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ARTICLE

Incidence of Fractures Attributable to Abuse in Young Hospitalized Children: Results From Analysis of a United States Database

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What's Known on This Subject

Only 1 regional study has estimated the incidence of fractures attributable to abuse among young children. No national US data examining the incidence of this problem are available.

What This Study Adds

This is the first US study examining the incidence of fractures attributable to abuse among hospitalized young children. This study shows the strengths and limitations of using a national database to estimate the incidence of this problem.

ABSTRACT

OBJECTIVE. The goal was to assess the proportion of children with fractures attributable to abuse and the incidence of fractures caused by abuse among children <36 months of age who were hospitalized in the United States.

METHODS. We used the Kids' Inpatient Database, which has discharge data on 80% of acute pediatric hospitalizations in the United States, for 3 time periods (1997, 2000, and 2003). Fractures attributable to abuse in children <36 months of age were identified by both an International Classification of Diseases, Ninth Revision, Clinical Modification code for fracture and a diagnosis external-cause-of-injury code for abuse. Weighted estimates of the incidence were calculated.

RESULTS. Among children <36 months of age who were hospitalized with fractures, the proportions of cases attributable to abuse were 11.9% in 1997, 11.9% in 2000, and 12.1% in 2003. The proportions of cases attributable to abuse decreased with increasing age; for example, in 2003, the proportions attributable to abuse were 24.9% for children <12 months of age, 7.2% for children 12 to 23 months of age, and 2.9% for children 24 to 35 months of age. In 2003, the incidence of fractures caused by abuse was 15.3 cases per 100 000 children <36 months of age. The incidence was 36.1 cases per 100 000 among children <12 months of age; this decreased to 4.8 cases per 100 000 among 12- to 23-month-old children and 4.8 cases per 100 000 among 24- to 35-month-old children.

CONCLUSIONS. The Kids' Inpatient Database can be used to provide reasonable estimates of the incidence of hospitalization with fractures attributable to child abuse. For children <12 months of age, the incidence was 36.1 cases per 100 000, a rate similar to that of inflicted traumatic brain injury (25–32 cases per 100 000). *Pediatrics* 2008;122:599–604

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Key Words
fracture, incidence, abuse

Abbreviations
CI— confidence interval
TBI—traumatic brain injury
KID—Kids' Inpatient Database
E-code— external-cause-of-injury code
ICD-9-CM—International Classification of Diseases, Ninth Revision, Clinical Modification

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ONE MAJOR CHALLENGE in the field of child maltreatment is determining the frequency with which maltreatment of children occurs. Investigators have relied on 4 major sources of data: (1) reports to child protective service agencies, (2) specifically designed prospective or retrospective studies in which cases of child maltreatment are identified, (3) surveys of parents about how they treat their children, and (4) surveys of adults, adolescents, or older children about their experiences growing up. The first 2 types of studies can provide information about the incidence of the problem, whereas the latter 2 types usually provide information about the prevalence.

A few studies have focused on the incidence of specific types of abusive injuries. For example, regional studies have determined the incidence of inflicted traumatic brain injury (TBI)[1–4] or inflicted abdominal injury,[5] and hospital-based studies have examined the proportion of fractures attributable to abuse.[6,7] Several studies have examined the epidemiological features of femur fractures, including those attributable to abuse, in children.[8,9]

Only 1 population-based study, however, has examined the incidence of fractures attributable to abuse in young children, despite the fact that fractures represent one of the most common types of serious injuries in young children. That study, which was conducted in Wales from 1996 to 1998, reported information about the occurrences of all serious physical abuse in children <30 months of age.[2] Fractures were the most common injuries caused by abuse, with the following estimates of incidence per 100 000 children: for children <24 months of age, the incidence was

31.9 cases per 100 000 children; for children 0 to 11 months of age, the incidence was 48.3 cases per 100 000 children; for children 12 to 23 months of age, the incidence was 15.6 cases per 100 000 children. Although that study used case surveillance, the population studied was small.

