 Years or Younger in North Carolina, January 2000–December 2001

	Inflicted Injuries		Noninflicted Injuries	
Characteristics	No.	Incidence Rate per 100 000 Person-Years (95% CI)	No.	Incidence Rate per 100 000 Person-Years (95% CI)
All children	80	17.0 (13.3-20.7)	72	15.3 (11.8-18.8)
Sex				
Male	50	21.0 (15.1-26.6)	37	15.4 (10.5-20.4)
Female	30	13.0 (8.4-17.7)	35	15.2 (10.2-20.2)
Race/ethnicity				
European American	32	9.5 (6.2-12.8)	39	11.5 (7.9-15.2)
African American	31	27.1 (17.5-36.6)	22	19.2 (11.2-27.2)
Other	17	95.7 (50.2-141.3)	11	62.0 (25.3-98.6)
Age, y				
≤1	71	29.7 (22.9-36.7)	48	20.1 (14.4-25.8)
>1	9	3.8 (1.3-6.4)	24	10.3 (6.2-14.5)

Abbreviation: CI, confidence interval.

RESULTS

A total of 152 cases of serious or fatal TBI were identified from a population of approximately 230 000, with 80 (53%) incurring inflicted TBI. There were 87 boys (57%) and 119 infants (78%). Twelve (7.9%) of the hospitalized children were identified retrospectively through chart review. Two cases had an undetermined etiology, both from the medical examiner's office, which were adjudicated by the primary investigators as 1 inflicted TBI and 1 noninflicted TBI. All other cases were either injuries witnessed by a disinterested person or had complete medical and social services evaluation. There were a total of 71 non-Hispanic European American children, 53 African American children, and 28 children from other minority groups. The "other" minority group comprised 18 children of Hispanic ethnicity, 6 multiracial children, 2 Asian children, 1 Native American child, and 1 Pacific Islander. One case of a North Carolina resident injured in North Carolina came from an out-of-state hospital. There were 40 TBI fatalities (26.3%).

Incidence

The incidence of inflicted TBI for all children aged 2 years or younger was 17.0 (95% CI, 13.3-20.7) per 100 000 person-years (TABLE 1). Rates were markedly higher in infants (29.7 [95% CI, 22.9-36.7] per 100 000 person-years) than children in the second 12 months of life (3.8 [95% CI, 1.3-6.4] per 100 000 person-years). Boys were more likely to incur inflicted injuries than girls, and non–European American children were more likely to incur inflicted injuries than European American children. There were 18 deaths from inflicted TBI (case-fatality rate, 22.5%).

The incidence of noninflicted TBI was 15.3 (95% CI, 11.8-18.8) per 100 000 person-years in the first 2 years of life. Unlike inflicted TBI, boys and girls with noninflicted TBI had similar rates of injury. However, like children with inflicted TBI, minority children had a higher incidence of noninflicted TBI than European American children. The incidence rates of both inflicted and noninflicted TBI decreased from the first to the second year of life; however, the decrease was much more pronounced in the inflicted TBI group. There were 22 noninflicted TBI deaths (case-fatality rate, 30.5%).

Child Demographics

Demographic characteristics of the children are shown in TABLE 2. A younger median age at injury was observed in the group with inflicted compared with noninflicted injuries (4.0 months vs 7.5 months; $P<.001$ by *t* test). Mean ages at injury were 5.9 (95% CI, 4.7-7.1) months and 7.6 (95% CI, 7.8-11.5) months in the inflicted and noninflicted TBI groups, respectively. Unadjusted odds ratios indi-

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cated that risk factors for inflicted TBI compared with North Carolina aggregate statistics included male sex, minority status, and multiple birth. These risk factors were also present in the comparison of children with inflicted vs noninflicted TBI; however, these estimates were less precise.

Maternal and Family Demographics

Maternal characteristics associated with increased risk of inflicted TBI compared with North Carolina aggregate data were young maternal age ($P<.001$ by t test), unmarried status at birth of child, prenatal care initiated after the first trimester, and the index child being the first child (Table 2). Maternal education level higher than high school appeared to be protective. The pattern was similar when comparing maternal characteristics of children with inflicted TBI vs those with noninflicted TBI; however, again, estimates were less precise.

Family and community characteristics (TABLE 3) associated with an increased risk of inflicted compared with noninflicted injuries included presence of extended family in the home and having a parent in the military.

