

Has This Child Experienced Physical Abuse?

The Rational Clinical Examination Systematic Review

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IMPORTANCE Nearly 100 000 children experience physical abuse each year in the US. Among approximately 2000 annual deaths related to child maltreatment, more than 40% resulted from physical abuse, and half of those children were younger than 1 year. Many of these young children had unidentified abusive injuries before the fatal event.

OBJECTIVE To determine the accuracy of clinical and radiologic findings for identifying physical abuse among children who have sustained an injury.

DATA SOURCES AND STUDY SELECTION MEDLINE, PubMed Central, and Embase were searched for articles published from 1970 to September 2024. Three authors identified studies describing clinical and radiologic characteristics in children and adolescents undergoing assessment for physical abuse.

DATA EXTRACTION AND SYNTHESIS The number of children with and without each clinical or radiologic finding, and the presence or absence of physical abuse, which had been determined by expert panels, predefined criteria, or standardized scales that quantify the level of concern for abuse, were recorded.

MAIN OUTCOMES AND MEASURES The sensitivity, specificity, and likelihood ratios (LRs) of each finding for the presence of physical abuse were calculated and the range or calculated summary measures were reported when the finding was evaluated in more than 1 study.

RESULTS Of 7378 unique articles, 18 studies met inclusion criteria. The prevalence of physical abuse in these 18 studies ranged from 5% to 79%. Studies that were focused on skin findings in children evaluated for trauma showed that the presence of oral injury such as a torn frenulum (positive LR, 6.6 [95% CI, 3.2-14.0]), bruising on the buttocks (positive LR range, 15-83) or neck (positive LR range, 2.2-84), patterned bruises (positive LR range, 2.0-66), and subconjunctival hemorrhage (positive LR range, 5.4-130) were associated with increased likelihood of physical abuse. In studies of hospitalized children with head injury, the presence of retinal hemorrhages (positive LR, 11.0 [95% CI, 4.0-32.0]), seizures (positive LR, 3.9 [95% CI, 2.4-6.5]), hypoxic ischemic injury (positive LR, 3.4 [95% CI, 1.8-6.4]), or a subdural hematoma (positive LR, 3.2 [95% CI, 2.6-3.8]) increased the likelihood of physical abuse. In studies examining children who underwent skeletal surveys, a single fracture (positive LR, 5.9 [95% CI, 2.9-12.0]) or multiple fractures (positive LR, 3.8 [95% CI, 2.4-6.0]) increased the likelihood of physical abuse.

CONCLUSIONS AND RELEVANCE A detailed physical examination that reveals oral injury, bruises on the buttocks or neck, patterned bruises, and subconjunctival hemorrhage in young children should alert clinicians to the possibility of physical abuse. Findings on neuroimaging and ophthalmologic evaluation in infants and young children with head trauma can help clinicians determine the likelihood of physical abuse.

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Clinical Scenario

In each of these clinical scenarios where the child was admitted to the hospital for trauma, the clinician must assess the likelihood that the injuries were the result of physical abuse.

Case 1

A 4-month-old minimally arousable female arrives via emergency medical services to the hospital with a reported history of falling from a couch onto a hardwood floor. After stabilization, computed tomographic imaging of the brain is performed and reveals a subdural hematoma. Neither an epidural hematoma nor skull fracture are identified. A thorough physical examination reveals a torn oral labial frenulum. No additional bruises or skin findings are identified. A skeletal survey does not show any fractures.

Case 2

A 6-month-old male is brought to the hospital by ambulance after being found unresponsive following a 3.5-foot fall from the diaper changing table. After stabilization, a detailed examination reveals a temporal scalp hematoma and bruising of his left forearm. Computed tomography of the brain identifies a temporal bone skull fracture with underlying epidural hematoma.

Background

Physical abuse is a type of child maltreatment that refers to acts that have caused or could have caused physical injury to a child.^{1,2} In 2022, more than 550 000 children experienced child maltreatment in the US, with 17% of those children subjected to physical abuse.¹ Of an estimated 1990 fatalities due to child maltreatment in 2022, a total of 838 were attributable to physical abuse, either exclusively or in combination with another maltreatment type, such as neglect, psychological abuse, or sexual abuse.¹ These data on maltreatment and physical abuse are likely underestimates because many cases are unreported or undetected.³ Children younger than 1 year are at greatest risk for physical abuse and resulting morbidity and mortality.^{1,4,5}

Several studies have demonstrated the importance of early detection of physical abuse due to its escalating nature.⁶⁻¹⁰ Up to one-third of 173 young children (<3 y) diagnosed with abusive head trauma had abusive injuries missed on a prior presentation, and approximately one-third of those missed cases subsequently returned with additional, often more severe, injuries from abuse.³ Children who experience recurrent physical abuse have significantly higher mortality (25%) compared with those who experience a single episode of physical abuse (10%).⁸ The World Health Organization and the American Academy of Pediatrics (AAP) have identified early detection as necessary to reduce further episodes of child maltreatment.¹¹⁻¹³

However, determination of physical abuse often presents a diagnostic challenge for clinicians caring for children for several reasons. Witnesses to the event (other than the perpetrator and child) are uncommon, as are admissions of guilt. Clinicians are trained to trust historical information provided by caregivers, making skepticism of the provided history less likely.¹³ Additionally, there is no uniform reference standard for the diagnosis of physical abuse, and cli-

Key Points

Question What is the accuracy of clinical and radiologic findings in identifying children who have been injured from physical abuse?

