Use and Utility of Skeletal Surveys to Evaluate for Occult Fractures in Young Injured Children

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ABSTRACT

OBJECTIVE: To describe the percentage and characteristics of children aged <24 months with non-motor vehicle crash (MVC)-related injuries who undergo a skeletal survey and have occult fractures.

METHODS: We performed a retrospective chart review of a stratified, systematic random sample of 1769 children aged <24 months with non-MVC–related bruises, burns, fractures, abdominal injuries, and head injuries at 4 children's hospitals between 2008 and 2012. Sampling weights were assigned to each child to allow for representative hospital-level population estimates. Logistic regression models were used to test for associations between patient characteristics with outcomes of skeletal survey completion and occult fracture identification.

RESULTS: Skeletal surveys were performed in 46.3% of children aged 0 to 5 months, in 21.1% of those aged 6 to 11 months, in 8.0% of those aged 12 to 17 months, and in 6.2% of those aged 18 to 24 months. Skeletal surveys were performed most frequently in children with traumatic brain injuries (64.7%) and rib fractures (100%) and least frequently in those with burns (2.1%) and minor head injuries (4.4%). In adjusted analyses, older age, private insurance, and reported history of accidental trauma were associated with decreased skeletal survey use ($P \leq .001$ for all). The prevalence of occult fractures on skeletal surveys ranged from 24.6% in children aged 0 to 5 months to 3.6% in those aged 18 to 24 months, and varied within age categories based on the presenting injury ($P < .001$).

CONCLUSIONS: The high rate of occult fractures in infants aged 0 to 5 months underscores the importance of increasing the use of skeletal surveys in this population. Further research is needed to identify the injury characteristics of older infants and toddlers most at risk for occult fractures.

KEYWORDS: child abuse; child maltreatment; skeletal survey

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WHAT'S NEW?

Skeletal surveys are frequently performed in young children with rib, abdominal, and brain injuries, but not in children with minor head injuries or burns. The prevalence of occult fractures within an age category is dependent on the type of presenting injury.

MORE THAN 120,000 children in the United States are victims of physical abuse each year.[1,2] The youngest children are at greatest risk of severe maltreatment, with >70% of hospitalizations for physical abuse and >50% of maltreatment fatalities occurring in children aged <24 months.[1–3] Delays by medical providers in diagnosing abuse contribute to the high morbidity and mortality in this age group. One study of children with abusive fractures found that 21% of the children had a previous medical encounter during which the diagnosis of abuse was missed, and before the diagnosis of abuse, 17% of the children suffered additional injuries.[4] Similarly, studies of children diagnosed with abusive head trauma (AHT) found that 25% to 31% had a previous medical encounter opportunity during which abuse could have been diagnosed.[5,6] Among the missed cases of AHT, 28% of the

children experienced reinjury before being diagnosed with AHT, and 41% experienced medical complications related to the delay in diagnosis.[5]

Owing to these and other findings of missed opportunities to diagnose abuse, clinicians and researchers have advocated for increased use of skeletal surveys (SSs) to evaluate for occult fractures in young children presenting with specific types of injuries.[7–10] SSs have been reported to reveal occult fractures in 11% to 34% of children evaluated because of concern for or with a diagnosis of abuse.[11–16] Accordingly, the American Academy of Pediatrics recommends that SSs be performed in all of cases of suspected physical abuse in children aged <24 months.[17,18] Despite this recommendation, there is wide variation regarding which young injured children are evaluated. Variation in rates of SS completion, as well as disparities based on patient demographics, provider characteristics, and location of care, have been identified.[7,8,10,19–23] Standardizing SS performance in young children with specific injury types may be an effective strategy for decreasing missed opportunities to diagnose abuse and protect children, as well as to decrease the amount of unnecessary imaging in other children.

To understand the potential impact of standardizing SS use in young children presenting with specific injuries, we sought to better understand rates of utilization and yield of SSs. Multiple studies have described the frequency of SS completion and the yield of SS among children in whom there is a strong suspicion of abuse, including children referred to hospital-based child protection teams (CPT)[12–14,24–27]; however, few studies have examined SS completion and yield among the larger population of injured children, the majority of whom are not evaluated by a CPT. Studies examining SS use in the population of children not evaluated by a CPT have been limited primarily to single-center studies of a single injury type[8,21] or have relied on administrative data and lacked clinical information.[10,20,22] Thus, the objectives of this study were to describe in a multicenter sample of children aged <24 months with non-motor vehicle crash (non-MVC)-related injuries the percentage and characteristics of children who underwent an SS and were found to have occult fractures.

