Context Of Injury Among Abusive And Accidental Injuries In Children

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Context of Injury among abusive and accidental injuries in children

A Thesis Submitted to the Yale University School of Medicine

in Partial Fulfillment of the Requirements for the

Degree of Doctor of Medicine

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2020
Child physical abuse is a significant public health challenge with an incidence of approximately 6.4 hospitalized cases per 100,000 children. Many abused children, however, will go undiagnosed by physicians evaluating these injuries. Assessing whether a child has been abused is a high-stakes decision: a missed case leaves a child vulnerable to future injury, but an inaccurate diagnosis of abuse may be greatly disruptive and stigmatizing to children and their families. Previous research has established key physical examination and radiographic findings that are associated with abusive injury. A gap in the literature, however, is the role of additional injury circumstances and details, such as the immediate behavior of the caregiver, in distinguishing abuse from accidental injury. While physicians do use such circumstances of the injury in diagnostic decision-making, evidence of which of these specific elements are associated with abusive injury is limited, particularly in cases of children with abusive fractures.

In this thesis, we performed a retrospective medical record review of 303 children evaluated by child abuse evaluation team (Diagnosis, Admission, Reporting, and Treatment, or DART, team) at Yale-New Haven Hospital over a ten-year period. We extracted information regarding what we termed the "context of injury": the elements related to the circumstances of the injury itself and the events leading to medical presentation for evaluation of the injury. We defined this to include caregivers present and the steps taken in seeking care for the injury. We
hypothesized that certain elements of the context of injury (e.g. the presence of multiple caregivers or the child's mother at the time of injury, call to 911, call for medical advice) would be associated with accidental injury, while others (e.g. father, boyfriend or babysitter present at time of injury, delay >24 hours in seeking care) would be associated with abusive injury.

Consistent with our initial hypotheses, we found that the presence of the child's mother at the time of the injury was associated with an accidental mechanism of injury (p<0.001). Conversely, we identified several factors associated with abusive injury: a delay in seeking care >24 hours (p<0.001) and the presence of the father (p=0.005), mother's male partner (p=0.004), or a babysitter/daycare worker at the time of the injury (p=0.014). Surprisingly, while the presence of multiple caregivers was similar between cases of abuse and accident, there was an association between clinicians not knowing who caregivers were at the time of the injury and an abusive mechanism of injury.

These results suggest that certain historical elements of the context in which a child’s injury occurred may be associated with either abusive or accidental injury, and thus might provide valuable diagnostic information to clinicians when evaluating cases of suspected child abuse. However, these preliminary results should be interpreted with caution as these results were drawn from a cohort of children who were evaluated in the inpatient setting due to suspicion of abuse. Thus, they may not be applicable to a population of children presenting to general practitioners or an emergency department with head injuries or fractures.
Acknowledgments

I would first like to thank my thesis advisor, Dr. Kirsten Bechtel, for all her help and guidance in creating this thesis. I could not have asked for a more supportive and responsive advisor in this sometimes daunting process.

I also want to thank Dr. John Leventhal for his wisdom and expertise in understanding this challenging topic and envisioning this thesis. I also appreciate the time and dedication given to this project by Dr. Julie Gaither, without whose statistical expertise this project could not have come to fruition. Thank you also to Dr. Andrea Asnes, whose insightful comments have helped not only to improve this thesis but also shape my understanding of the clinical aspects of child abuse evaluation.

Finally, to all those non-medical people in my life - you know who you are - thank you for listening. I love you all.
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1. INTRODUCTION

Epidemiology

Child abuse remains a significant public health challenge in the United States. While the exact number of cases is unknown, data gathered by Child Protective Services, as well as from inpatient hospital data, provide estimates of the prevalence of child abuse. In 2017, approximately 678,000 children in the United States (US) were victims of child maltreatment, comprising nearly 1% of all U.S. children.1 Of these cases, over 10% were cases of physical abuse alone, while an additional 15.5% were cases of multiple types of mistreatment, the most common being both abuse and neglect. One study based on aggregated nation-wide hospital data reports an incidence of 6.4 cases of abuse requiring hospitalization per 100,000 children under the age of 18 in 2009, a slight increase from 6.1 per 100,000 in 1997.2 Abusive injuries, particularly fractures and abusive head trauma, remain a major cause of disability and death in young children.3 Abuse in childhood carries a host of lifelong implications for future health outcomes and socioeconomic status.4,5 Thus, immense potential exists to improve the lives of children by preventing and recognizing physical child abuse.

Child Physical Abuse as a Medical Diagnosis

While child abuse is not a phenomenon new to the 20th century, it received little attention in the medical community prior to the last fifty years. In 1962, Kempe et al. first emphasized that physicians can play a role in the diagnosis of physical child abuse, which he termed the "battered-child syndrome."6 In his
seminal work, he attempted to estimate the incidence of severe child abuse as well as to describe techniques for the diagnostic evaluation of abusive injury, including key history, physical examination, and radiographic findings. Many of the findings that Kempe proposed as suggestive of physical abuse, such as multiple unexplained fractures in various stages of healing, came to be accepted by the medical community as important diagnostic clues for physical abuse in children.