The absence of data about the incidence of fractures caused by abuse in the United States has become especially striking now that child abuse prevention programs are becoming more widespread.[10] Without accurate data about the overall incidence of abuse in general or about specific types of abusive injuries, it is difficult to know whether prevention programs have had an impact on the rates of these problems.

In the United States, national databases that provide information on hospitalizations of children, with diagnosis codes and external-cause-of-injury codes (E-codes), have become available.[11] Although there has been concern that the use of E-codes might substantially underestimate the occurrence of abuse,[12] we recently used such national databases to estimate the incidence of inflicted TBI in hospitalized children <12 months of age and found that the incidence estimates based on those data were very similar to findings from smaller, regional, prospective studies.[13] In an effort to expand this work to other types of serious inflicted injuries and to fill the gap regarding the incidence of fractures attributable to abuse, we used the same national databases to examine fractures in children <36 months of age who were hospitalized. We focused on young children because almost all fractures attributable to abuse occur in this age range. The specific aims of the study, therefore, were (1) to estimate the incidence of abuse in children hospitalized with fractures, (2) to determine the location of fractures most frequently associated with abuse, (3) to describe the characteristics of children with fractures caused by abuse, and (4) to compare the incidence estimates with those from the only population-based study on fractures attributable to abuse.

METHODS

We used the Kids' Inpatient Database (KID),[11] developed by the Agency for Healthcare Research and Quality, for 1997, 2000, and 2003. The KID includes information about hospital discharges, including International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)[14] diagnosis codes and external-cause-of-injury codes (E-codes), for an 80% sample of all non–birth-related hospitalizations in the states included in the database.[11] The KID included 2521 hospitals from 22 participating states in 1997, 2784 hospitals in 27 states in 2000, and 3438 hospitals from 36 states in 2003. In 2003, those states represented >85% of the US population. Each database contains demographic, payment, and hospital information, including 15 fields for ICD-9-CM diagnosis codes or E-codes.

We defined fractures by using all ICD-9-CM codes for fractures (codes 800–829). Child abuse was identified by the presence of an E-code for assault (codes E960–E969) or the ICD-9-CM diagnosis code for child maltreatment syndrome (code 995.5). In addition, we used E-codes to categorize the cause of fractures, as follows: falls, motor vehicle accidents, other accidents (eg, colliding with a person or object), uncertain whether the injury was accidental or intentional, bone abnormalities, metabolic abnormalities, birth trauma, or no injury E-code.

We calculated the incidence of fractures attributable to abuse that resulted in hospitalization among children. To be included in the numerator, the child needed to have a diagnosis code for a fracture and ≥1 abuse or assault code in the diagnostic fields. The denominator was based on national census data for the specific age of interest for the specific year. Census data were obtained from the 2000 US Census and intercensual estimates for 1997 and 2003.[15]

We calculated the incidence for each year of the KID by dividing the number of children with fractures caused by abuse by the population of children in the specific age group. To correct the numerator on the basis of the sampling methods of the KID, the number of children with fractures attributable to abuse was weighted according to the weights provided in the documentation for the KID.[11] Confidence intervals (CIs) were calculated by using the Taylor Series in SAS 9.1.13 (SAS Institute, Cary, NC).

We also compared the incidence estimates from the KID with the only population-based study on abuse that provided estimates of the numbers of young children with fractures attributable to abuse.[2] In that study, the authors included all children with fractures caused by abuse, as opposed to the data from the KID, which included only hospitalized children. This study was considered exempt from review by the Yale University School of Medicine institutional review board.

RESULTS

Table 1 shows the weighted number of children <36 months of age who were hospitalized with fractures and the proportion of fractures attributable to abuse in each year of the KID; the proportions of fractures attributable to abuse varied from 11.9% to 12.1%. Because the results for each year of the KID were very similar, subsequent results are presented only for the 2003 KID.

