

Identifying Predictors of Physical Abuse Evaluation of Injured Infants

Opportunities to Improve Recognition

Emily A. Eismann, MS,* Robert Allan Shapiro, MD,*† Kathi L. Makoroff, MD, MED,*† Jack Theuerling, BA,* Nicole Stephenson, BS,* Elena M. Duma, MD,†‡ Emily T. Fain, MD,‡§ Theresa M. Frey, MD,‡ Lauren C. Riney, DO,‡ and Jonathan D. Thackeray, MD¶||

Objectives: To identify predictors of physical abuse evaluation in infants younger than 6 months with visible injury and to determine the prevalence of occult fracture and intracranial hemorrhage in those evaluated.

Methods: Infants 6.0 months or younger who presented with visible injury to a pediatric hospital-affiliated emergency department or urgent care between July 2013 and January 2017 were included. Potential predictors included sociodemographics, treatment site, provider, injury characteristics, and history. Outcome variables included completion of a radiographic skeletal survey and identification of fracture (suspected or occult) and intracranial hemorrhage.

Results: Visible injury was identified in 378 infants, 47% of whom did not receive a skeletal survey. Of those with bruising, burns, or intraoral injuries, skeletal survey was less likely in patients 3 months or older, of black race, presenting to an urgent care or satellite location, evaluated by a nonpediatric emergency medicine-trained physician or nurse practitioner, or with a burn. Of these, 25% had an occult fracture, and 24% had intracranial hemorrhage. Occult fractures were also found in infants with apparently isolated abrasion/laceration (14%), subconjunctival hemorrhage (33%), and scalp hematoma/swelling (13%).

Conclusions: Nearly half of preambulatory infants with visible injury were not evaluated for physical abuse. Targeted education is recommended as provider experience and training influenced the likelihood of physical abuse evaluation. Occult fractures and intracranial hemorrhage were often found in infants presenting with seemingly isolated “minor” injuries. Physical abuse should be considered when any injury is identified in an infant younger than 6 months.

Key Words: sentinel injury, maltreatment, abuse work-up, open wound, superficial injury

(*Pediatr Emer Care* 2020;00: 00–00)

Physical abuse is the second most common form of child maltreatment in the United States, with 122,067 victims and 639 deaths in 2016.¹ Children in their first year of life are at the greatest risk for child maltreatment.¹ Identifying physical abuse,

especially in infants, can be challenging because infants lack the verbal ability to disclose abuse, caregivers may provide false or misleading histories, and abusive injuries can be nonspecific.² The American Academy of Pediatrics (AAP) states that “ANY injury to a young, preambulatory infant” suggests abuse.² These physical injuries may be missed or may not raise suspicion for abuse because they may appear subtle or minor or may be explained as accidental by caregivers.^{3–7} One study found that 28% of physically abused infants had a previous “sentinel” injury reported in their medical history that was suspicious for abuse.⁸ These previous injuries were most often bruising (80%) or intraoral injuries, such as frenulum tears (11%).⁸ The AAP recommends a radiographic skeletal survey for infants with suspected physical abuse to investigate for occult fractures.^{2,9–11} One study of children younger than 6 months with sentinel injuries found that a skeletal survey was performed in only 13% with a burn, 20% with bruising, and 32% with an intraoral injury,¹² suggesting nonadherence with the AAP guideline. Recurrent child abuse is associated with increased morbidity and mortality¹³ and could be prevented by improved recognition and evaluation.

The purpose of this exploratory study is to identify (1) characteristics of the infant, treatment site, provider, injury presentation, and history that are associated with the decision to perform a radiographic skeletal survey to evaluate for physical abuse among infants 6.0 months or younger who present to the pediatric emergency department (ED) or urgent care (UC) with a visible injury and (2) the prevalence of fracture (suspected and occult) and intracranial hemorrhage in these infants. Better understanding of the factors influencing a health care provider's decision to pursue a physical abuse evaluation and the characteristics of injuries found could lead to targeted interventions for improving the early recognition of physical abuse and potentially prevent recurrent, more severe abuse.

METHODS

Study Population

This retrospective study was approved by the Cincinnati Children's Hospital Medical Center (CCHMC) Institutional Review Board, which granted a waiver of informed consent. All infants 6.0 months or younger identified with injury at a CCHMC ED or UC between July 1, 2013, and January 31, 2017 were reviewed. The cohort was limited to 6.0 months or younger to identify solely preambulatory infants. Locations included the main hospital, which is a Level 1 pediatric trauma center with 24-hour ED and UC services, and 4 satellite locations with UC services, of which one also has a 24-hour ED. This health care system uses Epic as its electronic medical record system. Patients were identified based on an automated electronic medical record search of International Classification of Diseases, Ninth and Tenth

From the *Mayerson Center for Safe and Healthy Children, Cincinnati Children's Hospital Medical Center; †Department of Pediatrics, University of Cincinnati College of Medicine; ‡Division of Emergency Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, OH; §Monroe Carell Jr. Children's Hospital at Vanderbilt, Nashville, TN; and ¶Department of Pediatrics, Dayton Children's Hospital; and ||Department of Pediatrics, Wright State University Boonshoft School of Medicine, Dayton, OH.