**Role of the Pediatrician in Child Abuse**

Abusive injury in childhood carries a major impact on the well-being of children, with persistent effects on their health into adulthood. In his groundbreaking paper, Kempe recognized the importance of the pediatrician in recognizing child abuse: "Physicians have a duty and responsibility to the child to require a full evaluation of the problem and to guarantee that no expected repetition of trauma will be permitted to occur." Since then, academic societies have affirmed this role. The American Academy of Pediatrics (AAP) has emphasized that one role of the pediatrician is to be an advocate for children who cannot speak for themselves. Intrinsic to this role is the identification and appropriate management of child abuse.

Children who have been abused often present to physicians with injuries caused by abuse that remain unrecognized. Indeed, studies suggest that upwards of a quarter of all abuse cases may have had missed opportunities for earlier diagnosis. Assessing whether a child has been abused is a high-stakes decision, in which a missed case leaves a child vulnerable to future injury, but an inaccurate diagnosis of abuse may be stigmatizing to children and their families and disruptive
to the relationship between the physician and the family. Furthermore, a report to Child Protective Services may result in outcomes unexpected or unwanted by the referring physician. Previous research documented that pediatricians factor their expectations of the response of Child Protective Services based on previous experience into the decision of whether or not to report abuse. Thus, pediatricians face many challenges when confronting cases of possible abusive injury.

**Identifying Child Abuse**

For a multiplicity of reasons, making a clear diagnosis of child abuse may present a significant challenge. In order to aid physicians in decision-making, previous research has sought to identify elements of a child’s presentation, physical examination and imaging findings to help physicians distinguish between accidental and abusive trauma. Most child abuse research to date has focused on the identification of abusive head trauma, though assessment of fractures and other types of abusive injuries, such as bruising, has emerged in the literature.

Specific clinical presentations have been associated with an abusive mechanism of injury in children presenting with head injury. Specifically, children who have been abused are more likely to present with seizures or respiratory distress than those with head injuries sustained by an accidental mechanism.

Other studies have demonstrated that certain physical examination findings are associated with abusive injury, particularly among non-ambulatory children. Bruising is the most common physical examination finding in child abuse, and may sometimes be the only sign of abuse. Specifically, a finding of bruising to the torso, buttocks, face, and neck in children under four years of age, as well as any bruising
at all in a pre-cruising infant, have been shown to be associated with physical child abuse.\textsuperscript{20-22} Based on this data, one set of investigators developed the “TEN-4” clinical decision-making rule to guide clinical decision-making. This decision rule suggests further abuse investigation in cases of bruising to the torso (T), ears (E), or neck (N) in children younger than 4 years old, as well as any in cases of bruising anywhere on an infant younger than 4 months of age,\textsuperscript{22} in whom rates of bruising in general are very low.\textsuperscript{23} Intra-oral injuries, such as a laceration to the lingual or labial frenulum in young, non-mobile infants, can also be a sign of abuse, although no single oral injury alone is pathognomonic for abuse.\textsuperscript{24,25}

Radiologic findings also can support a diagnosis of abusive injury. Certain rare radiologic findings (e.g. corner fractures of the metaphysis of long bones, rib fractures, scapular fractures, spinous process fractures, or sternal fractures) have a high specificity for abusive injury, particularly in a non-ambulatory child.\textsuperscript{26,27} Multiple injuries from a single traumatic mechanism may also raise suspicion for abusive trauma.\textsuperscript{26} Other patterns of injury, such as a spiral fracture of a long bone as the femur or humerus, were previously thought to be specific to abuse; while these can be presentations of abusive fractures, further research has shown that these injuries can occur accidentally as well.\textsuperscript{26,28,29} However, the most common abusive injuries are those that are also common among children who have been injured by accidental mechanisms. For example, one study found that 5% of skull fractures will have an abusive cause.\textsuperscript{29} Thus, a careful correlation between the reported mechanism of injury and physical examination and radiologic findings are key to an accurate diagnosis of abusive injury.
Guidelines developed by the AAP incorporate existing evidence to assist physicians in the successful diagnosis of both child abuse in general as well as abusive head trauma specifically.\textsuperscript{8,30} Consensus guidelines based on the opinions of child abuse physicians have also been developed for three of the most common types of abusive injuries: intracranial hemorrhage, long bone fracture, and skull fracture.\textsuperscript{31} More recently, an international consensus guideline was published by multiple societies including the AAP and the American College of Radiology affirmed the large and growing body of evidence that pediatricians employ when making a diagnosis of physical abuse.\textsuperscript{26}

**Decision-aids in clinician diagnosis of abuse**

Historically, the utility of decision-making tools to aid clinician decision-making in cases of possible abuse has been limited.\textsuperscript{32} More recently, however, clinical decision-making tools have been developed for the identification of abusive head trauma that have demonstrated improvements in sensitivity and specificity, though they still remain imperfect.\textsuperscript{16,17,33-35} These clinical decision-making tools incorporate a number of different diagnostic factors including patient presentation, physical examination, and diagnostic imaging findings, as well as additional studies, and are meant to aid physicians in making an accurate diagnosis.