Findings In this systematic review and meta-analysis, clinical and radiologic findings were identified that can assist clinicians in determining the likelihood of physical abuse in young children. The presence of an oral injury, bruising of the neck or buttocks, patterned bruises, and subconjunctival hemorrhage was associated with a higher likelihood of abuse; in hospitalized children with head injury, the presence of retinal hemorrhages, seizure, hypoxic ischemic injury, and subdural hematoma was associated with an increased likelihood of physical abuse.

Meaning When considering the possibility of physical abuse in children, clinicians should consider specific signs and symptoms that increase the likelihood of inflicted injury.

nicians recognize potential harms of misdiagnosis to the child and family, such as family separation, psychological stress, and prolonged litigation. Thus, in clinical practice, the evaluation conducted by child abuse specialists is often used to identify when physical abuse has occurred.¹³ This systematic review and meta-analysis was conducted to quantify the risk of physical abuse in the presence of clinical and radiologic findings, thereby aiding the clinician in the comprehensive evaluation of the injured child. Given the focus on the diagnostic accuracy of clinical findings, racial or socioeconomic disparities were not included in the evaluation of physical abuse as part of this review. This review highlights both sentinel injuries suggestive of physical abuse, as well as findings associated with physical abuse among injured children who have been hospitalized. In summarizing the highest quality evidence, this study aims to identify predictors of physical abuse among young children with a traumatic injury.

Clinical Context in Which Physical Abuse Should Be Considered

Most injuries in children are accidental and do not require medical attention. Nevertheless, pediatric visits for injury are common and millions of children seek medical care each year for injury.¹⁴ Among the large population of children with injuries, identifying those with possible physical abuse is challenging. Proper recognition and management of sentinel injuries can lead to opportunities for early intervention to protect vulnerable children. Sentinel injuries, defined as inflicted injuries that are apparently minor but precede more severe manifestations of physical abuse, are common in abused infants, but are rare in those not abused.¹⁵ Examples of these sentinel injuries include specific bruises, intraoral injuries such as frenula tears in infants, and certain fractures.¹⁵⁻¹⁹ In isolation, these injuries may seem minor given their high potential for recovery without treatment; however, it is important to identify them given their association with future inflicted injury. When there is concern for inflicted injury, child abuse experts should be consulted to guide further assessment and management.

In 2021, the AAP reaffirmed guidelines to assist clinicians in identifying and evaluating children for suspected abuse. These recommendations highlight specific details of obtaining medical history, performing a physical examination, and gathering ancillary diagnostic testing that may be helpful for clinicians to identify and prevent

further episodes of physical abuse.¹³ Children who experience physical abuse can present with a range of injuries, from minor to life-threatening. As with all patients, a severely injured child needs to be stabilized before further evaluation is undertaken.

Medical History

When a child presents for evaluation of an injury or one is identified during a routine visit, clinicians should obtain the history from caregivers, either jointly or separately, without interruption.¹³ Consensus recommendations suggest that clarifying questions should focus on elucidating how the injury occurred and describing activities and behaviors surrounding the event.¹³ The approach should be non-accusatory, with the understanding that even if physical abuse is suspected, identifying the person responsible for the inflicted injury is not the goal of the initial evaluation. Historical features that could raise concern for physical abuse include conflicting, vague, or substantive changes in explanations for significant injuries; histories that are inconsistent with the child's developmental stage or identified injuries; explicit denials of obvious injuries; or delays in seeking medical care.¹³ Consideration of the mechanism of injury, the child's age and development, the timing of the suspected injury in relation to when the child is brought for evaluation, and the severity of the injury can help identify injuries that warrant an evaluation for physical abuse.

Physical Examination

In all children with an injury, a thorough physical examination should be performed with the child in a gown. A detailed evaluation includes, but is not limited to, examination of the oropharynx; inspection of the skin; palpation of all extremities, abdomen, and torso; and complete neurologic assessment. Consensus recommendations suggest that concerns for physical abuse should arise with injuries involving multiple organ systems, multiple injuries in different stages of healing, unexplained injuries, or patterned injuries (a wound or bruise that reflects the shape of the object that caused it, such as handprints).¹³ Additionally, all young preambulatory infants presenting with injuries merit consideration of physical abuse.¹⁵ Although few single injuries are pathognomonic, injuries to the intraoral region, nonbony areas, or unusual locations (eg, torso, ears, neck, upper arms) should undergo careful consideration of physical abuse.¹³

Diagnostic Testing

When physical abuse is considered as a potential cause for a child's injury, a range of diagnostic testing can be performed. The extent of evaluation is based on several factors, such as a child's age and developmental status and the severity and type of injury.