METHODS

STUDY DESIGN OVERVIEW

We performed a retrospective study of children aged <24 months with non-MVC–associated injuries cared for at the Children's Hospital of Philadelphia, Children's Hospital of Pittsburgh of UPMC, Children's Mercy Kansas City, and Children's Hospital Colorado between 2008 and 2012. The study combined administrative data from the Pediatric Health Information System (PHIS), which was also used to identify cases with detailed data from chart review. The 4 hospitals contributed International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes, demographic information, and resource utilization data to the PHIS, an administrative database of coded diagnostic data from pediatric hospitals in the United States.[28] Through a joint effort by Children's Hospital Association, Thomson Reuters (Ann Arbor, Mich), and participating hospitals, PHIS data are subjected to reliability and validity checks.[28] Subjects from the 4 hospitals were first identified in the PHIS based on ICD-9-CM

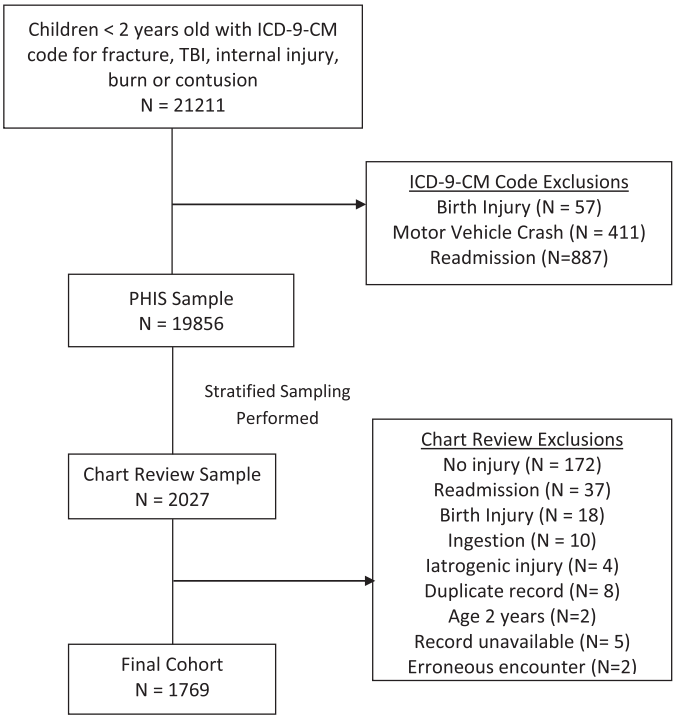

Figure 1. *Study cohort flow diagram.*

injury codes, after which a subset of subjects was sampled using the strategy described below. Detailed clinical information for the sampled eligible subjects was then extracted from chart review. The Institutional Review Boards of the 4 institutions approved this study.

Study Population and Sampling Strategy

Children aged <24 months discharged between January 1, 2008, and December 31, 2012, from the 4 hospitals with an ICD-9-CM code for any of the following injury types that may raise concern for abuse were identified in the PHIS using the injury ICD-9-CM codes listed in Appendix A: fracture, head injury, internal injury, burn, or bruising. We excluded hospitalizations with ICD-9-CM codes for birth or MVC-associated injuries as well as readmissions for previously diagnosed injuries to generate the PHIS sample (Figure 1). Next, we used stratified, random systematic sampling to ensure adequate representation by age, sex, injury type, injury etiology (abuse or nonabuse), and hospital.[29] The presence of an ICD-9-CM or E-code for child abuse or assault was used to identify cases as abuse for sampling purposes (Appendix A).[30,31] Twenty-six sampling strata were defined by a combination of age, injury type, injury etiology, and hospital. All sampling frequencies were integers in the interests of simplicity and transparency in application. Frequencies were chosen to produce an adequate number of sampled observations for each diagnosis category so that the confidence bounds of resulting rates would support estimates by diagnosis subgroups. In addition, the varying frequencies ensured that no hospital would be overburdened by an unduly large sample for which medical records needed to be abstracted. All sampling programs were written and implemented in SAS version 9.3 (SAS Institute, Cary, NC).

To permit estimation of hospital-level population estimates of proportions, the sampling program assigned to each sampled observation a weight equal to the inverse of the sampling frequency. For example, a discharge selected with a sampling frequency of 1 in 5 would carry a sampling weight of 5, to represent the child whose discharge was sampled and the 4 other children represented by the selected child. Once completed, the sum of the weighted sample equaled the total population of all children who met the inclusion and exclusion criteria defined by hospital and diagnosis. Thus, inferences from weighted analysis of the sample were representative of the population from which the sample was drawn.

Data Abstraction and Quality

Each sampled child's PHIS record was linked to his or her medical record. Chart abstractors at each hospital reviewed charts to ensure that cases met the inclusion criteria and to abstract detailed clinical data. Cases with an ICD-9-CM diagnosis code for an injury but no injury documented on physical examination or imaging were excluded. Children who on chart review were found to have iatrogenic injuries occurring in the hospital or were admitted for management of previously diagnosed injuries, birth injuries, or ingestions were excluded.

For each included case, chart abstractors reviewed the medical record, including imaging reports, and entered data on study outcomes and predictor variables (described below) in a data abstraction form created in REDCap, a secure, web-based application.[32] Instructions were imbedded within data forms and reviewed with chart abstractors. Quality checks were performed, including searches for missing data, out-of-range numerical fields, and inconsistencies in data entry. To assess interrater reliability of abstracted data, double data entry was performed by a second data abstractor at each site on a 10% random sample of the chart review sample for key variables. Interrater reliability was perfect for likelihood of abuse ($\kappa = 1.0$) and was substantial to near perfect for inclusion ($\kappa = 0.89$), SS results ($\kappa = 0.94$), reason for presentation ($\kappa = 0.68$), and first identified injury ($\kappa = 0.75$).