Berger et al. sought to guide emergency medicine providers to a correct decision about obtaining neuroimaging to evaluate for possible abusive head trauma in the emergency department and developed the Pittsburgh Infant Brain Injury Score (PIBIS).\textsuperscript{36} They evaluated well-appearing infants presenting with non-specific symptoms at a single institution to identify factors predictive of abnormal head
imaging findings, which in turn have been show to be suggestive of possible physical abuse. The score they developed included demographic, physical examination, and laboratory findings. Specific predictors of abusive injury identified were: age greater than three months; head circumference above the 90th percentile; hemoglobin level less than 11.2 gm/dl; and dermatologic examination findings consistent with trauma. This tool was evaluated prospectively and demonstrated a 93.3% sensitivity for abnormal head imaging findings, higher than previously published data for clinician diagnosis alone. While this decision-making tool may be valuable in allowing physicians to exclude cases of abuse without exposing children to unnecessary radiation and reducing resource utilization, it is sensitive rather than specific, and thus does not provide assistance with making the diagnosis of child abuse. Furthermore, this decision-making tool applies only to otherwise well-appearing infants younger than twelve months of age.

A second set of investigators developed a decision-making tool aimed at helping physicians to confirm or exclude abuse in cases of known intracranial injury. Their decision-making tool, PredAHT, utilized data from multiple existing studies on children younger than three years of age, thus evaluating a larger and more heterogeneous population than PIBIS. This decision-making tool focused on features of the initial presentation, physical examination, and imaging findings. Specifically, the factors that the investigators identified as predictive of abusive head trauma were retinal hemorrhage, rib or long bone fracture, apnea, seizures, and head or neck bruising. Unlike PIBIS, this study directly examined the question of whether an injury was abusive, and not whether additional diagnostic imaging was
needed. In addition, the tool was developed based on data from a large, multi-institutional cohort of children, making it more widely applicable to the clinical scenarios encountered by clinicians. However, this study was limited to cases of patients with intracranial hemorrhage and thus provides no decision support for cases of fractures, including skull fractures.

A third set of investigators, the Pediatric Brain Injury Research Network (PediBIRN), evaluated the question of whether abuse should be considered in the setting of abnormal neuroimaging in children in the Pediatric Intensive Care Unit (PICU).\textsuperscript{17,34,35} Similar to PredAHT, the initial derivation was based upon data from multiple institutions for children younger than three years of age.\textsuperscript{17} Factors the investigators initially identified as predictive of abuse included acute respiratory compromise, seizures, TEN bruising, interhemispheric or bilateral subdural hemorrhages, and skull fractures other than linear parietal fractures. Later iterations of this clinical decision-making tool based on prospective studies also included abnormal skeletal surgery findings, abnormal retinal examination, and hypoxic-ischemic brain injury or cerebral edema; seizures were excluded from this later decision-making tool.\textsuperscript{35} Similar to PredAHT, the study population included in both the derivation and validation of the tool included both infants and children up to three years of age, thus increasing its generalizability to other clinical populations. However, the tool applies only to cases of children hospitalized in the PICU, typically those with severe neurologic injury. Thus, its utility in evaluating milder forms of head injury, including skull fractures, is limited.
Ultimately, while these three decision-making tools represent a valuable advancement in creating an accurate and standardized approach to making the diagnosis of abuse, significant diagnostic uncertainty remains in cases of abusive injury. Additionally, similar diagnostic tools have not been developed for abusive fractures. In this setting, radiologic evaluation for fracture patterns consistent with abuse is paramount. However, poor correlation in diagnosing abuse between radiologists and clinicians points to the inadequacy of radiologic findings alone in the absence of clinical information.\textsuperscript{37}

Given diagnostic uncertainty from physical examination and radiologic findings alone, physicians must rely on additional historical information to make the diagnosis of abuse. AAP recommendations emphasize that a reported mechanism of injury consistent with injury pattern, such as a linear parietal skull fracture in an infant after a fall from a parent’s arms onto a hardwood floor, is reassuring for an accidental cause of injury; conversely, an absent history or a report of a mechanism of injury that is inconsistent with the nature and severity of the injury should raise concern for abusive trauma.\textsuperscript{8,38}

However, even an inconsistent history is an imperfect indicator of abusive trauma.\textsuperscript{35} Accidental trauma may not be witnessed in ambulatory children, or parents may miss initial symptoms of injury and thus misattribute the cause of injury to a non-injurious mechanism (e.g. attributing vomiting to a virus and forgetting that the child fell off bed several days ago). Furthermore, in a real world setting in which information is not always gathered in a systematic or standardized fashion by trained specialists, a thorough history of the mechanism of injury may
not even be elicited. Even with full clinical information, studies have shown that discrepancies do exist between physicians in the diagnosis of child abuse, suggesting that clinicians may interpret aspects of clinical scenarios differently.37,39

**Role of Social History and Risk of Bias**

Research has identified certain risk factors in a child’s social context that increase the risk of abuse. These include disrupted families (e.g. multiple non-biologic members in home) and domestic violence.40,41 However, the significance of other social risk factors has been variously reported; for example, while some studies suggest a strong association with factors such as parental substance use,42,43 others have found that a caregiver with substance use disorder does not increase the odds of abusive injury.40,44 This may in part be due to the heterogeneity of data sources across studies. Perhaps more importantly, population level risk factors such as poverty cannot be reliably extrapolated to the individual cases.8

