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

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. 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;130:193–201
Physical abuse is an important, and often overlooked, source of morbidity and mortality in childhood. Early detection can protect children because abuse is often an escalating phenomenon. Many abusive injuries are clinically occult, and serious injuries can be missed even with careful examination. Screening high-risk populations can increase detection of abuse, and siblings and other contacts who share a home with an abused child may represent 1 such population.

Violence often affects an entire household. Child abuse commonly coexists with intimate partner violence, and abuse of pets has been linked with both child abuse and intimate partner violence. Contacts of abused children are at especially high risk for injuries at the time of the initial referral is unknown. Case reports suggest that twins of abused children are at especially high risk for abuse, but this has never been tested rigorously.

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. 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. 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 and rates of screening (physical examination, SS, and neuroimaging) show high variability. The screening protocol articulated a common standard for contact screening, and child abuse physicians were free to recommend additional screening.

**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.

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). 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.
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 ≥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

Table: Characteristics of Index Children

<table>
<thead>
<tr>
<th>Level of concern</th>
<th>Index Children n = 2890 (%)</th>
<th>Physically Abused Index Children n = 627 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, Definitely not inflicted</td>
<td>150 (5.2)</td>
<td>324 (51.7)</td>
</tr>
<tr>
<td>2</td>
<td>613 (21.2)</td>
<td>40 (6.4)</td>
</tr>
<tr>
<td>3</td>
<td>437 (15.1)</td>
<td>448 (71.5)</td>
</tr>
<tr>
<td>4</td>
<td>341 (11.8)</td>
<td>75 (12.3)</td>
</tr>
<tr>
<td>5</td>
<td>355 (12.3)</td>
<td>260 (41.5)</td>
</tr>
<tr>
<td>6</td>
<td>400 (13.8)</td>
<td>367 (58.5)</td>
</tr>
<tr>
<td>7, Definitely inflicted</td>
<td>594 (20.6)</td>
<td>TBI traumatic brain injury.</td>
</tr>
</tbody>
</table>

TAble: Demographics of Index and Contact Children

<table>
<thead>
<tr>
<th>Age, (mo)a</th>
<th>Index Children n = 2890 (%)</th>
<th>Physically Abused Index Children n = 627 (%)</th>
<th>All Contacts n = 1927</th>
<th>Contacts of Physically Abused Index Children n = 478 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–6</td>
<td>980 (33.9)</td>
<td>331 (52.8)</td>
<td>170 (8.8)b</td>
<td>25 (5.2)</td>
</tr>
<tr>
<td>6–12</td>
<td>521 (18.0)</td>
<td>110 (17.5)</td>
<td>214 (4.4)</td>
<td></td>
</tr>
<tr>
<td>12–24</td>
<td>474 (16.4)</td>
<td>68 (10.8)</td>
<td>270 (14.0)</td>
<td>88 (18.4)</td>
</tr>
<tr>
<td>24–60</td>
<td>634 (21.9)</td>
<td>102 (16.5)</td>
<td>839 (43.5)</td>
<td>221 (46.1)</td>
</tr>
<tr>
<td>60–120</td>
<td>281 (9.7)</td>
<td>16 (2.6)</td>
<td>617 (32.0)</td>
<td>115 (24.0)</td>
</tr>
</tbody>
</table>

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 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.
consistent with accidental injury. No contacts, bruises were described as wise concerning for abuse. In 6 other injuries that were patterned or other-
the contacts with bruises as having abrasions, 2 with burns, and 1 with an
months (median 26.4 months). Injuries identi
completed in 259 (73.0%). Injuries were
examination was recommended for 343

teria for physical examination. Physical

Fractures Identified in Contacts by SS

<table>
<thead>
<tr>
<th>Bone</th>
<th>Contacts</th>
<th>Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rib</td>
<td>n = 16</td>
<td>n = 51 (9%)</td>
</tr>
<tr>
<td>Hand/foot</td>
<td>9 (56)</td>
<td>29 (57)</td>
</tr>
<tr>
<td>DML</td>
<td>4 (25)</td>
<td>6 (12)</td>
</tr>
<tr>
<td>Long bone a</td>
<td>3 (19)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Skull</td>
<td>2 (13)</td>
<td>2 (4)</td>
</tr>
</tbody>
</table>

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

and none were suspected clinically before
the SS.

Table 3 Fractures Identified in Contacts by SS

The number of contacts does not sum to 16 because con-
tacts with multiple types of fractures are counted more
than once. DML, 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 pro-
tocol criteria for SS, 16 (11.9%) were
twins, and 9 of these (56.3%) had frac-
tures 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 cri-
teria for physical examination. Physical
examination was recommended for 343
(96.6%) of these children and com-
pleted in 259 (73.0%). Injuries were
identified in 27 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 other-
wise concerning for abuse. In 6 other
contacts, bruises were described as
consistent with accidental injury. No
information was given about the spec-
ificity of the remaining injuries for
abuse. Failure to thrive was not cate-
gorized as an identified injury but was
noted in 4 additional contacts.

