Characteristics of accidental versus abusive pediatric burn injuries in an urban burn center over a 14-year period

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The aim of this study was to determine the demographic and associated characteristics of abusive burn injuries in children. Understanding the characteristics of burn injuries may help clinicians differentiate and recognize abusive injuries. We conducted a retrospective study of patients less than 5 years old admitted to an urban burn center from March 1999 to July 2013. Per protocol, all patients with burn injuries were evaluated by a multidisciplinary team (child abuse pediatrician, social worker, and nurse clinician). Demographic information, social risk factors, clinical presentation, caregiver at time of injury, radiographic studies and results, multidisciplinary team determination, and the Department of Children and Family Services investigation outcome were abstracted from the American Burn Association Burn Registry and patient's chart. Patient characteristics were evaluated with abuse status through Wilcoxon rank sum tests for continuous variables and chi-square tests or Fisher's exact test for categorical variables. A multiple logistic regression was fit to identify factors associated with abusive burns. One hundred and ten patients under 5 years were categorized as abuse (38) or accident (72). Demographic characteristics were similar between the abuse and accident groups. A determination of abuse was significantly associated with caregiver type (paramour), site of incident (outside of kitchen), time to seeking help (>4 hours), and the presence of nonburn skin injuries. A detailed history of the burn mechanism as well as psychosocial family risk factors are critical when evaluating pediatric patients with burn injuries, as it may assist the physician in distinguishing abusive from accidental burn injuries.

Differentiating between accidental and abusive pediatric burns can be challenging. Clinicians are confronted with recognizing abuse injuries as early as possible to initiate necessary medical evaluation and referral to child protective services. The recognition of abusive injuries can be difficult because the caregivers of these victims often omit, change, or fabricate the history or mechanism of injury. Studies have shown that 35% of abused children may be revictimized if abuse is not recognized and the child is sent back to the same environment and 5 to 10% of them may die at the hands of their perpetrator.[1–3]

Unintentional injuries are the leading cause of death in the United States among children between 0 and 17 years of age.[4] Burn injuries are the third most common cause of pediatric deaths after motor vehicle accidents and drowning.[4] The highest incidence of pediatric burns occur in children under 5 years of age with the most common mechanism being a scald.[5] Burn injuries have previously been reported to account for 6 to 20% of all child abuse cases.[6,7] In 2016, more than 1500 children (0–17 years old) died as a result of child abuse/neglect and 71% of these deaths were in children aged <3 years, at a cost of close to $124 billion each year.[4,8] Burn injuries in children can adversely affect every major organ system and have long-lasting physical, psychosocial, and economical effects.

There are certain risk factors that may place children at risk for child abuse. Characteristics that may increase a child's risk of abuse include children with behavioral problems, chronic illness, physical or developmental disabilities, preterm babies, and unwanted/unplanned pregnancies.[9–12] Certain characteristics may also place a child at risk for abuse including intimate partner violence, low self-esteem, substance abuse, young age, mental illness, poverty, unemployment, and single-parent homes.[13] Similarly, some psychosocial risk factors have been identified as having a higher association with physical abuse, such as intimate partner violence and having a criminal history in the family, among others.[13–16]

There are few published studies that have rigorously studied differences in sociodemographic characteristics, burn characteristics, coexisting injuries, place of burn occurrence, and time to seeking care in children who have been evaluated by a multidisciplinary team (MDT). In a systematic review of features indicative of intentional scald burn injuries in children, burn characteristics supported by the highest level of evidence included immersion, clear upper margins, scald symmetry, isolated lower extremities, isolated buttocks/perineum, combination of buttock/perineum and lower extremities, history incompatible with examination findings, coexisting fractures, previous abuse, and domestic violence, among others.[17] Another historical feature that has been associated with abusive burn injuries is delay in seeking care.[18] However, many of the characteristics associated with inflicted burn injuries are not objective and require a certain amount of interpretation.

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Furthermore, there are conflicting data regarding some of the above-associated characteristics.

The aim of this study is to determine the demographics and associated characteristics of pediatric burn injuries referred to an urban burn center's MDT for suspicion of abuse or neglect that could help differentiate accidental from abusive burn injuries. This study enhances and supplements associations of characteristics of abusive vs accidental burn injuries in children, some of which have not been previously reported.

