

PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Prevalence of Abusive Injuries in Siblings and Household Contacts of Physically Abused Children

Daniel M. Lindberg, Robert A. Shapiro, Antoinette L. Laskey, Daniel J. Pallin, Emily A. Blood and Rachel P. Berger

Pediatrics; originally published online July 9, 2012;

DOI: 10.1542/peds.2012-0085

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/early/2012/07/03/peds.2012-0085>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2012 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



Prevalence of Abusive Injuries in Siblings and Household Contacts of Physically Abused Children

AUTHORS: Daniel M. Lindberg, MD,^{a,b} Robert A. Shapiro, MD,^c Antoinette L. Laskey, MD, MPH,^d Daniel J. Pallin, MD, MPH,^{a,b} Emily A. Blood, PhD,^e and Rachel P. Berger, MD, MPH^f

^aDepartment of Emergency Medicine, Brigham & Women's Hospital, Boston, Massachusetts; ^bDivision of Emergency Medicine, and ^cClinical Research Program, Children's Hospital Boston, Boston, Massachusetts; ^dMayerson Center for Safe & Healthy Children, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; ^eDepartment of Pediatrics, Children's Health Services Research, Indianapolis, Indiana; and ^fDepartment of Pediatrics, Children's Hospital Pittsburgh of University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania

KEY WORDS

abuse, siblings, skeletal survey, screening

ABBREVIATIONS

CI—confidence interval

CPS—child protective services

SS—skeletal survey

www.pediatrics.org/cgi/doi/10.1542/peds.2012-0085

doi:10.1542/peds.2012-0085

Accepted for publication Mar 27, 2012

Address correspondence to Daniel M. Lindberg, MD, Department of Emergency Medicine, Brigham & Women's Hospital, 75 Francis St—Neville House, Boston, MA 02132. E-mail: dlindberg@partners.org

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2012 by the American Academy of Pediatrics

FINANCIAL DISCLOSURE: Drs Lindberg, Shapiro, and Laskey have provided paid expert testimony for prosecution and defense in cases of alleged child physical abuse; and Drs Pallin, Blood, and Berger declare they have no financial relationships relevant to this article to disclose.

FUNDING: This project was supported by a grant from the Health Resources and Services Administration/Maternal and Child Health Bureau, Emergency Medical Services for Children Program (grant H34MC19346-01-02). Dr Lindberg's effort is funded in part by an Eleanor and Miles Shore Fellowship for Scholars in Medicine from Harvard Medical School. The funders played no role in design and conduct of the study; in collection, management, analysis, and interpretation of the data; and in preparation, review, or approval of the manuscript.



WHAT'S KNOWN ON THIS SUBJECT: Siblings and other contacts of abused children, especially twins, are thought to be at higher risk for abuse than other children. However, the rate at which screening tests identify injuries in contacts is currently unknown.



WHAT THIS STUDY ADDS: Contacts of abused children with serious injuries have fractures identified on skeletal survey at significant rates. Twins are at substantially increased risk for fracture. Physical examination findings were not sensitive for fractures.

abstract

OBJECTIVE: Siblings and other children who share a home with a physically abused child are thought to be at high risk for abuse, but rates of injury in these contact children are unknown and screening of contacts is highly variable. Our objective was to determine the prevalence of abusive injuries identified by a common screening protocol among contacts of physically abused children.

METHODS: This is an observational, multicenter cross-sectional study of children evaluated for physical abuse, and their contacts, by 20 US child abuse teams who used a common screening protocol for the contacts of physically abused children with serious injuries. Contacts underwent physical examination if they were <5 years old, physical examination and skeletal survey (SS) if they were <24 months old, and physical examination, SS, and neuroimaging if they were <6 months old.

RESULTS: Protocol-indicated SS identified at least 1 abusive fracture in 16 of 134 contacts (11.9%, 95% confidence interval [CI] 7.5–18.5) <24 months of age. None of these fractures had associated findings on physical examination. No injuries were identified by neuroimaging in 19 of 25 eligible contacts (0.0%, 95% CI 0.0–13.7). Twins were at substantially increased risk of fracture relative to nontwin contacts (odds ratio 20.1, 95% CI 5.8–69.9).

CONCLUSIONS: SS should be obtained in the contacts of injured, abused children for contacts who are <24 months old, regardless of physical examination findings. Twins are at higher risk of abusive fractures relative to nontwin contacts. *Pediatrics* 2012;130:1–9

Physical abuse is an important, and often overlooked, source of morbidity and mortality in childhood.^{1,2} Early detection can protect children because abuse is often an escalating phenomenon.^{3–5} Many abusive injuries are clinically occult, and serious injuries can be missed even with careful examination.^{6,7} Screening high-risk populations can increase detection of abuse,^{8,9} and siblings and other contacts who share a home with an abused child may represent 1 such population.^{10,11}

Violence often affects an entire household. Child abuse commonly coexists with intimate partner violence,^{12–15} and abuse of pets has been linked with both child abuse and intimate partner violence.¹⁶ Contacts of abused children are victimized at high rates in the years after an initial report of abuse, but the number of contacts who have injuries at the time of the initial referral is unknown.^{17,18} Case reports suggest that twins of abused children are at especially high risk for abuse, but this has never been tested rigorously.^{19,20}