Sources of Funding: This study was supported by Ohio Attorney General Mike DeWine and the Ohio Children's Hospital Association Foundation, Columbus, OH.

Disclosure: The authors declare no conflict of interest.

Reprints: Robert A. Shapiro, MD, Mayerson Center for Safe and Healthy Children, Cincinnati Children's Hospital Medical Center, University of Cincinnati College of Medicine, 3333 Burnet Ave, MLC 3008, Cincinnati, OH 45229 (e-mail: bob.shapiro@cchmc.org).

Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.
ISSN: 0749-5161

Editions (ICD-9 and ICD-10) codes for injury. The ICD codes for the following injuries were searched because they have been identified as concerning for physical abuse in infants: subconjunctival hemorrhage,¹⁴ intracranial hemorrhage,¹⁵ injury to an internal organ (excluding the thorax, heart, and lung),¹⁶ ecchymosis,¹⁷ contusion,¹⁷ fracture,¹⁸ open wound,^{19,20} superficial injury,^{19,20} and burn^{21,22} of any body part. Superficial injuries (abrasions), open wounds (lacerations), subconjunctival hemorrhage, and scalp hematoma/swelling were included in this study (but assessed separately) to better understand the frequency of skeletal survey completion and fracture and/or intracranial hemorrhage identification in relation to them. Patients were excluded if the injury (1) was birth-related, including subconjunctival hemorrhage in infants younger than 0.5 months of age; (2) was due to a motor vehicle accident; (3) could be explained by a medical condition/procedure or hair tourniquet; (4) was caused by an animal; or (5) was a corneal abrasion. The search query excluded patients who met these criteria based on ICD codes, so the total number of patients who met exclusion criteria is unknown. Following the initial data query, the electronic medical records of all patients were manually reviewed to confirm the injury and eligibility and to collect necessary data. A secondary reviewer verified the eligibility of questionable cases. Patients were also excluded if there was no evidence of visible injury on initial physical examination, which included patients diagnosed with fractures and/or intracranial hemorrhage who had no visible injury (n = 73) (eg, incidental findings on chest radiograph, symptoms of lethargy, vomiting, seizures, cardiac or respiratory arrest, and so on, without visible injury or a history of injury without visible injury).

Data Collection

Patient sociodemographic characteristics were collected, including age, sex, race, ethnicity, and insurance type (see Table 1 for categories used in analyses). Treatment site characteristics included initial presentation to UC or ED, satellite location or main hospital, and hospital transfer/referral or self-presentation. Those transferred from UC to ED were classified as initially presenting to UC, and those transferred from a satellite location to the main hospital were classified as initially presenting to a satellite location. Initial provider characteristics included role (attending physician, Advanced Practice Registered Nurse [APRN], fellow, or resident) and training for attending physicians (pediatric emergency medicine [PEM] or non-PEM). All fellows were in process of PEM training. The categories used in analyses related to the treatment site and provider characteristics can be found in Table 2.

Injury characteristics included visible injury type and location. Injury to a nonbony location, specifically the Torso-Ears-Neck (TEN), was also documented.^{23,24} The categories used in analyses related to characteristics of the injury can be found in Table 3.

The chief complaint of the caregivers at presentation was obtained, and the following categories were created: alleged physical abuse, injury or fall, and other (see Table 4 for the chief complaints included in each of these categories). The trauma history provided by the caregivers over the course of the encounter was considered “concerning” if the health care team documented that this history was not consistent with the injuries, was not consistent with the physical and/or developmental capabilities of the patient, varied considerably over time or between caregivers, included admission of inflicted injury, or included delay in obtaining medical care.^{2,25,26} Absence of a trauma history was also recorded.² Concerning trauma history and absence of a trauma history were analyzed separately.