METHODS

Sample

We conducted a retrospective review of the hospital's burn registry and medical records of pediatric patients less than 5 years old. Patients were seen at an urban burn center between March 1999 and July 2013 and were evaluated by the hospital's MDT. These patients were presented with either a burn injury as their primary complaint or a burn injury as a secondary finding. Protocol at this institution dictates that all pediatric patients with a burn injury are evaluated by the MDT. The MDT evaluation includes the medical assessment conducted by a child abuse pediatrician and a nurse clinician and a psychosocial assessment conducted by a social worker. Patients were identified through the hospital's burn registry, which is a participating hospital for the American Burn Association (ABA) Burn Registry, which follows the National Burn Data Standard (NBDS). The NBDS seeks to establish a national standard for the collection and exchange of burn data and serves to specify the operational definitions of the data elements for the burn registry. The burn registry information is collected to ultimately improve burn patient care and quality outcomes. These data are used as a clinical, research, and benchmarking tool.

Measures

For the purpose of analysis, the MDT determination was dichotomized into suspected abuse and suspected accident categories, which will be referred to as abuse and accident in what follows for clarity. The abuse category included children whose MDT determination was either abuse and/or abuse with neglect. The accident category included children whose MDT determination was either accident or accident with neglect and poor supervision. Patients ≥5 years of age, patients with no documented MDT determination (abuse, accident, or indeterminate), and patients with a documented MDT determination of indeterminate were excluded.

Chart Review Methodology

All of the information was abstracted from the hospital's burn registry and patient's chart. Data abstracted from patient's chart included demographic information (age, sex, race), social risk factors (presence of violence in the home), clinical presentation (total burn surface area, burn mechanism, need for grafting, presence of other nonburn skin injuries such as bruises, lacerations, abrasions, scars), place in the home where the burn occurred (kitchen, bathroom, and other which includes bedroom, living room, and unspecified room in the home), caregiver at the time of injury (parent, paramour, other, which includes babysitter, foster parent, friend, relative, and unsupervised), medical imaging studies and results (skeletal survey, CT scan of the head, CT scan of the abdomen), MDT determination, and the Department of Children and Family Services (DCFS) investigation outcome. For the radiographic studies, the attending radiologist reads from the medical chart were used. The results of skeletal surveys were reported in children <2 years of age based on the American Academy of Pediatrics and the American College of Radiology recommendation for obtaining a skeletal survey in children <2 years of age when there is a suspicion of physical abuse.[19,20] The results of the CT scans of the head were reported in children <6 months of age and in children <12 months of age based on the recommendation that a CT scan of the head without contrast should be obtained in all children <6 months of age and should be considered in children 6 to 12 months of age who are suspected victims of physical abuse.[21,22] Delay in seeking care was defined as a failure to seek medical care within 4 hours of the burn injury. The urban center's institutional review board approved this study. Informed consent was waived in this retrospective study.

Data Analysis

We summarized patient characteristics with counts and percentages for quantitative variables and medians and ranges for continuous variables. We evaluated the marginal association of case characteristics with abuse status through Wilcoxon rank sum tests for continuous variables and chi-square tests or Fisher's exact test for categorical variables. We fit a logistic regression model predicting MDT determination of abuse with variables determined to be associated with abuse on univariate analysis. Odds ratios and 95% confidence intervals were derived from this model. The administration of skeletal surveys in children <2 years and CT scans in children <12 months was analyzed descriptively, as were the discovery of internal injuries from these evaluations. All data analyses were performed with the open-source R software environment (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

There were 174 patients evaluated by the hospital's MDT. Sixty-four patients were excluded from the analysis: 30 (17.2%) patients were ≥5 years of age; 23 (13.2%) did not have a MDT determination documented in the chart; and 11 (6.3%) patients had a MDT classification of indeterminate. The remaining 110 patients constituted the study population (Figure 1).

Of the 110 patients included, 38 (35%) were classified as having been abused. The median age of all patients was 1, with ages ranging from 0 to 4 years. Most patients were male, African American, arrived at the hospital <4 hours after the incident, and had 10% or more of their total body surface affected. Few patients suffered from smoke inhalation or fractures, and the majority did not require a skin graft, did not display nonburn skin injuries, and did not have a family history of home violence. The most common mechanisms documented were scald (63%) followed by contact (30%). Most incidents occurred in the kitchen or a room other than the bathroom, and most patients were under the supervision of a parent when the incident occurred (Table 1). There was one known fatality.