Child abuse physicians are subspecialty consultants who recommend screening when there is concern for physical abuse, although they rely on cooperation from child protective services (CPS) and others to complete testing.²¹ CPS agencies are governmental organizations charged with, among other things, investigating reports of abuse and protecting children. In index children, several organizations support guidelines including skeletal survey (SS) for all children with concern for abuse <24 months old.^{22,23} However, in contact children, in the absence of data about injury prevalence, disagreement about the need for screening is common between medical and CPS professionals,^{11,24} and rates of screening (physical examination, SS, and neuroimaging) show high variability.^{10,24}

METHODS

This was a prospective, observational, cross-sectional study involving 20 child abuse teams in the United States who shared a common, minimum standard of care for screening the contacts of abused children. Each team and the coordinating center obtained approval from their respective institutional review board with waiver of informed consent. All screening for abuse was undertaken as part of routine care, and no testing was done for research purposes. Each site established an independent, prospective method for tracking the census of eligible patients, and we tracked enrollment with monthly audits. Missed patients were entered retrospectively. On the basis of monthly censuses, all participating centers completed enrollment for >90% of eligible patients.

Patients

We defined index children as children <120 months (10 years) old who were evaluated by a child abuse physician for concerns of physical abuse. Contact children were defined as children <120 months (10 years) old who, in the previous month, were known to share the same household or other care environment where abuse was suspected in an index child. We included contacts from in-home day cares but excluded contacts from commercial day cares because of the potential for large numbers of contacts and the very low rates of abuse at commercial day cares.²⁵ When multiple children from 1 household presented simultaneously with concerns of abuse, all were designated as index children.

We defined index children as “physically abused” if they had both a high likelihood of abuse and at least 1 serious injury (Fig 1). Our screening protocol was used for the contacts of such physically abused index children. The likelihood of abuse was described by

the child abuse physician using a previously published 7-point scale. A score of 6 or 7 on this scale was considered “high likelihood” (Appendix).²⁶ This scale uses example cases for each category to improve interrater reliability but ultimately relies on the opinion of the responsible child abuse physician. For example, patterned bruises or burns are listed as an example of category 7, definite inflicted injury, but a child abuse physician could choose to describe a child differently if, for example, the pattern was consistent with an accidental injury or if the child had a bleeding diathesis. Serious injury was defined as fracture(s), burns of >5% total body surface area, traumatic brain injury, intra-abdominal or intrathoracic injury, ICU admission, or death.

Screening Protocol for Contacts

The common screening protocol was used for contacts of physically abused index children as defined earlier. For these contacts, the protocol determined the minimum screening recommendations by age. Child abuse physicians were expected to recommend in-person examination by CPS personnel or physical examination by a medical provider for contacts <5 years old. For contacts <24 months of age, the protocol directed child abuse physicians to recommend SS and physical examination by a medical provider. Contacts <6 months old were expected to undergo neuroimaging in addition to SS and physical examination.

The protocol articulated a common minimum standard for contact screening, and child abuse physicians were free to recommend additional screening. Although the protocol defined the recommendations to be made by child abuse physicians, it could not ensure that screening was ultimately completed, because this may have depended on cooperation from CPS, other medical providers, law enforcement, and others.