The primary dependent variable was completion of a radiographic skeletal survey (yes or no). This health care system follows the standard protocol for radiographic skeletal surveys recommended by the AAP Section on Radiology.⁹ The physical abuse evaluation guideline at this hospital includes a radiographic skeletal survey, computed tomography (CT) of the head, laboratory testing, and social worker consultation when there is concern for physical abuse in infants. Head CT, laboratory testing, and social worker consultation were not included in the primary dependent variable as these evaluations are also performed on patients without a concern for physical abuse. The secondary dependent variables, in cases where a skeletal survey was completed, were identification of a fracture (suspected and occult) and intracranial hemorrhage (subdural, subarachnoid, or epidural). Fractures were classified as “suspected” if the health care provider documented bruising, abrasion, laceration, swelling, hematoma, edema, tenderness to palpation, limited mobility, or increased fussiness with limb movement in the area where the fracture was located during the initial physical examination and as “occult” if they did not document any signs or symptoms in the area where the fracture was located. Patients with multiple fractures could have both suspected and occult fracture. The majority of patients who had a skeletal survey also had a head CT (94%, 193/205), so intracranial hemorrhage was included as an outcome variable.

Statistical Analyses

Descriptive statistics were generated to characterize the full study population. Logistic regression was performed with 1 predictor variable analyzed at a time (see Tables 1–4 for each predictor and their related categories) and with the dependent variable of skeletal survey completion on the subset of patients who were documented to have bruising, burn, or intraoral injury upon initial physical examination because the AAP considers these specific injuries in nonambulatory infants to be indications for obtaining a skeletal survey.² Logistic regression was not performed for categories with less than 15 patients. Odds ratios with 95% confidence interval were recorded as an indicator of effect size. Statistical significance was set at *P* less than 0.05. The rates of skeletal survey completion and additional injury identification for the subset of patients with only abrasion/laceration, subconjunctival hemorrhage, and/or scalp hematoma/swelling were assessed as a separate cohort because these injuries have not been consistently included as indications for obtaining a skeletal survey in nonambulatory infants.

RESULTS

Sample Characteristics

There were 387 infants younger than 6 months who presented to the pediatric ED and UC with a visible injury over the 43-month study period (average of 9 infants per month). The study sample had an average age of 3.3 ± 1.8 months and was 53% (n = 204) male. The majority were Caucasian or white (59%, n = 230) or African American or black (22%, n = 85), non-Hispanic or non-Latino (92%, n = 357), and publicly insured (78%, n = 302). The most common injury location was the scalp/forehead (57%, n = 219), followed by the face (24%, n = 91), extremities (20%, n = 77), torso (10%, n = 40), eye (9%, n = 33), intraoral (5%, n = 19), ear (4%, n = 14), then neck (<1%, n = 2). Sixty-eight (18%) infants had visible injuries in multiple locations. Scalp hematoma/swelling was the most common visible injury (39%, n = 152), followed by abrasion/laceration (36%, n = 141), bruising (31%, n = 121), subconjunctival hemorrhage

TABLE 1. Radiographic Skeletal Survey Completion and Additional Injury Rates Among Infants Under 6 Months of Age Who Presented to Urgent Care or the Emergency Department With Bruising, Burns, and/or Intraoral Injury Based on Patient Characteristics

Patient Characteristics	Skeletal Survey Completed (n = 91, N = 157)			Additional Injury Found (N = 91)		
	% (n/N)	OR (95% CI)	P	Occult Fracture(s)	Suspected Fracture(s)	Intracranial Hemorrhage
				% (n/N)	% (n/N)	% (n/N)
Total	58% (91/157)	—	—	25% (23/91)	26% (24/91)	24% (22/91)
Age						
<3 mo	67% (49/73)	Ref		33% (16/49)	20% (10/49)	29% (14/49)
≥3 mo	50% (42/84)	0.49 (0.26–0.94)	0.031*	17% (7/42)	33% (14/42)	19% (8/42)
Sex						
Female	55% (41/75)	Ref		32% (13/41)	32% (13/41)	27% (11/41)
Male	61% (50/82)	1.30 (0.69–2.45)	0.42	20% (10/50)	22% (11/50)	22% (11/50)
Race						
Caucasian or white	62% (64/103)	Ref		25% (16/64)	27% (17/64)	27% (17/64)
African American or black	39% (12/31)	0.38 (0.17–0.88)	0.023*	25% (3/12)	25% (3/12)	8% (1/12)
Ethnicity						
Non-Hispanic or non-Latino	58% (87/150)	—		25% (22/87)	26% (23/87)	23% (20/87)
Hispanic or Latino	50% (3/6)	—	—	33% (1/3)	0% (0/3)	33% (1/3)
Insurance type						
Private	44% (11/25)	Ref		36% (4/11)	27% (3/11)	55% (6/11)
Public	61% (74/122)	1.96 (0.82–4.68)	0.13	24% (18/74)	28% (21/74)	19% (14/74)
Self-pay	60% (6/10)	—	—	17% (1/6)	0% (0/6)	33% (2/6)

OR, odds ratio; Ref, reference category.

*P < 0.05.

(8%, n = 31), then burn (5%, n = 21). Seventy-six (20%) infants had multiple visible injury types.