Head trauma is the leading cause of fatality from physical abuse and occurs most commonly in infants.^{20,21} Because of the high morbidity associated with abusive head trauma, young infants with suspected physical abuse may benefit from head imaging, regardless of whether they have neurologic symptoms.¹³

Computed tomography (CT) without intravenous contrast is the preferred modality for children presenting with a head injury. Head CT has high sensitivity and specificity for diagnosing acute hemorrhage (intraparenchymal, subarachnoid, subdural, and epidural). In addition, the AAP recommends that magnetic resonance imaging (MRI) of the brain be performed in all children with abnormal

head CT findings and in select children with normal CT results but strong clinical concerns for physical abuse.²² MRI is more sensitive than CT imaging for detecting intracranial injury (extraaxial collections, intraparenchymal hemorrhages, ischemic injury contusions, shear injuries, and cerebral edema), in part because it is more sensitive to parenchymal injuries.^{20,22} As part of a comprehensive evaluation of physical abuse, expert opinion suggests that MRI of the brain, when available, is preferred over CT to detect asymptomatic intracranial injury in infants with noncranial injuries suggestive of physical abuse.^{13,20} Studies have shown the possibility of fast MRI (abbreviated motion-tolerant sequences to complete neuroimaging without sedation) as a feasible and accurate alternative to CT, although the AAP has not yet offered guidance on this modality with respect to physical abuse.²³

Retinal hemorrhages are seen frequently, but not universally, in children with abusive head trauma.²⁴ A normal retinal examination, even when conducted with indirect ophthalmoscopy by a qualified ophthalmologist, is not an adequate screening test for abusive head trauma because an asymptomatic child with suspected physical abuse may have neuroimaging abnormalities without retinal hemorrhages.¹³ Conversely, studies have shown that if clinical and radiologic findings do not suggest intracranial injury, fundoscopic examination may be unnecessary.^{13,25}

Fractures associated with abuse have been described in nearly every bone in the body. Skeletal surveys are a systematically performed series of radiologic imaging that encompass the entire skeleton and are the standard screening tool for detecting asymptomatic fractures in children younger than 2 years undergoing an evaluation for physical abuse.^{22,26} A normal physical examination in children younger than 2 years does not rule out the need for a skeletal survey if there is concern for abuse.¹³ Although no single fracture is pathognomonic for physical abuse, certain fracture types, such as posterior rib fractures or classic metaphyseal lesions in nonambulatory children, are associated with physical abuse.^{27,28} A skeletal survey can be considered in select children aged 2 to 5 years, especially those with craniocerebral trauma, abdominal injuries, or unusual fractures highly specific for abuse.^{26,29} However, a skeletal survey may not be necessary to screen older children for fractures because they can frequently report the location of skeletal pain.²²

Methods

The systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagnostic test accuracy guideline.³⁰

Search Strategy

The databases of MEDLINE, PubMed Central, and Embase were searched for articles published from January 1970 to September 2024 without language limits. Two authors (S.N.S. and H.F.) independently screened all titles and abstracts. Articles were entered into the full-text review after receiving at least 1 vote for inclusion. The same authors reviewed the full text of eligible articles for inclusion. Disputes were resolved by discussion to consensus with a third author (M.I.N.). The detailed search strategy appears in eContent 1 and eTable 1 in the [Supplement](#).

Eligibility Criteria

Eligibility criteria for study selection were determined a priori through study team consensus. Observational studies that described clinical or radiologic characteristics in children younger than 18 years who underwent determination for physical abuse were eligible for inclusion. Eligible settings included outpatient clinics, emergency departments (EDs), and inpatient or intensive care units. Studies examining data from specialty child abuse registries were also included.

Prospective and retrospective studies were eligible for inclusion. To assess the accuracy of clinical and radiologic findings in differentiating between the presence or absence of physical abuse, studies were included if each clinical feature was described and compared to a reference standard for physical abuse, as defined below.

Legally, child abuse and neglect in the US are defined by federal and state statutes. Each state has its own definition of child abuse and neglect that is based on standards set by federal law. At the state level, child abuse and neglect may be defined in both civil and criminal statutes.^{1,2} Clinically, the determination of child abuse is made by a careful and thorough evaluation incorporating elements of history and physical examination findings, often with additional diagnostic imaging. We considered studies that used 1 of the following 3 reference standards to determine the likelihood of physical child abuse: expert consensus (panel of clinical specialists trained in the identification of child abuse),¹³ predetermined criteria of physical abuse established by experts that were consistently used in peer-reviewed studies,³¹⁻³⁴ or a standardized 7-point scale used by child abuse subspecialists to communicate their assessment of abuse likelihood (a rating of 5 considered "high" likelihood of abuse and a rating of 7 considered "definite" abuse).^{35,36}

Risk of Bias in Individual Studies

Studies were critically appraised using the second version of the Quality Assessment of Diagnostic Accuracy Studies tool.³⁷ Study quality was summarized using the Rational Clinical Examination levels of evidence (see eContent 2 in the [Supplement](#)).³⁸ Only studies with levels 1 to 4 evidence were included in the pooled estimates. Each included full-text study underwent a risk of bias and applicability assessment as well as level of evidence determination performed independently by 2 authors (S.N.S. and H.F.) with discussion to consensus to resolve any conflicts.