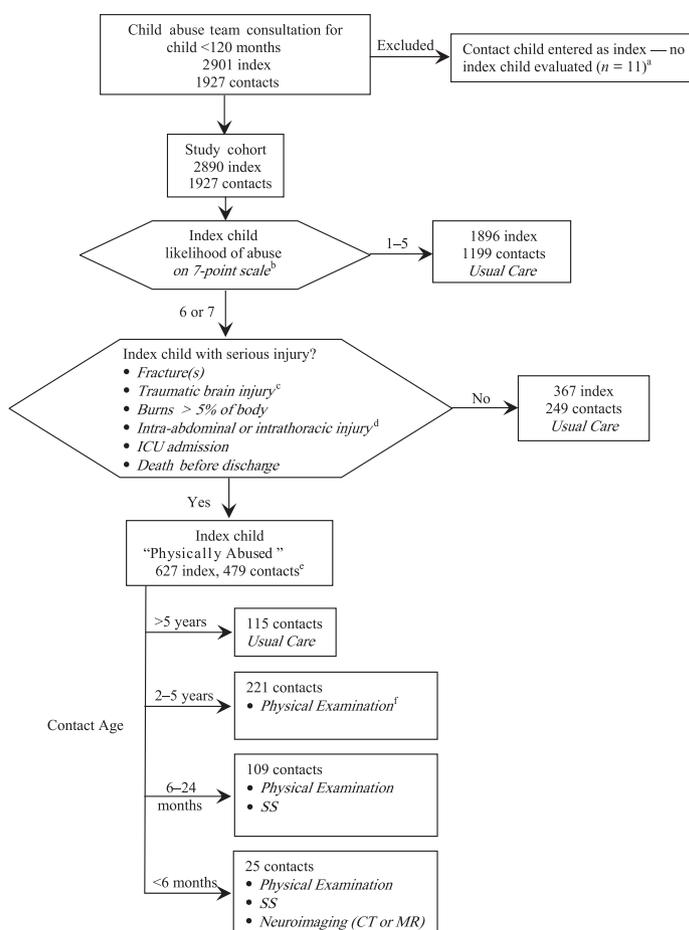


FIGURE 1

Screening protocol and patient flow. All participating centers used this protocol to determine minimum screening for contact children. Screening beyond this protocol was recommended at the discretion of the clinical team caring for the patient. ^aThese cases included children for whom the concern for abuse stemmed from injuries to a child that had been evaluated at another center or cases in which the index child died before being brought for evaluation. ^bA 6 on the scale represents “Substantial Evidence of Inflicted Injury,” such as inappropriate delay in seeking care or multiple severe injuries of different ages without plausible explanation. A “7” is “Definite Inflicted Injury,” such as unexplained posterior rib fractures, metaphyseal fractures, or characteristic retinal hemorrhages. Although the scale includes examples for each category, the opinion of the consulting child abuse physician ultimately determined the rating (see appendix). ^cTraumatic brain injury is defined as an intracranial injury. Children with isolated skull fracture were not considered to have traumatic brain injury. ^dIntra-abdominal or intrathoracic injury required radiographic or pathologic evidence of injury. Abnormal laboratory testing alone (eg, elevated aspartate aminotransferase or lipase) was not considered evidence of injury. ^eThe number of contacts sums to 470 because 9 contacts in this group were of unknown age. ^fFor contacts aged 2 to 5 years, physical examination could consist of an in-person evaluation by CPS and/or a full physical examination by a health care provider.

All participating centers conducted SS according to guidelines published by the American Academy of Pediatrics and the American College of Radiology.^{22,27} SS were interpreted by attending radiologists with experience reading SS as part of their clinical duties at each participating center. Physical examinations were conducted according to the normal practices of

the examiner. Neuroimaging could consist of CT or MRI, but not ultrasound.

Endpoints

The main outcome measure was the proportion of protocol-indicated SS that identified an abusive fracture in a contact child. Secondary outcomes included the proportions of protocol-indicated physical examinations and

neuroimaging that identified injuries in contacts.

Sample Size

Our sample size was determined by using the presumption that clinicians would routinely order SS for a group in which the rate of abusive fractures identified was >5%. To have 80% power at the 2-sided .05 significance level to exclude a rate of 5% if the true rate of abusive fractures is $\geq 9.3\%$, we would need to recruit 250 contacts who meet protocol criteria for SS. A pilot study of 8 participating child abuse teams suggested that we would enroll 250 such contacts if we enrolled at least 2500 index subjects, and our funding was budgeted to enroll this number. However, we were only able to enroll 134 contacts meeting protocol criteria for SS when our funding limit was reached, despite enrolling 2890 index children.

Statistical Analysis

Data were entered via a secure, web-based data entry form (Quickbase, Intuit, Waltham, MA). Data included the initial history of trauma or chief complaint in the index child, demographic information, screening tests performed, and all injuries identified for index and contact children. Race and ethnicity of index children were collected to determine if these characteristics were related to the decision to undertake screening. Race was recorded by the child abuse physician according to the information reported at hospital registration by the patient or their caregiver. We calculated proportions and their associated confidence intervals (CIs) by using intercept-only generalized estimating equations, which account for the correlation of observations from contacts with the same index child. Odds ratios were calculated with logistic generalized estimating equations assuming a compound symmetric working

correlation structure to account for correlation of observations from contacts with the same index child. We used SAS 9.2 (The SAS Institute, Cary, NC) for all analyses.

RESULTS

Between January 15, 2010, and April 30, 2011, we evaluated 2901 children for concerns of physical abuse (index children). These index children had 1927 identified contacts. We excluded 11 consultations in which contact children were initially coded as index children. In these cases, data were not available for the true index child because the child died before presentation or was evaluated at a nonparticipating center (Fig 1). Among these index children, 627 (21.7%) met our research definition of “physically abused,” and these children had 479 contacts, of whom 134 were <24 months old.

Index children had as many as 9 contacts identified (Table 1). Level of concern for abuse and injuries identified among index children are shown in Table 2. As with other large groups of children evaluated for physical abuse, index children were predominantly infants, and there was a slight majority of boys.^{2,9} Index and contact children included 80 pairs of twins and 2 sets of triplets. Most contacts (1141, 59.2%) were biological siblings of the index child, with others being half-siblings (470, 24.3%), other relatives such as cousins (130, 6.7%), adopted or step-siblings (51, 2.6%), and in-home daycare contacts (51, 2.6%).

Skeletal Survey

The protocol indicated SS for 134 contacts. The SS was recommended by the child abuse physician in 122 (91.0%) of these cases and was completed in 101 (75.4%). SS identified ≥ 1 abusive fracture in 16 of 134 contacts (11.9%, 95% CI 7.5–18.5).