Research has shown that provider bias exists in making the diagnosis of abuse, and reliance on population-level risk factors risks perpetuates these biases. For example, in one study, children of minority race and ethnicity were more likely to be referred to Child Protective Services than white children with the same types of fractures.45 As minority communities are more likely to be impacted by poverty and have lower rates of intact families, physicians must be wary that extrapolating these population-level data to individual cases has the potential to lead to an incorrect diagnosis of abuse, thereby creating unnecessary trauma to individual families.
Existing guidelines vary on the degree to which psychosocial factors should be included in physician decision making when considering abuse. While all guidelines do recommend eliciting a detailed history and events leading to presentation, the degree to which social history is emphasized differs. Clinical guidelines from the AAP do recommend eliciting a detailed social history from caregivers, including not only history of domestic violence but also financial history and resources, postpartum depression, substance use disorder, and involvement with law enforcement. In contrast, consensus guidelines from child abuse physicians recommend eliciting a thorough history of child care setting as well as violence in the home, but do not recommend asking about caregiver substance use or mental health. Indeed, the authors of these guideline remark that "the final consensus guideline reflects uncertainty regarding the reliability of these psychosocial factors in shaping early diagnostic decisions." Understanding the immediate context in which the child was injured is, however, widely accepted to be important for an accurate diagnosis of abuse. However, there is little evidence regarding the value of specific features of the events surrounding a child's injury and presentation in predicting a diagnosis of abuse. Thus, further research evaluating the context in which the injury occurred (i.e. "context of injury") is critical to increase diagnostic accuracy while reducing risk of bias.

A further complicating factor in the study of the circumstances surrounding an injury is a lack of standardized definitions, which limits the ability of clinicians to extrapolate findings from research to their own clinical practice. For example, no standard definition exists for who is considered to be a child's caregiver. Is every
adult within the home a possible caregiver? And at what age or level of responsibility does a sibling or another child in the home considered a caregiver? The lack of standardized answers to these questions poses a challenge for research in this field.

**Context of injury and effect on physician diagnostic decision-making**

The circumstances related to the injury itself and the events leading to a child's presentation to medical care, including caregiver involvement and steps taken to seeking care, are factors which are known to influence a physicians' diagnosis. Indeed, one study of child abuse physicians demonstrated that clinicians do record many positive and negative social "cues" in an abuse assessment.\(^{46}\)

Some aspects of the events leading to patient presentation have been previously studied in the existing literature. For example, research has shown that certain factors such as a male caregiver or a babysitter caring for a child have been associated with a diagnosis of abuse.\(^{47,48}\) Other factors, such as the mother's presence at the time of injury, have been shown to be associated with an accidental mechanism of injury.\(^{48}\)

It is important to note that reliance on these circumstances introduces the risk for bias, as many cues that physicians may rely upon when making a diagnosis have not been demonstrated to increase the risk of abuse in existing literature. For example, while a delay in seeking care for an injured child may increase a physician's suspicion for abuse, confounding factors such as minor trauma in an accidental injury may appropriately lead a caregiver to delay seeking care. Additionally, multiple studies have found no link between time to seeking care and
abuse.\textsuperscript{48,49} Furthermore, data from Fingarson et al. (2019) suggests that multiple caregivers present at the time of an injury was associated with an increased likelihood that an injury was determined to be abusive.

Additional research is needed both to clarify the diagnostic utility of these elements to improve diagnostic accuracy as well as to limit bias in the consideration that an injury may be abusive. Ultimately, incorporating these elements into existing information-gathering tools and decision-making frameworks may strengthen physicians’ ability to accurately and reliably distinguish accidental from abusive injury.

Previous research at our institution has studied the cases evaluated by the DART team over time to add to the literature on physical examination and radiologic findings suggestive of abusive injury in cases of both fractures\textsuperscript{27,29} and head injury.\textsuperscript{15} However, while context of injury is taken into account by DART clinicians when assessing likelihood of abuse, the significance of different context of injury features has not been studied in this population.
2. STATEMENT OF PURPOSE

The primary purpose of this research study is to identify features in the caregiver-reported context of injury that are associated with accidental and abusive injury among children undergoing assessment for child abuse by the DART clinicians at Yale New Haven Hospital. Based on existing literature and expert clinician opinion, we hypothesized that the following features would be associated with abusive injury:

1. Single caregiver present at time of injury
2. Caregiver unrelated to child present at time of injury. In particular, we hypothesized that male partner of mother not biologically related to child and a babysitter would be associated with abuse.
3. Delay in seeking care >24 hours

Conversely, we hypothesized that the following features would be associated with accidental injury:

1. Multiple caregivers present at time of injury
2. Mother present at time of injury
3. Caregiver called for medical advice
4. Caregiver called 911
5. Care sought within 24 hours

A secondary aim was to characterize how these features impacted clinician diagnosis of abusive and accidental injury. Specifically, we hypothesized that
blinding clinicians to these circumstances of injury factors would result in a greater number of cases being rated as indeterminate rather than as abuse or accident.

This study builds upon existing literature that has identified context of injury features that may be associated with accidental and abusive injury by incorporating both factors that have been previously studied (e.g. caregiver identity, time to care) as well as novel features (e.g. call to 911). In addition, to our knowledge this study is unique in that it includes both abusive head injuries and fractures. Findings from this study could guide future practice in abuse evaluations at YNHH as well as contribute to the literature on abusive injury more broadly by clarifying the utility of gathering context of injury information.
3. METHODS

Definitions

We have termed the circumstances related to the injury itself and the events leading to a child's presentation to medical care as the "context of injury." We defined this to include caregiver involvement and the steps the caregiver(s) took in seeking care. These features map out who was present at the time of injury and the caregiver's response to the initial presenting symptoms.

