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Child Abuse and Bone Fractures in Young Children: Local Trends Over Three Decades

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CHILD ABUSE AND BONE FRACTURES IN YOUNG CHILDREN: LOCAL TRENDS OVER THREE DECADES

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The purpose of this study was to determine the patterns of fractures in children less than three years of age that are distinctive of abuse, and to examine changes in the frequency of abusive fractures in young children evaluated at a major pediatric hospital over three time periods: 1979-1983 (early), 1991-1994 (middle), and 1999-2002 (late).

All children 0 to 36 months of age who were treated for bone fractures at a major medical center from 1/99 to 12/02 were selected. Medical records were abstracted for sociodemographic and clinical characteristics, and radiographs were examined. Using specific criteria, each case was rated by 2 clinicians and 2 pediatric radiologists on a 7-point scale ranging from definite abuse to definite accident. Cases were rated independently by each reviewer; when disagreements occurred, a consensus rating was reached. Cases rated as definite, likely, or questionable abuse were considered abuse. Demographics of the abused children were compared to those with either accidental fractures or fractures of unknown etiology using chi-square statistics. The proportion of children rated as abuse in the late sample was compared to the proportions previously

identified in the early and middle time periods using adjusted odds ratios controlling for race and physician type (clinic vs. private).

Several fracture types were highly associated with abuse; 100% of rib fractures, 29.2% of femur fractures, 19.5% of humerus fractures, and 12.8% of tibia/fibula fractures were rated as abuse. Abused children were more likely than those with accidental or unknown fractures to present with vague or missing histories to explain the fracture (60.0% vs. 11.6%), and were more likely to be less than 12 months of age (68.0% vs. 26.6%), insured by Medicaid or to be self-pay patients (68.0% vs. 41.1%), and of minority race (56.0% vs. 29.9%).

For the late time period, 10.8% of 232 cases were classified as abuse; in the middle group, 10.0% of 240 cases, and in the early group, 22.5% of 200 cases. Children in the early group had two and a half times the odds of an abusive fracture when compared with the late group (adjusted OR 2.58, 95% CI=1.43, 4.65). The odds of abuse did not differ significantly between the middle and late groups (adjusted OR 0.86, 95% CI=0.46, 1.63).

Fractures of the ribs, femur, humerus, and tibia/fibula were most highly associated with abuse. Abused children were more likely to present with vague or missing histories to explain the fracture, and were more likely to be less than 12 months of age, of minority race, and either self-pay patients or insured by Medicaid. The rate of fractures due to abuse has decreased dramatically over the past three decades at one major pediatric center.

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INTRODUCTION

National Child Abuse Incidence and Trends

Child maltreatment is a serious and pervasive problem in the United States. In 2002, more than 896,000 children were reported to their state's Child Protective Services agency and were substantiated as victims of physical abuse, neglect, sexual abuse, or emotional abuse – a victimization rate of 12.3 per 1000 children. Of these maltreated children, 18.6% were physically abused and 1,400 children died as a result of maltreatment.[1]

Although death is one significant outcome, child abuse has other negative effects on both individual children and on society. Research shows that victims of abuse and neglect have higher rates of violence, substance abuse, and mental health problems.[2] Long-term physical sequelae of abuse may also occur. The economic burden of child maltreatment is substantial. In 2004, a nation-wide study showed that children hospitalized for abuse or neglect had longer and more costly hospital stays than other children.[3]

The National Child Abuse and Neglect Data System (NCANDS) publishes yearly data based on reports to state Child Protective Services (CPS). These data show an increase in rates of child maltreatment since the mid 1970s, with a peak in the early 1990s and a subsequent decline in maltreatment rates.[1]

NCANDS data reflect only those cases which have been reported to CPS. Since not all cases are reported, other studies have attempted to achieve a more accurate assessment of the incidence of child maltreatment by including estimates of unreported

cases. The National Incidence Studies included both investigations by CPS and reports of other cases by sentinel community professionals not involved with CPS. The Third National Incidence Study of Child Abuse and Neglect (NIS-3) estimated that there were 1.5 million cases of child abuse or neglect in the United States during 1993-94. This was a 67% increase from the 931,000 cases reported in NIS-2 (1986-87) and a 149% increase from the 625,100 cases reported in NIS-1 (1979-80). Cases of physical abuse showed a similarly dramatic 42% increase from NIS-2 to NIS-3. When cases of physical abuse were classified based on the severity of the sustained injury, an increase was observed among children with serious injuries as well. The increase in serious cases strengthens the probability that increased rates were real and did not simply reflect heightened sensitivity in identifying or reporting child maltreatment.[4] NIS-4 is currently in progress and will provide important information regarding incidence trends after 1994.

The Current Study

Our study examines the patterns of fractures in young children that are distinctive of abuse and describes changes in the proportion of fractures due to abuse in a major pediatric hospital in Connecticut over three time points: early (1979-1983), middle (1991-1994), and late (1999-2002). This introduction will outline risk factors for physical child abuse and describe previous research regarding abusive fractures in young children. Finally, in order to explain differences in the groups of study subjects over the three time periods, we will present local child abuse statistics, examples of local child abuse prevention strategies, and information regarding the demographics of Connecticut and New Haven County.

Risk Factors for Physical Abuse

Several risk factors have been identified for physical child abuse. Age is one important predictor of the likelihood of abuse. In 2002, the national rates of child maltreatment among children from birth to age three were reported at 16 per 1000 children, well above the overall rate of 12.3 per 1000 children. Furthermore, over three-quarters of fatalities occurred in children under four years of age, and maltreated children under three years of age were the most likely to experience a later recurrence of abuse or neglect.[1]

Other familial characteristics that place children at higher risk of abuse include poverty, young parental age, single-parent family structure, co-occurring domestic violence, parental history of substance abuse or depression, parental history of childhood abuse, and lack of social supports for the family. Prematurity, low birth weight, and disability put individual children at higher risk of abuse.[5]

Minority children have higher rates of substantiated abuse and neglect than white children. Race, therefore, may be another risk factor for abuse. In 2002, Lane et al examined 388 children less than three years of age who were hospitalized with skull or long-bone fractures. They found that while minority children did have higher rates of abusive fractures, minority children 12 months of age or older were almost nine times more likely to have a skeletal survey performed and four times more likely to be reported to Child Protective Services than white children, even after controlling for the likelihood of an abusive fracture. In children less than one year of age, the racial differences in ordering of skeletal surveys had borderline significance.[6] By showing that physicians

were more likely to pursue suspicions of abuse in minority children than in white children, this study raises the important issue of physician bias and questions whether race and ethnicity are true risk factors for abusive fractures in children over 12 months of age.

Abusive Fractures

Fractures are an example of a serious and common manifestation of physical abuse, second in occurrence only to soft tissue injuries.[7] The importance of recognizing fractures that are secondary to abuse cannot be overemphasized; the risk of additional injury in cases where children with an abusive fracture are returned to unsafe environments has been estimated to be as high as 50%.[8]

Fractures have long been associated with child maltreatment. In 1946, Caffey reported six cases of children with puzzling long-bone fractures and subdural hematomas. None of these children presented with histories of significant trauma, and none had evidence of a skeletal disease to which these fractures could be attributed. Caffey concluded that both the fractures and the head injures must be the result of trauma and raised the question of intentional maltreatment in some of the children.[9] Kempe and colleagues first coined the term "battered child syndrome" in an article published in JAMA in 1962. They noted that this syndrome should be considered in "any child exhibiting evidence of a fracture of any bone, subdural hematoma, failure to thrive, soft-tissue swellings or skin bruising, in any child who dies suddenly, or where the degree and type of injury is at variance with the history given regarding the occurrence of the trauma."[10]

Since that time, several studies have described victims of abuse and have identified fractures of the long-bones and ribs as the most common types of abusive fractures. For example, King et al reported a series of 429 fractures in 189 battered children less than 13 years of age. The majority (68.8%) of the children were less than 1 year of age, and only 13.8% were over 2 years of age. Over one-half of the children had a single fracture; the most commonly fractured bones were the humerus, femur, and tibia, with transverse fractures being the most common type.[11] A later study examined 31 infants who died with inflicted skeletal trauma and found 165 fractures including 84 (51%) rib fractures and 72 (44%) long-bone fractures.[12]

Other studies have reported consecutive children with bone fractures in an attempt to estimate the proportion of fractures that are abusive. In 1982, Rosenberg et al described 49 children under one year of age who presented with fractures and found that skull and long-bone fractures were the most common types in both accidental and abusive cases. They estimated that 45% of the fractures were abusive and found that while falls were the most commonly reported history in the accidental cases, in all abuse cases, the children presented without a clear history of trauma.[13] That same year, McClelland et al reported 34 children under one year of age with 55 fractures (21 skull fractures and 19 long-bone fractures) and concluded that 56% of the cases were abusive.[14] In 1993, Leventhal et al published a series of 253 fractures in 215 children less than 3 years of age. The group reported that 24.2% of these fractures were secondary to abuse. Fractures that were considered to be abusive were most commonly femur fractures in children less than 1 year of age, midshaft or metaphyseal fractures of the humerus, and fractures of the radius/ulna or tibia/fibula.[15]