Among contacts who had SS, 9 children with fractures were identified among

TABLE 1 Demographics of Index and Contact Children

	Index Children <i>n</i> = 2890 (%)	Physically Abused Index Children <i>n</i> = 627 (%)	All Contacts <i>n</i> = 1927	Contacts of Physically Abused Index Children <i>n</i> = 479 (%)
Age, (mo) ^a				
0–6	980 (33.9)	331 (52.8)	170 (8.8) ^b	25 (5.2)
6–12	521 (18.0)	110 (17.5)		21 (4.4)
12–24	474 (16.4)	68 (10.8)	270 (14.0)	88 (18.4)
24–60	634 (21.9)	102 (16.3)	839 (43.5)	221 (46.1)
60–120	281 (9.7)	16 (2.6)	617 (32.0)	115 (24.0)
Unknown	NA	NA	31 (1.6)	9 (1.9)
Gender				
Male	1687 (58.4)	355 (56.6)	871 (45.2)	208 (43.4)
Female	1203 (41.6)	272 (43.4)	874 (45.4)	223 (46.6)
Unknown	NA	NA	182 (9.4)	48 (10.0)
Twins/triplets ^c	91 (3.1)	21 (3.3)	75 (3.9)	17 (3.5)
Number of contacts			NA	NA
0	1670 (57.8)	314 (50.1)		
1	741 (25.6)	198 (31.6)		
2–5	457 (15.8)	115 (18.3)		
6–9	8 (0.3)	0 (0.0)		
Unknown ^d	14 (0.5)	0 (0.0)		

NA, not applicable.

^a A child is younger than 6 mo until the moment of their 6-mo birthday. A child that is 6 mo and 1 min old is grouped with the 6- to 12-mo cohort.

^b Although all index children are brought for care, precise data from contact children who are not brought for care may not be available. Estimates of age within 1 year were used in some cases, such as when abuse experts were told that there was an “infant” at home, but the child’s birth date was unknown.

^c Includes 73 twin pairs of 1 index and 1 contact; 7 twin pairs where both twins were index; and 2 sets of triplets, 1 was 3 index children, the other was 1 index and 2 contacts.

^d The number of contacts could not be determined in cases in which there was an unknown number of day-care contacts or when the precise age of a potential contact was not known and the child may have been older or younger than 120 mo (10 y).

TABLE 2 Characteristics of Index Children

	Index Children <i>n</i> = 2890 (%)	Physically Abused Index Children <i>n</i> = 627 (%)
Level of concern		
1, Definitely not inflicted	150 (5.2)	
2	613 (21.2)	
3	437 (15.1)	
4	341 (11.8)	
5	355 (12.3)	
6	400 (13.8)	260 (41.5)
7, Definitely inflicted	594 (20.6)	367 (58.5)
With identified injuries		
Bruises	1081 (37.4)	324 (51.7)
Burns	221 (7.6)	40 (6.4)
Fracture(s)	1208 (41.8)	448 (71.5)
TBI	586 (20.3)	280 (44.7)
Retinal hemorrhages	256 (8.9)	196 (31.3)
Abdominal/thoracic	95 (3.3)	79 (12.6)

TBI, traumatic brain injury.

the 22 who were <6 months old (40.9%), compared with 4 of 16 (25.0%) contacts 6 to 12 months old and 3 of 63 (4.8%) contacts 12 to 24 months old. Contacts 0 to 12 months old were significantly more likely to have fractures than contacts 12 to 24 months old (odds ratio 10.4, 95% CI 2.5–50.8). Eight

children had isolated fractures and 8 had multiple fractures, with 51 fractures identified in all (Table 3). Seven contacts were noted to have at least 1 fracture with evidence of healing. None of the fractures had associated signs or symptoms such as bruising, swelling, or tenderness on physical examination,

TABLE 3 Fractures Identified in Contacts by SS

Bone	Contacts <i>n</i> = 16 (%)	Fractures <i>n</i> = 51 (%)
Ribs	9 (56)	29 (57)
Hand/foot	4 (25)	6 (12)
CML	3 (19)	10 (20)
Long bone ^a	3 (19)	4 (8)
Skull	2 (13)	2 (4)

The number of contacts does not sum to 16 because contacts with multiple types of fractures are counted more than once. CML, classic metaphyseal lesion.

^a Long bones affected were humerus (2) and tibia (2).

and none were suspected clinically before the SS.

Among the 134 contacts meeting protocol criteria for SS, 16 (11.9%) were twins, and 9 of these (56.3%) had fractures on SS. Twins were significantly more likely than nontwin contacts to have a fracture identified on SS (odds ratio 20.1, 95% CI 5.8–69.9).

Neuroimaging

There were 25 contact children who met criteria to undergo neuroimaging. Neuroimaging was recommended in 22 (88.0%) and completed in 19 (76.0%). No study demonstrated an intracranial injury (0%, 95% CI 0–13.7). One head CT identified a skull fracture that had previously been identified by SS.

Physical Examination

There were 355 contacts who met criteria for physical examination. Physical examination was recommended for 343 (96.6%) of these children and completed in 259 (73.0%). Injuries were identified in 22 contacts (6.2% 95% CI 4.1–9.3) with ages ranging from 2.5 to 59 months (median 26.4 months). Injuries included 19 children with bruises and abrasions, 2 with burns, and 1 with an upper labial frenulum tear.