Study Outcomes

Primary study outcomes were completion of an initial SS to evaluate for occult fractures and positive initial SS. Completion of a standard SS was confirmed based on review of radiology reports. SSs were considered to be positive and to identify occult fracture if a fracture not previously suspected clinically or detected on previous imaging was identified. Two authors (MK Henry and JN Wood) reviewed abnormal radiology reports. Occult fractures described as probable or definite were categorized as present. Findings described as equivocal or possible fractures were not considered occult fractures. Disagreements were resolved by consensus. Data were collected on secondary outcomes of likelihood of abuse and disposition. The likelihood of abuse was recorded as definite abuse, probable abuse, indeterminate, probable accident, or definite accident based on the CPT's documented assessment or assessment of the primary medical team if CPT was not consulted. We collapsed the definite and probable categories for the analyses. Disposition on discharge from the hospital was categorized as home, out of home placement, deceased or other. Children discharged home were categorized as home with services if at the time of discharge CPS planned to provide in home services.

Predictor Variables

Predictor variables included demographic and clinical characteristics previously identified as predictors of SS completion and/or predictors of occult fracture detection: age in months (0−5, 6−11, 12−17, or 18−23), insurance type (private or public/uninsured), race (non-Hispanic white, Hispanic, black, or other/unknown), reason for presentation, first identified injury, and hospital.[4,16,20,33,34] The reason for presentation was based on the primary reason the caregiver provided for bringing the child for care and was categorized as 1) reported history of accidental trauma, 2) reported history of inflicted trauma, 3) abnormal

Table 1. Unadjusted Associations of Demographic and Clinical Characteristics with Skeletal Survey Receipt and Positive Skeletal Survey (Unweighted N = 1769)

Characteristic	Skeletal Survey Obtained		Skeletal Survey Positive*	
	%	*P* Value	%	*P* Value
Demographic characteristics				
Age category		<.001		<.001
0–5 mo (16.3%)	46.3		24.6	
6–11 mo (21.9%)	21.1		9.7	
12–17 mo (30.0%)	8.0		6.4	
18–23 mo (31.8%)	6.2		3.6	
Sex		.74		.40
Female (44.2%)	16.2		13.7	
Male (55.8%)	16.8		16.5	
Race		.09		.72
White non-Hispanic (54.5%)	18.4		14.1	
Black (24.6%)	13.7		15.6	
Hispanic (10.2%)	12.5		17.4	
Other/unknown (10.7%)	17.4		20.6	
Insurance		<.001		.004
Private (44.5%)	12.0		9.0	
Public/uninsured (55.2%)	20.3		18.4	
Unknown (0.3%)	10.7		-	
Clinical characteristics				
History at presentation†		<.001		.02
History of accidental trauma (86.4%)	9.1%		11.5	
History of inflicted trauma (0.7%)	61.4%		11.4	
Signs, symptoms suggestive of injury (11.5%)	65.5%		17.7	
Medical concerns unrelated to injury (1.1%)	64.0%		32.3	
First identified injury		<.001		.07
Extremity fracture (23.6%)	19.6		17.9	
Head injury, minor (22.7%)	4.4		7.8	
Bruises (17.3%)	18.7		14.2	
Burns (13.2%)	2.1		6.0	
Other injury (9.3%)	3.1		24.9	
Traumatic brain injury (7.0%)	64.7		16.0	
Skull fracture (6.4%)	33.7		7.8	
Abdominal injury (0.3%)	52.3		16.7	
Rib fracture (0.3%)	100.0		45.9	
Child abuse evaluation and determination				
Child protection team consulted		<.001		<.001
No (86.8%)	5.7		3.2	
Yes (13.2%)	88.1		20.4	
Report made to Child Protective Services		<.001		<.001
No (86.2%)	5.5		0.5	
Yes (13.8%)	85.8		21.2	
Disposition		<.001		<.001
Home without services (87.3%)	6.7		0.9	
Home with services (7.5%)	84.8		8.9	
Out-of-home placement (4.0%)	96.5		45.8	
Deceased (0.4%)	77.3		36.6	
Other (0.8%)	27.3		15.8	

The weighted percentages of the population with the characteristics are indicated in parentheses. Because percentages represent weighted samples, they cannot be used to extrapolate unweighted Ns.

*The percentage of patients who underwent a skeletal survey (SS) and had a positive SS, defined as detection of occult fractures, is presented. Thus, the denominator includes only children who underwent an SS.

†An additional 0.03% presented because they were a close contact of a suspected victim of abuse, and 0.3% presented for other or unknown reasons.

symptoms or signs suggestive of injury, or 4) medical concerns unrelated to injury. For example, a child who presented with leg swelling and no history of trauma and was found to have a tibia fracture would be category 3 (ie, abnormal symptoms or signs suggestive of injury), whereas a child who presented with signs of pneumonia and was incidentally found to have rib fractures on chest radiograph would be category 4 (ie, medical concerns unrelated to injury). The first identified injury was categorized as burn, bruise, minor head injury, skull fracture (without intracranial injury), traumatic brain injury (TBI), abdominal injury, extremity fracture, rib fracture, or other. Minor head injuries included bruises, abrasions, or swelling of the head/scalp without a skull fracture or intracranial injury. All head injuries with any type of intracranial hemorrhage

Table 2. Unadjusted Associations of Care Setting Characteristics with Skeletal Survey Receipt and Positive Skeletal Survey (Unweighted N = 1769)

	Skeletal Survey Obtained		Skeletal Survey Positive*	
Care Setting Characteristics	%	*P* value	%	*P* value
Hospital		<.001		.13
A (26.7%)	11.7		16.6	
B (29.2%)	17.1		19.7	
C (21.0%)	26.6		10.5	
D (23.1%)	12.3		15.5	
Care setting†		<.001		<.001
Inpatient (10.7%)	66.8		25.1	
Emergency Department (84.8%)	8.9		9.6	
Observation (4.5%)	41.8		0.6	

The weighted percentages of the population with the characteristics are indicated in parentheses.