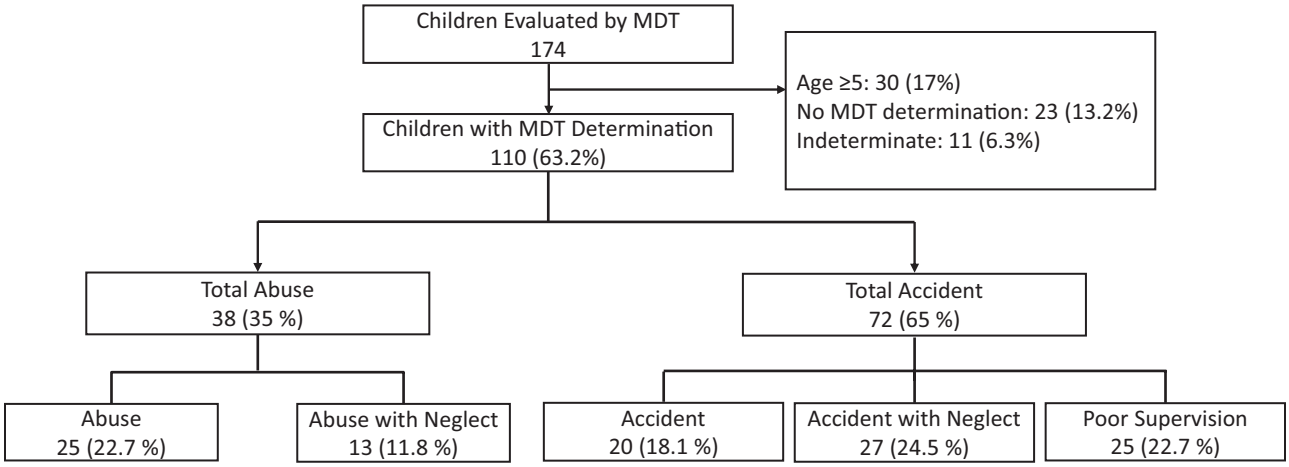

Figure 1. Total sample of patients evaluated by the multidisciplinary team (MDT) and final determination.

A MDT determination of abuse was significantly associated with caregiver type, site of incident, time to seeking medical assistance, and nonburn skin injuries (Table 2). Abuse was more likely to have been determined when a patient was under the care of a paramour at the time of the incident compared with other nonparent caregivers (Table 3). Abuse cases occurred more frequently in a bathroom or other location compared to kitchen. Patients who took ≥4 h to seek medical attention and had nonburn skin injuries were more likely to have been abused. A majority of accident cases (40 [56%]) had multiple burns, whereas the majority of abuse cases (23 [61%]) had burns in a single location, although this difference did not reach statistical significance ($\chi^2_1 = 1.97$, $P = .16$). Burn locations in the body did not help differentiate between the abuse and accident groups (Table 4). Among included patients, burns to the feet were more likely seen in abuse cases and burns to the face were more likely seen in accident cases, although these effects were not statistically significant.

Of the 110 patients who constituted the study population, 73 were <24 months of age (24 abuse and 49 accident). In the abuse group, 24/24 (100%) patients received a skeletal survey compared to 42/49 (86%) in the accident group. In the accident group, there was no documentation of whether a skeletal survey was done in one patient. There were 19 patients <6 months of age (6 abuse and 13 accident). In the abuse group, 2/6 (33%) patients received a CT scan of the head. In the abuse group, there was no documentation of whether a CT scan of the head was done in two patients. In the accident group, 7/13 (54%) received a CT scan of the head. Similarly, of the 36 patients <12 months of age (7 abuse and 29 accident), 2/7 (26%) patients in the abuse group received a CT scan of the head compared with 11/29 (38%) patients in the accident group. There was no documentation of whether a CT scan of the head was done in three patients in the abuse group and in six patients in the accident group.

Although there were few internal injuries in the abuse group (eight fractures, one subdural hemorrhage, and two abdominal injuries in six children; Table 5), no children in the accident group had any internal injuries. Of the 83 skeletal surveys available for review, three (3.5%) revealed eight fractures (five ribs, one femur, one clavicle, one skull) and one revealed a foreign body in the groin area. In two (6.5%) of the patients in the abuse group, an occult fracture was identified with a skeletal survey. One was a 6-month-old male with a 5% TBSA partial thickness immersion scald burn injury of his bilateral feet. This patient had healing fractures of ribs 3 through 6. The other was a 5-month-old male with a 3% TBSA superficial partial thickness burn of his left shin and dorsum of foot. Four months prior, the patient had a simple skull fracture after he fell from a bed. Of the four CTs of the abdomen done, one revealed a liver laceration and a rib fracture and another one revealed a liver contusion. One patient had an intracranial injury (subdural hemorrhage).