Multivariate Analysis

Inflicted vs Noninflicted TBI. The adjusted estimates largely confirmed the findings of the bivariate analysis. When comparing inflicted with noninflicted TBI, younger maternal age, younger child age, and having a parent in the

Table 2. Child and Maternal Characteristics of Children Aged 2 Years or Younger With Inflicted Traumatic Brain Injury (N = 80) Compared With Noninflicted Traumatic Brain Injury (n = 72) and NC Aggregate Data*

Characteristics	Inflicted Injuries†	Noninflicted Injuries†	General Population at Risk (NC Aggregate)†	Odds Ratio (95% CI): For Inflicted vs Noninflicted Injuries	Odds Ratio (95% CI): For Inflicted Injuries vs NC Aggregate
Child Characteristics					
Age at injury, median (IQR), mo	4.0 (2.5-8.0)	7.5 (2.0-16.0)	NA		
Sex					
Female	30 (37.5)	35 (48.6)	58 964 (49.0)	1.0	1.0
Male	50 (62.5)	37 (51.4)	61 282 (51.0)	1.6 (0.9-3.2)	1.6 (1.0-2.6)
Race/ethnicity					
European American	32 (40.0)	39 (54.2)	86 341 (71.2)	1.0	1.0
African American	31 (38.8)	22 (30.6)	29 336 (24.4)	1.7 (0.8-3.8)	2.9 (1.7-4.8)
Other	17 (21.3)	11 (15.3)	4570 (3.8)	1.9 (0.7-5.1)	10.0 (5.3-18.7)
Premature birth	12 (15.6)	4 (6.2)	16 013 (13.1)	2.8 (0.8-12.5)	1.2 (0.6-2.2)
Multiple birth	4 (5.3)	1 (1.5)	1829 (1.5)	3.7 (0.4-186.0)	3.4 (1.1-9.7)
Developmental/physical delay	6 (8.7)	5 (8.9)	‡	1.1 (0.3-5.7)	NA
Maternal Characteristics at Birth of Child					
Age, median (IQR), y	22 (19-25)	26 (23-30)	26 (22-31)		
>26	15 (18.7)	27 (37.5)	150 (50.0)	1.0	1.0
22-26	21 (26.3)	22 (30.6)	84 (28.0)	1.7 (0.7-4.5)	2.5 (1.2-5.4)
≤21	35 (43.8)	12 (16.7)	66 (22.0)	5.3 (1.9-14.6)	5.3 (2.6-11.0)
Missing data	9 (11.3)	11 (15.3)	0	NA	NA
Education level					
High school	28 (35.0)	21 (29.2)	37 689 (31.3)	1.0	1.0
Higher than high school	22 (27.5)	23 (31.9)	55 484 (46.1)	0.7 (0.3-1.8)	0.5 (0.3-1.0)
Lower than high school	20 (25.0)	15 (20.8)	26 720 (22.2)	0.9 (0.4-2.6)	1.0 (0.6-1.9)
Missing data	10 (12.5)	13 (18.1)	354 (0.3)	NA	NA
Marital status					
Married	34 (42.5)	37 (51.4)	80 150 (66.6)	1.0	1.0
Not married	38 (47.5)	26 (36.1)	40 090 (33.4)	1.6 (0.8-3.3)	2.2 (1.4-3.6)
Missing data	8 (10.0)	9 (11.4)	22 (0.0)	NA	NA
Trimester in which prenatal care began					
First	45 (56.3)	40 (55.5)	100 988 (84.0)	1.0	1.0
After first	22 (27.5)	21 (29.2)	18 428 (15.3)	1.1 (0.5-2.4)	2.7 (1.6-4.6)
Missing data	13 (16.3)	11 (15.3)	830 (0.7)	NA	NA
First child in family					
No	34 (42.5)	43 (59.7)	79 042 (65.7)	1.0	1.0
Yes	46 (57.5)	27 (37.5)	40 982 (34.1)	2.2 (1.1-4.4)	2.6 (1.6-4.2)
Missing data	0	2 (2.8)	223 (0.2)	NA	NA

Abbreviations: CI, confidence interval; IQR, interquartile range; NA, not applicable; NC, North Carolina.
*Aggregate state data are based on percentage of NC live births (N = 120 247) in 2000.
†Data are expressed as No. (%) unless otherwise noted.
‡Data not available.