*The percentage of patients who underwent a skeletal survey (SS) and had a positive SS, defined as detection of occult fractures, is presented. Thus, the denominator includes only children who underwent an SS.

†Patients cared for in the emergency department and subsequently admitted to the inpatient setting were categorized as inpatient.

or parenchymal injury were categorized as TBI. Hospital was included as a predictor variable based on research demonstrating variation in SS utilization across hospitals.[10,20,22]

Analysis

Data analysis was conducted using Stata 13.0 software (StataCorp, College Station, Tex). Study population characteristics were described using frequencies for categorical variables. Logistic regression models tested for associations between demographic and clinical characteristics with the primary outcomes of SS completion and positive SS for occult fracture. Sibling evaluations and cases with other injury types or other/unknown race were excluded from the regression analyses. Marginal standardization was implemented in logistic regression to generate the standardized estimated proportions of children undergoing an SS (and having a positive SS) for each predictor variable.[35,36] Next, the regression model was repeated, testing for an interaction between age category and injury type, because the association between age and occult fractures may vary depending on injury type. We then calculated and graphed the predicted probabilities of SS completion and a positive SS based on patient age category and injury type.

Results

Study Population Characteristics

A total of 21,211 encounters were identified with ICD-9-CM codes for fractures, head injuries, internal injuries, burns, or contusions (Figure 1). After excluding readmissions and encounters with diagnosis codes for birth and MVC-related injuries, a total of 19,856 encounters remained, from which we sampled 2027 encounters for chart review. On chart review completion, 1769 encounters (88.5% of the weighted sample) met our inclusion criteria. The majority of cases that were excluded based on chart review had an ICD-9-CM code for an injury but no documented injury on physical examination or imaging (Figure 1).

In the weighted study cohort, 54.5% of children were non-Hispanic white and 55.2% had public insurance or were uninsured (Table 1). The majority of children presented with a history of accidental trauma (86.4%) or abnormal symptoms and signs suggestive of an injury with no history of trauma (11.5%). The most common presenting injuries were extremity fractures (23.6%) and minor head injury (22.7%), and the least common were abdominal injuries (0.3%) and rib fractures (0.3%). A report was made to Child Protective Services (CPS) in 13.8%.

SS Completion

Overall, 16.6% of the weighted sample of children aged <24 months underwent an SS, but the percentage was dependent on age, decreasing from 46.3% among infants aged 0 to 5 months to 6.2% among toddlers aged 18 to 23 months (Table 1). In unadjusted analyses, children with public insurance/no insurance were more likely to undergo an SS than those with private insurance (20.3% vs 12.0%; $P < .001$), but there was no difference by race ($P = .09$). The frequency of SS completion was highest in children whose first identified injury was a rib fracture (100%), a TBI (64.7%), or an abdominal injury (52.3%) and lowest in children with burns (2.1%) and minor head injuries (4.4%; $P < .001$). SS was performed in >60% of children with no history of trauma, but in only 9.1% of children with a history of accidental trauma. The frequency of SS completion was higher among children referred to a CPT compared with children not referred (88.1% vs 5.7%; $P < .001$; Table 1) and varied by hospital (Table 2). In adjusted analyses, younger age, insurance type, presenting injury, and hospital all remained associated with likelihood of SS ($P \leq 0.001$; Table 3).

Analyses examining the interaction of injury type and age demonstrated that for some injuries, the percentage of children receiving SS declined sharply with increasing age, but for other injury types, the rate of SS remained fairly constant across the age range (Figure 2). For example, the percentage of children

Table 3. Standardized Predictors of Skeletal Survey Performance and Occult Fracture Detection