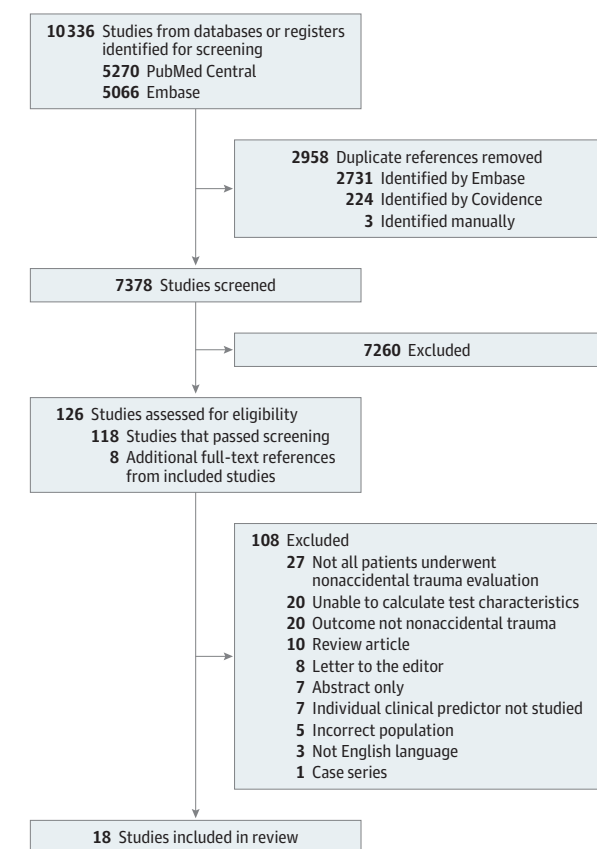
Data Extraction

For articles meeting inclusion criteria, study characteristics and 2 × 2 tables of clinical variables were extracted by one author (S.N.S.) and verified by a second (H.F.). Details of the data extraction methods appear in eContent 2 in the [Supplement](#).

Data Synthesis and Meta-Analysis

The age of children in each study was reported as a range, along with the median or mean age for studies when provided. The association of sex with physical abuse was expressed as an odds ratio. For clinical and radiologic findings, we calculated the sensitivity, specificity, and likelihood ratios (LRs). For findings evaluated in 2 studies, we provided the range. For findings evaluated in 3 studies, we calculated the univariate random effects summary measures. For findings evaluated in 4 or more studies, we calculated the bivariate random effects summary measures. We highlight the findings that

Figure. PRISMA Flow Diagram of Studies Screened for Findings of Physical Abuse in Children



increased the likelihood of physical abuse with LR greater than or equal to 2.0 and address those findings that decrease the likelihood of physical abuse with LR less than or equal to 0.5.

Results

Study Characteristics

Of the 7378 unique titles and abstracts screened (Figure), 118 full-text articles were assessed for eligibility and 18 studies met inclusion criteria. Publication dates for included studies ranged from 2004 to 2023. Eight of the 18 included studies were prospective³⁹⁻⁴⁶ and the remainder were retrospective. All but 3 studies⁴⁶⁻⁴⁸ occurred in the US. Specific details regarding each study's inclusion criteria, physical abuse definition, sample size, and level of evidence classification are described in Table 1.

Twelve^{39,41,42,47-54,56} of the 18 studies were classified as Rational Clinical Examination level 4 evidence, where the presence of a clinical finding or reference-standard test result was used as inclusion criteria for the study. The quality assessment of individual studies and a summary of bias across all included studies appear in eTable 2, eFigure 1, and eFigure 2 in the [Supplement](#). The pooled result of the meta-analyses with clinical or radiologic findings that have LRs greater than or equal to 2.0 or LRs less than or equal to 0.5 are described in Table 2.

Table 1. Study Characteristics

Type of injury	Study type	Data source	Physical abuse determination	Age		Country	Physical abuse prevalence/total No. (%)	Level of evidence ^a
				Range	Mean			
Bruising								
Harper et al, ³⁹ 2014	Prospective	EXSTRA dataset ^b	Likert scale concern for abuse ^c	<6 mo	3 mo	US	73/146 (50)	4
Kemp et al, ⁴⁷ 2014	Retrospective	Child protection team database	Expert consensus	<6 y	20.8 mo	UK	346/502 (69)	4
Pierce et al, ⁴⁰ 2021	Prospective	Children presenting to emergency department	Expert consensus	<4 y	2.1 y	US	410/2161 (19)	1
Burn injury								
Fagen et al, ⁴⁹ 2015	Retrospective	Child protection team database (TBSA not reported)	Expert consensus	1–110 mo	15 mo	US	45/112 (40)	4
Hodgman et al, ⁵⁰ 2016	Retrospective/prospective	Patients hospitalized for burn injury (mean TBSA, 12%–17%)	Expert consensus	≤18 y	With abuse: 1.7 y; without abuse: 2.0 y	US	297/5553 (5)	4
Pawlik et al, ⁵¹ 2016	Retrospective/prospective	EXSTRA dataset (TBSA ≤9% for 85% of patients) ^b	Likert scale concern for abuse ^c	≤10 y	With burns, 20 mo; without burns, 10 mo	US	88/215 (41)	4
Wibbenmeyer et al, ⁴¹ 2014	Prospective	Patients hospitalized for burn injury (mean TBSA, 5%–10%)	Expert consensus	0–12 y	With abuse: 2.56 y; without abuse: 5.81 y	US	16/68 (24)	4
General assessment								
Baab et al, ⁵² 2023	Retrospective	Trauma registrar database	Expert consensus	1 wk–15 y	0.54 y	US	86/109 (78.9)	4
Head injury								
Baerg et al, ⁴² 2017	Prospective	Hospital records of admitted patients with head injury (2011–2016)	Expert consensus	<3 y	With abuse: 5 mo; without abuse: 10 mo	US	52/73 (71)	4
Bechtel et al, ⁴³ 2004	Prospective	Hospital records of admitted patients with head injury (2000–2002)	Predefined criteria ^d	<2 y	With abuse, 6.5 mo; without abuse, 9 mo	US	15/82 (18)	2
Hymel et al, ⁴⁴ 2007	Prospective	PediBIRN dataset (2003–2006)	Predefined criteria ^e	<36 mo	With abuse, 5 mo; without abuse, 4 mo	US	11/54 (20)	3
Hymel et al, ⁴⁵ 2013	Prospective	Dataset of admitted PICU patients with head injury (2010–2011)	Predefined criteria ^f	<3 y	7 mo	US	95/209 (45)	1
Kelly et al, ⁴⁸ 2015	Retrospective	Child protection team database (1991–2010)	Expert consensus	<13 y	7 mo	New Zealand	206/345 (60)	4
Notrica et al, ⁵³ 2021	Retrospective/prospective	Child protection team database (2010–2016)	Expert consensus	<5 y	7 mo	US	242/758 (32)	4
Oral injury								
Dorfman et al, ⁵⁴ 2018	Retrospective/prospective	EXSTRA dataset ^b	Likert scale concern for abuse ^c	≤10 y	With oral injury, 20.9 mo; without oral injury, 21.9 mo	US	984/2890 (34)	4