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military remained important risk factors, although the estimates were imprecise (TABLE 4). The presence of a father in the home and maternal education level higher than high school appeared to be protective. Race/ethnicity was not associated with the odds of an inflicted TBI vs a noninflicted TBI given that the child had incurred a TBI.

Inflicted TBI vs Birth Certificate Comparison Group. Adjusted estimates comparing the odds of incurring an inflicted TBI with the North Carolina birth certificate comparison group showed an increased risk associated with minority children, younger maternal age, male children, and multiple birth, adjusted for all covariates in the model (Table 4). The odds of incurring an inflicted TBI increased with decreasing maternal age in all racial/ethnic groups. Among European American children, the adjusted odds of inflicted injury increased to 2.7 (95% CI, 1.2-6.0) for children born to mothers aged 22 to 26 years and increased further to 4.6 (95% CI, 1.9-11.4) for children born to mothers aged 21 years or younger compared with children born to the oldest maternal age group (>26 years). Similarly, the odds of inflicted TBI for African American children increased from 5.6 (95% CI, 1.9-16.2) to 9.8 (95% CI, 3.2-29.8) and for other minorities from 16.0 (95% CI, 4.1-62.9) to 28.0 (95% CI, 6.5-120.2) with each decrease in maternal age group compared with children of mothers older than 26 years.

COMMENT

This study is the first to report prospective, population-based estimates of the incidence of serious inflicted TBI in young children in the United States. It shows that inflicted TBI is a serious public health problem, with approximately 30 per 100 000 infants experiencing a severe or fatal brain injury.

Our estimate for the incidence of inflicted TBI in the first year of life is within the confidence limits of the study by Barlow and Minns (24.6 [95% CI, 14.9-38.5] per 100 000 person-years).[9] However, our estimates have greater precision, possibly because we were able to calculate incidence rates for a larger base population. The study by Barlow and Minns differed from ours because they did not restrict their population to children admitted to a monitored setting. It is unclear why they found no children

Table 3. Family and Community Characteristics of Children Aged 2 Years or Younger With Inflicted Traumatic Brain Injury (N = 80) Compared With Noninflicted Traumatic Brain Injury (N = 79)

Characteristics	Inflicted Injuries, No. (%)	Noninflicted Injuries, No. (%)	Odds Ratio (95% CI)
Extended family in home			
No	43 (53.8)	41 (56.9)	1.0
Yes	24 (30.0)	10 (13.9)	2.3 (1.0-5.4)
Missing data	13 (16.3)	21 (29.2)	NA
Father resident in home			
No	30 (37.5)	14 (19.4)	1.0
Yes	47 (58.8)	51 (70.8)	0.5 (0.2-0.9)
Missing data	3 (3.8)	7 (9.7)	NA
Parent in military			
No	62 (77.5)	56 (77.8)	1.0
Yes	12 (15.0)	3 (4.2)	3.6 (0.9-20.8)
Missing data	6 (7.5)	13 (18.0)	NA
Community			
Urban	31 (38.7)	29 (40.3)	1.0
Rural	49 (61.3)	43 (59.7)	1.1 (0.6-2.0)
Insurance type			
Private/military	22 (27.5)	16 (22.2)	1.0
None	11 (13.8)	7 (9.7)	1.1 (0.3-3.9)
Public	36 (45.0)	32 (44.4)	0.8 (0.4-1.9)
Missing data	11 (13.8)	17 (23.6)	NA

Abbreviations: CI, confidence interval; NA, not applicable.

Table 4. Multivariate Models of the Odds of Inflicted Injury Compared With NC Birth Certificate Data and With Noninflicted TBI*

Characteristics	Inflicted vs Noninflicted TBI	Inflicted TBI vs NC Birth Certificate Data
Maternal Characteristics		
Race/ethnicity		
European American	1.0	1.0
African American	1.3 (0.4-4.3)	2.1 (1.1-4.2)
Other	1.0 (0.2-4.6)	6.0 (2.2-16.8)
Age, y		
>26	1.0	1.0
22-26	3.0 (0.9-10.2)	2.7 (1.2-6.0)
≤21	4.1 (1.0-16.3)	4.7 (1.9-11.4)
Education level higher than high school vs other	0.4 (0.1-1.4)	0.9 (0.4-1.9)
Married vs not married at birth of child	0.9 (0.3-3.2)	1.0 (0.5-2.0)
Prenatal care started in first trimester vs later	0.6 (0.2-1.7)	0.8 (0.4-1.6)
First child in family vs not	1.9 (0.7-5.2)	1.6 (0.9-3.1)
Child Characteristics		
Age at injury ≤1 y vs >1-2 y	7.4 (1.9-28.4)	†
Male sex	1.4 (0.5-4.0)	2.0 (1.1-3.9)
Premature birth (<37 wk)	‡	1.3 (0.6-2.9)
Multiple vs singleton birth	‡	5.0 (1.2-21.5)
Family characteristics		
Father resident in home vs not	0.4 (0.1-1.5)	†
Parent in military vs not	4.7 (0.7-30.2)	†