Prevalence of Physical Abuse Evaluation

Of the total study sample of 387 infants with visible injury, 53% (n = 205) underwent a skeletal survey. Of the subset of 157 infants presenting with bruising, burns, and/or intraoral injury, 58% (n = 91) underwent a skeletal survey. The following analyses were performed on this subset because the AAP considers these specific visible injuries in nonambulatory infants to be indications for obtaining a skeletal survey.²

Predictors of Physical Abuse Evaluation

Infants with bruising, burns, and/or intraoral injury (n = 157) were significantly less likely to undergo a skeletal survey if they were 3 months or older, African American or black (Table 1), initially presented to UC or a satellite location, had an initial physical examination by a non-PEM attending physician (Table 2), had a burn (Table 3), or had a chief complaint of “injury or fall” (Table 4). Also, none of the 11 patients examined by an APRN underwent a skeletal survey (Table 2).

Infants were significantly more likely to undergo a skeletal survey if they had been referred from an outside hospital or primary care provider, had an initial physical examination by a PEM attending physician or resident (Table 2), had bruising, facial injury, torso injury, or TEN injury (Table 3), had a chief complaint of alleged physical abuse, a concerning trauma history, or lack of a trauma history (Table 4). All 11 patients with an eye injury underwent a skeletal survey (Table 3).

Prevalence of Fracture and Intracranial Hemorrhage

Of the total study sample of 205 infants with visible injury who had a skeletal survey, 19% (n = 39) were found to have occult fracture and 51% (n = 104) had suspected fracture. Intracranial hemorrhage was also found in 38% (n = 77). Of the subset of 91 infants with bruising, burns, and/or intraoral injury who underwent a skeletal survey, 25% (n = 23) were found to have an occult fracture and 26% (n = 24) had a suspected fracture. Intracranial hemorrhage was also found in 24% (n = 22), with 11 (12%) infants having both occult fracture and intracranial hemorrhage. Data on the prevalence of occult and suspected fracture and intracranial hemorrhage by characteristics of the patient, treatment site, provider, injury, and history are summarized in Tables 1–4.

Separate Analyses for Superficial Injuries

Superficial injuries, including abrasion/laceration, subconjunctival hemorrhage, and/or scalp hematoma/swelling, were assessed separately because these injuries have not been consistently included as indications for obtaining a skeletal survey in nonambulatory infants.² Of the 76 infants presenting with apparently isolated abrasion/laceration, skeletal survey was completed on 18% (n = 14), and of those, 14% (n = 2) had occult fracture, 21% (n = 3) had suspected fracture, and 7% (n = 1) had intracranial hemorrhage. Of the 18 infants presenting with apparently isolated subconjunctival hemorrhage, skeletal survey was completed on 33% (n = 6), and of those, 33% (n = 2) had occult fracture, 0% (n = 0) had suspected fracture, and 33% (n = 2) had intracranial hemorrhage. Of the 115 infants presenting with apparently isolated scalp hematoma/swelling, skeletal survey was completed on 75% (n = 86), and of those, 13% (n = 11) had occult fracture,

TABLE 2. Radiographic Skeletal Survey Completion and Additional Injury Rates Among Infants Under 6 Months of Age Who Presented to Urgent Care or the Emergency Department With Bruising, Burns, and/or Intraoral Injury Based on Treatment Site and Provider Characteristics

Site/Provider Characteristic	Skeletal Survey Completed (n = 91, N = 157)			Additional Injury Found (N = 91)		
	% (n/N)	OR (95% CI)	P	Occult Fracture(s)	Suspected Fracture(s)	Intracranial Hemorrhage
				% (n/N)	% (n/N)	% (n/N)
Initially presented to UC						
Yes	17% (4/24)	0.11 (0.03–0.33)	<0.001*	25% (1/4)	50% (2/4)	0% (0/4)
No	65% (87/133)	Ref		25% (22/87)	25% (22/87)	25% (22/87)
Initially presented to satellite location						
Yes	32% (12/37)	0.25 (0.11–0.55)	0.001*	17% (2/12)	42% (5/12)	17% (2/12)
No	66% (79/120)	Ref		27% (21/79)	24% (19/79)	25% (20/79)
Hospital transfer/referral						
Yes	74% (23/31)	2.45 (1.02–5.90)	0.045*	35% (8/23)	30% (7/23)	30% (7/23)
No	54% (68/126)	Ref		22% (15/68)	25% (17/68)	22% (15/68)
Attending physician						
PEM-trained	66% (65/99)	2.94 (1.31–6.63)	0.009*	—	—	—
Non-PEM-trained	39% (13/33)	Ref		—	—	—
APRN						
Yes	0% (0/11)	—	—	—	—	—
No	62% (91/146)	—	—	—	—	—
Fellow						
Yes	81% (13/16)	3.50 (0.96–12.82)	0.059	—	—	—
No	55% (78/141)	Ref		—	—	—
Resident						
Yes	72% (63/87)	3.94 (2.01–7.70)	<0.001*	—	—	—
No	40% (28/70)	Ref		—	—	—

*P < 0.05.