(continued)

Table 1. Study Characteristics (continued)

Type of injury	Study type	Data source	Physical abuse determination	Age			Country	Physical abuse prevalence/total No. (%)	Level of evidence ^a
				Range	Median	Mean			
Retinal hemorrhage									
Bhardwaj et al., ⁴⁶ 2017	Prospective	Hospital records of admitted patients	Expert consensus	1-36 mo			Australia	21/118 (18)	3
Binenbaum et al., ⁵⁵ 2009	Retrospective	Hospital records of admitted patients	Expert consensus	≤15 mo	3 mo		US	49/110 (45)	1
Subconjunctival hemorrhage									
Wolford et al., ⁵⁶ 2022	Retrospective/prospective	ExSTRA dataset ^b	Likert scale concern for abuse ^c	≤10 y	5 mo		US	106/250 (42)	4
Abbreviations: ExSTRA, Evidence-Based Screening for Siblings and Contacts of Abused Children; PediBIRN, Pediatric Brain Injury Network; NA, not applicable; PICU, pediatric intensive care unit; TBSA, total body surface area.									
Studies with level 1 evidence (highest level) were prospective and included at least 100 consecutive children; level 2, prospective and included <100 consecutive children and adolescents; level 3, retrospective or included nonconsecutive children and adolescents; level 4, included comparisons of the index test with the reference standard that were not strictly independent such that the test result or reference standard may have been used to select patients for the study.									
Dataset of specialty child abuse evaluations gathered across multiple sites.									
Developed by Lindberg et al. ³⁵									
Criteria for abuse: inflicted head injury, clinical and radiological evidence of brain injury with no history of traumatic event (fall, blow to head, motor vehicle crash), history of traumatic event that is incompatible with developmental level, witnessed inflicted head injury, confession by alleged perpetrator to inflicting the head injury, or evidence of other physical injuries consistent only with inflicted injuries (eg, pattern bruises, occult rib, or extremity fractures). ^{34,43}									
Cases in which the child's primary caregiver admitted abusive acts that could be linked to the child's acute clinical presentation for traumatic cranial injuries; an independent witness verified abusive acts that could be linked to the child's acute clinical presentation for traumatic cranial injuries; a child not yet cruising or walking became clearly and persistently ill with signs of acute cardiorespiratory compromise linked to his/her traumatic cranial injuries while in the care of a primary caregiver who denied any knowledge of a head injury event; the child's primary caregiver provided an explanation for the child's head injury event that was clearly developmentally inconsistent with the parent(s)' description of their child's developmental capabilities; the child's primary caregiver provided an explanation for the child's head injury event that was highly inconsistent with repetition over time; and the child with a head injury revealed ≥2 noncranial injuries considered moderately or highly specific for abuse. ⁴⁴									
Criteria for abuse: the primary caregiver admitted abusive acts; abusive acts by the primary caregiver were witnessed by an unbiased, independent observer; the primary caregiver specifically denied that the preambulatory child in his/her care had experienced any head trauma; the primary caregiver provided an account of the child's head injury event that was clearly historically inconsistent with repetition over time; the primary caregiver provided an account of the child's head injury event that was clearly developmentally inconsistent with the child's known (or expected) gross motor skills; further workup confirmed the presence of 2 or more categories of extracranial injuries considered moderately or highly suspicious for abuse. ^{32,33,44,45,57}									