Characteristic (n weighted)	Skeletal Survey Performance		Skeletal Survey Positive*	
	Standardized Proportion (95% CI)	*P* Value	Standardized Proportion (95% CI)	*P* Value
Age category		<.001		<.001
0–5 mo	27.4 (22.1–32.7)		25.6 (18.7–32.4)	
6–-11 mo	20.1 (16.7–23.6)		9.5 (3.3–15.8)	
12–-17 mo	11.5 (8.4–14.5)		5.1 (1.1–9.1)	
18–-23 mo	12.4 (8.9–16.0)		2.2 (0.0–5.0)	
Sex		.50		.26
Male	17.2 (14.9–19.5)		16.7 (11.1–22.4)	
Female	18.4 (16.1–20.6)		12.4 (7.9–16.8)	
Race		.87		.94
Non-Hispanic White	17.5 (15.5–19.5)		14.5 (10.7–18.3)	
Black	18.6 (15.0–22.2)		15.9 (7.7–24.1)	
Hispanic	17.6 (11.9–23.3)		13.8 (4.1–23.5)	
Insurance		<.001		.01
Private	14.3 (12.0–16.6)		8.9 (4.5–13.3)	
Public/uninsured	20.8 (18.3–23.4)		17.7 (13.3–22.2)	
History at presentation†		<.001		.13
Accidental trauma	11.4 (9.7–13.2)		12.9 (6.7–19.1)	
Inflicted trauma/abuse	58.7 (28.1–89.4)		14.3 (3.8–24.9)	
Signs or symptoms suggestive of injury	51.4 (42.9–59.9)		15.2 (10.4–19.9)	
Medical concerns	48.9 (22.80–74.9)		27.5 (14.6–40.4)	
First Identified Injury		<.001		.14
Extremity fracture	19.5 (15.4–23.6)		23.4 (14.0–32.8)	
Head injury, minor	6.7 (3.1–10.4)		6.3 (0.0–13.7)	
Bruises	15.4 (11.7–19.0)		15.1 (6.4–23.8)	
Burns	4.2 (0.4–8.0)		8.1 (0.0–18.1)	
Traumatic brain injury	46.2 (36.3–56.1)		11.1 (6.8–15.4)	
Skull fracture‡	26.5 (19.0–34.0)		9.4 (0.0–19.4)	
Abdominal	32.6 (6.7–58.4)		25.4 (0.0–55.0)	
Rib fracture	100.0 (NA)§		20.1 (6.4–33.7)	
Hospital		<.001		.14
A	15.1 (11.6–18.7)		20.9 (12.5–29.3)	
B	17.0 (14.0–20.0)		16.8 (9.5–24.1)	
C	25.9 (21.9–29.8)		9.7 (5.1–14.3)	
D	11.9 (9.1–14.7)		17.1 (10.2–24.0)	

Logistic regression models tested for associations between the listed demographic characteristics and clinical characteristics with the primary outcomes of skeletal survey (SS) completion and positive SS. Marginal standardization was implemented in logistic regression to generate the standardized estimated percentages of children receiving a SS (and having a positive SS) for each predictor variable.

*Only children who received a skeletal survey were included in the model.

†Excludes children evaluated because contact of suspected victim of abuse.

‡Includes children who presented with a skull fracture without intracranial injury.

§All patients with rib fractures as first identified injury underwent skeletal survey. 95% CI unable to be calculated.

with extremity fractures undergoing an SS decreased from 72.6% in infants aged 0 to 5 months to 8.4% in toddlers aged 18 to 23 months, whereas the percentage of children with TBI undergoing an SS decreased from 67.0% in infants aged 0 to 5 months to 51.3% in toddlers aged 18 to 23 months ($P < .001$; Figure 2).

Occult Fracture Detection on SS

Overall, 15.3% of children undergoing an SS had a positive SS. The unadjusted percentage of SSs that were positive ranged from a high of 24.6% in infants aged 0 to 5 months to a low of 3.6% in toddlers aged 18 to 24 months (Table 1). Positive SSs were more common in children with public/no insurance compared with children with private insurance (18.4% vs 9.0%; $P = .004$). The percentage of positive SSs was highest in children presenting with medical concerns unrelated to the injury (32.3%) and lowest in children with a reported history of inflicted trauma (11.4%) or accidental trauma (11.5%). In adjusted analyses, young age and public/no insurance remained associated with a positive SS, but presenting history did not (Table 3).

As shown in Figure 3, among children with extremity fractures and, to lesser degree, children with bruises, the prevalence of occult fractures decreased with increasing age. In Figure 4, the prevalence of occult fractures by age and injury type are presented, but in contrast to Figure 3, all children, including those children not undergoing an SS, are included in the denominator. Among infants aged 0 to 5 months with extremity fractures, the prevalence of occult fractures remained high, at 31.2% (95% CI, 16.7%–45.6%). In contrast, the prevalence of occult fractures in infants aged 0 to 5 months with burns decreased from 30.2% to 2.9% (95% CI, 0.0%–6.6%)