In addition, we used the following definitions for context of injury elements:

- Caregiver - adapted from Hymel et al. (2013); defined as "person responsible for the child when he/she was acutely head injured or first became clearly and persistently ill with clinical signs linked to the presenting complaint."

- Caregiver present - defined as caregiver in the home who could reasonably be expected to be aware of events

- Delay - defined as ≥24 hours lapsed between examination of child's injury and taking next steps to seek care (e.g. next steps might include calling primary care provider, taking child directly to ED)

- Called for advice - defined as call made by any caregiver to ask advice related to chief complaint as reported by caregiver. This included calls to both medical and non-medical personnel. Call to schedule appointment or inform family member of plan were excluded.

- Call to 911 - defined as call made by any caregiver to 911

Context of injury factors were subdivided into two categories (examples given):
(1) Caregiver involvement

- Who was present at time of event?
- What was the caregiver doing at the time of the event (e.g. were they with the child? Preparing dinner in another room?)
- Was the caregiver alone at the time of event?
- If not, who else witnessed event? Who heard the event?
- Who saw child after the event?

(2) Steps to seeking care

- Called for advice? If so, whom?
- Called 911?
- Any delay in seeking care?

In our final analysis, we examined a subset of these context of injury factors based on available data. The context of injury factors included in the final analysis were:

- Number of caregivers: classified as 1, multiple, or unknown
- Mother, Father, male partner, or babysitter/daycare worker present: classified as "yes" if reported by family and "no" if not present or information unavailable
- Call 911: classified as no, yes, or unknown
- Any call for medical advice: classified as no, yes, or unknown
- Delay in seeking care: classified as <24 or ≥24 hours
Assessment of Child Abuse at YNHH

Given the complexity involved in the diagnosis and management of child abuse, the AAP recommends that abuse evaluations be carried out by dedicated child abuse pediatricians. At Yale New Haven Hospital, a group of designated child abuse practitioners form the Diagnosis, Admission, Reporting, and Treatment (DART) program, who may be consulted by frontline clinicians for assistance in the evaluation of cases of possible child abuse. DART clinicians review available about cases as well as gather more information as needed, including by soliciting a more detailed history. The DART clinician also provides recommendations regarding additional imaging studies, laboratory tests, or specialty consults such as ophthalmology, genetics and hematology. The DART provider assigns a score assessing the likelihood of abuse on a 1-7 scale which has been previously described in the literature.

Rating of abusive versus accidental injury

A rating score was generated at the time of abuse evaluation by the initial DART physician based on all available data. All cases were rated on a one to seven scale that has previously been described. This rating was known as the "DART rating" and was not blinded to context of injury features.

To avoid circular reasoning, we developed a "clinician consensus rating" excluding context of injury features. To do this, this thesis author summarized each case in clinical vignettes which included relevant history, physical examination, and radiographic data (e.g. chief complaint, injury pattern, skeletal survey and ophthalmology examination). Context of injury features were excluded from these
vignettes. The cases were then rated separately by two DART physicians on the same one to seven scale. Discrepancies were resolved by discussion between the two physicians. The final rating was considered the "clinician consensus rating" and was used as the gold standard for this analysis.

Consistent with prior literature published by this group, scores of 1-2 were considered "abusive," 3-5 were considered "indeterminate," and 6-7 were considered "accidental."\textsuperscript{37}

**Study population**

304 cases of head trauma and fractures referred to the DART team at YNHH across a ten-year period (June 2008 to June 2017) were identified for this study. One case for whom the MRN was not recorded in DART documentation was excluded from the analysis.

**Data Extraction**

Data were extracted from the electronic medical record (EMR) as well as paper DART charts. Data extracted included demographics, presenting characteristics, clinical course, and circumstances of injury. A coding schema was created by an expert child abuse physician (JL) and modified with input from other study authors (LE, KB). Data were extracted by a research team including the thesis author, thesis advisor, and two other research assistants. The thesis advisor reviewed the initial cases coded by each of the other data extractors for consistency. In order to ensure the greatest degree of standardization, the primary source of data was the DART physician's note. However, when elements of data were absent,
information was also extracted from other provider notes (e.g. emergency department physician, referring provider).

Statistical Analysis

Basic frequency counts were conducted in Excel (Version 14.6.5) by the thesis author. Chi Square and Fisher's exact tests were performed in SAS using p<0.05 for significance; statistical analysis was conducted by Julie Gaither, PhD.

IRB Approval

This study was approved by the Yale Human Research Protections Program (HRPP# 1607018140)
4. RESULTS

Demographics and Clinical Characteristics

There were 303 patients included in this analysis, of which 201 had head injury, including both skull fractures and intracranial bleeds, and 102 were cases of isolated fracture (Table 1). The proportion of cases rated as abuse, indeterminate, and accident did vary significantly across injury type (p<0.001). Of the 201 cases of head injury, 106 children were diagnosed with a skull fracture, 41 with an intracranial bleed, and 54 with both a skull fracture and intracranial bleed; there was a statistically significant difference in the proportion of abuse cases across type of head injury (p<0.001), with the highest proportion of abuse (56.1%) in the bleed only cohort. There also were differences in the proportion of cases diagnosed as abuse based on number of fractures, with a higher proportion of abuse diagnosed in cases of no fracture (50.0%) and multiple fractures (57.4%) versus one fracture (13.1%). Baseline demographic characteristics including age, race, and ethnicity did not differ significantly across the abuse and accident cohorts.