Table 2 shows the major causes of injuries for the 15 143 children (weighted total) with fractures in 2003, based on ICD-9-CM diagnosis codes and E-codes; the most common causes were accidental falls, abuse, other accidents, and motor vehicle accidents. In addition to the accidental and abusive injuries, some children had fractures that were coded as uncertain whether they were attributable to an accident or were intentional, and a few children had fractures resulting from bone abnormalities

TABLE 1 **Weighted Proportions of Fractures Attributable to Abuse in Each Year of the KID**

Year	No. of Fractures	Proportion Attributable to Abuse, %
1997	13 407	11.9
2000	14 315	11.9
2003	15 143	12.1

TABLE 2 **Causes of Injuries in Children <36 Months of Age With Fractures in the 2003 KID (Weighted *N* = 15 143)**

Cause	Proportion, %
Fall	50.42
Abuse	12.08
Other accident	11.60
Motor vehicle accident	11.40
Uncertain whether accidental or intentional	2.17
Bone abnormality	0.85
Metabolic abnormality	0.12
Birth trauma	0.05
No injury E-code	11.32
Total	100.01

(mostly osteogenesis imperfecta), metabolic abnormalities (eg, rickets), or birth trauma.

The abused children had a mean age of 6.8 months (SD: 7.7 months); 59% were male, 33% were white, 18% black, 17% Hispanic, 5% other, and 27% unknown, and the majority (77%) were receiving Medicaid or had no medical insurance. Table 3 shows the weighted incidence estimates for children with fractures and children with fractures attributable to abuse. Overall, the incidence of fractures was 125.5 cases per 100 000 children 0 to 35 months of age. The incidence estimates for fractures were similar in the youngest (0–11 months) and oldest (24–35 months) age groups (145.0 and 163.8 cases per 100 000, respectively). In contrast, when the incidence of fractures resulting from abuse was examined, the estimate was highest for children <12 months of age (36.1 cases per 100 000), and this rate was almost 8 times higher than the rates for the 2 older age groups (4.8 and 4.8 cases per 100 000). Also shown in Table 3 are the proportions of fractures attributable to abuse; the proportion was largest for children <12 months of age (24.9%) and smallest for children 24 to 35 months of age (2.9%).

Table 4 shows the number of fractures of each bone and the proportion attributable to abuse in each age group. For children <12 months of age, the proportion of fractures attributable to abuse was >50% for the following bones: ribs, radius/ulna, and tibia/fibula. In this age group, only 30.5% of femur, 28.1% of clavicle, and 17.1% of skull fractures were attributable to abuse. In contrast, for children 24 to 35 months of age, the proportion of fractures attributable to abuse exceeded 5% for only rib and clavicle fractures. In this age group, fractures of the humerus and femur were the most common but were seldom attributable to abuse (1.6% and 2.5%, respectively).

As shown in Table 5, the likelihood of abuse increased fourfold to sixfold for children who had ≥3 fractures, compared with those with only 1 fracture. For example, in children <12 months of age, 18.5% of 5076 children with a single fracture were diagnosed with abuse, compared with 55.1% of 477 children with 2 fractures and 85.4% of 298 children with ≥3 fractures.

Table 6 compares the 2003 KID estimates of the incidence of fractures attributable to abuse with those of the only published case-surveillance study, which was conducted by Sibert et al[2] in Wales. Because the Welsh study collected data through 30 months of age, the comparisons focus on children <24 months of age. For children <12 months of age, the incidence in the Welsh study (48.3 cases per 100 000) was 1.3 times greater than our estimate from the KID (36.1 cases per 100 000), and the 95% CI for the Welsh study included the point estimate from the KID. In contrast, the difference between the 2 studies was striking for children 12 to 23 months of age; the incidence in the Welsh study was 3.3 times greater than our estimate. The CIs in the Welsh study were large, reflecting the relatively small sample size.