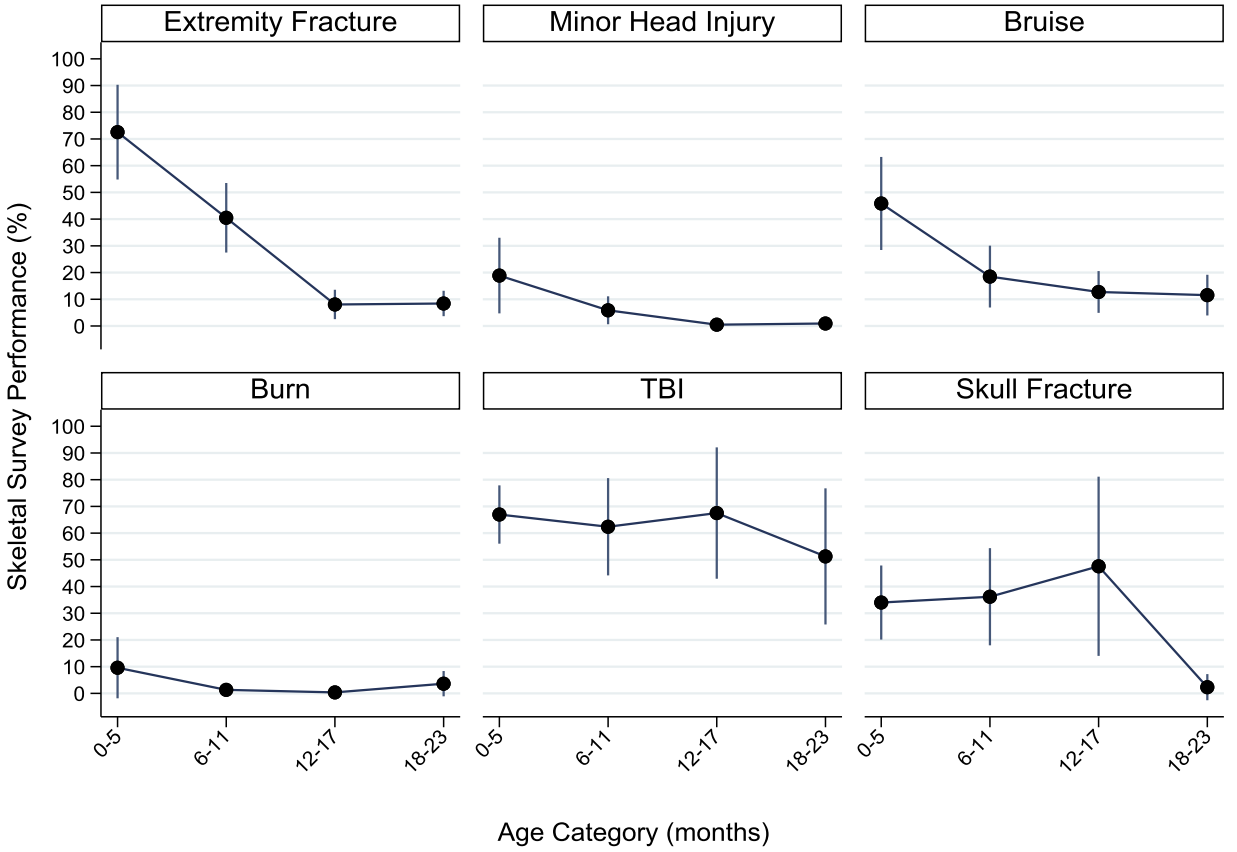

Figure 2. *Skeletal survey performance by presenting injury type and age. Results (with 95% confidence intervals) were generated from logistic regression analysis using marginal standardization, adjusting for insurance, hospital, sex, insurance type, race, history of presentation, and the interaction of age category with presenting injury type. Results for rib fractures and abdominal injuries are not included due to the low number of subjects by age category.*

when all children, including those not undergoing an SS, were included in the denominator (Figs. 3 and 4).

DISCUSSION

Results from this multicenter study demonstrate that the majority of children aged <24 months with non-MVC −related injuries cared for at 4 pediatric hospitals were not evaluated by a CPT and did not undergo an SS. Only 16.7% of children underwent an SS, in striking contrast to the high rates of SS reported in previous studies focusing on the subset of children evaluated by a CPT [13,25,37] or the subset of children with severe injuries, such as TBI and femur fracture.[10,22] The low rate of SSs (<6%) among children not evaluated by a CPT, along with the 6-fold higher rate of positive SS among those evaluated by a CPT compared with those not evaluated by a CPT, suggest that caution should be taken when extrapolating results from studies of children evaluated by CPTs to the larger population of injured children presenting for care. Children with negative SSs may be more likely to be discharged home without a CPT evaluation, whereas children with positive SSs may be preferentially referred to CPTs, thus enriching the yield of SSs among the subset of children evaluated by a CPT. There also may be differences in the risk profiles and likelihood of occult fractures between infants evaluated by a CPT and those not evaluated, because the CPT may be consulted only when there is suspicion of abuse.

Rates of SS were high in some age and injury groups. The majority of infants aged 0 to 5 months with a TBI or an extremity fracture underwent an SS. These infants had a particularly high rate of occult fractures. Even if one conservatively assumes that all the infants aged 0 to 5 months who did not undergo an SS did not have an occult fracture, the rate of occult fractures would be 31.1% in those with an extremity fracture and 14.5% in those with a TBI. These high rates of occult fracture demonstrate a significant risk of abuse in these infants and strongly suggest that the current rate of SS completion in these infants is too low. There is a need for a more standardized approach to ensure that cases of abuse are not being missed.

Drawing precise conclusions regarding the potential impact of standardizing SS use in other populations of injured children who had low rates of SS completion is more challenging. For example, a recent multicenter study of children with burns evaluated by CPTs found that 86.7% of infants aged 0 to 5 months underwent an SS. In that study, occult fractures were identified in 23.1% of infants aged 0 to 5 months undergoing an SS and in 20.0% of all infants aged 0 to 5 months.[27] In contrast, in our study, which included infants not evaluated by a CPT, 9.6% of infants aged 0 to 5 months with a burn underwent an SS. Occult fractures were identified in 30.2% of those