Several types of clinical histories are associated with abusive fractures. In the study by Leventhal et al, fractures that were considered abusive were most commonly those in which the caretaker reported either no history or a history of only minor trauma with a more severe injury.[15] Pierce et al attempted to examine clinical histories in a more systematic way by seeking details regarding the initial position and location of the child, the fall dynamics, and the final position and location of the child. They found that in a group of children presenting with femur fractures after reported falls from stairs, the caretakers were unable to answer these detailed questions in the cases that were deemed suspicious for abuse.[16]

Femur Fractures

Research has also focused upon specific types of fractures, including femur fractures, in an attempt to differentiate accidental and abusive fractures. Rex et al reported a series of 14 abusive femoral fractures and compared them to 33 accidental femoral fractures. All of but one of the abusive fractures occurred in children under one year of age, whereas the accidental fractures were more evenly distributed across the age range from 0 to 16 years. The most common fracture site was the middle third of the diaphysis, and the most common type was a spiral fracture in both accidental and abusive groups.[17] The importance of a child's age in the evaluation of femur fractures has been supported by other studies.[18] Schwend et al found that 42% of femur fractures were abusive if a child was not yet walking, compared to only 2.6% of fractures in older children.[19] Scherl et al reported a series of 207 children with femur fractures and found that 38% of fractures were transverse, 27% spiral, and 17% oblique; 76 (36%) of the

fractures were investigated for possible abuse, and 17% of those investigated (or 6% of the total cases) were substantiated. Although spiral fractures were no more common in abused children, they were overrepresented in children reported to CPS, indicating that spiral fractures continue to be inappropriately considered suspicious by many physicians.[8]

Humerus Fractures

Fractures of the humerus have also been studied. One study retrospectively reviewed the charts of 124 children who presented with humerus fractures and determined that 36% of fractures in children less than 15 months of age were abusive, versus only 1% in children between 15 months and three years of age. The majority of the abusive humerus fractures were spiral; however, there were also several abusive supracondylar fractures .[20] When excluding all supracondylar fractures, a common accidental type of injury in ambulatory toddlers, another study found that 18% of humerus fractures were the result of abuse.[21]

Rib Fractures

The majority of rib fractures in young children have been found to be caused by abuse. In a series of 39 infants with rib fractures, 82% were inflicted, 7.7% attributable to significant accidental trauma, 2.6% due to birth injury, and 7.7% secondary to abnormal bone fragility.[22] Others have supported the high association between rib fractures and abuse in young children,[15] and Barsness et al found a 95% positive predictive value of a rib fracture as an indicator of abuse in children less than three years

of age. This value was increased to 100% when children with known skeletal abnormalities and those involved in motor vehicle accidents were excluded.[23]

Child Abuse at the Local Level

There are several local and state organizations that work in the area of child abuse. The Department of Children and Families (DCF) is the state agency in Connecticut charged with providing child protection. This department investigates and substantiates reports of child abuse and neglect within the state and, when necessary, provides maltreated children with temporary and long-term placement.

Yale-New Haven Children's Hospital's Detection, Assessment, Reporting, and Treatment (DART) Committee was established in 1967 and is a multidisciplinary, hospital-based committee that meets weekly to review cases of child maltreatment and high risk social situations. Committee members also provide consultation services for inpatients with concerning injuries.[24]

Rates of child abuse in Connecticut have largely mirrored nation-wide trends, with an increase in rates until the early 1990s and a subsequent decline since that time. In 1983, 14,100 children were reported to DCF in Connecticut. That year, approximately 28% of cases nationwide were substantiated; assuming a similar rate of substantiation in Connecticut, we can estimate approximately 4,000 victims of child abuse and neglect in 1983.[25] In 1992, there were 15,957 substantiated victims in the state, and in 2002, DCF reported 11,861 victims of substantiated abuse or neglect. Of these, 1,737 children (14.6%) suffered from physical abuse. [26] Within the age group of birth to three years, the victimization rate in Connecticut was 19.8 per 1000 children, the highest for any age

group.[1] In 2002, the city of New Haven had 830 substantiated victims of abuse and neglect; among these, 165 (19.9%) were victims of physical abuse.[26]

Child abuse prevention strategies have been aimed at families at highest risk of perpetrating child abuse and attempt to educate parents about early childhood development and predictable difficulties of child-rearing. At-risk families have been identified through pre- or post-natal screening questionnaires, identification of susceptible infants at birth, or through programs targeting high-risk communities such as young, single mothers and families of low socioeconomic status. In the state of Connecticut, over 30 sites, including the city of New Haven, have prevention programs funded through the Connecticut Children's Trust Fund. These programs include home visits by trained staff with oversight by masters-level social workers.[27] Other local programs include the New Haven Child Development and Community Policing Program, which partners law enforcement and child mental health providers in an attempt to respond to the needs of children and families affected by violence, including domestic violence and child abuse.[28] The Coordinating Council for Children in Crisis provides parent aids to eligible families, and the City Health Department has several active programs to prevent child abuse.[29]

Population and Demographics of Connecticut

In the state of Connecticut, the population of children less than 3 years of age increased by 24% between 1981 and 1992 (from 114,450[30] to 141,983[31]) and then decreased by 7.9% to 130,813 in 2000.[32] Overall, there was a 14.3% increase in the population of children less than 3 years of age from 1981 to 2000.

Statistics for New Haven County are presented only in five-year age intervals; in 1981, the County had 46,368 children less than 5 years of age,[30] 58,765 in 1992,[31] and 53,094 in 2000.[32] These numbers show a trend similar to the statewide data, with a population increase of 26% from1981 to 1992, a 9.6% decrease from 1992 to 2000, and an overall increase of 14.5% from 1981 to 2000.

Statewide, the percentage of children under 5 years of age who were identified as of Hispanic origin was 5.3% in 1981.[30] Census reporting provides data for children under 3 years of age for the two later time groups; the percentage of children who were of Hispanic origin was 11.8% in 1992,[31] and 15.4% in 2000.[32]

Yale-New Haven Children's Hospital is a major pediatric referral center for the state. During the "early" time period of the study (1979-83), approximately 15,000 children visited the Pediatric Emergency Department each year. Between 1991 and 1994, approximately 17,500 patients were treated each year, and approximately 25,000 were treated each year between 1999 and 2002.

The Current Study

Our study is the first to examine changes in the rates of fractures due to abuse in a major medical center over three time periods. Although national data exist showing an increase in the rates of child abuse through the early 1990s and a subsequent decline since that time, no study has examined a specific type of injury to determine the changing rates of abuse. We chose to examine fractures as an identifiable marker of serious child abuse and included children less than 3 years of age because of the higher prevalence of abusive fractures within this population as compared with older children.

STATEMENT OF PURPOSE

To determine the patterns of fractures in children less than three years of age that are distinctive of abuse.

To examine changes in the proportion of fractures due to abuse at one major pediatric medical center over three decades.

METHODS

Subject Identification

Eligible children were identified through the Yale-New Haven Hospital (YNHH) Pediatric Emergency Department Log and the hospital's child abuse Detection, Assessment, Reporting, and Treatment (DART) committee records. All children under 36 months of age who were treated at this hospital for bone fractures between January 1, 1999 and December 31, 2002 were selected. Children were excluded because of congenital or acquired bone disorders including osteogenesis imperfecta, rickets, and tuberous sclerosis. Fractures secondary to birth trauma were excluded as were children who presented to YNHH for a cast check after diagnosis and casting at another hospital.

Children from two previous time periods (1979 through 1983 and 1991 through 1994) were previously identified by Susan Thomas, M.D. and Sujatha Singaracharlu, M.D., respectively. These subjects were selected from the YNHH Emergency Department Log and the DART registry using the same procedure.

This study was approved by the Yale University School of Medicine Human Investigation Committee (HIC Protocol # 9801008263).

Data Abstraction

Medical records of eligible subjects were reviewed by this author and by two research assistants and abstracted onto standardized forms (See Appendix A). Demographic data including age, gender, race, place of residence, primary provider (private physician vs. clinic), and insurance type were abstracted. Data about the fracture event was recorded, including the chief complaint, the description of the fracture event

given by the caregiver, the height of the fall and the landing surface if applicable, delay in presenting for care, presence or absence of witnesses, and any force or twist noted. Additional clinical findings including the presence or absence of bruises, failure to thrive, developmental delay, or signs of abuse such as burns, frenulum lacerations, and internal injuries were noted. Outcomes of skeletal surveys and ophthalmologic exams were abstracted if such studies were performed. Past medical problems were noted as was family history of drug abuse, violence, or criminal offense, or involvement with the Department of Children and Families, the YNHH DART committee, or the social work department. Finally, fracture healing status and any future medical problems or concerns for abuse were noted. Similar information was abstracted by previous authors and research assistants for each case in the early and middle time periods.

Case Ratings

Data abstracted from the medical records were presented to two clinicians (one of whom is an expert in child abuse) who independently rated each case on a seven-point scale from definite abuse to definite accident. Each of the seven categories (definite abuse, likely abuse, questionable abuse, unknown cause, questionable accident, likely accident, and definite accident) had explicit definitions for inclusion (See Appendix B).[18] For example, a rating of definite abuse required a positive skeletal survey, an eye witness, multiple internal injuries, physical findings of unexplained or suspicious burns or scars, or a suspicious injury with definite later abuse. A rating of definite accident required either that the child was involved in a motor vehicle accident or that there was a witness to the accident other than the child's primary caregiver. Each clinician rated each case

independently; in cases where the two ratings disagreed, a joint rating was assigned after discussion. A rating of "unknown" was assigned if inadequate information was present or if a consensus could not be reached. All cases for the three time periods were rated by Dr. John Leventhal; cases for the current time period were rated by Ilse Larson, those for the 1991-1994 group by Dr. Sujatha Singaracharlu, and those for the 1979-1983 group by Dr. Susan Thomas.