DISCUSSION

This study provides the first national US estimates of the incidence of hospitalization with fractures attributable to abuse among young children. We found that, in 3 different years (1997, 2000, and 2003), the proportion of fractures attributable to abuse was 11.9% to 12.1%, based on the KID. In 2003, the proportion of fractures attributable to abuse in children <12 months of age was 24.9%; this proportion decreased to 2.9% in children 24 to 35 months of age. The overall incidence of abusive fractures was 15.3 cases per 100 000 for children 0 to 36 months of age and 36.1 cases per 100 000 for children <12 months of age. In the youngest age group, >50% of fractures of the ribs, radius/ulna, and tibia/fibula were attributable to abuse. In contrast, of the 3363 cases of skull fractures in this age group, only 17.1% were categorized as abuse. For children 24 to 35 months of age, the most commonly fractured bones were the humerus and femur, and the likelihood of abuse was extremely low.

In the only other population-based study of fractures attributable to abuse in young children, Sibert et al[2]

TABLE 3 **Weighted Rates of Abusive Fractures, According to Age Group, in the 2003 KID**

Age, mo	Weighted No. of Fractures	Incidence of Fractures, Estimate (95% CI), Cases per 100 000[a]	Incidence of Abusive Fractures, Estimate (95% CI), Cases per 100 000[b]	Proportion of Abuse, %
0–11	5850	145.0 (131.3–158.7)	36.1 (31.0–41.2)	24.9
12–23	2677	67.1 (59.8–74.4)	4.8 (3.8–5.9)	7.2
24–35	6616	163.8 (136.5–191.1)	4.8 (3.4–6.1)	2.9
Total	15 143	125.5 (112.5–138.6)	15.3 (13.2–17.3)	12.1

[a] Weighted incidence of fractures per 100 000 children in age group.
[b] Weighted incidence of fractures attributable to abuse per 100 000 children in age group.

TABLE 4 **Weighted Proportions of Fractures Attributable to Abuse, According to Age and Bone, in the 2003 KID**

	0–11 mo		12–23 mo		24–35 mo		0–36 mo	
	No. of Fractures	Proportion From Abuse, %	No. of Fractures	Proportion From Abuse, %	No. of Fractures	Proportion From Abuse, %	No. of Fractures	Proportion From Abuse, %
Ribs	809	69.4	96	28.5	96	27.6	1001	61.4
Radius/ulna	261	62.1	103	19.8	293	4.7	657	29.8
Tibia/fibula	493	58.0	192	16.1	384	4.7	1069	31.1
Humerus	518	43.1	545	6.8	2108	1.6	3172	9.3
Femur	1257	30.5	761	4.8	2008	2.5	4026	11.7
Clavicle	227	28.1	65	16.7	95	6.0	388	20.7
Skull	3363	17.1	948	8.6	1575	3.7	5886	12.1

found that the incidence of abuse was 1.3 times higher in children <12 months of age (48.3 vs 36.1 cases per 100 000) and 3.3 times higher in children 12 to 23 months of age (15.6 vs 4.8 cases per 100 000), compared with our findings. In the study by Sibert et al,[2] case surveillance was used in the region to identify cases of fractures caused by abuse. Some of the differences between the incidence estimates in the 2 studies reflect differences in the populations studied. The Welsh study was not confined to hospitalized children, whereas the KID included only hospitalized cases. It is likely that some abused children, especially those whose fractures could be treated in an emergency department, would not be admitted to the hospital. For example, in our study of 672 children <36 months of age who had fractures evaluated at Yale-New Haven Hospital, 15% of the children with fractures attributable to abuse among those <12 months of age and 29% among those 12 to 23 months of age were not admitted to the hospital.[7] The absence of other case-surveillance studies of the incidence of abusive fractures limits our ability to determine whether the results of the KID are accurate for hospitalized young children or whether they underestimate the incidence of the phenomenon, compared with prospective, case-surveillance studies.