85% (n = 73) had suspected fracture, and 59% (n = 51) had intracranial hemorrhage.

DISCUSSION

Injuries, even minor ones, in preambulatory infants are highly concerning for physical abuse.² This study found that 47% of all infants younger than 6 months who presented with visible injury to the pediatric ED or UC were not evaluated for physical abuse. When a skeletal survey was completed, about 1 (19%) in 5 infants was found to have occult fracture, and about 2 (38%) in 5 infants had intracranial hemorrhage. Of the subset of infants with indications for obtaining skeletal survey including bruising, burns, and/or intraoral injury, 42% were not evaluated for physical abuse. When a skeletal survey was completed, about 1 (25%) in 4 of these infants was found to have occult fracture, and about 1 (24%) in 4 infants had intracranial hemorrhage. It is unknown how many of the infants who were not evaluated for physical abuse may have had occult fracture and/or intracranial hemorrhage. A previous retrospective study found that 52% of children younger than 2 years who had been diagnosed with physical abuse during a hospital encounter had not undergone evaluation for occult fracture, and it was estimated from prior research that about 25% to 30% would have been expected to have occult fractures.²⁷ The lack of evaluation is concerning because evidence suggests that missing physical abuse at initial presentation can increase risk for recurrent abuse and subsequent morbidity and mortality.^{3,13}

In infants with bruising, burns, and/or intraoral injury, physical abuse evaluations were significantly less likely to be completed if the infant presented to an UC (17%) or satellite location (32%) and if they were treated by a non-PEM-trained attending physician (39%) or APRN (0%). A prior study involving interviews with ED providers identified several barriers to successfully recognizing child maltreatment, including desire to believe caregivers, failure to recognize that the patient's presentation could be caused by child maltreatment, desire to rapidly address the patient's presenting complaint, and provider biases.²⁸ It is unclear what role these factors played in provider decision making in this study. It is also possible that infants presenting to UC or treated by an APRN had less severe injuries. Regardless, these findings suggest that targeted education for non-PEM-trained attending physicians and APRNs on the universal physical abuse evaluation guideline for preambulatory infants with injury is needed.

Interestingly, physical abuse evaluation was also less likely to be completed when there was a chief complaint of any type of injury or fall. It is possible that health care providers consider physical abuse more often in infants younger than 6 months, even when provided with a compatible trauma history. Occult fractures were detected on skeletal survey in 16% of these infants.

Physical abuse evaluation was more likely to be completed among Caucasian or white infants and younger infants, which contrasts prior findings of greater skeletal survey completion among black infants and older infants.²⁹ Physical abuse evaluation was also more likely to be completed when infants were identified with bruising (66%) and TEN injuries (84%), suggesting that

TABLE 3. Radiographic Skeletal Survey Completion and Additional Injury Rates Based on the Injury Presentation of Infants Under 6 Months of Age Who Presented to Urgent Care or the Emergency Department With Bruising, Burns, and/or Intraoral Injury

Injury Type/Location	Skeletal Survey Completed (n = 91, N = 157)			Additional Injury Found (N = 91)		
	% (n/N)	OR (95% CI)	P	Occult Fracture(s)	Suspected Fracture(s)	Intracranial Hemorrhage
				% (n/N)	% (n/N)	% (n/N)
Bruising						
Yes	66% (80/121)	4.43 (1.99–9.90)	<0.001*	26% (21/80)	25% (20/80)	25% (20/80)
No	31% (11/36)	Ref				
Burn						
Yes	24% (5/21)	0.18 (0.06–0.53)	0.002*	0% (0/5)	0% (0/5)	0% (0/5)
No	63% (86/136)	Ref				
Intraoral injury						
Yes	47% (9/19)	0.61 (0.23–1.61)	0.32	44% (4/9)	44% (4/9)	22% (2/9)
No	59% (82/138)	Ref				
Scalp/forehead injury						
Yes	47% (25/53)	0.51 (0.26–1.01)	0.052	16% (4/25)	24% (6/25)	36% (9/25)
No	63% (66/104)	Ref				
Facial injury						
Yes	83% (49/59)	6.53 (2.97–14.38)	<0.001*	29% (14/49)	27% (13/49)	24% (12/49)
No	43% (42/98)	Ref				
Eye injury						
Yes	100% (11/11)	—	—	55% (6/11)	36% (4/11)	9% (1/11)
No	55% (80/146)	—				
Ear injury						
Yes	80% (4/5)	—	—	50% (2/4)	0% (0/4)	50% (2/4)
No	57% (87/152)	—				
Neck injury						
Yes	100% (1/1)	—	—	0% (0/1)	0% (0/1)	100% (1/1)
No	58% (90/156)	—				
Torso injury						
Yes	82% (28/34)	4.44 (1.72–11.49)	0.002*	39% (11/28)	25% (7/28)	25% (7/28)
No	51% (63/123)	Ref				
Extremity injury						
Yes	62% (37/60)	1.28 (0.66–2.47)	0.46	27% (10/37)	32% (12/37)	24% (9/37)
No	56% (54/97)	Ref				
Torso-ear-neck (TEN) injury						
Yes	84% (32/38)	5.42 (2.11–13.93)	<0.001*	41% (13/32)	22% (7/32)	31% (10/32)
No	50% (59/119)	Ref				