Each case was also rated by two pediatric radiologists. The late group was rated by Drs. TR Goodman and Cindy Miller, the middle group by Drs. Dana Schwartz and Suzanne Grasso, and the early group by Drs. Nancy Rosenfield and Richard Markowitz. The radiologists were provided with available radiographs (including x-rays, skeletal surveys, CT scans, and MRIs) for each injury and were provided only with the child's age and a brief description of the injury event. They were blinded to other demographic and social data and to the clinicians' ratings. The radiologists were asked to describe the location, age, and type of the fractures (See Appendix C). Each radiologist rated each case on a seven-point scale (See Appendix D) with categories of definite abuse, likely abuse, questionable abuse, unknown cause, questionable accident, likely accident, and definite accident; when the two ratings differed a joint rating was agreed upon.

Radiologic and clinical ratings were then compared, and in cases where ratings differed, all four raters reviewed the case together to form a final consensus rating, often with additional clinical information provided to the radiologists. In the analysis, cases rated as definite, likely, or questionable abuse were collapsed into one category ("abuse") and those rated definite, likely, or questionable accident were collapsed into one category ("accident").

When categories of “abuse” and “accident” were defined in a more conservative manner (with the “abuse” category including only definite and likely cases, “accident” consisting of definite and likely cases, and “unknown” including cases rated as questionable abuse, unknown cause, or questionable accident) the analysis was not significantly altered.

A final consensus rating was achieved for 180 cases. In 57 cases, radiologic rating could not be completed because radiographic studies were performed at another institution or were inaccessible for our review. In 18 cases, radiographs were completed at another institution, in 9 cases, the subject’s radiographs were checked out of the film library by a private orthopaedic surgeon and could not be located even after speaking with the office, and in 30 cases, the subject’s file was located in the YNHH film library but the radiographs of the fracture were not in the file. For these 57 cases, this author reviewed the medical record for details about the fracture in the original radiology report or in clinical notes from Emergency Department, Orthopaedic, or DART team physicians. Recorded information included bone type and fracture location as well as any available descriptors of the fracture (for example, spiral, transverse, or greenstick fracture). Information regarding the estimated age of the fracture was recorded if it was noted in the records. Five cases were excluded because review of the medical record revealed an original radiology report with an official reading of no fracture. The remaining 52 cases were compared to the larger group in which radiographic studies were available for rating. Because there were few differences between the two groups, these cases were included in the analysis and the clinical rating was substituted for a consensus rating.

Data Analysis: The Late Group

We used chi-square tests to compare children without available radiographs and those where radiographs were available, examining demographic characteristics, clinical ratings, and fracture types. We also used a t-test to examine the significance of the difference in the mean clinical ratings between the two groups.

Inter-rater reliability was examined using a kappa statistic.[33] Kappa varies from -1 (no agreement) to +1 (perfect agreement), with a value of zero representing the degree of agreement that would be expected by chance. Since the radiologists were provided only with a brief history of the fracture incident and the clinical raters had access to much more information (including demographics, other physical signs of abuse, and histories of previous or future injuries), we compared the two clinical raters to each other and the two radiologic raters to each other.

Demographic characteristics of the late group were analyzed, comparing the cases rated as abuse to those rated as accident or unknown. Since there was a very small number of cases in the unknown category and these small values would invalidate the chi-square test, the unknown and accidental cases were combined into one category for demographic analyses.

Data Analysis: Changes over Time

To assess changes in the frequency of abusive fractures over the three time periods, we used adjusted odds ratios with 95% confidence intervals, controlling for race and physician type (private vs. clinic). We used a Breslow-Day test[34] to determine whether the odds ratios describing the association between age and abuse were

significantly different across the three time periods. Finally, we examined changes in the demographic characteristics, the types of fractures, and the percentage of each fracture type that was due to abuse. All statistical analysis was completed by Katherine Ellingson, M.Phil.

Subjects from the early time period were selected and abstracted by Dr. Susan Thomas, and those from the middle period by Dr. Sujatha Singaracharlu. Cases for the late time period were selected and abstracted by Ilse Larson, with the help of Sara Shiffman and Sarah Coleman. Lyla Johnson, Casey Goodshall, and Julie Monteagudo assisted with locating radiology files and arranging radiologic rating. Cases for the late time period were rated by Ilse Larson and Drs. John Leventhal, TR Goodman, and Cindy Miller. Katherine Ellingson completed the statistical analysis presented in this thesis.

RESULTS

Demographic Characteristics of the Late Group (1999-2002)

In the late sample, 287 cases were abstracted and reviewed; 97.1% of cases were identified through Emergency Department logs, and 11.4% of cases were listed in the DART records. Thirteen cases were excluded – 6 because their visit to the ED was for a cast check and the Emergency Department record did not include information on the history of the fracture, 4 because of congenital or acquired bone abnormalities, 1 because the fracture was the result of a birth injury, and 2 because the subjects were over 35 months of age. After radiologic review, 40 cases were excluded because no fracture was identified by the pediatric radiologists, and 5 cases with missing radiographs were excluded because secondary review of the medical record revealed no fracture. The remaining 229 children had 232 incidents (3 children had two separate fracture incidents) and sustained 253 fractures; 221 children had one fracture, 6 had two fractures, 3 had three, 1 had five, and 1 child had six fractures.

Radiographs were not available for review or rating in 52 cases. Table 1 compares the sociodemographics of those children where a radiograph was available and those where it was not available. Gender, insurance type, primary physician type, age, and county of residence were not significantly different between the two groups. Race was the only characteristic that was significantly different, with a higher percentage of the children without an x-ray being white and a lower percentage being black or Hispanic ($p=0.03$).

Table 1 also shows a comparison of the clinical ratings of abuse, unknown, and accident for the two groups, as well as ratings on the 7-point scale from definite abuse to

definite accident. Neither rating scale showed significant differences between the two groups. A t-test showed no difference in the mean clinical ratings of the two groups with a mean of 5.50 for the children with x-rays and 5.52 for the children without ($p=0.93$). Fracture type and the presence of multiple fractures were not associated with whether or not an x-ray was available.

Based on the fact that the only significant difference between the two groups was race, the group of children without x-rays was included in the larger sample for analysis. For the children without radiologic ratings (and therefore without a consensus rating), the clinical rating was substituted for a final rating.

The demographic characteristics of the late sample are shown in Table 2. Fifty-two percent of the sample was male. Racially, 59.5% were white, 15.1% black, 17.7% Hispanic, and 7.7% of other races. Forty-four percent were insured by Medicaid or were self-pay patients, 53.5% had private insurance or an HMO, and 2.5% had unknown insurance status. Nearly eighty percent of the subjects had private primary physicians, and 20% received their care at a clinic. Approximately one-third of the subjects were in each age grouping (0-11 months, 12-23 months, and 24-35 months). Eighty percent of the sample resided in New Haven County.

Thirty-six percent of the children were admitted to the hospital after their presentation with a fracture, and the social work department was involved in 28.8% of the cases. The DART team was consulted in 11.2% of cases, and DCF was notified in 12.9% of cases.

Case Ratings

Of the 232 cases, we rated 25 (10.8%) as abuse, 4 (1.7%) as unknown, and 203 (87.5%) as accidental. Table 3 shows Clinical, Radiologic, Consensus, and Final Ratings on a 7-point scale. If we group categories in a more conservative way as outlined in the Methods section (with "abuse" including only definite and likely abuse, "accident" including definite and likely accident, and "unknown" being redefined to include both cases with insufficient information and those rated as questionable abuse and questionable accident), the rate of abuse does not change significantly, with 7.3% of cases rated as abuse, 16.8% as unknown, and 75.9% as accident.

Of the 180 cases with both clinical and radiologic ratings, there were 56 cases (31.1%) where the ratings differed and a discussion was necessary to reach consensus; however, in the majority of these cases, the disagreement was regarding the amount of certainty (i.e. likely accident vs. questionable accident). These differences were probably due to differing criteria for clinical and radiologic rating as well as differing amounts of available information. When we consider the overall ratings of abuse vs. accident, all cases with a radiologic rating of accident also had a clinical rating of accident, and only 19 (10.5%) cases had a radiologic rating of abuse and a clinical rating of accident. Of these 19, after discussion between the clinicians and radiologists, 5 cases had a consensus rating of abuse, 1 had a rating of unknown, and 13 cases had a consensus rating of accident.

In the 52 cases where x-rays were not available for review, the clinical rating was substituted as a final rating. To predict the extent to which our final ratings may have differed if all 232 cases had radiologic input, we examined clinical and consensus ratings

for the 180 cases with available radiographs. Table 4 compares clinical and consensus ratings for these 180 cases. The shaded boxes represent perfect agreement. All cases with clinical ratings of definite, likely, or questionable abuse (ratings of 1, 2, or 3) had consensus ratings of abuse, and the majority of cases with clinical ratings of definite, likely, or questionable accident (7, 6, or 5) had consensus ratings of accident. Importantly, of the 160 cases with a clinical rating of either questionable or likely accident (5 or 6), five cases (3.1%) had a consensus rating of questionable abuse. These cases are shown in bold in Table 4.