Child abuse physicians described 6 of the contacts with bruises as having injuries that were patterned or otherwise concerning for abuse. In 6 other contacts, bruises were described as consistent with accidental injury. No

information was given about the specificity of the remaining injuries for abuse. Failure to thrive was not categorized as an identified injury but was noted in 4 additional contacts.

Contacts Not Screened

For each of these modalities, approximately one-quarter of patients did not undergo screening indicated by the protocol, either because child abuse physicians did not recommend testing or because recommended tests were not completed. We did not detect a difference in the age, gender, or type of insurance (a surrogate marker for socioeconomic status) of contacts who were not screened relative to those who were. However, contacts were more likely to undergo screening if the associated index child was of nonwhite race or Hispanic ethnicity (Table 4).

DISCUSSION

To our knowledge, this is the first study to prospectively evaluate screening for physical abuse in contacts of abused children. Nearly half of all index children had at least 1 contact child who shared the same potentially harmful environment. We identified abusive injuries in a significant proportion of contacts who underwent protocol-indicated screening, even though contacts were almost always asymptomatic. These data support obtaining a SS in all children <24 months old who share a household with a physically abused child with a serious injury. The rate of fractures in this group (11.9%) is similar to that of <24-month-old index children being evaluated with concerns for abuse, in whom American Academy of Pediatrics considers the SS to be “mandatory.”^{22,28,29}

Physical examination identified some children with abusive injuries such as patterned bruising and a frenulum tear, but there were no indications of the identified fractures on physical

examination. Some injuries identified by physical examination were not specific for abuse and similar injuries are likely to exist in similarly aged children with no risk for abuse.^{30,31} We recommend physical examination of the young contacts of physically abused children because physical examinations are inexpensive, safe, and may identify specific indications of abuse. However, we wish to underscore that the absence of injury on physical examination does not exclude the potential for other abusive injuries.^{6,7,9,32}

Although neuroimaging did not identify any injuries, our small sample size is not sufficient to support a conclusion about neuroimaging. Because cases of unsuspected abusive head trauma in asymptomatic contacts have been reported,²⁰ it seems reasonable to continue to screen some contacts with neuroimaging until additional data can be obtained.

Because some forms of abuse (shaking, suffocation, punching) can occur without resulting in visible injury, and because injuries could heal before the child is brought for evaluation, the true rate of abuse to contacts is almost certainly higher than the rate of injuries identified in our study.^{33,34} Because abuse is frequently a progressive process with serious and irreversible outcomes,^{3,4} identification of subtle abusive injuries is an important opportunity for secondary prevention. Although the injuries we identified in contacts were rarely a significant source of morbidity or mortality, these injuries demonstrate that children who share a home with an abused child are at high risk and should be included when planning out-of-home placement or other protective interventions.

Our data show that twins are at higher risk for abuse relative to other contact children. Twins may be at increased risk because of the increased stress of caring for 2 children simultaneously or

TABLE 4 Comparison of Contacts Receiving and Not Receiving Indicated Screening

	Physical Examination		SS		Neuroimaging		All Indicated Screening	
	259/355 screened	<i>P</i> value	101/134 screened	<i>P</i> value	19/25 screened	<i>P</i> value	245/355 screened	<i>P</i> value
Contact age, mean (SD) ^a		.59		.20		.32		.48
Screened	1.9 (1.3)		0.62 (0.49)		3.1 (1.2) ^a		120 (72)	
Not screened	2.4 (1.3)		0.76 (0.44)		2.6 (1.3) ^a		119 (74)	
Contact gender, <i>n</i> (%) ^b		.56		.13		.7		.49
Female	129 (78)		54 (75)		11 (73)		120 (72)	
Male	123 (76)		46 (85)		8 (80)		119 (74)	
Insurance, <i>n</i> (%)		.23		.41		CNE		.13
Private	26 (84)		10 (83)		6 (100)		25 (81)	
Public/None	233 (72)		91 (74)		13 (68)		220 (68)	
Index race, ethnicity, <i>n</i> (%)		.02		.05		.54		.02
White, non-Hispanic	110 (67)		45 (67)		10 (71)		103 (63)	
Nonwhite	149 (78)		56 (83)		9 (82)		142 (74)	

CNE, could not estimate.

^a Data for age was available in months for all contacts <12 mo old but only in years for some older contacts. Comparisons of age are therefore made in years for all modalities except neuroimaging, for which all contacts eligible for screening were <12 mo old, and age is therefore given in months.

^b Because the gender of some contacts was not reported, the total of male and female contacts may not be the same as the total number of screened contacts.

because rates of abuse are higher in children with a history of prematurity.³⁵ Twins are also more likely to share other, unmeasured factors, such as their biological relationship to the perpetrator, which may make them more likely to be concurrently abused.

These data do not include results of testing outside our protocol, at the discretion of the child abuse physician, and should not be interpreted to discourage testing of children beyond the protocol.