Table 2. Meta-Analysis for Clinical Characteristics to Identify Physical Abuse^a

Clinical		No.	(95% CI)				
Presentation	Finding	Studies	Patients	Sensitivity	Specificity	Positive LR	Negative LR
Head injury	Retinal hemorrhage	7 ^{42,43,46,48,51,52,55}	1052	0.40 (0.20-0.64)	0.97 (0.97-0.99)	11.0 (4.0-33.0)	0.62 (0.40-0.81)
Head injury	Seizure	3 ^{43,45,53}	1323	0.33 (0.09-0.71)	0.93 (0.78-0.98)	3.9 (2.4-6.5)	0.70 (0.48-0.998)
Head injury	Hypoxic ischemic injury	3 ^{45,48,53}	1259	0.13 (0.03-0.43)	0.99 (0.88-0.99)	3.4 (1.8-6.4)	0.82 (0.66-1.0)
Head injury	Subdural hematoma	5 ^{42-44,48,53}	1246	0.67 (0.50-0.81)	0.79 (0.7-0.85)	3.2 (2.6-3.8)	0.41 (0.26-0.60)
Head injury	Absence of skull fracture	5 ^{43-45,48,53}	1382	0.68 (0.65-0.72)	0.67 (0.56-0.76)	2.0 (1.5-2.8)	0.48 (0.40-0.58)
Head injury	Absence of soft tissue injury head	3 ^{43,44,53}	1155	0.84 (0.80-0.86)	0.54 (0.34-0.72)	1.8 (1.2-2.5)	0.42 (0.34-0.53)
Head injury	Absence of epidural	4 ^{43,44,48,53}	1173	0.97 (0.95-0.98)	0.09 (0.05-0.98)	1.1 (1.01-1.1)	0.34 (0.16-0.77)
Children undergoing abuse evaluation for bruising or suspected physical abuse	Oral injury	3 ^{40,51,54}	5228	0.07 (0.05-0.08)	0.99 (0.98-0.99)	6.6 (3.2-14)	0.95 (0.93-0.96)
Children with head injury, burns, or undergoing abuse evaluation	Any fracture	5 ^{42,48,49,51,53}	1229	0.16 (0.09-0.26)	0.97 (0.95-0.99)	5.9 (2.9-12.0)	0.87 (0.76-0.94)
Children with head injury, burns, or undergoing abuse evaluation	Multiple fractures	3 ^{42,52,53}	759	0.34 (0.16-0.58)	0.91 (0.74-0.97)	3.8 (2.4-6.0)	0.74 (0.58-0.93)
Children with bruising on examination ^b	Buttocks	2 ^{40,47}	2625	0.24-0.29	0.98-1.00	15-83	0.72-0.76
Children with bruising on examination ^b	Neck	2 ^{40,47}	2625	0.15-0.20	0.91-1.00	2.2-84	0.86-0.88
Children with bruising on examination ^b	Patterned	2 ^{39,40}	2269	0.27-0.39	0.86-0.99	2.0-66	0.62-0.84
Subconjunctival hemorrhage ^b		2 ^{40,56}	2373	0.08-0.38	0.93-1.00	5.4-130	0.67-0.93

^a See eTable 2 in the Supplement for results from individual findings.^b Likelihood ratio (LR) results are reported as ranges because only 2 studies reported on the finding.

Demographic Features

The prevalence of physical abuse in included studies ranged from 5% to 79%. Most studies were either conducted in ED or inpatient units or data were obtained from a registry of patients evaluated for physical abuse. Although the age of children in included studies ranged from 0 to 18 years, 9 of the 18 studies restricted the age to younger than 5 years and all studies had a median or mean age of younger than 6 years. Mean age ranged from 3 months to 5.8 years and median age ranged from 3 months to 2.0 years for all included studies. Among 10 studies in which patient sex was reported (n = 9397), there was no difference in rates of physical abuse between males and females (odds ratio, 1.06 [95% CI, 0.72-1.56]).^{40-44,47-50,53}

Physical Abuse and Head Injury

Six studies examined children with head injuries (n = 1521) that were severe enough to require neuroimaging.^{42-45,48,53} Data from all of the studies were either collected prospectively from the hospital (ED or inpatient) setting or obtained from existing datasets of hospitalized children in whom physical abuse evaluations were performed. For 5 of the 6 studies, age of enrollment ranged from 0 to

5 years, with a median age ranging from 4 to 10 months. The study that included children younger than 13 years reported a median age of 7 months⁴⁸ (Table 1). In these studies, retinal hemorrhages were diagnosed by ophthalmologists performing dilated fundus examinations and indirect ophthalmoscopy.

The prevalence of physical abuse in children with head injury undergoing neuroimaging ranged from 18% to 71%. Among hospitalized children with a head injury, the findings that increased the likelihood of physical abuse were the presence of retinal hemorrhages (positive LR, 11.0 [95% CI, 4.0-32]; negative LR, 0.62 [95% CI, 0.40-0.81]), seizures (positive LR, 3.9 [95% CI, 2.4-6.5]; negative LR, 0.70 [95% CI, 0.48-1.0]), hypoxic ischemic injury (positive LR, 3.4 [95% CI, 1.8-6.4]; negative LR, 0.82 [95% CI, 0.66-1.0]), or a subdural hematoma (positive LR, 3.2 [95% CI, 2.6-3.8]; negative LR, 0.41 [95% CI, 0.26-0.60]). Conversely, the presence of a skull fracture (negative LR, 0.48 [95% CI, 0.40-0.58]), soft tissue head or scalp injury (negative LR, 0.42 [95% CI, 0.34-0.53]), or epidural hematoma (negative LR, 0.34 [95% CI, 0.16-0.77]) decreased the likelihood of physical abuse. However, the presence of any of these 3 clinical findings does not rule out physical abuse.

Oral Injury

Three studies^{40,51,54} (n = 5228) investigated the association between oral injury and physical abuse. In one study, children younger than 4 years with bruising were identified through physical examination in the ED,⁴⁰ while the other 2 studies obtained data from a prospectively collected dataset of children undergoing child abuse evaluations.^{51,54} In these studies, oral injury involved the lip, tongue, frenula, gingiva, or dentition. Oral injuries may be inflicted, for example, by forceful insertion of eating utensils, bottles, fingers, or scalding liquids or caustics.