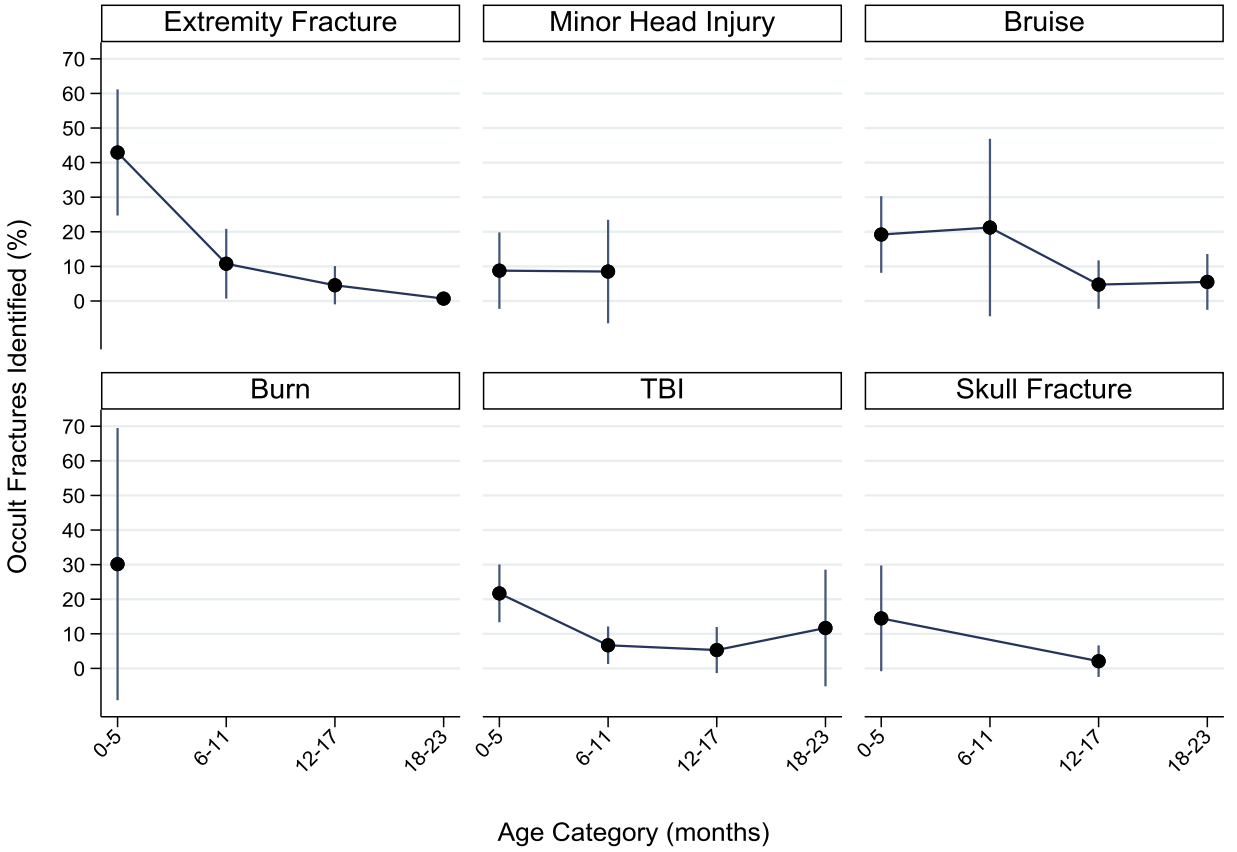

Figure 3. *Occult fracture detection by presenting injury type and age category in the subset of children undergoing a skeletal survey (SS). Results (with 95% confidence intervals) were generated from logistic regression analysis using marginal standardization, adjusting for insurance, hospital, sex, insurance type, race, history of presentation, and the interaction of age category with presenting injury type. The denominator includes only children who underwent an SS. Results for rib fractures and abdominal injuries are not included due to the low number of subjects by age category. No data point is presented if there were 0 children with a positive skeletal survey in a given category.*

undergoing an SS and in <3% of all infants aged 0 to 5 months with burns. Unfortunately, we do not know the rate of occult fractures among the infants who did not undergo an SS. Thus, it is also possible that the true prevalence of occult fractures was significantly greater than 3%. Due to the low rate of SS in infants with burns, drawing conclusions regarding the potential impact of increasing SS rates is difficult.

Our findings need to be interpreted in light of the study's strengths—including the multicenter design, detailed chart review, and inclusion of children not referred to CPTs—and limitations. First, this was a retrospective study and thus was limited by selection biases in who underwent an SS. Second, unobserved patient-level factors, including details of the reported history might have influenced the decision to obtain an SS. Third, the results might not be representative of care at other pediatric centers, and cannot be generalized to nonpediatric centers. Furthermore, the full spectrum of burns might not be represented, because children with severe burn injuries may have been admitted to a burn center. Moreover, the low prevalence of a positive SS in certain subpopulations limited the power to identify predictors of positive SS. Finally, the data reported herein are from 2008 to 2012, but the relationships between patient characteristics and the likelihood of occult fractures would not be expected to change over time.