There exists no gold-standard diagnostic test for abuse, and ratings of abuse likelihood are highly variable between child abuse physicians.^{27,36} Our definition of whether a child was “physically abused” contained subjective elements²⁶ and excluded children with a high likelihood of abuse but without serious injury (eg, a child with witnessed assault that results only in bruises). If clinicians use a lower threshold to determine that a patient is physically abused, the proportion of injuries identified by the protocol is likely to be lower.

Although each participating center considered the protocol to be a minimum standard of care, as with all protocols, consultants occasionally deviated from

the standard. In other cases, testing was recommended by the child abuse physicians but never performed, perhaps as the result of disagreements between CPS and child abuse physicians.¹¹ In total, approximately one-quarter of eligible contacts did not have indicated testing for each modality. Screening was more likely to be completed in contacts who were of nonwhite race or Hispanic ethnicity, a finding consistent with other studies of the effects of race in abuse screening.^{3,37} Our estimate of the rate of injuries identified by the protocol should therefore be considered a lower limit because contacts who were not tested were counted as if they had no injury.

The SS findings that are most concerning for abuse are subtle and require an experienced radiologist to exclude findings that can mimic abusive fractures.^{22,38,39} Although all participating centers had enough experience in abuse evaluation to support a dedicated child protection team, and all conducted SS according to published guidelines, we did not review the primary imaging data for children with or without identified fractures. Therefore, some fractures may have been missed that would have been identified by other radiologists or findings that were

considered fractures on the clinical interpretation might not have been confirmed by outside review. However, these methods reflect the real-world circumstances likely to face clinicians who cannot routinely refer SS for outside review. We did not measure the time between initial presentation of the index child and completion of the SS in the contact child. However, as fractures show evidence of healing for several months or more,⁴⁰ we feel it is not likely that a significant number of fractures were missed because of delayed SS.

Similarly, because physical examination or in-person evaluation by CPS was performed according to the normal practices of the examiner, it is possible that abusive injuries may have been missed when examinations did not include specific components such as dedicated retinal or genital examination. It is therefore possible that an even more aggressive protocol of examination would identify a greater number of injuries.

Our conclusion that routine SS is warranted rests on the assumption that the injuries we identified would not have been detected if child abuse physicians had recommended contact screening on a case-by-case basis, according to

other measured and unmeasured factors such as parental age or behavior or social risk factors such as known alcoholism or drug use in the home. A study that prospectively asked child abuse physicians to report whether they felt testing was warranted could determine whether such a case-by-case approach would eliminate unnecessary testing, or would miss injuries or increase potential for testing bias.⁴¹ We are conducting further analysis of these data to determine whether other measured factors can identify subsets of contacts at higher or lower risk for injury.

CONCLUSIONS

Young contacts of physically abused children are at high risk for physical abuse, with risk to twins being relatively increased relative to other contacts. A SS should be performed in contacts <24 months old when the index child is

physically abused with serious injury, regardless of physical examination findings.

ACKNOWLEDGMENTS

The Examining Siblings To Recognize Abuse (ExSTRA) investigators were as follows: Jayme Coffman, MD, Cook Children's Hospital (Ft Worth, TX); Deb Bretl, APNP, Children's Hospital Wisconsin (Wauwatosa, WI); Nancy Harper, MD, Driscoll Children's Hospital (Corpus Cristi, TX); Katherine Deye, MD, Children's National Medical Center (Washington, DC); Tara Harris, MD, Riley Hospital for Children (Indianapolis, IN); Yolanda Duralde, MD, Mary Bridge Children's Health Center (Tacoma, WA); Marcella Donaruma-Kwoh, MD, Texas Children's Hospital (Houston, TX); Daryl Steiner, DO, Akron Children's Hospital (Akron, OH); Ken Feldman, MD, Seattle Children's Hospital (Seattle, WA); Kimberly Schwartz, MD, University of Massachusetts Medical Center (Worcester, MA); Mary Greiner,

MD, Cincinnati Children's Hospital Medical Center (Cincinnati, OH); Alice Newton, MD, Boston Children's Hospital (Boston, MA); Ivone Kim, MD, Children's Hospital Pittsburgh of University of Pittsburgh Medical Center (Pittsburgh, PA); Kent Hymel, MD, Dartmouth-Hitchcock Medical Center (Lebanon, NH); Suzanne Haney, MD, Children's Hospital & Medical Center (Omaha, NE); Alicia Pekarsky, MD, SUNY Upstate Medical University (Syracuse, NY); Andrea Asnes, MD, Yale-New Haven Children's Hospital (New Haven, CT); Paul McPherson, MD, Akron Children's Hospital (Youngstown, OH); Neha Mehta, MD, Sunrise Children's Hospital (Las Vegas, NV); and Gwendolyn Gladstone, MD, Exeter Pediatric Associates (Exeter, NH). Mithat Gönen, PhD provided initial advice about statistical analysis.

We thank Kristine Campbell for her important contributions to early versions of the project protocol.