The age of children in the included studies ranged from 0 to 10 years, with mean age ranging from 10 months to 2.1 years across the studies. The prevalence of physical abuse in children with oral injury ranged from 19% to 41% in the included studies. The presence of an oral injury was associated with a higher likelihood of physical abuse (positive LR, 6.6 [95% CI, 3.2-14]).

Fractures Identified on Skeletal Survey

Six studies^{42,48,49,51-53} (n = 1388) examined the association between the presence or absence of a fracture on skeletal survey and physical abuse. Although all children were assessed for possible abuse, the settings for these studies were varied, including hospitalized children with head injury or burns and children referred to clinical specialists in child abuse as outpatients. Indications for obtaining the skeletal surveys were not always reported. The age of children in the included studies ranged from 0 to 15 years, with a median age range of 5 to 20 months. Identification of a fracture on skeletal survey ranged from 3% to 50%, and prevalence of physical abuse ranged from 41% to 79% across these studies.

The presence of at least 1 fracture on a skeletal survey was associated with a higher likelihood of physical abuse (positive LR, 5.9 [95% CI, 2.9-12.0]).^{42,48,49,51,53} Among children who underwent skeletal survey for evaluation of physical abuse, children with multiple fractures had a greater likelihood of physical abuse (positive LR, 3.8 [95% CI, 2.4-6.0]) compared with children without fractures.^{42,52,53}

Burn Injuries

Four studies^{41,49-51} were conducted in children with burn injuries (n = 5948). Children in the included studies ranged in age from 0 to 18 years, with 3 of the 4 studies reporting a mean age range of 10 months to 5.8 years. In the fourth study,⁵⁰ median age for children with and without physical abuse was 1.7 years and 2.0 years, respectively. Among children with burn injuries who were evaluated for abuse, 5% to 41% were ultimately diagnosed with physical abuse.

Two studies^{41,50} were conducted in hospitalized children with mean total body surface area burns ranging from 5% to 17%, and a third study reported total body surface area less than or equal to 9% for 85% of children.⁵¹ The fourth study did not report total body surface area.⁴⁹ Given this broad clinical presentation of burn severity and resultant heterogeneity, these data were not combined for analysis. When specifying location of burns, each study used distinct groupings (eg, "head or neck" vs "face, head, neck and shoulder"), preventing their combination. From the available data, consistent utility for the type of burn among contact, flame, or scald burns could not be detected (see eTable 2 in the [Supplement](#)). Immersion burns, which occur when a child is placed into hot liquid, increase the likelihood of physical abuse. However, the LR varied between those hospitalized for care of immersion burns (positive LR, 29 [95% CI,

4.0-213.0])⁴¹ and those referred for child abuse evaluation from a variety of outpatient settings (positive LR, 2.7 [95% CI, 1.5-4.7]).⁵¹ A consistent association was not identified between physical abuse and anatomic location of a burn on the arm, leg, head and neck, or trunk (see eTable 2 in the [Supplement](#)). The largest study of burns (5553 children hospitalized in a burn center) found increased likelihood of physical abuse for those with perineum burns (positive LR, 7.8 [95% CI, 6.4-9.4]) or buttocks burns (positive LR, 5.5 [95% CI, 4.7-6.4]).⁵⁰

Bruising

Three studies^{39,40,47} (n = 2809) examined the association between bruising characteristics and physical abuse. The age of children in included studies ranged from 0 to 4 years, with mean age ranging from 6 months to 2.1 years. Among included studies, 19% to 69% of patients had injuries consistent with physical abuse based on expert review. Two studies^{39,47} were based on a dataset of children in whom child abuse evaluations were performed and 1 study⁴⁰ was conducted in an emergency department. Bruising on the buttocks (positive LR range, 15.0-83.0) or neck (positive LR range, 2.2-84.0) were suggestive of physical abuse if present.^{40,47} Patterned bruises were also associated with physical abuse (positive LR range, 2.0-66.0).^{39,40}

Subconjunctival Hemorrhage

Two studies^{40,56} assessed the association between subconjunctival hemorrhage and physical abuse. In one study, 2161 patients in the ED younger than 4 years underwent a comprehensive skin examination to identify bruising. Comprehensive data collection, including photographs and injury mapping, was performed. An expert panel then determined the presence or absence of abuse based on detailed review of these data and the medical record, independent of the assessment by clinicians at the ED visit. Prevalence of physical abuse in this study was 19%; children with obvious causes of bruises (such as motor vehicle accidents, coagulopathy, or neuromuscular disorders resulting in spasticity and falls) were excluded.⁴⁰ A second study used a dataset of children younger than 10 years (median age, 5 months; prevalence of subconjunctival hemorrhage, 1.7% [50 of 2890 children]) to create a case-control study of children undergoing child physical abuse evaluation by a child abuse specialist.⁵⁶ In this study, the majority of children (76% [38/50]) with a subconjunctival hemorrhage also had other bruises, most commonly on the face and neck. The presence of subconjunctival hemorrhage was associated with greater likelihood of physical abuse (positive LR range, 5.4-130).