Caregiver Involvement

Overall, the presence of a single caregiver was not associated with abusive injury; in fact, the proportion of cases of abuse (23.7% versus 23.4%), indeterminate (14.7% versus 16.9%), and accident (61.1% versus 59.7%) were similar in cases in which a single or multiple caregiver were present (Table 2). However, there was a statistically significant difference in number of caregivers driven by the high proportion of abusive cases (47.2%) in which the number of
caregivers was unknown and the correspondingly low number of accidental cases (13.9%) (p<0.001).

The presence of mother as caregiver at the time of injury was associated with accidental injury (p<0.001). In contrast, the presence of the father was associated with abusive injury (p=0.005), as was the presence of a male partner (p=0.004) or babysitter/daycare worker (p=0.014).

**Steps to Seeking Care**

Among the cohort in which 911 was called, there was a higher proportion of abusive injury (40.0%) than the cohort in which no call to 911 was made (23.4%) or in which it was unknown whether a call was made (22.2%); the overall difference between groups was statistically significant (p=0.011) (Table 2). There was also a trend towards a higher proportion of accidental injury when calls to other individuals were made, but this did not meet statistical significance (p=0.072).

There was an association between seeking care within 24 hours and an accidental mechanism of injury (p<0.001) (Table 2).

**Clinician Agreement**

The overall number of cases rated as abuse, indeterminate, and accident were similar across the DART and clinician consensus ratings (Table 3). However, there were a significant number of cases classified as indeterminate by DART practitioners which were classified as abuse (n=11, 16.9%) or accident (n=28, 43.1%) by the clinician consensus rating. Conversely, there were a large number of cases (n=26, 47.2%) rated as indeterminate by the clinician consensus that were
determined to be accidental when evaluated by the DART team. Only three (5.5%) rated as indeterminate by the clinician consensus were determined to be abusive by the DART team.
5. DISCUSSION

This analysis identified several elements of caregiver involvement and steps to seeking care that were associated with accidental and abusive injury. Specifically, the presence of mother at time of injury was associated with an accidental mechanism. Conversely, a delay in seeking care >24 hours, a call to 911, and the presence of the father, mother's male partner, or babysitter/daycare worker were associated with abusive injury.

Caregiver Involvement

While we initially hypothesized that the presence of multiple caregivers would be associated with accidental injury, in our cohort, we found instead that there was no significant difference between the abuse and accident cohorts. This is in contrast to the findings of Fingarson et al., who found that the presence of multiple caregivers increased the odds of a diagnosis of abusive injury. However, we did find that not knowing the number of caregivers was associated with abuse. This could be due to the fact that in cases most consistent with abuse based on injury pattern and other clinical information, DART physicians may gather a less detailed clinical history. Based on the experience of study authors, this is consistent with clinical practice. This finding suggests that the number of caregivers present is of limited diagnostic utility in unambiguous cases. Alternatively, caregivers may be less forthcoming with information about who was present at time of injury in cases of abuse. Further research is needed to investigate these hypotheses.
Consistent with Fingarson et al., we found that the presence of the mother reported at the time of injury was associated with a diagnosis of accidental injury.\textsuperscript{48} We also found the presence of the father, male partner, or babysitter/daycare worker to be associated with abusive injury. However, these results must be interpreted with caution, as due to our initial coding schema it was difficult to disaggregate cases in which the caregiver was not present from those in which the identity of caregivers present at time of injury was not documented. In order to better understand these results, we would need to disaggregate these two populations. This will serve as a focus of future analysis.

**Steps to seeking care**

In contrast to our initial hypothesis, there was a trend towards association between a call to 911 and abusive rather than accidental injury. While the reason for this trend is unclear, one hypothesis is that it may be due to differences in the severity of injury in cases caused by an abusive versus an accidental mechanism; specifically, we hypothesize that children injured by abuse would have more severe injuries than those injured by an accidental mechanism. Further analysis would be needed to delineate whether rates of calls to 911 would be different when controlling for severity of injury.

There was a trend towards accidental injury in cases in which a call for advice was made, though this did not meet statistical significance. It is possible that there is no association between any call for advice and an accidental mechanism of injury; alternatively, this analysis may have been underpowered to detect a true difference. Of note, however, this study assessed the association between abuse or
accident and calls made to any individual, including calls made to both medical and non-medical personnel. A more detailed analysis would be required to assess whether a call to a medical provider is associated with either abusive or accidental injury.

Our finding that there was an association between a delay from the time of the injury to seeking medical care and abusive injury differs from prior literature.\(^4^9\) This may be due to a different definition of delay, which in our study was defined as ≥24 hours.