REFERENCES

- Sedlak AJ, Mettenburg J, Besena M, et al. *Fourth National Incidence Study of Child Abuse and Neglect (NIS-4): Report to Congress*. Washington, DC: US Department of Health & Human Services; 2010
- US Department of Health and Human Services. *Child Maltreatment 2010*. Washington, DC: Administration for Children & Families, Administration on Children, Youth & Families, Children's Bureau; 2011
- Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA*. 1999;281(7):621-626
- Alexander R, Crabbe L, Sato Y, Smith W, Bennett T. Serial abuse in children who are shaken. *Am J Dis Child*. 1990;144(1):58-60
- Oral R, Yagmur F, Nashelsky M, Turkmen M, Kirby P. Fatal abusive head trauma cases: consequence of medical staff missing milder forms of physical abuse. *Pediatr Emerg Care*. 2008;24(12):816-821
- Rubin DM, Christian CW, Bilaniuk LT, Zazyczny KA, Durbin DR. Occult head injury in high-risk abused children. *Pediatrics*. 2003;111(6 pt 1):1382-1386
- Peters ML, Starling SP, Barnes-Eley ML, Heisler KW. The presence of bruising associated with fractures. *Arch Pediatr Adolesc Med*. 2008;162(9):877-881
- Kellogg ND; American Academy of Pediatrics Committee on Child Abuse and Neglect. Evaluation of suspected child physical abuse. *Pediatrics*. 2007;119(6):1232-1241
- Lindberg D, Makoroff K, Harper N, et al; ULTRA Investigators. Utility of hepatic transaminases to recognize abuse in children. *Pediatrics*. 2009;124(2):509-516
- Campbell KA, Bogen DL, Berger RP. The other children: a survey of child abuse physicians on the medical evaluation of children living with a physically abused child. *Arch Pediatr Adolesc Med*. 2006;160(12):1241-1246
- Vitale MA, Squires J, Zuckerbraun NS, Berger RP. Evaluation of the siblings of physically abused children: a comparison of child protective services caseworkers and child abuse physicians. *Child Maltreat*. 2010;15(2):144-151
- Berkowitz CD. Domestic violence: a pediatric concern. *Pediatr Rev*. 2004;25(9):306-311
- Edelson JL. The overlap between child maltreatment and woman abuse. *Violence Against Women*. 1999;5(2):134-154
- Cahill L, Sherman P. Child abuse and domestic violence. *Pediatr Rev*. 2006;27(9):339-345
- Casanueva C, Martin SL, Runyan DK. Repeated reports for child maltreatment among intimate partner violence victims: findings from the National Survey of Child and Adolescent Well-Being. *Child Abuse Negl*. 2009;33(2):84-93
- McPhedran S. Animal abuse, family violence and child wellbeing: a review. *J Fam Violence*. 2009;24(1):41-52
- Ellaway BA, Payne EH, Rolfe K, et al. Are abused babies protected from further abuse? *Arch Dis Child*. 2004;89(9):845-846
- Hamilton-Giachritsis CE, Browne KD. A retrospective study of risk to siblings in abusing families. *J Fam Psychol*. 2005;19(4):619-624
- Groothuis JR, Altemeier WA, Robarge JP, et al. Increased child abuse in families with twins. *Pediatrics*. 1982;70(5):769-773
- Hansen KK. Twins and child abuse. *Arch Pediatr Adolesc Med*. 1994;148(12):1345-1346
- Block RW, Palusci VJ. Child abuse pediatrics: a new pediatric subspecialty. *J Pediatr*. 2006;148(6):711-712