DISCUSSION

There is published evidence for distinguishing abusive vs accidental burn injuries in children. However, in our study, we found some interesting differences from the published literature worth discussing. These differences also highlight the need for larger prospective multicenter research that focuses on differences between abusive vs accidental burn injuries in children. Similar to other studies of abusive burn injuries in children, our study did not show any significant differences in age, gender, or race between the abuse and the accident groups.[17,18,23] Maguire et al did a systematic review of the features that indicate intentional scalds in children. In studies where the data were broken down by gender, there was no significant difference between the intentional and unintentional scalds.[17] On the other hand, some studies that have analyzed the association between age/gender/race and child maltreatment in children presenting with burn injuries have reported mixed results. For instance, Hobbs reported "the usual excess of boys in both groups, more pronounced in the case of abuse where boys outnumbered girls by two to one." No detailed figures were given in this study.[24] In a retrospective review from the American Burn Association National Burn Repository (ABA-NBR) of over 15,800 children younger than 12 years, Thombs found that children admitted to the hospital with suspected abuse-related injuries were significantly more likely to be younger and female.[25]

In our study, burn mechanism, body location, and coexisting fractures did not reach statistical significance between the

Table 1. Case characteristics

Parameter	*N* = 110
Age (yr)	1 [0, 4]
Race	
AA	88 (80)
Other	22 (20)
Male sex	64 (58)
Time to help	
<4 hr	66 (60)
≥4 hr	39 (35)
Missing	5 (5)
BSA%	
<10	29 (26)
≥10	81 (74)
Inhalation	2 (2)
Mechanism	
Scald	69 (63)
Grease	5 (5)
Flame	4 (4)
Contact	33 (30)
Electrical	1 (1)
Chemical	2 (2)
Graft	28 (25)
Site	
Bathroom	26 (24)
Kitchen	42 (38)
Other	42 (38)
Caregiver	
Parent	74 (67)
Paramour	10 (9)
Other	23 (21)
Missing	3 (3)
Nonburn skin injuries	
No	79 (72)
Yes	30 (27)
Missing	1 (1)
Fractures	6 (5)
Home violence	
No	70 (64)
Yes	39 (35)
Missing	1 (1)
MDT determination	
Abuse	38 (35)
Accident	72 (65)

AA, African-American; *MDT*, multidisciplinary team.
Values median [minimum, maximum], or count (%).

abuse and accident groups. In contrast, Maguire et al identified features of intentional scalds, including immersion, hot tap water, scald symmetry (extremities), isolated scald lower extremities, isolated scald buttocks/perineum, associated unrelated injuries, coexisting fractures, and domestic violence.[17,26] Likewise, Thombs found that children with suspected abuse-related injuries were four to five times likely to have a burn on their buttocks and three to four times as likely to have a perineum burn.[25] Similar to other published literature, our study also found that children in the abuse group were significantly more likely to have coexisting nonburn skin injuries.

Even though some studies have found an association between burn severity and abusive burns, in their systematic review Maguire et al reported no difference in TBSA between intentional and unintentional cause.[17] Comparably, in our study, burn severity (size and depth) was not statistically significant between the abuse and accident groups. Along the same lines, in our study, the need for grafting was not different between the abuse and accident groups. In contrast, in Thombs's review from the ABA-NBR, hospitalized children with suspected abuse-related injuries were significantly more likely to have larger total and third-degree TBSA burned and have required intensive care.[25] Similarly, in their review of 408 pediatric burns, Collier et al found that burn size and depth were statistically significant between the inflicted and noninflicted burn groups.[18] In their retrospective secondary analysis of 215 patients of children 10 years and younger, Pawlik et al found that burns affecting ≥10% of the TBSA or full thickness burns had a significant association with abuse.[27]

Studies of nonaccidental burn injuries in children have shown rates of 0 to 33% of positive skeletal surveys for occult fractures.[23,28–30] In our study population, there were two (6.5%) patients in the abuse group with occult fractures identified, although our data on skeletal surveys was missing in one patient. Fagen et al retrospectively identified children with burn injuries that had undergone a skeletal survey as part of their diagnostic workup. Skeletal surveys were positive in 33% (15/45) of the patients in the abuse group.[23] Similarly, Pawlik et al identified a new injury with a skeletal survey in 16% (19/119) of children, the majority (32%) of children between 0 and 6 months of age.[27] In contrast, in a study of children 0 to 12 years of age hospitalized for burns, none of their skeletal surveys were positive (n = 15).[28] Our data supports that all children <2 years of age where abuse is suspected should undergo a skeletal survey, including those children presenting with burn injuries.