**Clinician Agreement**

While we initially hypothesized that the clinical consensus rating would result in greater uncertainty due to the lack of context of injury in the coding schema, and thus more indeterminate classifications, than the DART coding schema, this was not the case. However, there were discrepancies between which cases were thought to be indeterminate between the DART and clinician consensus ratings. This suggests that there are cases in which additional context of injury information may allow a clinician to more confidently diagnosis abuse. However, there also may be cases in which the introduction of additional context of injury information can, in fact, introduce greater ambiguity into the diagnosis. These results should be interpreted with caution as it is possible that other factors that were not included in the clinician consensus rating but are external to context of injury (e.g. collateral information from the primary care pediatrician) may have informed the DART physicians' initial diagnosis. Further analysis examining those cases in which abuse...
likelihood ratings differed between the DART clinicians and the clinician consensus would be required to better understand what might be driving these discrepancies.

**Planned Analysis**

While these findings pose interesting insight into context of injury factors that are associated with abusive or accidental mechanisms of injury, this initial statistical analysis also raised a number of additional questions that we were unable to answer in this thesis. Specifically, we would like to understand the impact of injury severity on some aspects of context of injury, such as delay in seeking care, and whether this impact could explain some of the differences between cases of abusive injury, accidental injury, and indeterminate cases.

Additionally, while there is a statistically significant difference in injury type between cases of abuse and accident, we did not control for injury type in our initial analyses. Thus, it is possible that our results could be explained by a difference in injury type, though mechanisms of this difference are unclear. Further analysis controlling for these variables is necessary to confirm our initial findings.

Furthermore, while we initially planned to assess consistency of the narrative explaining a child’s injury as part of our analysis, our coding schema did not collect this information independently. Thus, we were not able to assess this element as part of the initial analysis. Extraction of additional information regarding the story told by the parents to explain the child’s injury, and its possible evolution, could help answer this question within this cohort.

Finally, we would like to explore whether there are certain factors in the context of injury that were associated with discrepancy between the DART and
clinician consensus rating (i.e. if knowledge that a boyfriend was present at time of injury was associated with cases which were rated by the DART team as abuse but by the clinician consensus team as indeterminate, or conversely, if knowledge of a delay in seeking care might be associated with the clinician consensus rating of indeterminate and a DART rating of accident).

**Strengths**

This study has a number of unique strengths that underscore its contribution to the existing child abuse literature. First, this is the only study to our knowledge that examines context of injury factors as they relate both to head injuries and to fractures, rather than to head injury alone. Including fractures adds to the strength of our analysis for a number of reasons. First, as demonstrated by our cohort, abusive fractures comprise a significant proportion of all cases of abuse. Second, many of the additional physical examination findings associated with abusive head trauma, such as retinal hemorrhages, are unlikely to be diagnosed in cases of abusive fracture. Thus, these cases may have significant ambiguity, and clinicians may instead attribute greater weight to historical factors including context of injury. Third, it is possible that predictive features of the context of injury vary between cases of abusive head trauma and fractures. Thus, examining factors associated with abuse within both populations is critical to guide accurate clinician decision-making. However, as mentioned above, this study is limited as we did not stratify our analysis by injury type.
In addition to the inclusion of multiple injury types, this was a large and demographically diverse cohort spanning 10 years, increasing the generalizability of our study. Additionally, all cases included in this cohort were evaluated by DART practitioners, who are trained child abuse specialists. Thus, information elicited is similar across cases and detailed context of injury information was available for the large majority of patients in this cohort. However, despite some standardization, data collection remained imperfect as no single data collection tool was used by the DART clinicians when evaluating children for suspected abusive injury.

Finally, this is the first study to our knowledge that examined elements of caregiver behavior aside from time to seeking care, specifically calls for medical advice and calls to 911.

Limitations

Child abuse is a challenging topic to study, particularly as clinical definitions and data collection methods have not been standardized. In addition to the analytical challenges noted above, our study suffers from a number of shortcomings common in the child abuse literature, as well as a few unique to our specific research questions.

First, while our study population includes a heterogeneous group of children, this is a single institution study and thus may have limited generalizability to other clinical contexts. Rates of abuse as well as avenues for seeking care may vary across different geographic regions and practice settings. Furthermore, the findings from this study may only apply within this high-risk cohort for whom referring
physicians already have some concern for abuse. While many low-risk injuries were included in this cohort (e.g. linear skull fracture), it is possible that some clinicians chose not to refer to DART in these cases and thus this study may not be applicable to a population which includes all patients younger than 3 years old with a head injury or a fracture. For example, it is possible that while the presence of the father at the time of injury was associated with abuse in a cohort with existing suspicion of abuse, this may not be generalizable to all children presenting to the ED with head injuries or fractures. As referrals to DART are typically a standard part of the care pathway in evaluating young children with head injuries, the results in this subset are likely generalizable. However, standard protocols for evaluation of fractures are less clear and thus findings from this subset may be less generalizable.

Second, this study relies on caregiver-reported histories. Actual actions taken might be different than those reported; for example, caregivers may report seeking care within 24 hours even when this was not the case. Indeed, this may impact the results of the study if caregivers are more likely to lie about their behavior (e.g. state that they sought care immediately) in cases of abuse for fear of recognition of the injury as abusive. However, unless there are other independent eyewitnesses that can provide a history of the mechanism of injury, the history from a caregiver is the only information that is provided in the majority of cases of injury in young children.