22. Kleinman PK, Di Pietro MA, Brody AS, et al; Section on Radiology; American Academy of Pediatrics. Diagnostic imaging of child abuse. *Pediatrics*. 2009;123(5):1430–1435
23. McDonald KC. Child abuse: approach and management. *Am Fam Physician*. 2007;75(2):221–228
24. Campbell KA, Squires J, Cook LJ, Berger RP. Disparities in the medical examination of children in the home of a child with suspected physical abuse. *Child Abuse Negl*. 2009;33(9):612–617
25. Chadwick DL, Bertocci G, Castillo E, et al. Annual risk of death resulting from short falls among young children: less than 1 in 1 million. *Pediatrics*. 2008;121(6):1213–1224
26. Lindberg DM, Lindsell CJ, Shapiro RA. Variability in expert assessments of child physical abuse likelihood. *Pediatrics*. 2008;121(4):e945–e953
27. ACR Appropriateness Criteria: Suspected Physical Abuse—Child. Reston, VA: American College of Radiology; 2009
28. Duffy SO, Squires J, Fromkin JB, Berger RP. Use of skeletal surveys to evaluate for physical abuse: analysis of 703 consecutive skeletal surveys. *Pediatrics*. 2011;127(1). Available at: www.pediatrics.org/cgi/content/full/127/1/e47
29. Belfer RA, Klein BL, Orr L. Use of the skeletal survey in the evaluation of child maltreatment. *Am J Emerg Med*. 2001;19(2):122–124
30. Sugar NF, Taylor JA, Feldman KW; Puget Sound Pediatric Research Network. Bruises in infants and toddlers: those who don't cruise rarely bruise. *Arch Pediatr Adolesc Med*. 1999;153(4):399–403
31. Carpenter RF. The prevalence and distribution of bruising in babies. *Arch Dis Child*. 1999;80(4):363–366
32. Laskey AL, Holsti M, Runyan DK, Socolar RR. Occult head trauma in young suspected victims of physical abuse. *J Pediatr*. 2004;144(6):719–722
33. Southall DP, Plunkett MC, Banks MW, Falkov AF, Samuels MP. Covert video recordings of life-threatening child abuse: lessons for child protection. *Pediatrics*. 1997;100(5):735–760
34. Hymel KP; American Academy of Pediatrics; ; Committee on Child Abuse and Neglect; National Association of Medical Examiners. Distinguishing sudden infant death syndrome from child abuse fatalities. *Pediatrics*. 2006;118(1):421–427
35. Ghahreman A, Bhasin V, Chaseling R, Andrews B, Lang EW. Nonaccidental head injuries in children: a Sydney experience. *J Neurosurg*. 2005;103(3 suppl):213–218
36. Laskey AL, Sheridan MJ, Hymel KP. Physicians' initial forensic impressions of hypothetical cases of pediatric traumatic brain injury. *Child Abuse Negl*. 2007;31(4):329–342
37. Lane WG, Dubowitz H. What factors affect the identification and reporting of child abuse-related fractures? *Clin Orthop Relat Res*. 2007;461:219–225
38. Kleinman PK. Problems in the diagnosis of metaphyseal fractures. *Pediatr Radiol*. 2008;38(suppl 3):S388–S394
39. Kleinman PK, Sarwar ZU, Newton AW, Perez-Rossello JM, Rebello G, Herliczek TW. Metaphyseal fragmentation with physiologic bowing: a finding not to be confused with the classic metaphyseal lesion. *AJR Am J Roentgenol*. 2009;192(5):1266–1268
40. Kleinman PK. *Diagnostic Imaging of Child Abuse*. 2nd ed. St Louis, MO: Mosby; 1998
41. Gupta M, Schriger DL, Hiatt JR, Cryer HG, Tillou A, Hoffman JR, et al. Selective use of computed tomography compared with routine whole body imaging in patients with blunt trauma. *Ann Emerg Med* 2011;58(5):407–416.e15.

APPENDIX Rating Scale for Abuse Likelihood

Rating	Criteria	Explanation
1 Definitely not inflicted injury	Significant, independently verifiable mechanism (MVC, pedestrian struck) Disinterested witness (police, ambulance, video documentation) Mimic (Mongolian spot, hemangioma)	Although no evaluation can completely exclude abuse, our evaluation has not raised a reasonable suspicion of abuse. The injuries or findings that we have described could reasonably be explained by accidental or benign events. Please do not hesitate to renew discussion if circumstances change (ratings 1 and 2).
2 No concern for inflicted injury	Mechanism explains all injuries, consistent history	
3 Mildly concerning for inflicted injury	Somewhat concerning injuries with no offered history (multiple, nonpatterned bruises in a cruising child without bleeding diathesis, unexplained humerus fracture in 10-mo-old) Otherwise unconvincing injury with past suspicious injury and same caregiver	
4 Intermediately concerning for inflicted injury	Insufficient information to offer opinion Sequence of events clear but uncertain whether they constitute abuse Necessary laboratory tests/consultation pending Concerning injury in the setting of bone fragility/bleeding diathesis	
5 Very concerning for inflicted injury	Given history unlikely to produce documented injuries Concerning injury with no history of trauma (4-mo-old with unexplained femur fracture)	
6 Substantial evidence of inflicted injury	Severe injury with no offered history in a child incapable of inflicting the injury on himself or herself History inconsistent with identified injuries Serious injuring with changing history or history inconsistent between caregivers Inappropriate delay in seeking care Multiple severe injuries of different age without plausible explanation	
7 Definite inflicted injury	Pattern bruises/burns Unexplained posterior rib fractures, characteristic retinal hemorrhages Highly suspicious injury (liver laceration, burn, pinna bruising, unexplained fracture) with definite subsequent abuse Reliable eyewitness of abuse Suspicious injury and concurrently abused sibling Obvious injury with significant, unexplained delay in seeking care (serious burn, unresponsive child, apparent prolonged seizure)	To a reasonable degree of medical certainty, the injuries/findings that we have described cannot plausibly be explained by accidental injury, preexisting medical illness, reasonable discipline, or benign events (ratings 6 and 7).

From Lindberg et al.²⁶ MVC, motor vehicle crash.

Prevalence of Abusive Injuries in Siblings and Household Contacts of Physically Abused Children

Daniel M. Lindberg, Robert A. Shapiro, Antoinette L. Laskey, Daniel J. Pallin, Emily A. Blood and Rachel P. Berger

Pediatrics; originally published online July 9, 2012;

DOI: 10.1542/peds.2012-0085

Updated Information & Services	including high resolution figures, can be found at: http://pediatrics.aappublications.org/content/early/2012/07/03/peds.2012-0085
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Office Practice http://pediatrics.aappublications.org/cgi/collection/office_practice
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://pediatrics.aappublications.org/site/misc/Permissions.xhtml
Reprints	Information about ordering reprints can be found online: http://pediatrics.aappublications.org/site/misc/reprints.xhtml

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2012 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