Of the 52 cases without radiologic review, 47 had clinical ratings of either questionable or likely accident (5 or 6). If radiologic input had affected the consensus ratings for these 47 cases in a similar manner as occurred with the 180 cases with radiologic review, we would expect that 3.1% (or 1.5) additional cases would have a final rating of abuse, for a new total of 26.5 abuse cases. The rate of abuse for the entire sample of 232 could therefore be projected to increase slightly from 10.8% to 11.4% if all cases had radiologic review.

We performed kappa statistics to examine the extent of agreement between the two clinical raters and between the two radiologic raters. The kappa for the clinical raters was 0.92 and the kappa for the radiologists was 0.95, indicating a very high level of inter-rater agreement.

Characteristics of the Fractures

In the late group, 253 fractures were seen in 232 cases. Table 5 shows the location of the fractures and the final ratings. Radius/ulna, skull, humerus, and

tibia/fibula fractures were the most common in the sample. The fracture type most highly associated with abuse in the sample was rib fractures—100% of the 12 rib fractures were rated as abuse. Several other fracture types were highly associated with abuse, with 29.2% of femur fractures, 19.5% of humerus fractures, and 12.8% of tibia/fibula fractures rated as abuse. Scapula and spine fractures were associated highly, but the absolute number of these types of fractures was very small. Thirty-six percent of abused children had multiple fractures at the time of presentation compared to only 1% of children with either accidental fractures or fractures of unknown etiology. Fractures of the hand, radius/ulna, skull, and clavicle were most likely to be rated as accidental.

Characteristics of the Presentation

The most common chief complaint upon presentation was an injury to an extremity (62.9%), followed by a fall (21.1%) and an injury to the head (11.6%). Approximately 4% of cases presented with "other" chief complaints including motor vehicle accidents, respiratory distress, or bleeding.

When asked for more detailed descriptions of the fracture events, 165 (71.1%) of the 232 events were described as a fall (either from an object such as a bed, down stairs, or a fall while running). In 26 (11.2%) of the cases, the adult bringing the child to medical care could not describe a fracture event but instead noted an abnormality such as swelling or decreased use of a limb.

Adults reported witnessing the fracture event in 34% of cases; 22% were un-witnessed, and in 44% of cases there was no information regarding adult witnesses in the medical record. When the timing of the fracture was examined, 71.1% of children

presented for medical care within 5 hours of the fracture event, 4.3% presented 6 to 12 hours after the event, 10.2% 13 to 24 hours after, and 14.4% over 24 hours after the event.

Description of Falls

Among those children whose fracture was the result of a fall, 46 children fell from a bed or sofa, 40 fell down stairs, 21 fell from a care-giver's arms, and 15 from a table or counter. Seventy-eight children fell an estimated distance of under two feet, 63 fell less than four feet, 20 fell less than eight feet, and 2 fell over eight feet.

Characteristics of Cases Rated as Abuse

Among the 25 cases rated as abuse, the distribution of chief complaints was quite different than that of the general group: 56.1% presented with an injury to an extremity, 12% with an injury to the head, and 24% with a question of child abuse. The children who presented with a chief complaint of questionable abuse were either sent to the ED by a primary physician or were transferred from another institution.

More detailed descriptions of the events differed as well. As opposed to 71.1% of the general group, only 3 (12%) of the abuse cases was described as a fall. In the 25 abuse cases, 60% presented with a noted abnormality like swelling or deformity rather than with a known fracture event. This rate was only 11.2% in the general group. Other descriptions given in cases rated as abuse included that of a 5-month-old child who was found "jumping in a bouncy chair," a 10-month-old who was "banging his head against a hard surface," and a 5-month-old who "rolled onto her arm."

The abuse cases differed in other ways as well. When we compare cases rated as abuse to those rated as unknown or accident, there were differences in the age, insurance status, and race of the two groups of children. As shown in Table 2, the abused children were more likely to be black (28% vs. 13.5%) or Hispanic (28% vs. 16.4%). These children also had statistically different sources of payment, with 68.0% of the abused children and only 41.1% of children with unknown or accidental fractures insured by Medicaid or self-pay. Private or HMO medical insurance was reported in 20.0% of abused children and 57.5% of children with unknown or accidental fractures. Finally, 68.0% of the abused children were under 1 year of age as compared to 26.6% of the children with unknown or accidental fractures.

A larger proportion of the abused children were admitted to the hospital (76% vs. 36.6%), and 76% of these children were referred to the DART committee. DCF was notified in 76% of cases rated as abuse, and the hospital social work department was involved in 22 of the 25 cases. There was a greater delay in presentation in those cases rated as abuse with 41.7% of the abused children presenting to medical care over 24 hours after the fracture event compared to only 14.4% of the general sample.

Femur Fractures

Table 6 shows ratings of the femur fractures by age group. Of the 24 femur fractures in the late group, 29.2% were rated as abuse. Half of the children with femur fractures were less than 12 months of age. When we specifically examine the 7 femur fractures that were rated as abuse, 71.4% were in children less than 12 months of age and all were in children less than 18 months of age.

All 7 abusive femur fractures presented without a clear history of trauma and with a chief complaint of either decreased limb movement or pain. In 42.9% of the cases of abusive femur fractures, the children had a positive skeletal survey; one skeletal survey of a 5-month-old revealed an occult, older rib fracture, one in a 2-month-old revealed a recent tibia fracture, and the 18-month-old child who was transferred from another institution had multiple rib fractures of various ages, an old tibia fracture, a recent skull fracture, and a recent fracture of the humerus.

Three of the abusive femur fractures were spiral, two were horizontal, one was a buckle fracture, and one was a metaphyseal corner fracture. Four of the seven abusive femur fractures were in the mid-third of the diaphysis.

Humerus Fractures

Table 7 shows the ratings of the humerus fractures by age. There were 41 humerus fractures in 39 children (one child presented with 3 humerus fractures). Six (15.4%) of the cases were classified as abuse; since one of the abused children had 3 humerus fractures, 8 (19.5%) of the total humerus fractures were rated as abuse. Of the abusive humerus fractures, 66.6% occurred in children less than 12 months of age, and the age range was from 2 to 18 months with a mean age of 8 months. The accidental fractures occurred largely in older children; 3% were in children less than 12 months, and only 33.3% were in children less than 18 months.

Two of the children (ages 2 months and 13 months) with abusive humerus fractures were transferred from other institutions—both with multiple fractures on skeletal survey. One 7-month-old child presented with a chief complaint of “fall from

bed" and the other three children, ages 4 months, 11 months, and 18 months, presented without clear histories of trauma but with decreased movement of the affected arm.

Two of the abusive fractures were located in the proximal third of the diaphysis of the humerus, two in the middle third, one in the distal third, and one in the metaphysis. The fractures were equally distributed between horizontal, Salter, spiral, and oblique fractures.

Comparison of the Three Time Periods (Early, Middle, and Late)

In the early sample (1979-1983), there were 232 fractures in 200 children, in the middle sample (1991-1994), 263 fractures in 240 children, and in the late sample (1999-2002), 253 fractures in 232 children. These numbers correlate with a rate of 40 children per year in the early sample and 60 children per year in the middle and late groups. Utilization of the YNHH Pediatric Emergency Department has increased during the study period from approximately 15,000 patients per year during the early time period to 17,500 per year in the middle group and 25,000 in the late group. Using these figures and assuming an even age distribution of emergency room patients from 0 to 15 years, we can estimate a yearly fracture incidence for children less than 3 years of age presenting to the YNHH Pediatric Emergency Department in the early, middle, and late time periods of 1.3%, 1.7%, and 1.2%, respectively. Since the estimated fracture incidence in our study population does not seem to have changed over time, the increase in yearly fracture rates from the early to middle time periods may reflect the population increase in the area. As noted in the Introduction, there was a 26% increase in the population of children less than 5 years of age in New Haven County and a 24% increase in the number of children less

than 3 years of age in the state of Connecticut between 1981 and 1992. However, there was an even greater increase (50%) between the early and middle samples in the number of children presenting with fractures, and this number remained stable between the middle and late groups despite a 7.9% decrease in the state-wide population less than 3 years of age and a 9.6% decrease in the number of children less than 5 years of age in the County. Since we do not have information regarding the city of residence for children in the early group, it is not possible to examine changes in the Emergency Department's catchment area over the three time periods. When comparing the middle and late time periods, however, there was not a significant difference in the percentage of study subjects who resided in New Haven County (85.2% in the middle vs. 80.2% in the late).

Table 8 shows the sociodemographic characteristics of the three samples. There were no significant differences between the three groups in terms of gender. There were, however, significant differences in the race and ethnicity of the children, with more Hispanic children and fewer African-American children in the middle and late groups compared to the early. This likely reflects the state-wide increase in the Hispanic population, as outlined in the Introduction. There was also a significant difference in the type of medical insurance, in the type of primary physician (private vs. clinic), and in the age of the children between the three time periods.