Third, the diagnosis of abuse is imperfect. There is no “gold standard” test for abuse and its diagnosis relies upon available evidence and the clinical reasoning of clinicians. We therefore relied upon clinician’s rating of abuse based on known injury patterns and historical factors external to the context of injury. We did not,
however, have data on whether these claims were substantiated by Child Protective Services. It is possible that cases of abuse were misdiagnosed as accidents or indeterminate by clinicians, or that there were missed cases of abuse.

Fourth, due to the subjective nature of many elements of the context of injury and the fact that multiple coders were involved in the data extraction process, there may be inconsistencies in coding practice. We attempted to ensure consistency by relying on a single code book and a supervisor (KB) who resolved discrepancies when they were identified. However, it is likely that certain variables (e.g. "present") may not be clearly defined. As noted previously, there is no standardized definition in the literature for many of these elements of the context of injury, and this challenge exists across the field.

Finally, while the DART assessment does rely on a standardized history-taking format, different DART practitioners may elicit slightly different information. Furthermore, context of injury information may be limited in cases with a very high or very low suspicion for abuse, in which clinicians felt this information was unlikely to change their diagnosis.

Conclusion

In summary, these results suggest that certain historical elements of the context of in which a child’s injury occurred may be associated with either abusive or accidental injury, and thus might provide valuable diagnostic information to clinicians when evaluating cases of suspected child abuse. Specifically, the presence of mother at time of injury was associated with accidental injury. Conversely, a delay in seeking care >24 hours was associated with abusive injury, as was the presence of
the father, mother's male partner, or babysitter/daycare worker. Our findings may serve to inform future information-gathering and clinical decision-making by DART practitioners when evaluating cases of suspected abuse. These results also may help to inform clinical evaluation at other institutions, adding to a body of literature that could ultimately serve to augment the existing decision-making tools which rely almost exclusively upon physical examination and radiographic findings. However, these preliminary results should be interpreted with caution as we did not control for possible confounding variables, specifically injury type (i.e. head injury versus fracture) and injury severity. Additionally, these results were drawn from a cohort of children who were evaluated due to suspicion of abuse; thus, they may not be applicable to a population of children presenting with head injuries or fractures to general practitioners. Further research is needed to understand the associations within our cohort and to validate these findings in other populations.
6. REFERENCES

7. FIGURES

Figure 1: DART rating scale

<table>
<thead>
<tr>
<th>Medical Clinical Abuse Scale</th>
<th>Questionable Accident</th>
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<tr>
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<td>1.1 Positive skeletal survey- multiple recent injuries</td>
<td>5.1 Isolated incident, MSW/MD no suspicion of abuse, story somewhat inconsistent with extent of injury, but consistent with type of injury</td>
</tr>
<tr>
<td>1.2 Positive skeletal survey- fractures of various ages</td>
<td>5.2 Story somewhat inconsistent with extent of injury, MSW/MD no suspicion of abuse, neglect involved</td>
</tr>
<tr>
<td>1.3 Eye Witness</td>
<td>5.3 Isolated incident, no suspicion of abuse, story not known</td>
</tr>
<tr>
<td>1.4 Multiple internal injuries</td>
<td>5.4 Isolated incident, MSW/MD with suspicion of abuse, story, somewhat inconsistent</td>
</tr>
<tr>
<td>1.5 Physical findings: Bruises, suspicious or unexplained burns or scares</td>
<td>5.5 Other</td>
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<tr>
<td>1.6 Sibling abused at the same time</td>
<td></td>
</tr>
<tr>
<td>1.7 A definite intentional act causing physical harm to child</td>
<td></td>
</tr>
<tr>
<td>1.8 A parental fight- injury not directed at child</td>
<td></td>
</tr>
<tr>
<td>1.9 Suspicious injury with definite later abuse</td>
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</tr>
<tr>
<td>1.9 Other</td>
<td></td>
</tr>
<tr>
<td>2.1 Original doctors called injury abuse and history inconsistent or inappropriate delay in seeking care or history unknown</td>
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</tr>
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<td>2.2 Other</td>
<td></td>
</tr>
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<td>3.1 History inconsistent or inappropriate delay in seeking care</td>
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</tr>
<tr>
<td>3.2 Other</td>
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</tr>
<tr>
<td>4.1 Insufficient information available in charts</td>
<td></td>
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Modified from Thomas et al. (1991)\(^{50}\)
## 8. TABLES

### Table 1: Demographic & Clinical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>All (n, %)</th>
<th>Abuse (n, %)</th>
<th>Indeterminate (n, %)</th>
<th>Accident (n, %)</th>
<th>P-value</th>
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<td>17 50</td>
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<td>10 29.4</td>
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<td>Multiple</td>
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### Table 2: Context of Injury

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<th>All (n, %)</th>
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<th>Accident (n, %)</th>
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<td>&gt;1 caretaker</td>
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<td>33 39.3</td>
<td>25 29.8</td>
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<td>18 12.2</td>
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<td>4 35.7</td>
<td>6 42.9</td>
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<td><strong>Call to 911</strong></td>
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<td>96 59.6</td>
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<td>26 100</td>
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<td><strong>Delay</strong></td>
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<td>&gt;24 hours</td>
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<td>12 46.2</td>
<td>3 11.5</td>
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Table 3: Agreement between DART and Clinician Consensus Ratings

<table>
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<tr>
<th>DART Rating</th>
<th>Abuse</th>
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<th>Accident</th>
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<td>67</td>
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