Contacts Not Screened

For each of these modalities, approxi-
ately 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 dif-
ference 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 as-
sociated 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 chil-
dren had at least 1 contact child who
shared the same potentially harmful
environment. We identified abusive inju-
ries in a significant proportion of con-
tacts who underwent protocol-indicated
screening, even though contacts were
almost always asymptomatic. These
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because rates of abuse are higher in children with a history of prematurity. 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. Our definition of whether a child was “physically abused” contained subjective elements and excluded children with a high likelihood of abuse but without serious injury (e.g., 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. 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. 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. 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, 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

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**TABLE 4 Comparison of Contacts Receiving and Not Receiving Indicated Screening**

<table>
<thead>
<tr>
<th>Physical Examination</th>
<th>SS</th>
<th>Neuroimaging</th>
<th>All Indicated Screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact age, mean (SD)*</td>
<td>P value</td>
<td>259/355 screened</td>
<td>101/134 screened</td>
</tr>
<tr>
<td>Screened</td>
<td>1.9 (1.3)</td>
<td>0.62 (0.49)</td>
<td>3.1 (1.2)*</td>
</tr>
<tr>
<td>Not screened</td>
<td>2.4 (1.3)</td>
<td>0.76 (0.44)</td>
<td>2.6 (1.3)*</td>
</tr>
<tr>
<td>Contact gender, n (%)</td>
<td>P value</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Screened</td>
<td>.56</td>
<td>129 (78)</td>
<td>123 (76)</td>
</tr>
<tr>
<td>Not screened</td>
<td>.13</td>
<td>54 (75)</td>
<td>46 (85)</td>
</tr>
<tr>
<td>Contact race, ethnicity, n (%)</td>
<td>P value</td>
<td>White, non-Hispanic</td>
<td>Nonwhite</td>
</tr>
<tr>
<td>Screened</td>
<td>.02</td>
<td>110 (67)</td>
<td>149 (78)</td>
</tr>
<tr>
<td>Not screened</td>
<td>.02</td>
<td>45 (67)</td>
<td>56 (83)</td>
</tr>
</tbody>
</table>

* 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.

* 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.

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REFERENCES


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 who 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.

ACKNOWLEDGMENTS

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We thank Kristine Campbell for her important contributions to early versions of the project protocol.
## APPENDIX Rating Scale for Abuse Likelihood

<table>
<thead>
<tr>
<th>Rating</th>
<th>Criteria</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Definitely not inflicted injury</td>
<td>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).</td>
</tr>
<tr>
<td></td>
<td>Significant, independently verifiable mechanism (MVC, pedestrian struck)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disinterested witness (police, ambulance, video documentation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mimic (Mongolian spot, hemangioma)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>No concern for inflicted injury</td>
<td>Sequence of events clear but uncertain whether they constitute abuse</td>
</tr>
<tr>
<td></td>
<td>Mechanism explains all injuries, consistent history</td>
<td>Necessary laboratory tests/consultation pending</td>
</tr>
<tr>
<td>3</td>
<td>Mildly concerning for inflicted injury</td>
<td>Concerning injury in the setting of bone fragility/bleeding diathesis</td>
</tr>
<tr>
<td></td>
<td>Somewhat concerning injuries with no offered history</td>
<td>Otherwise un concerning injury with past suspicious injury and same caregiver</td>
</tr>
<tr>
<td></td>
<td>(multiple, nonpatterned bruises in a cruising child</td>
<td></td>
</tr>
<tr>
<td></td>
<td>without bleeding diathesis, unexplained humerus fracture in 10-mo-old</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Intermediately concerning for inflicted injury</td>
<td>Given history unlikely to produce documented injuries</td>
</tr>
<tr>
<td></td>
<td>Insufficient information to offer opinion</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Very concerning for inflicted injury</td>
<td>Concerning injury with no history of trauma (4-mo-old with unexplained femur fracture)</td>
</tr>
<tr>
<td></td>
<td>Severe injury with no offered history in a child</td>
<td></td>
</tr>
<tr>
<td></td>
<td>incapable of inflicting the injury on himself or herself</td>
<td></td>
</tr>
<tr>
<td></td>
<td>History inconsistent with identified injuries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Serious injuring with changing history or history</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inconsistent between caregivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inappropriate delay in seeking care</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multiple severe injuries of different age without plausible explanation</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Substantial evidence of inflicted injury</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe injury with no offered history in a child</td>
<td></td>
</tr>
<tr>
<td></td>
<td>incapable of inflicting the injury on himself or herself</td>
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</tr>
<tr>
<td></td>
<td>Multiple severe injuries of different age without plausible explanation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexplained posterior rib fractures, characteristic retinal hemorrhages</td>
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<td></td>
<td>Reliable eyewitness of abuse</td>
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<td></td>
<td>Suspicious injury and concurrently abused sibling</td>
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<tr>
<td></td>
<td>Obvious injury with significant, unexplained delay in seeking care (serious burn, unresponsive child, apparent prolonged seizure)</td>
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</tr>
<tr>
<td>7</td>
<td>Definite inflicted injury</td>
<td>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).</td>
</tr>
<tr>
<td></td>
<td>Pattern bruises/burns</td>
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<td></td>
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</table>

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, Rachel P. Berger and for the ExSTRA Investigators

*Pediatrics* 2012;130;193; originally published online July 9, 2012; DOI: 10.1542/peds.2012-0085

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