CONCLUSIONS

The foregoing limitations notwithstanding, our study demonstrates some important findings. The high rate of occult fractures in injured infants aged 0 to 5 months underscores the importance of SSs in this population. Efforts are needed to improve and standardize the use of SSs in young children presenting with high-risk injuries. These efforts will need to involve emergency department (ED) providers, because the majority of children were discharged from the ED without CPT evaluation. In a few hospital settings with infants with select injury types, implementation of child abuse evaluation pathways has been shown to increase rates of SS utilization, decrease bias in SS utilization, and increase the detection of child abuse.[7,8] Thus, clinical pathways implemented in the ED and inpatient settings may be one tool for improving SS use in populations of children at high risk for occult abusive fractures. Such pathways could provide guidance for SS performance and/or involvement of the CPT. Additional data regarding the prevalence of occult abusive fractures among certain populations of young injured children, such as infants with burns, and the risk factors associated with occult fractures are needed to inform the development of pathways. Furthermore, the impact of implementation of pathways on patient outcomes,

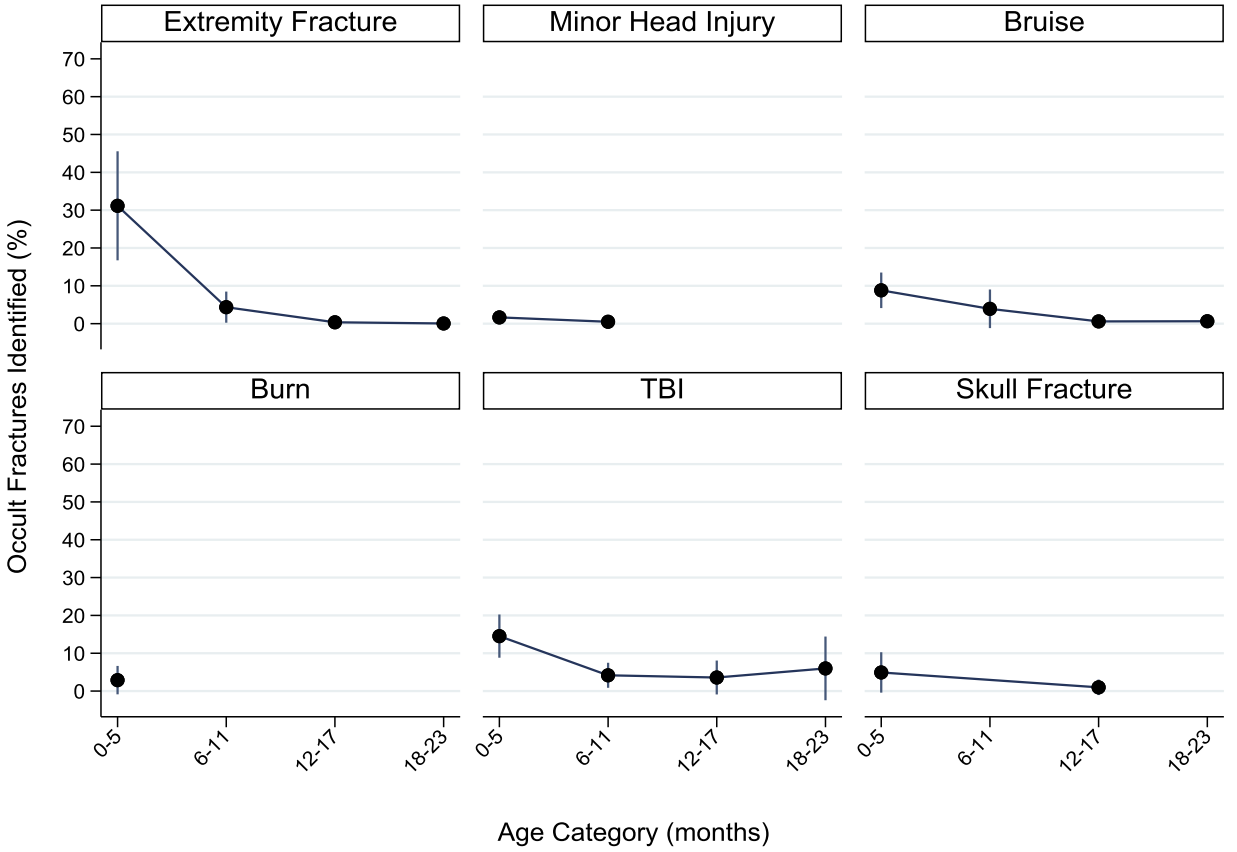

Figure 4. *Occult fracture detection by presenting injury type and age category among all children regardless of skeletal survey (SS) performance. Results (with 95% confidence intervals) were generated from logistic regression analysis using marginal standardization, adjusting for insurance, hospital, sex, insurance type, race, history of presentation, and the interaction of age category with presenting injury type. The denominator includes all children, even those who did not undergo SS. Results for rib fractures and abdominal injuries are not included due to the low number of subjects by age category. No data point is presented if there were 0 children with a positive SS in a given category.*

including detection of occult injuries, diagnoses of abuse, and any adverse outcomes, including increased length of stay, will need to be monitored. Although concerns regarding radiation exposure from SSs have been raised, recent research has demonstrated that the risk is low.[38] Adjustments to the pathways may need to be considered based on the data gathered to ensure that they are appropriately targeted to identify the populations of children who are at risk of abuse. Future studies will need to include children who are and are not referred to a CPT to better understand the utility of SSs in these potentially different groups. Furthermore, future studies will need to follow children beyond their initial injury presentation to better understand outcomes, including rates of occurrence of new abusive injuries, among children not evaluated for abuse during their initial presentation.

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Supplementary Data

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