*P < 0.05.

providers recognize some physical examination findings that are concerning for abuse in ambulatory children.² Physical abuse evaluation, however, was less frequent for burns (24%) and intraoral injury (47%), suggesting that there remain gaps around provider recognition of when to conduct a physical abuse evaluation.

Physical abuse evaluation was completed frequently (75%) for infants with apparently isolated scalp hematoma/swelling. Intracranial hemorrhage was identified in 59% of these infants and occult fracture in 13%. It is unclear why so many of these infants had a physical abuse evaluation compared with those with other superficial injuries, but these findings support the need for imaging and physical abuse evaluation when scalp hematoma/swelling is identified in an infant younger than 6 months.^{2,9,10} This recommendation is in contrast to the Pediatric Emergency Care Applied Research Network (PECARN) pediatric head injury guideline which recommends observation over imaging for children

between 3 months and 2 years of age who have a scalp hematoma without a Glasgow Coma Scale score less than 15, other signs of altered mental status, or a palpable skull fracture.³⁰ The PECARN guideline recommendations are based on risk for clinically important traumatic brain injury.³⁰ Although “minor” injuries may not represent clinically important traumatic brain injury, they can be critically important for recognizing child abuse and preventing future injury.

The trauma history was a strong predictor of whether or not a physical abuse evaluation was completed. The vast majority (88%) of infants with a concerning trauma history, defined as the caregiver providing a history for the trauma that was either inconsistent with the injury or the physical/developmental capabilities of the patient, that varied considerably over time or between caregivers, or that included admission of inflicted injury or delay in obtaining medical care, underwent physical abuse evaluation in this study, suggesting that health care providers recognize these

TABLE 4. Radiographic Skeletal Survey Completion and Additional Injury Rates Among Infants Under 6 Months of Age Who Presented to Urgent Care or the Emergency Department With Bruising, Burns, and/or Intraoral Injury Based on the Trauma History

Trauma History	Skeletal Survey Completed (n = 91, N = 157)			Additional Injury Found (N = 91)		
	% (n/N)	OR (95% CI)	P	Occult Fracture(s)	Suspected Fracture(s)	Intracranial Hemorrhage
				% (n/N)	% (n/N)	% (n/N)
Chief complaint						
Alleged physical abuse*						
Yes	94% (29/31)	14.97 (3.43–65.40)	<0.001 [†]	38% (11/29)	21% (6/29)	21% (6/29)
No	49% (62/126)	Ref				
Injury or fall [‡]						
Yes	46% (49/107)	0.16 (0.07–0.38)	<0.001 [†]	16% (8/49)	33% (16/49)	29% (14/49)
No	84% (42/50)	Ref				
Other [§]						
Yes	70% (14/20)	1.82 (0.66–5.01)	0.25	36% (5/14)	14% (2/14)	14% (2/14)
No	56% (77/137)	Ref				
Trauma history						
Concerning trauma history [¶]						
Yes	88% (21/24)	6.30 (1.79–22.14)	0.004 [†]	38% (8/21)	24% (5/21)	29% (6/21)
No	53% (70/133)	Ref				
No trauma history						
Yes	80% (39/49)	4.20 (1.90–9.26)	<0.001 [†]	41% (16/39)	28% (11/39)	21% (8/39)
No	48% (52/108)	Ref				

*Suspected physical child abuse, nonaccidental trauma, rule out physical abuse.

[†] P < 0.05.

[‡] Fall of any type, laceration, abrasion, lesion, swelling, bleeding, burn, bite, bruise, ecchymosis, petechiae, head lump or knot, or injury of any body part.

[§] Fussiness, lethargy, decreased eating, pain, vomiting, seizure, BRUE (Brief Resolved Unexplained Events), fever, nasal congestion, difficulty breathing, pneumonia, cough, constipation, croup, food allergy, feeding tube problem, rash.