Our data showed an association between having a paramour as a caregiver at the time of injury and a diagnosis of abuse. To our knowledge, no other comparative study of abusive burn injuries in children has reported this association. Even though Purdue et al reported 18/3 boyfriends/girlfriends out of 57 cases responsible for the burn injury, no analysis was done for statistical significance.[31] Some studies on child physical abuse have reported what seems to be an overrepresentation of male caregivers in cases of abusive head trauma and fatal child abuse. Schnitzer et al analyzed household composition as an independent risk factor for fatal inflicted injuries among young children.[32–39] They reported that children living in households with an adult unrelated to them were almost 50 times more likely to die of an inflicted injury than children living in households with two biological parents.[40] Even though more prospective studies of burn injuries in children are needed to support this association, this finding reinforces the importance of obtaining a thorough psychosocial history in patients being evaluated for abuse.

An interesting finding in our study was the location in the home where the burn occurred. In our study, a burn occurring anywhere outside of the kitchen was associated with a determination of abuse. Whereas if the burn occurred in the kitchen, it was significantly more associated with an accidental burn. To our knowledge, no studies have looked at location

Table 2. Demographics and clinical characteristics by abuse status

Parameter	Abuse (n = 38)	Accident (n = 72)	Test Statistic	P
Age (yr)	1 [0, 4]	1 [0, 4]	—	.14
Male	25 (66)	39 (54)	$\chi^2_1 = 0.94$	.33
Non-African American	10 (26)	12 (17)	$\chi^2_1 = 0.91$	.34
% TBSA: ≥10	9 (24)	20 (28)	$\chi^2_1 = 0.06$	.81
Caregiver*			-	.003
Parent	25 (68)	49 (70)		
Paramour	8 (22)	2 (3)		
Other	4 (11)	19 (27)		
Site			$\chi^2_2 = 16.97$	<.001
Bathroom	15 (39)	11 (15)		
Kitchen	5 (13)	37 (51)		
Other	18 (47)	24 (33)		
Home violence*	18 (49)	21 (29)	$\chi^2_1 = 3.23$	.07
Time to help ≥4 hr*	22 (63)	17 (24)	$\chi^2_1 = 13.26$	<.001
Single body part	23 (61)	32 (44)	$\chi^2_1 = 1.97$	.16
Mechanism: Scald	24 (63)	44 (61)	$\chi^2_1 \leq 0.001$	1.0
Graft	8 (21)	20 (28)	$\chi^2_1 = 0.29$	.59
Nonburn skin injuries*	19 (51)	11 (15)	$\chi^2_1 = 14.19$	<.001
Fractures	3 (8)	3 (4)	—	.41

Values are median [range] or count (%). Test statistics for Wilcoxon rank sum test (age) and Fisher's exact test (caregiver, fractures) not reported.
*Parameter has missing values. Counts of missing values (abuse/accident): Caregiver (1/2), home violence (1/0), time to help (4/3), nonburn skin injuries (1/0).

Table 3. Odds ratio, 95% confidence intervals, and P values from multiple logistic regression

Parameter	Odds Ratio (95% CI)	P
Caregiver		.007
Other*	(Reference)	
Parent	4.2 (0.9, 25.3)	.09
Paramour	18.2 (2.0, 243.3)	.02
Site		<.001
Kitchen	(Reference)	
Bathroom	13.6 (2.8, 88.0)	.002
Other†	8.0 (1.9, 48.1)	.01
Time to help ≥4 hr	5.4 (1.8, 17.9)	.004
Nonburn skin injuries	5.2 (1.6, 18.3)	.01

CI, confidence interval.
*Other includes babysitter, foster parent, friend, relative, and unsupervised.
†Other includes bedroom, living room, and unspecified room in the home.