Abbreviations: NC, North Carolina; TBI, traumatic brain injury.
*Data are expressed as odds ratios, adjusted for all other covariates in the model (95% confidence intervals).
†Data not available.
‡Premature birth and multiple birth were not included in the regression analysis because of sparse data.

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with inflicted TBI older than 12 months, but this may be related to the size of their base population.

Sixty-two percent of children with inflicted TBI were boys, which is consistent with other reports suggesting that male infants are at increased risk for inflicted TBI.[9,13,14] This study found the mean age of inflicted TBI (5.9 months) to be consistent with mean ages in previous studies (2.2-8.7 months).[9,13,14] The fact that our study restricted the age of children to 24 months or younger may have lowered the mean age compared with studies that included children as old as 3 years. Although previously not a predictor of inflicted TBI,[15] in this study, race/ethnicity was highly predictive of inflicted injury compared with the general North Carolina population. The "other minority" group appeared to be at especially high risk; however, this estimate was imprecise. Race/ethnicity was not a good predictor of inflicted TBI vs noninflicted TBI; rather, minority children were at increased risk of all types of TBI, suggesting that the role of race/ethnicity is a marker for other social factors that put children at risk for injury. An association between inflicted TBI and active military service has been previously described (odds ratio, 3.5; 95% CI, 1.4-8.3).[16] This estimate is very close to our adjusted estimate for military dependents (odds ratio, 4.7; 95% CI, 0.7-30.2); however, our estimate is imprecise because of small numbers.

Young maternal age, prematurity, and multiple birth have been previously reported as risk factors for child maltreatment.[11,17] Overpeck et al,[1] in a national study linking infant birth and death certificates, found that two thirds of infant homicide occurs by the sixth month of life. Identified risk factors for infanticide included maternal age younger than 19 years, less than 12 years of education, late or no prenatal care, and premature birth.[1] Our study found that inflicted TBI appears to have many of the same risk factors as those for child maltreatment and homicide. Because mothers are generally not the perpetrator in cases of inflicted TBI,[18] these risk factors may be related to a decreased choice of suitable caregivers.

It is possible that this study may have systematically underascertained cases of serious inflicted TBI. Clinicians vary in their practice of placing children in a PICU for observation following a head injury. However, because it is most common to watch infants in a closely monitored setting if they have a new intracranial injury, and because of the medicolegal aspects of inflicted TBI, this bias is not likely to be large. Ascertainment bias has been reported for children with fractures screened for physical abuse in the emergency department, with more minority children screened than nonminority children[19]; however, this is less likely with serious TBI because the children are hospitalized and a workup for inflicted TBI is pursued after the child has been stabilized.

We studied only children who had injuries that were serious enough to present to a PICU. However, many children may never present for medical care after the first episode of inflicted TBI, and of those who do present for medical care, many may be missed because of the nonspecificity of complaints in infants with head injuries.[20] It is known that some children are found later in life to have had inflicted TBI when they are evaluated with neuroimaging for other problems, such as developmental delay or increasing head circumference.[6] Thus, our estimate is a lower-bound estimate of the overall problem of inflicted TBI.

Author Contributions: *Study concept and design:* Keenan, Runyan, Sinal.
Acquisition of data: Keenan, Nocera, Sinal.
Analysis and interpretation of data: Keenan, Runyan, Marshall, Merten, Sinal.
Drafting of the manuscript: Keenan, Runyan.
Critical revision of the manuscript for important intellectual content: Marshall, Nocera, Merten, Sinal.
Statistical expertise: Keenan, Marshall.
Obtained funding: Keenan, Runyan.
Administrative, technical, or material support: Runyan, Nocera, Sinal.
Study supervision: Runyan, Sinal.

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