[¶] History that was inconsistent with injuries or physical/developmental capabilities, varied considerably over time or between caregivers, was admittedly inflicted, or included delay in obtaining medical care.

characteristics of the trauma history as concerning for abuse.^{2,26} However, about 1 (21%) in 5 infants without a concerning trauma history were found to have an occult fracture. Therefore, the plausibility and consistency of the trauma history should not be considered solely sufficient to rule out concern for physical abuse among young infants because caregivers may provide convincing, yet inaccurate, trauma histories. Because physicians are taught to rely on the history provided by caregivers, particularly with non-verbal infants,² it can be challenging to not take the trauma history into consideration, especially if the caregiver gives a potentially plausible cause for the injury.

Physical abuse evaluations were completed less frequently for infants who presented with an apparently isolated “minor” injury, including abrasion/laceration (18%) and subconjunctival hemorrhage (33%). Of those who underwent a skeletal survey, occult fracture was found in 14% of infants with apparently isolated abrasion/laceration and 33% with apparently isolated subconjunctival hemorrhage. Some definitions of “sentinel” injuries have excluded superficial abrasions.^{8,31} However, the findings from this study suggest that abrasions may warrant physical abuse evaluation when identified in infants younger than 6 months. Two recent studies have found that open wounds or superficial injuries are risk factors for recurrent episodes of physical abuse in children.^{19,20} Both studies suggested that this increased rate of physical abuse recurrence may be explained by seemingly “minor” injuries either not being reported to child protective services or from children not being removed from the unsafe environment.^{19,20}

The present study raises concern that physical abuse may go undetected and leave infants unprotected if physical abuse evaluation is not completed when injury is identified by health care providers.

The findings from this study must be interpreted within the context of its limitations. First, patients with injuries were identified based on ICD coding, which may have resulted in missed patients due to inappropriate coding. Second, other factors may have contributed to providers’ decisions to perform a physical abuse evaluation that were not considered (eg, cost, concern for litigation). Third, not all infants with an injury underwent a skeletal survey, so it is unknown how many of the infants who were not evaluated would have been found to have a fracture or intracranial hemorrhage. Therefore, the true prevalence of fracture or intracranial hemorrhage based on the different demographic, presentation, and history characteristics investigated remains unknown. Further research is needed to better understand the benefit-cost ratio of performing physical abuse evaluations universally for preambulatory infants with injury, as the benefit of increased recognition of abuse in some infants must be counterbalanced with the possibility of false positive results, the stigma of suggesting child abuse, and the cost of unnecessary evaluation of some infants who have not been abused. Furthermore, because not all injured infants undergo a skeletal survey, the sample size became smaller when looking at fracture and intracranial hemorrhage rates based on specific injury presentations. Fourth, as a retrospective study, the providers’ true indications for ordering a physical abuse evaluation and true suspicion of fracture can be difficult to ascertain based on medical chart

documentation. Lastly, these findings may not be generalizable to other institutions, although the study was performed at a tertiary hospital with a reasonably large sample and inclusive methodologic approach.

This study found that infants younger than 6 months with visible injury presenting to emergency and UC settings do not universally undergo physical abuse evaluation. Physical abuse evaluation was less likely in patients 3 months or older, of black race, presenting to a UC or satellite location, evaluated by a non-PEM-trained physician or nurse practitioner, or with a burn. When completed, occult fractures and intracranial hemorrhage are commonly found in these infants, regardless of injury history or presentation, and including seemingly “minor” injuries, such as apparently isolated abrasion/laceration, subconjunctival hemorrhage, and scalp hematoma/swelling. These specific examination findings should be added to the definition of sentinel injury. Additional education for health care providers on the importance of universal physical abuse evaluation of preambulatory infants with any injury is needed to improve recognition of abusive injuries and promote the secondary prevention of recurrent abuse.

ACKNOWLEDGMENTS

The authors would like to thank the entire Timely Recognition of Abusive Injuries (TRAIN) Collaborative. The TRAIN Collaborative is funded by the Office of the Ohio Attorney General Mike DeWine.