Table 9 shows the distribution of ratings for the three time periods. The percentage of cases rated as abuse decreased from 22.5% in the early group to 10.0% in the middle and 10.8% in the late group. When we compared the early and late samples controlling for race and physician type, the adjusted odds ratio is 2.58 (95% CI=1.43, 4.65, p=0.0016), indicating that children in the early group had two and a half times the

odds of an abusive fracture when compared to the late group. There was not a statistically significant difference in the odds of abuse between the middle and late groups (adjusted OR 0.86, 95% CI=0.46, 1.63, p=0.65).

Table 10 shows a stratified analysis of abuse rates in each age group for the three time periods. In the early group, 38.7% of the children less than 12 months of age were rated as abuse; this percentage was 22.8% in the middle group and 23.6% in the late group. The odds ratios describing the association between age and abuse were 6.88 (95% CI=3.09 to 15.31) for the early group, 7.62 (95% CI=2.89 to 20.11) for the middle, and 5.88 (95% CI=2.40 to 14.37) for the late group. We performed a Breslow-Day test to determine whether these odds ratios were significantly different. The p-value of the Breslow-Day was 0.93, indicating that we cannot reject the null hypothesis that the odds ratios are homogenous; in fact, the magnitude of association between age and rating of abuse was almost identical in all three time periods. The greater number of fractures in children less than 12 months of age in the early period is therefore likely due to the higher incidence of abuse in this time period as compared to the two later groups.

The percentage of cases rated as “unknown” also differed significantly between the three groups. The proportion of cases rated as unknown decreased from 7.5% in the early group to 2.1% in the middle group and 1.7% in the late group. This could be the result of better emergency department documentation (and, therefore, fewer cases with inadequate information).

Table 11 and Figure 1 show the location of the fractures and the proportion of each fracture type that was due to abuse for the three time periods. There were changes over time in the percentage of certain fracture types that were rated as abuse. Notably,

there were significant decreases in the percentage of skull, radius/ulna, and tibia/fibula fractures rated as abuse over the three time periods. The proportion of femur and humerus fractures that were rated as abuse decreased from the early to the middle period and increased again in the late period. Rib fractures were consistent, with 100% of fractures in all three periods rated as abuse.

DISCUSSION

The purpose of our study was twofold: to determine patterns of fractures in young children that are distinctive of abuse, and to examine changes in the rates of abusive fractures over three time periods. The discussion section will highlight important findings related to each objective and will address several strengths and weaknesses of the current study as well as implications for practice and for future research.

Key Findings: Characteristics of Fractures Rated as Abuse in the Late Group

In the late group (1999-2002), the most common fractures seen in children less than three years of age were of the radius/ulna, skull, humerus, and tibia/fibula. Fractures of the ribs, femur, humerus, and tibia/fibula were most highly associated with abuse. As in other studies,[17, 19-21] the rates of abusive femur and humerus fractures were even higher in children less than 12 months of age. When we examine femur and humerus fractures more specifically, there was not an association between fracture type (such as spiral fractures) and abuse.

In the group at large, falls were the most commonly reported history, described in 71.1% of presentations. Amongst children with fractures rated as abuse, we found a much lower frequency of reported falls (12%) and a higher frequency of children presenting without a history of trauma but with a noted abnormality such as swelling or decreased movement (60%). This finding of vague, limited, or absent fracture history in abuse cases has been reported in other studies.[13, 15, 16] Abused children in our sample also had a greater delay from the time of the injury to presentation than children with accidental fractures.

Several demographic features differed between the group with abusive fractures and those with accidental fractures. Abused children were younger, more likely to be African-American or Hispanic, and more likely to have Medicaid or to be self-pay patients. Young age, minority race, and low socioeconomic status have been shown in other studies to be risk factors for child abuse.[1, 5, 6, 15]

Key Findings: Changes over Time

In young children, the proportion of fractures due to abuse has decreased dramatically over the past three decades at one major medical center, with rates decreasing from 22.5% in the early group (1979-83) to 10.0% in the middle group (1991-94), and 10.8% in the late group (1999-2002). Children in the early group had two and a half times the odds of an abusive fracture when compared with the late group; the odds of abuse did not differ significantly between children in the middle group and those in the late group.

In contrast, both national and state data show an increase in the incidence of substantiated cases of child maltreatment from the 1970s to the early 1990s, with a subsequent decline in rates since that time.[1, 26] The dramatic decrease in abusive fractures in young children who were evaluated at YNHH during this same time period is not in accordance with these data. However, this is the first study to examine changing rates of a specific type of injury as a marker for serious physical abuse. The decrease in abusive fractures seen in our study may be the result of an increased awareness of child abuse, the early recognition of less serious forms of child maltreatment, and the implementation of preventive measures in the local community. These efforts may be allowing for the early

identification of children who are at risk of abuse, thereby decreasing the subsequent occurrence of serious abusive injuries such as fractures.

There were several changes in the demographics of the study subjects over the three time periods, but each factor was controlled for in the analysis and they are therefore unlikely to contribute to the observed decline in abuse rates. There were differences in the age distribution of the children in the early sample as compared to the middle and late groups. Although young age is a known risk factor for abuse, age-stratified analysis shows a stable association across the three time periods between age less than 12 months and increased risk of abuse. The observed decrease in abuse rates is, therefore, unlikely to be due to the fact that there were more children under one year of age in the early sample than in the later two groups.

The changes in race and ethnicity over the three time periods reflect state-wide changes in demographics. Differences in insurance and primary physician type also occurred, with more children in the late period having private medical insurance and a private primary physician than in the previous two time periods. However, the increased risk of abuse in the early group is independent of these demographic variables; after controlling for race and physician type, adjusted odds ratios show a significantly increased risk of abuse in the early group as compared with the late group.

Limitations of the Current Study

There are several limitations to our study. First, the study is not population-based. Instead, study subjects included children evaluated for fractures at YNHH. The hospital is a large pediatric referral center, but there are other sources of pediatric emergency and

in-patient care in the city of New Haven and in surrounding areas. Data regarding place of residence was not available for children in the early time period; however, there was not a significant difference in the percentage of children who were residents of New Haven County between the middle and late time periods, indicating relative stability in referral patterns.

Second, cases from each of the three time periods were rated by different individuals. Each time period utilized different pairs of radiologists, and although one clinician rated all cases in all three time periods, the second clinician differed for each group. The criteria used to rate cases, however, was clearly defined and remained stable throughout the study.

Finally, the retrospective methodology of the study has inherent drawbacks. Since our only source of clinical information was the medical record, our data were limited. In some cases, it was difficult to determine if the history seemed incomplete because parents or others reporting the incident were presenting vague or incomplete stories or because documentation in the medical record was imperfect. Since the study dates were before the implementation of electronic medical records and electronic radiographs at our institution, we were also subject to the reality of missing documents and radiographs.

Strengths of the Current Study

Our study is the first to examine trends in abusive fractures over three time periods, and was conducted over a relatively long span of 24 years. We included all consecutive children who presented with fractures, thereby eliminating the bias towards

more severe injuries that is inherent in studies that only examine children identified as abused. Our categorizations of abuse, unknown, and accident were strengthened by a methodology including specific rating criteria as well as 2 independent clinical reviews with a very high kappa for agreement, 2 independent radiologic reviews, also with a very high kappa, and a consensus final rating if possible. Finally, each of the three time periods included over 200 children, allowing for reliable statistical analysis.

Implications for Practice and Future Research

Clinicians must recognize the types of fractures most highly associated with abuse and must be especially attune to the possibility of abuse in children less than one year of age who present with a fracture and in children who present with vague or missing clinical histories.

Local efforts to prevent child abuse may be aiding in the early detection of children at risk of abuse and of children suffering from less severe abusive injuries, thereby decreasing the occurrence of serious injuries such as fractures. Outcome studies evaluating the impact of local interventions would be beneficial. Further examination of certain fracture types such as humerus, tibia/fibula, and skull fractures (where the percent rated as abuse decreased substantially between the early and middle groups) would also be interesting, as would further analysis of the changes in abusive fracture rates within high-risk racial and socioeconomic groups.

Conclusions

In our study of fractures in children less than three years of age at one major pediatric medical center, fractures that were most distinctive of abuse included rib and tibia/fibula fractures, femur and humerus fractures in children less than eighteen months of age, and fractures that were associated with a vague or absent history of trauma. Over the past 24 years, the frequency of abusive fractures at this institution decreased from 22.5% in the early period (1979-1983) to 10.0% in the middle period (1991-1994), and 10.8% in the late period (1999-2002). This decrease may reflect important changes in the early recognition of less serious forms of maltreatment and the prevention of serious abuse, such as fractures.