This study has at least 5 limitations. The first limitation concerns the use of E-codes and ICD-9-CM codes to identify abused children. Because the US incidence estimates are derived from administrative databases, there is a legitimate concern that children with fractures attributable to abuse were undercounted. If undercounting did occur, then the proportion of fractures attributable to abuse and the incidence would be higher than our results. In a study that examined the accuracy of E-codes in identifying abused children, Winn et al[12] showed that E-codes underestimated the occurrence of abuse. That study was conducted in 1991–1992. Since then, there has been increased attention to the use of E-codes by hospitals and the recognition of abuse. Whether these changes have influenced the accuracy of E-codes in the KID data set is an important empirical question. For a hospitalized child to be categorized correctly as having abuse, physicians must recognize the injury as abuse and clearly indicate that diagnosis in the medical record; coders then must code the abuse correctly by using either the ICD-9-CM code for abuse (code 995.5) or an E-code for assault (codes E960–E969). Because the proportions of children with fractures diagnosed as abusive did not change substantially from 1997 (11.9%) to 2003 (12.1%), it is likely that changes in coding of abuse did not affect this categorization.

We have some data to indicate that the use of E-codes and ICD-9-CM codes does not underestimate abuse when the results are compared with those from case-surveillance studies. In the first year of life, the incidence estimates of inflicted TBI from the KID (1997, 2000, and 2003) were very similar to the results from 2 British[2,4] and 1 North Carolina[3] case-surveillance studies. Because almost all children <12 months of age with inflicted TBI are admitted to the hospital, there was little concern in those comparisons that estimates based only on data for hospitalized children would underestimate the true incidence of the problem. The similarities between the estimates from the KID and case-surveillance studies suggest that, at least for TBI, codes for abuse are accurate.

Another approach to determining the accuracy of the results derived from the KID is to compare the proportion of fractures resulting from abuse in the KID with proportions in similar samples of young children with fractures. These samples might be derived either from administrative databases on hospitalized children from states or regions in the United States or other countries or from clinical samples of consecutive children with

TABLE 5 **Weighted Proportions of Abusive Fractures and Numbers of Fractures in the 2003 KID**

Age, mo	1 Fracture		2 Fractures		≥3 Fractures	
	No.	Proportion From Abuse, %	No.	Proportion From Abuse, %	No.	Proportion From Abuse, %
0–11	5076	18.5	477	55.1	298	85.4
12–23	2489	5.7	149	26.1	39	30.8
24–35	6306	2.6	248	6.2	62	17.6
Total	13 870	9.0	873	36.3	399	69.5

TABLE 6 **Comparison of Incidence Estimates of Abusive Fractures in the KID and the Welsh Case-Surveillance Study[2]**

Age, mo	Incidence, Estimate (95% CI), Cases per 100 000[a]	
	KID (2003)	Welsh Study (1996–1998)
0–11	36.1 (31.0–41.2)	48.3 (30.2–77.3)
12–23	4.8 (3.8–5.7)	15.6 (6.9–35.1)
0–23	20.6 (18.2–22.9)	31.9 (21.2–48.1)

[a] Incidence of fractures attributable to abuse per 100 000 children in age group.

fractures. The advantage of using a clinical sample is that the diagnosis of abuse is usually made through careful review of the clinical data and sometimes by using specific criteria for the diagnosis of abuse. For example, in a retrospective study by Leventhal et al,[7] clinicians and radiologists used specific criteria to review the records for 672 consecutive children <3 years of age with fractures who were evaluated at Yale-New Haven Hospital during 3 time periods (1979–1983, 1991–1994, and 1999–2002). Because the data for the middle and late time periods (total of 472 children) were similar they were combined, and the proportion of children who had fractures attributable to abuse and were hospitalized was determined. When a broad definition of abuse (definite, likely, or questionable) was used, 20.5% of cases of fractures in the hospitalized sample were categorized as abuse. When the definition was narrowed to include only definite and likely cases, 17.4% were classified as abuse. This narrower definition is likely comparable to a definition that might be used by clinicians and result in a case being classified as abuse in the KID. Therefore, the proportions of fractures resulting from abuse in the KID data sets of 11.9% to 12.1% are lower than but in a similar range as the 17% found in the smaller, clinically based study.