Table 4. Burn location by body part*

Location	Abuse	Accident	P
Hand	9 (24%)	22 (31%)	.56
Arm	8 (21%)	21 (30%)	.46
Front	11 (29%)	29 (41%)	.31
Back	9 (24%)	15 (21%)	.95
Feet	17 (45%)	18 (25%)	.06
Leg	16 (42%)	25 (35%)	.61
Face	6 (16%)	25 (35%)	.055
Multiple	15 (39%)	40 (56%)	.14

Some patients had multiple burn locations; therefore, counts and percentages do not add to total.
*There was one patient with missing values on burn location.

of the incident where the burn occurred and its association with abuse.

One of the important findings in our study was the independent association between delay in seeking medical care and a determination of abuse. We often associate delay in seeking medical care as a concerning indicator for child maltreatment. Several studies mention delay in seeking medical care as an indicator of abusive injuries; however, most of them are inpatient victims of abusive head trauma or fractures.[41–43] In a study by Anderst looking at covariates associated with referral to child protective services of children <3 years of age with head trauma, he found that delay in seeking medical care (defined as failure to seek medical care within 6 hours despite a caregiver's report that the child's head injury triggered acute clinical symptoms) had a statistically significant independent association.[44] A few studies address delay in seeking medical care in victims of burn injuries by abuse.[18,28,31] Even though delay in seeking medical care could aid in appropriate consultation and early diagnoses, using delay as an indicator of child abuse may not always be appropriate. Factors such as transportation, severity of injury, social factors, and immigration status should be considered before using delay in seeking medical care as an indicator for abuse. Furthermore, no objective data are available to help understand how a "reasonable parent" would act with a child with burn injuries.

Violence in the home has been clearly associated with child maltreatment.[45,46] In our study, home violence was also associated with patients whose burn injuries were classified as abuse; however, this association did not reach statistical significance.

Health care providers who care for children with burn injuries should familiarize themselves with the burn and associated

Table 5. Coexisting injuries in abuse cases

Patient	Age	Sex	TBSA Burn	Location	Mechanism	Internal Injuries	Nonburn Skin Injuries
1	6 mo	Male	5%	Bilateral feet	Immersion scald	SS: healing fractures of ribs 3 to 6.	
2	14 mo	Male	21%	Face, neck, chest, back, bilateral LEs, genitals, buttocks	Scald	SS: linear metallic density in groin area. CT head: cerebral contusion, SDH, gliosis. CT abd: flank and pelvis skin hematoma. Foreign body in groin area (knitting needle).	Bruises to buttocks and mastoids. Scalp soft tissue swelling and laceration.
3	2 yr	Male	25%	Thighs, perineum, penis, buttocks, abdomen, back, shoulders	Scald	CT abd: liver contusion.	Eye bruise
4	14 mo	Female	N/A	"Road burns" to chest	Friction burns	SS: spiral femur and clavicle fractures.	
5	3 yr	Male	8%	Face, neck, right shoulder, right hand	Scald	CT abd: healing fracture of rib 9. Small nonfunctional right kidney. Hepatic laceration.	
6	5 mo	Male	3%	Left shin and dorsum of foot	Scald	SS: simple skull fracture (h/o bed fall 4 mo prior).	

abd, abdomen; *CT*, computed tomography; *LEs*, lower extremities; *SDH*, subdural hemorrhage; *SS*, skeletal survey

characteristics that may help distinguish abusive vs accidental burns. This may better equip them with tools to help identify those children at higher risk of abuse. Furthermore, systematically screening all children with burn injuries that present to a health care facility could improve patient outcomes and help ensure that patients are not discharged back into an abusive environment where they may be at risk of further and escalating abuse. The major limitation of this study is that it is a retrospective analysis of a burn registry database and chart review. As such, the factors we have identified as being associated with abuse cannot be considered causative. Data were missing for a few of the variables included in our abuse association analysis, although the cumulative number of missing observations was small. Our sample size was relatively small, which limited our ability to implement more complex models of abusive burns and led to relatively wide interval estimates of odds ratios. Furthermore, it is not possible to include all the factors considered by the MDT in making a determination of abuse.

CONCLUSIONS

A detailed history with its appropriate documentation in the medical record of not only the surrounding aspects of the burn injury itself but also of the child's environment is critical when assessing burn injuries in pediatric patients. Such information may prove useful to distinguish accidental from abusive burn injuries.

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