Table 1

COMPARISON OF X-RAY AND NO X-RAY GROUPS

	X-Ray	**No X-Ray**	**P**
Characteristics	**N (% of 180)**	**N (% of 52)**	
Gender:			
Male	95 (52.8%)	26 (50%)	0.72
Ethnicity:			
White	101 (56.1%)	37 (71.2%)	**0.03**
Black	29 (16.1%)	6 (11.5%)	
Hispanic	38 (21.1%)	3 (5.8%)	
Other	12 (6.7%)	6 (11.5%)	
Medical Insurance:			
Medicaid/Self Pay	83 (46.1%)	19 (36.5%)	0.16
Insurance/HMO	94 (52.2%)	30 (57.7%)	
Unknown	3 (1.7%)	3 (5.8%)	
Primary Physician:			
Private	139 (77.2%)	45 (86.5%)	0.18
Clinic	39 (21.7%)	7 (13.5%)	
Unknown	2 (1.1%)	0	
Age (months):			
0-11	57 (31.7%)	15 (28.9%)	0.70
12-23	58 (32.2%)	20 (38.4%)	
24-35	65 (36.1%)	17 (32.7%)	
Residence:			
New Haven County	146 (81.1%)	40 (76.9%)	0.50
Clinical Ratings (7-pt)			
1—Definite Abuse	10 (5.6%)	2 (3.8%)	0.73
2—Likely Abuse	5 (2.8%)	2 (3.8%)	
3—Questionable Abuse	1 (0.6%)	0	
4—Unknown	2 (1.1%)	0	
5—Questionable Accident	15 (8.3%)	8 (15.4%)	
6—Likely Accident	145 (80.5%)	39 (75%)	
7—Definite Accident	2 (1.1%)	1 (1.9%)	
Clinical Ratings (3-pt)			
Abuse	16 (8.9%)	4 (7.7%)	0.72
Unknown	2 (1.1%)	0	
Accident	162 (90%)	48 (92.3%)	

Table 2

RATINGS BY DEMOGRAPHIC CHARACTERISTICS
Late Sample (1999-2002)

Characteristics	**Total N (% of 232)**	**Abuse N (% of 25)**	**Unknown & Accident (% of 207)**	**P**
Gender:				
Male	121 (52.2%)	15 (60.0%)	106 (51.2%)	0.41
Ethnicity:				
White	138 (59.5%)	11 (44.0%)	127 (61.4%)	**0.04**
Black	35 (15.1%)	7 (28.0%)	28 (13.5%)	
Hispanic	41 (17.7%)	7 (28.0%)	34 (16.4%)	
Other	18 (7.7%)	0	18 (8.7%)	
Medical Insurance:				
Medicaid/Self Pay	102 (44.0%)	17 (68.0%)	85 (41.1%)	**<0.0001**
Insurance/HMO	124 (53.5%)	5 (20.0%)	119 (57.5%)	
Unknown	6 (2.5%)	3 (12.0%)	3 (1.4%)	
Primary Physician:				
Private	184 (79.3%)	19 (76.0%)	165 (79.7%)	0.91
Clinic	46 (19.8%)	5 (20.0%)	41 (19.8%)	
Unknown	2 (0.9%)	1 (4.0%)	1 (0.5%)	
Age (months):				
0-11	72 (31.0%)	17 (68.0%)	55 (26.6%)	**0.0001**
12-23	78 (33.6%)	5 (20.0%)	73 (35.3%)	
24-35	82 (35.4%)	3 (12.0%)	79 (38.1%)	
Residence:				
New Haven Co.	186 (80.2%)	18 (72.0%)	168 (81.2%)	0.28

Table 3

CLINICAL, RADIOLOGIC, CONSENSUS AND FINAL RATINGS
ON 7-POINT SCALE

	Clinical Rating	Radiologic Rating	Consensus Rating	Final Rating
Def Abuse – 1	12	11	12	14
Likely Abuse – 2	7	6	1	3
Questionable Abuse – 3	1	19	8	8
Unknown – 4	2	11	4	4
Questionable Accident – 5	23	12	19	27
Likely Accident – 6	184	120	134	173
Definite Accident – 7	3	1	2	3
Total	**232**	**180**	**180**	**232**

Table 4

COMPARISON OF CLINICAL AND CONSENSUS RATINGS

	CONSENSUS RATING							
	Def Ab 1	**Likely Ab 2**	**Quest Ab 3**	**Unk 4**	**Quest Acc 5**	**Likely Acc 6**	**Def Acc 7**	**Total**
CLINICAL RATING								
Def Abuse – 1	10	0	0	0	0	0	0	10
Likely Abuse – 2	2	1	2	0	0	0	0	5
Quest Abuse – 3	0	0	1	0	0	0	0	1
Unknown – 4	0	0	0	2	0	0	0	2
Quest Accident – 5	0	0	**3**	2	4	6	0	15
Likely Accident – 6	0	0	**2**	0	15	128	0	145
Definite Accident – 7	0	0	0	0	0	0	2	2
Total	12	1	8	4	19	134	2	180

Table 5

RATINGS BY LOCATION OF FRACTURES
Late Sample (1999-2002)

Bone	**N**	**% of total fractures**	**Abuse**	**Unknown**	**Accidental**
Radius/Ulna	53	20.9%	4 (7.5%)	0	49 (92.5%)
Skull	51	20.2%	4 (7.8%)	1 (1.9%)	46 (90.2%)
Humerus	41	16.2%	8 (19.5%)	0	33 (80.5%)
Tib/Fib	39	15.4%	5 (12.8%)	0	34 (87.2%)
Femur	24	9.5%	7 (29.2%)	0	17 (70.8%)
Clavicle	17	6.7%	1 (5.9%)	1 (5.9%)	15 (88.2%)
Ribs	12	4.7%	12 (100%)	0	0
Hand	8	3.2%	0	0	8 (100%)
Foot	6	2.4%	1 (16.7%)	2 (33.3%)	3 (50%)
Scapula	1	0.4%	1 (100%)	0	0
Spine	1	0.4%	1 (100%)	0	0
TOTAL	**253**	100%	44	4	205

* Note: This table includes the total number of fractures, not the number of cases which included a specific fracture type. For humerus, tibia/fibula, and radius/ulna fractures, several cases included multiple fractures.

# of Fractures	**Total** **N (% of 232)**	**Abuse** **N (% of 25)**	**Unknown & Accidental** **N (% of 207)**
Single Fracture	221 (95.3%)	16 (64.0%)	205 (99.0%)
Multiple Fractures	11 (4.7%)	9 (36.0%)	2 (1.0%)

Table 6

CASES WITH FEMUR FRACTURES BY AGE AND RATING

Age	**Abuse**	**Unknown**	**Accidental**	**Total**
0-11 mo	5 (41.7%)	0	7 (58.3%)	12
12-23 mo	2 (40%)	0	3 (60%)	5
24-35 mo	0	0	7 (100%)	7
Total	7 (29.2%)	0	17 (70.8%)	24

Table 7

CASES WITH HUMERUS FRACTURES BY AGE AND RATING

Age	**Abuse**	**Unknown**	**Accidental**	**Total**
0-11 mo	4 (80%)	0	1 (20%)	5
12-23 mo	2 (10.5%)	0	17 (89.5%)	19
24-35 mo	0	0	15 (100%)	15
Total	6 (15.4%)	0	33 (84.6%)	39

* Note: This table describes cases with humerus fractures (39 cases with 6 rated as abuse), not the total number of humerus fractures (41). One case of abuse presented with three separate humerus fractures.

Table 8

DEMOGRAPHIC CHARACTERISTICS OF SAMPLES

	EARLY 1979-83	**MIDDLE 1991-94**	**LATE 1999-02**	**P**
Characteristics	**% of 200**	**% of 240**	**% of 232**	
Gender:				
Male	54.5	56.3	52.2	0.67
Ethnicity:				
White	54.5	55.4	59.5	**<0.0001**
Black	33.5	21.3	15.1	
Hispanic	10.5	19.2	17.7	
Other	1.5	4.2	7.8	
Medical Insurance:				
Medicaid/Self Pay	61.0	58.4	44.0	**<0.0001**
Private Insurance	34.5	32.5	53.5	
Unknown	4.5	9.2	2.5	
Primary Physician:				
Private	46.0	61.7	79.3	**<0.0001**
Clinic	52.0	29.6	19.8	
Unknown	2.0	8.7	0.9	
Age (months):				
0-11	46.5	32.9	31.0	**0.01**
12-23	24.5	32.5	33.6	
24-35	29.0	34.6	35.3	
Residence:				
New Haven County	Not available	85.2	80.2	0.16

Table 9

DISTRIBUTION OF RATINGS

	EARLY 1979-83	**MIDDLE 1991-94**	**LATE 1999-02**
Ratings	**N (%)**	**N (%)**	**N (%)**
Abuse	45 (22.5%)	24 (10.0%)	25 (10.8%)
Unknown	15 (7.5%)	5 (2.1%)	4 (1.7%)
Accident	140 (70.0%)	211 (87.9%)	203 (87.5%)
Total	200	240	232