REFERENCES

- U.S. Department of Health and Human Services, Administration for Children and Families, Administration on Children, Youth and Families, Children's Bureau. *Child Maltreatment 2016*. Available at: <http://www.acf.hhs.gov/programs/cb/research-data-technology/statistics-research/child-maltreatment>. Accessed February 5, 2018.
- Christian CW, Committee on child abuse and neglect. The evaluation of suspected child physical abuse. *Pediatrics*. 2015;135:e1337–e1354.
- Jenny C, Hymel KP, Ritzen A, et al. Analysis of missed cases of abusive head trauma. *JAMA*. 1999;281:621–626.
- Ravichandiran N, Schuh S, Bejuk M, et al. Delayed identification of pediatric abuse-related fractures. *Pediatrics*. 2010;125:60–66.
- Thackeray JD. Frena tears and abusive head injury: a cautionary tale. *Pediatr Emerg Care*. 2007;23:735–737.
- King WK, Kiesel EL, Simon HK. Child abuse fatalities: are we missing opportunities for intervention? *Pediatr Emerg Care*. 2006;22:211–214.
- Barrett R, Ornstein A, Hanes L. Minor injuries...major complications: watching out for sentinel injuries. *Paediatr Child Health*. 2016;21:29–30.
- Sheets LK, Leach ME, Koszewski IJ, et al. Sentinel injuries in infants evaluated for child physical abuse. *Pediatrics*. 2013;131:701–707.
- Section on Radiology; American Academy of Pediatrics Diagnostic imaging of child abuse. *Pediatrics*. 2009;123:1430–1435.
- Campbell KA, Olson LM, Keenan HT. Critical elements in the medical evaluation of suspected child physical abuse. *Pediatrics*. 2015;136:35–43.
- Barber I, Perez-Rossello JM, Wilson CR, et al. The yield of high-detail radiographic skeletal surveys in suspected infant abuse. *Pediatr Radiol*. 2015;45:69–80.
- Lindberg DM, Beaty B, Juarez-Colunga E, et al. Testing for abuse in children with sentinel injuries. *Pediatrics*. 2015;136:831–838.
- Deans KJ, Thackeray J, Askegard-Giesmann JR, et al. Mortality increases with recurrent episodes of nonaccidental trauma in children. *J Trauma Acute Care Surg*. 2013;75:161–165.
- Deridder CA, Berkowitz CD, Hicks RA, et al. Subconjunctival hemorrhages in infants and children. *Pediatr Emerg Care*. 2013;29:222–226.
- John SM, Kelly P, Vincent A. Patterns of structural head injury in children younger than 3 years: a ten-year review of 519 patients. *J Trauma Acute Care Surg*. 2013;74:276–281.
- Wood J, Rubin DM, Nance ML, et al. Distinguishing inflicted versus accidental abdominal injuries in young children. *J Trauma*. 2005;59:1203–1208.
- Harper NS, Feldman KW, Sugar NF, et al. Additional injuries in young infants with concern for abuse and apparently isolated bruises. *J Pediatr*. 2014;165:383–388.e1.
- Leventhal JM, Martin KD, Asnes AG. Incidence of fractures attributable to abuse in young hospitalized children: results from analysis of a United States database. *Pediatrics*. 2008;122:599–604.
- Deans KJ, Thackeray J, Groner JI, et al. Risk factors for recurrent injuries in victims of suspected non-accidental trauma: a retrospective cohort study. *BMC Pediatr*. 2014;14:217.
- Thackeray J, Minneci PC, Cooper JN, et al. Predictors of increasing injury severity across suspected recurrent episodes of non-accidental trauma: a retrospective cohort study. *BMC Pediatr*. 2016;16:8.
- DeGraw M, Hicks RA, Lindberg D, Using Liver Transaminases to Recognize Abuse (ULTRA) Study Investigators. Incidence of fractures among children with burns with concern regarding abuse. *Pediatrics*. 2010;125:e295–e299.
- Wibbenmeyer L, Liao J, Heard J, et al. Factors related to child maltreatment in children presenting with burn injuries. *J Burn Care Res*. 2014;35:374–381.
- Pierce MC, Kaczor K, Aldridge S, et al. Bruising characteristics discriminating physical child abuse from accidental trauma. *Pediatrics*. 2010;125:67–74.
- Maguire SA, Upadhyaya M, Evans A, et al. A systematic review of abusive visceral injuries in childhood—their range and recognition. *Child Abuse Negl*. 2013;37:430–445.
- Vadivelu S, Esernio-Jenssen D, Rekate HL, et al. Delay in arrival to care in perpetrator-identified nonaccidental head trauma: observations and outcomes. *World Neurosurg*. 2015;84:1340–1346.
- Hettler J, Greenes DS. Can the initial history predict whether a child with a head injury has been abused? *Pediatrics*. 2003;111:602–607.
- Wood JN, French B, Song L, et al. Evaluation for occult fractures in injured children. *Pediatrics*. 2015;136:232–240.
- Tiyyagura G, Gawel M, Koziel JR, et al. Barriers and facilitators to detecting child abuse and neglect in general emergency departments. *Ann Emerg Med*. 2015;66:447–454.
- Wood JN, Hall M, Schilling S, et al. Disparities in the evaluation and diagnosis of abuse among infants with traumatic brain injury. *Pediatrics*. 2010;126:408–414.
- Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009;374:1160–1170.
- Petska HW, Sheets LK. Sentinel injuries: subtle findings of physical abuse. *Pediatr Clin North Am*. 2014;61:923–935.