A second limitation, inherent in the use of administrative databases, is that it is impossible to know how physicians made decisions about the occurrence of abuse. These decisions might have resulted in overdiagnosis, underdiagnosis, or both. The variability in the diagnosis of abuse was recently studied by using data from the 1997 KID to examine children <1 year of age with TBI or femur fractures.[16] The authors showed that there was marked variability in the likelihood of the diagnosis of abuse according to whether the child was evaluated at a children's hospital, where 29% of the cases were diagnosed as abuse, compared with 13% at general hospitals.

A third limitation, as noted previously, is that the KID includes only hospitalized children; therefore, the incidence estimates do not include abused children who were diagnosed and not admitted to the hospital. Because very young children (eg, those <12 months of age) with fractures attributable to abuse are more likely to be admitted to the hospital than are older children, the difference between the total number of abused children with fractures and the number included in a hospitalized sample is likely to be smaller for very young children than for older ones.

The fourth limitation is that the KID counts hospitalizations, as opposed to individual children, and it is possible that specific children were hospitalized twice for the same injury in the same year and were counted twice in the data set. To the extent that this occurred, it might have falsely elevated the incidence of the phenomenon.

The final limitation is that the KID does not include all US states and does not sample the regions of the United States equally. Regional variations in the incidence of fractures attributable to abuse are possible. Each year for which KID data are available represents a different sample of US hospitals, and the finding that overall rates of fractures attributable to abuse are consistent from year to year suggests that regional variation is not likely to be a significant factor.

The incidence estimates from the KID for children hospitalized with fractures attributable to abuse are similar to those for inflicted TBI; in the 2003 KID data for children <12 months of age, the incidence of fractures resulting from abuse is 36.1 cases per 100 000 and the incidence of inflicted TBI is 32.2 cases per 100 000 (95% CI: 26.9–37.4 cases per 100 000).[13] When these children with abuse are counted only once, the overall incidence for children <12 months of age with abuse resulting in a fracture and/or inflicted TBI is 52.5 cases per 100 000 children (or 1 in 1905 births).

Prevention programs for abuse and neglect in general, and for abusive head trauma in particular, have become more widespread, and a challenge for such programs is to show decreases in the occurrence of serious abusive injuries. The availability of data from administrative databases such as the KID may be helpful in tracking changes in the occurrence of serious injuries in hospitalized children over time and in comparing the incidences of these phenomena in different regions.

CONCLUSIONS

By using the 2003 KID, we have shown that national data about fractures attributable to abuse in hospitalized children can be obtained and that fractures attributable to abuse are common. In the first year of life, 25% of children hospitalized with fractures were abused and the incidence of fractures attributable to abuse was 36.1 cases per 100 000.

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STUDY SUPPORTS HEALTH BENEFITS OF SMOKING BAN

"A new study from Scotland provides what public-health experts in the United States say is the strongest evidence yet that public bans on smoking—being debated in several locales—improve health by reducing exposure to secondhand smoke. According to the study, which appears in Thursday's edition of the *New England Journal of Medicine*, hospital admissions for heart attacks and acute coronary problems fell 17% overall, and even more for nonsmokers, in the year after Scotland banned smoking in public places. 'There has long been a claim from smokers that they are affecting their own bodies, and why should the public care?' said David Cohen, director of cardiovascular research at Saint Luke's Mid America Heart Institute in Kansas City, MO, who wasn't involved in the study. 'This shows that the public should absolutely care . . . that is an incredibly powerful finding.' The study found that nonsmokers accounted for 67% of the overall reduction in heart-disease hospitalizations, said Jill Pell, the University of Glasgow professor who led the study. Nonsmokers saw a 20% reduction in their hospital admissions following the ban. Smokers' admissions were down 14%."

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