Table 10

STRATIFIED ANALYSIS OF ABUSE IN EACH AGE GROUP AND TIME PERIOD

% Abuse

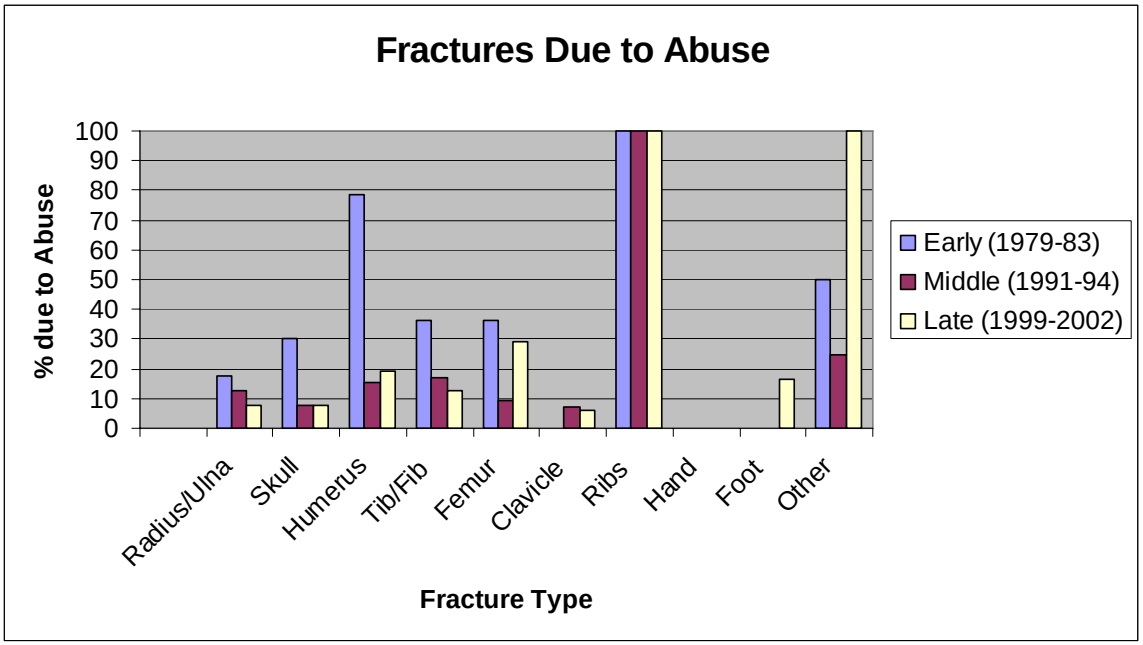
	EARLY	**MIDDLE**	**LATE**
< 12 mo	38.7%	22.8%	23.6%
12-23 mo	14.3%	6.4%	6.4%
24-35 mo	3.4%	1.2%	3.7%

Table 11

LOCATION OF FRACTURE

	EARLY 1979-83		MIDDLE 1991-94		LATE 1999-02	
Bone	**N**	**% Abuse**	**N**	**% Abuse**	**N**	**% Abuse**
Radius/Ulna	17	17.6	40	12.5	53	7.5
Skull	90	30.0	65	7.7	51	7.8
Humerus	14	78.6	32	15.6	41	19.5
Tib/Fib	33	36.4	41	17.1	39	12.8
Femur	25	36.0	32	9.4	24	29.2
Clavicle	25	0	14	7.1	17	5.9
Ribs	10	100	12	100	12	100
Hand	10	0	18	0	8	0
Foot	6	0	5	0	6	16.7
Other	2	50.0	4	25.0	2	100
TOTAL	232		263		253	

Figure 1



Appendix A

CLINICAL ABSTRACTION FORM

1. Subject #:

2. Event #:

3. Date of Abstraction:

4. Reviewer: _____

5. Date of Hospital Visit:

6. Date of Birth:

7. Sex of Patient:
   1=Female 2=Male

8. Race of Patient:
   1=Black 2=White 3=Asian 4=Hispanic 5=Black/White
   6=Hispanic/White 7=Hispanic/Black 8=Other 9=Unknown

9. Address (City, State): _____, _____

10. Type of Physician: [_____]
    name if private
    0=None 1=HSR 2=HHC 3=FHC 4=PMD 5=PCC 6=CHCP 7=Other Clinics 8=YHP 9=Unknown

11. Billing:
    1=T-19 2=City 3=Self 4=Insurance or HMO 9=Unknown

12. Was the child listed in the YNHH Pediatric ER log?
    0=No 1=Yes

13. Was the child listed in the MIS log?
    0=No 1=Yes

14. Was the child listed in the DART log?
    0=No 1=Yes

15. Was the child listed in the Pediatric Trauma Admissions log?
    0=No 1=Yes

16. Was the patient admitted to the hospital?
    0=No 1=No, because signed out against medical advice 2=Yes

17. Chief Complaint: _____

18. Event Description: _____
_____
_____
_____

19. Was the event witnessed?
    0=No 1=Yes 2=Unknown
20. Delay since reported accident:
    1= 0-5hrs 2= 6-12hrs 3= 13-24hrs 4= >24hrs 5=Unknown

21. Fall From: _____ Height: _____
    Onto: _____

22. Special Equipment Involved: _____

23. Added Twist Noted:
    0=No 1=Yes 2=Unknown

24. Added Blow Noted:
    0=No 1=Yes 2=Unknown

25. Radiology Report:
    Date: _____

    Location of Films: _____

    Finding: _____
    _____
    _____
    _____

    Was Skeletal Survey Done?
    0=No 1=Yes, negative 2=Yes, positive _____

HISTORY AND PHYSICAL:

26. Bruises on body?
    0=No 1=Yes, old 2=Yes, new 3=Yes, old and new
    4=Yes, unspecified 5=No mention

27. Bruises on face and head?
    0=No 1=Yes, old 2=Yes, new 3=Yes, old and new
    4=Yes, unspecified 5=No mention

28. Was an eye exam performed by an ophthalmologist?
    0=No 1=Yes, normal
    2=Yes, abnormal with retinal hemorrhage

29. Concerns about developmental delay?
    0=No 1=Yes 2=No mention

30. Concerns about failure to thrive?
    0=No 1=Yes 2=Weight low, but no mention 3=No mention

31. Other signs of abuse: _____
    _____
    _____

PAST MEDICAL HISTORY:

32. Did the patient have any previous fractures?
    0=No 1=Yes 2=Unknown
    If yes, what was the type and date of fracture?
        FX 1: 0=Skull 1=Limb 2=Other bone
        _____
        FX 2: 0=Skull 1=Limb 2=Other bone
        _____

33. Past History of medical concerns: _____
    _____
    _____

SOCIAL HISTORY:

34. Was a social worker involved?
    0=No 1=No, because parents refused 2=Yes

35. Was abuse considered in the chart?
    0=Yes, considered definite abuse
    1=Yes, considered likely abuse
    2=No, considered uncertain
    3=No, considered likely accident
    4=No, considered definite accident
    9=Not mentioned

    If yes, who was the suspected perpetrator? _____
    How certain is the reviewer of this?
        0=Definite (confession, arrest) 1=Probable 2=Uncertain
        Reason: _____

_____

36. Is there a history of drug abuse by parent(s)?
    0=No 1=Yes, in past 2=Yes, in present 3=Yes, both
    4=Yes, unspecified 5=Yes, suspected 9=No mention
        If yes, by whom?
        0=Mother 1=Father 2=Both 9=No mention

37. Is there a history of criminal offense by parent(s)?
    0=No 1=Yes, in past 2=Yes, in present 3=Yes, both
    4=Yes, unspecified 5=Yes, suspected 9=No mention
        If yes, by whom?
        0=Mother 1=Father 2=Both 9=No mention

38. Is there a history of family violence?
    0=No 1=Yes, in past 2=Yes, in present 3=Yes, both
    4=Yes, unspecified 5=Yes, suspected 9=No mention
    If yes, involving whom?
        0=father and mother 1=adult and child
        2=ex-husband and mother 9=no mention

39. Was patient DARTed?
    0=No 1=Yes 2=No mention

40. Was DCF notified?
    0=No 1=Yes 2=No mention
    If yes, what action did DCF take? _____
    _____
    _____

41. Did family have a past history with DCF/DART prior to event?
    0=No 1=Yes, DCF only 2=Yes, DART only 3=Yes, both
    4=No mention 5=Yes, DCF, DART no mention
    6=Yes, DART, DCF no mention. 7=No DCF, DART no mention.
    8=No DART, DCF no mention
    Reason: _____
    _____
    _____

42. Was there every any previous concern about child abuse?
    0=No 1=No mention 2=Yes, abuse 3=Yes, neglect
    4=Yes, both 5=Yes, unspecified 9=Unknown

Additional Information: _____
_____

FOLLOW UP INFORMATION (If YNHH is not primary medical center, please circle unknown.)

43. Status of Fracture:
    1=Healing normally
    2=Complications [_____]
    9=Unknown

44. Did patient have another fracture at a later date?
    0=No 1=Yes 9=Unknown
    If yes, what was the type and date of fracture?
        0=Skull 1=Limb 2=Other bone
        _____
        Please describe the event: _____
        _____
        _____

45. Was abuse/neglect considered at any later date?
    0=No mention 1=Yes, abuse considered in chart
    2=Yes, abuse considered by reviewer
    3=Yes, neglect considered in chart
    4=Yes, neglect considered by reviewer
    5=Yes, both considered in chart
    6=Yes, both considered by reviewer
    9=Unknown
    If yes, reason: _____
    _____

46. Was the child ever hospitalized at any later date?
    0=No 1=Yes 2=No, because signed out AMA
    9=Unknown
    If yes, reason: _____
    _____

47. What is the custody status of the child in most recent records?
    1=Still at home 2=Returned to home 3=Foster care
    4=Relative's care 9=Unknown
    What is the date of the most recent records?

