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## Research article

## Abusive fracture incidence over three decades at a level 1 pediatric trauma center



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## ARTICLE INFO

## Keywords:

Physical child abuse  
Fractures  
Incidence

## ABSTRACT

Few studies have examined the incidence of abusive fractures in children. Only one study to date, from a single pediatric trauma center, has reported on the incidence of abusive fractures over time. That study showed a decrease in abusive fractures over a 24-year period. Our objective for this current study was to compare these published data with recent data from this same trauma center, allowing for a detailed comparison of the incidence of abusive fractures over a 30-year period. We included children < 36 months of age who presented to the emergency department of a level 1 pediatric trauma center (2007–2010) with  $\geq 1$  fracture. Six experts from 3 different fields rated each case on the likelihood the fracture(s) was caused by abuse using an established 7-point scale, and a consensus rating was agreed upon for each case. The incidence of abusive fractures was calculated per 10,000 children < 36 months of age living in the geographic region and per 10,000 ED visits and was compared to previously published data for three prior time periods (1979–1983, 1991–1994, and 1999–2002) at the same pediatric trauma center. From 2007–2010, 551 children were identified, including 31 children who were rated as abused. The incidence of a child presenting with an abusive fracture in the county per year was 2.7/10,000 children < 36 months of age. The previous three time periods showed a countywide incidence of 3.2/10,000 (1979–1983), 1.7/10,000 (1991–1994), and 2.0/10,000 (1999–2002) ( $p$  for trend 0.34). The incidence per ED visit was 2.5/10,000 in the recent time period compared to 6.0/10,000 (1979–1983), 3.4/10,000 (1991–1994), and 2.5/10,000 (1999–2002) ( $p$  for trend < 0.001). In this single institution review of fractures in children < 36 months of age, the incidence of abusive fractures has remained relatively constant over a 30-year period.

## 1. Introduction

Child maltreatment is a pervasive public health problem in the United States, and strategies for addressing the problem rely on

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<https://doi.org/10.1016/j.chiabu.2017.11.008>

Received 3 August 2017; Received in revised form 3 November 2017; Accepted 13 November 2017

0145-2134/© 2017 Published by Elsevier Ltd.

understanding its extent (United States Administration, 2016). In a recent study highlighting the immensity of the problem, the authors estimated that by age 18, 1 in 8 U.S. children would be a confirmed victim of child maltreatment (Wildeman et al., 2014). After neglect, physical abuse is the most common form of child maltreatment (United States Administration, 2016), and fractures are the most common manifestation of physical abuse after soft tissue injuries (Leventhal & Gaither, 2012; Loder & Feinberg, 2007).

The population-based incidence of abusive fractures in young children has been reported infrequently (Clarke, Shelton, Taylor, Khan, & Needhirajan, 2012; Leventhal et al., 2007; Leventhal, Martin, & Asnes, 2008). Studies using large, national databases have shown the incidence of abusive fractures varies based on age, with children less than 2 years of age and particularly those less than 12 months of age at highest risk (Leventhal et al., 2008; Leventhal, Martin, & Asnes, 2010; Loder & Feinberg, 2007). While large database studies are valuable, these analyses do not allow for a detailed examination of individual cases nor is it possible to confirm a diagnosis of abuse. Therefore, we aimed to determine the incidence of abusive fractures at an urban level 1 pediatric trauma center by analyzing individual fracture patients less than 36 months of age presenting to the pediatric emergency department during a recent 4-year time period. We then compared these results to published data from 3 other time periods at the same center (Leventhal et al., 2007), allowing for a 30-year evaluation of the incidence of abusive fractures at a single trauma center.

## 2. Methods

Institutional Review Board approval was obtained to perform this study. All children under 36 months of age who presented from January 1, 2007 to December 31, 2010 to the pediatric emergency department of a single level 1 trauma center with one or more fractures were considered for inclusion in the study. Fracture patients were identified by searching a hospital database for all fracture ICD-9 codes (800–829) as well as searching the Child Abuse Division's abuse registry. Exclusion criteria included underlying metabolic bone disease and other medical conditions that predispose to fractures. A chart review was performed to obtain detailed information about each patient including demographic data, reported mechanism of injury, medical and social history, radiographic study results, treatment, social work and child abuse team assessments and disposition. Our analytic sample consisted of 551 children. Each patient's clinical data were then reviewed in detail by 2 child abuse pediatricians, 2 pediatric orthopaedic surgeons and 2 pediatric radiologists. The radiologists were given less clinical information than surgeons or pediatricians in order to be consistent with previous study methodology and to mimic the limited information typically available to radiologists.

There were two differences in methodology from prior time periods. First, data from the prior study periods was collected from hand-written logs in both the emergency department as well as the child abuse registry. The current study relied on searching the hand-written child abuse registry log as well as the hospital's database for fracture ICD-9 codes as hand-written logs were no longer maintained in the ED. Second, pediatric orthopaedic surgeons were involved in the rating of fractures in the current time period. The rationale for including orthopaedic surgeons is that pediatric orthopaedists often encounter and care for patients with abusive fractures. In fact, it is estimated that one in 3 physically abused children will be treated by an orthopaedic surgeon (Akbarnia, Torg, Kirkpatrick, & Sussman, 1974; Loder & Feinberg, 2007).

The fractures were rated independently by each physician for the likelihood of abuse using a previously developed 7-point scale (Thomas, Rosenfield, Leventhal, & Markowitz, 1991) (Tables 1 and 2). The ratings scales, which are slightly different for clinicians and radiologists, were developed specifically to aid in distinguishing physical child abuse from accidental injury. Ratings of 1, 2 and 3 (definite, likely or questionable abuse) were considered abuse and ratings of 5, 6 and 7 (questionable, likely or definite accident) were considered accident. A rating of 4 was given when a mechanism of injury could not be determined. After each physician individually evaluated and rated the likelihood that the patient's fracture(s) was caused by abuse, the two physicians in each subspecialty met and came to a consensus rating for cases where there was a discrepancy. All 6 physicians then met and discussed each case ( $n = 42$ ) when there was not complete agreement on whether the fracture(s) was caused by abuse or accident in order to come to a final likelihood of abuse rating for each case. A detailed analysis of the fracture rating process, including inter- and intra-rater reliability measurements, was reported in a separate study (Buesser et al., 2017).

### 2.1. Data analysis

We used descriptive statistics to characterize the samples across each of the four time periods: 1979–1983, 1991–1994, 1999–2002 and 2007–2010. Differences in demographic trends, fracture ratings and fracture location were assessed with  $\chi^2$ -tests.

To provide a population estimate of the incidence of abusive and total fractures in children less than 36 months of age, our denominator was the number of children of this age living in New Haven county in 2010 (based on census data (Bureau, 2010)); the numerator was the mean number of children with abusive fractures or fractures per year for the four-year period. The analysis was restricted to children in New Haven County because children living in other counties may have sought care at other medical centers, and thus, the numerator for these children would be incomplete. We calculated annual rates for total fractures and abusive fractures per 10,000 ED visits for 2010 as well as for the other 3 time periods. The Cochran-Armitage test for trend was used to assess for changes in incidence over time.

All analyses were performed using SAS software, version 9.3 (SAS Institute, Cary, NC). A two-sided statistical significance level of 0.05 was applied to all analyses.

## 3. Results

A total of 551 children under 36 months of age presented to the emergency department over a 4-year period between January 1,

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