Discussion

In this systematic review, 18 high-quality studies focusing on the accuracy of clinical and radiologic findings for the diagnosis of physical abuse in children were identified. The presence of oral injury, bruising on the buttocks or neck, patterned bruising, and subconjunctival hemorrhage were the most clinically predictive findings associated with physical abuse. Among children with head injury, presentation with seizure was associated with physical abuse. Neuroimaging findings of subdural hematoma and hypoxic ischemic injury were associated with physical abuse, while the presence

of epidural hematoma, skull fracture, and soft tissue head injury were more likely to be associated with other causes of injury. The results of this meta-analysis also affirm the association between retinal hemorrhages and the presence of a fracture on skeletal survey with physical abuse. However, no single finding was definitive for the presence or absence of physical abuse. These findings highlight the importance of a detailed physical examination combined with diagnostic imaging when appropriate for children presenting with possible physical abuse.

Children with inflicted trauma can present with a broad range of injury severity and to a multitude of health care settings. Those with major trauma typically undergo a detailed assessment for physical abuse; however, clinicians evaluating children with minor injuries or in less acute care settings should recognize that certain subtle physical examination or clinical findings merit consideration of physical abuse. Among children with inflicted injury, approximately 25% have prior sentinel injuries, and among children with abusive head trauma, one-third have prior opportunities for diagnosis of physical abuse.¹³ Therefore, knowledge of findings associated with physical abuse, particularly sentinel injuries that may be subtle, is important for all clinicians caring for children.

Careful consideration and consultation with child abuse experts is warranted in all suspected cases of physical abuse. An accurate, early diagnosis of physical abuse may be lifesaving for a child, whereas a missed diagnosis can result in severe physical injury and even death. Furthermore, because physical abuse experienced during childhood may be associated with adverse physical and mental health outcomes in adulthood, early identification and prevention should be emphasized.⁵⁸ Conversely, an inaccurate diagnosis of child physical abuse may have detrimental consequences on both the child and family, such as family separation, psychological stress, and prolonged litigation. Misdiagnosis may also cause affected individuals to lose trust in clinicians and the health system and may result in reluctance to seek future medical care. Clinicians should use a thorough, nonbiased, evidence-based approach when assessing a child's risk for physical abuse.

Limitations

This review has several limitations. First, the absence of a criterion standard for the definition of physical abuse leads to predictable variability among included studies. An attempt to mitigate the variability was made by applying 3 rigorous research standards to determine the presence or absence of physical abuse and only including studies that used one of these 3 reference standards. Second, 12 of 18 included studies were rated level of evidence 4, in which the clinical finding or a test result was used as inclusion criteria for the study. As a result, the assessment of physical abuse may be biased, given individual findings may have been factors used to determine the presence of abuse. This is a limitation in child abuse research because the identification of patients for enrollment is often based on the presence of a clinical finding or a referral to hospital child protection teams. However, because randomized clinical trials cannot be conducted in child abuse research, the methodology used in this systematic review identified the best available evidence through a rigorous, standardized selection process, with a quality and bias assessment of each included article.

Third, given the specific settings and inclusion criteria of the studies in this systematic review and meta-analysis, the findings may

not be generalizable to all children with concern for physical abuse. Fourth, the heterogeneous presentation of results in some articles, particularly in patients with burns and bruising, limited the ability to combine the data for statistical analysis. Fifth, inclusion criteria for this systematic review and meta-analysis required that all children underwent expert review for determination of physical abuse, which allowed for a rigorous study selection and generation of pooled estimates, but may have resulted in overestimation of effect.

Scenario Resolution

In children undergoing neuroimaging based on clinical presentation of head injury, the pretest probability of physical abuse ranges from 18% to 71%. In the 2 cases, the likelihood of physical abuse changes based on the clinical presentation. To more accurately reflect the prevalence of physical abuse in the general population and avoid overestimation of the effect, 18% was selected as the pretest probability.

Case 1

This 4-month-old minimally responsive child with head injury was found to have a subdural hematoma (positive LR, 3.2 [95% CI, 2.6-3.8]) and oral injury (positive LR, 6.6 [95% CI, 3.2-14]). Based on these findings, starting with a pretest probability of 18%, the posttest probability of physical abuse becomes 41% to 60%. Therefore, a complete abuse evaluation should be strongly considered in this child.

Case 2

This 6-month-old child with head injury had an epidural hematoma (negative LR, 0.34 [95% CI, 0.02-0.77]). Based on this finding alone, the posttest probability of physical abuse in this child was 7%. Therefore, clinicians should complete a thorough history and physical evaluating evidence suggestive of physical abuse while also investigating other causes of head injury.

Clinical Bottom Line

Among children with physical abuse as a possible diagnosis, a detailed skin and intraoral examination should be performed and neuroimaging should be strongly considered. Physical examination findings of buttock or neck bruising, patterned bruising, oral injury, and subconjunctival hemorrhage are highly suggestive of physical abuse. Neuroimaging that reveals subdural hematoma or hypoxic ischemic injury are associated with physical abuse. The presence of epidural hematoma or skull fracture should direct the clinician to consider other causes of injury.

Conclusions

The best available current evidence suggests that a detailed physical examination revealing oral injury, bruises on the buttocks or neck, patterned bruises, and subconjunctival hemorrhage in young children should alert clinicians to the possibility of physical abuse. Findings on neuroimaging and ophthalmologic evaluation in infants and young children with head trauma can help clinicians determine the likelihood of

physical abuse. Given the substantial morbidity and mortality associated with child physical abuse, and the importance of early detec-

tion, uniformly adopted research standards and case definitions of physical abuse in children would enhance the quality of evidence.

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Critical review of the manuscript for important intellectual content: Fong, Haney, Harper, Pierce, Neuman.

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