Other follow up information: _____
_____
_____

Appendix B

CLINICAL CRITERIA TO DISTINGUISH ABUSE FROM ACCIDENTS

1) Definite Abuse
    - 1.1 – Positive skeletal survey
    - 1.2 – Eye witness
    - 1.3 – Multiple internal injuries
    - 1.4 – Physical findings: unexplained or suspicious bruises, burns, scars
    - 1.5 – Sibling abused at the same time
    - 1.6 – A definite intentional act causing physical harm to child
    - 1.7 – Parental fight, injury not directed at child
    - 1.8 – Suspicious injury with definite later abuse

2) Likely Abuse
    - 2.1 – Original doctors called injury abuse AND history inconsistent:
        - History not sufficient for injury and/or
        - Story of accident changes and/or
        - Family members present different versions of history and/or
        - Inappropriate delay in seeking care and/or
        - History Unknown

3) Questionable Abuse
    - 3.1 – History inconsistent:
        - History not sufficient for injury and/or
        - Story of accident changes and/or
        - Family members present different versions of history and/or
        - Inappropriate delay in seeking care

4) Unknown Cause
    - 4.1 – Insufficient information available in chart

5) Questionable Accident
    - 5.1 – Isolated incident, MSW/MD no suspicion of abuse, story somewhat inconsistent with extent of injury, but consistent with type of injury
    - 5.2 – Story somewhat inconsistent with extent of injury, MSW/MD no suspicion of abuse, neglect involved
    - 5.3 – Isolated incident, no suspicion of abuse, story not known
    - 5.4 – Isolated incident, MSW/MD with suspicion of abuse, story somewhat inconsistent

6) Likely Accident
    - 6.1 – Consistent story, MSW/MD no suspicion of abuse, isolated injury
    - 6.2 – Consistent story, no suspicion of abuse, neglect involved
    - 6.3 – Minimal but consistent story, MSW/MD no suspicion of abuse, isolated incident

6.4 – Story consistent with injury; aggressive or irresponsible behavior involved, however injury not directly inflicted (ex: fall from bed < 2 years old, fall down un-gated stairs < 2 years old, fall from table < 1 year old, fall from open window)
6.5 – Consistent story, underlying bone pathology
6.6 – Consistent story, MSW/MD no suspicion of abuse, but old injury newly discovered without history to explain it

7) Definite Accident
7.1 – Motor Vehicle accident
7.2 – Multiple witnesses (police report, ambulance at scene)
7.3 – Pedestrian hit by automobile

Appendix C

Radiological Abstraction Form

Subject #: _____

Date of Review: _____

Patient Age: ____ mos Date of X Rays: _____

Admission History: _____
_____
_____
_____
_____

RADIOLOGICAL FINDINGS: (Please complete in joint session only)

If there is a skeletal survey, please indicate whether it is positive or negative:
0=No survey 1=Positive 2=Negative

RADIOGRAPHS USED:
MR of Head?
0=No 1=Yes 2=Not available
CT of Head?
0=No 1=Yes 2=Not available
CT of Abdomen?
0=No 1=Yes 2=Not available

TYPE OF PRIMARY FRACTURE:
1=Skull bone 2=Other bone 3=No fracture

AGE OF PRIMARY FRACTURE:
1=less than 1 week 2=1-2 weeks
3=2 weeks-3 months 4=>3months

SKULL:
1=Parietal 2=Occipital 3=Basilar 4=Temporal 5=Frontal
6=Parieto-occipital 7=Fronto-parietal 8=Sphenoid

1=Unilateral 2=Bilateral

1=Diastatic 2=Hairline 3=Depressed 4=Simple 5=Comminuted

1=Branching 2=Nonbranching

1=Long length 2=Short length 3=Very short length

1=Epidural Hematoma 2=Subdural Hematoma
3=Intracerebral Hematoma 4=Other _____

IF THE FRACTURED BONE IS NOT THE SKULL:
1=Humerus 2=Radius 3=Ulna 4=Femur 5=Tibia 6=Fibula
7=Radius/Ulna 8=Tibia/Fibula 9=Clavicle 10=Hand
11=Foot 12=Spine 13=Rib(s) 14=Pelvis
1=Prox Third 2=Mid Third 3=Distal Third
4=Epiphyseal 5=Metaphyseal

1=Spiral 2=Oblique 3=Horizontal 4=Greenstick
5=Torus 6=Salter 7=Other

1=Toddler's Fracture 2=Buckle Fracture 3=Supracondylar

IF SECOND FRACTURE THEN PLEASE FILL IN INFORMATION BELOW:

RADIOGRAPHS USED:
MR of Head?
0=No 1=Yes 2=Not available
CT of Head?
0=No 1=Yes 2=Not available
CT of Abdomen?
0=No 1=Yes 2=Not available

TYPE OF PRIMARY FRACTURE:
1=Skull bone 2=Other bone 3=No fracture

AGE OF PRIMARY FRACTURE:
1=less than 1 week 2=1-2 weeks
3=2 weeks-3 months 4=>3months

SKULL:
1=Parietal 2=Occipital 3=Basilar 4=Temporal 5=Frontal
6=Parieto-occipital 7=Fronto-parietal 8=Sphenoid

1=Unilateral 2=Bilateral

1=Diastatic 2=Hairline 3=Depressed 4=Simple

1=Branching 2=Nonbranching

1=Long length 2=Short length 3=Very short length

1=Epidural Hematoma 2=Subdural Hematoma
3=Intracerebral Hematoma 4=Other _____

IF THE FRACTURED BONE IS NOT THE SKULL:
1=Humerus 2=Radius 3=Ulna 4=Femur 5=Tibia 6=Fibula
7=Radius/Ulna 8=Tibia/Fibula 9=Clavicle 10=Hand
11=Foot 12=Spine 13=Rib(s) 14=Pelvis

1=Prox Third 2=Mid Third 3=Distal Third
4=Epiphyseal 5=Metaphyseal

1=Spiral 2=Oblique 3=Horizontal 4=Greenstick
5=Torus 6=Salter 7=Other

1=Toddler's Fracture 2=Buckle Fracture 3=Supracondylar

IF THIRD FRACTURE FOUND THEN PLEASE FILL IN INFORMATION BELOW:

RADIOGRAPHS USED:
MR of Head?
0=No 1=Yes 2=Not available
CT of Head?
0=No 1=Yes 2=Not available
CT of Abdomen?
0=No 1=Yes 2=Not available

TYPE OF PRIMARY FRACTURE:
1=Skull bone 2=Other bone 3=No fracture

AGE OF PRIMARY FRACTURE:
1=less than 1 week 2=1-2 weeks
3=2 weeks-3 months 4=>3months

SKULL:
1=Parietal 2=Occipital 3=Basilar 4=Temporal 5=Frontal
6=Parieto-occipital 7=Fronto-parietal 8=Sphenoid

1=Unilateral 2=Bilateral

1=Diastatic 2=Hairline 3=Depressed 4=Simple

1=Branching 2=Nonbranching

1=Long length 2=Short length 3=Very short length

1=Epidural Hematoma 2=Subdural Hematoma
3=Intracerebral Hematoma 4=Other _____

IF THE FRACTURED BONE IS NOT THE SKULL:
1=Humerus 2=Radius 3=Ulna 4=Femur 5=Tibia 6=Fibula
7=Radius/Ulna 8=Tibia/Fibula 9=Clavicle 10=Hand
11=Foot 12=Spine 13=Rib(s) 14=Pelvis

1=Prox Third 2=Mid Third 3=Distal Third
4=Epiphyseal 5=Metaphyseal

1=Spiral 2=Oblique 3=Horizontal 4=Greenstick
5=Torus 6=Salter 7=Other

1=Toddler's Fracture 2=Buckle Fracture 3=Supracondylar

1. RADIOLOGIST'S DIAGNOSIS: (Please explain decision noted below.)

Def.Ab. Lik. Ab. Ques.Ab. Unk. Ques.Ac. Lik.Ac Def.Ac NoFx

Please Initial: _____

2. RADIOLOGIST'S DIAGNOSIS: (Please explain decision noted below.)

Def.Ab. Lik. Ab. Ques.Ab. Unk. Ques.Ac. Lik.Ac Def.Ac NoFx

Please Initial: _____

JOINT RADIOLOGIST'S DIAGNOSIS:

Def.Ab. Lik. Ab. Ques.Ab. Unk. Ques.Ac. Lik.Ac Def.Ac NoFx

Appendix D

RADIOLOGICAL CRITERIA TO DISTINGUISH ABUSE FROM ACCIDENTS

1) Definite Abuse
    - 1.1 – Serious trauma must have been involved, not reflected in history.
    - 1.2 – Serious trauma must have been involved, suspicious delay in reporting.
    - 1.3 – Multiple fractures found, not explained by history.
    - 1.4 – Healing fractures found, not explained by history.

2) Likely Abuse
    - 2.1 – Injury severe, history does not reflect sufficient severity.

3) Questionable Abuse
    - 3.1 – Suspicious fracture, check history for further explanation.
    - 3.2 – Suspicious delay in reporting.

4) Unknown Cause
    - 4.1 – Fracture not suspicious, story incomplete, check further.

5) Questionable Accident
    - 5.1 – Fracture not suspicious, story consistent, not enough details.

6) Likely Accident
    - 6.1 – Fracture not suspicious, story consistent with fracture.

7) Definite Accident
    - 7.1 – Fracture not suspicious, story consistent and thorough, witnesses (e.g. MVA, police, teacher, doctor, etc).

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