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Investigating the Incidence of Fractures in Children Under 5: A Comprehensive Analysis

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Abstract: Fractures in children aged under five years constitute a priority concern owing to their distinctive epidemiological features and the differential diagnosis between accidental and non-accidental injury. This meta-analysis pools evidence from seven seminal epidemiological studies published between 1983 and 2024, including retrospective cohorts, national registries, insurance claims databases, and systematic reviews, to clarify the incidence, anatomical location, and mechanisms of pediatric fractures. The review finds that the incidence of fracture is comparatively low among non-ambulant infants aged less than 12 months but rises dramatically with the commencement of independent ambulation, with the distal forearm, tibia, and clavicle being predominantly affected while in our study Falls from low heights are the major injury mechanism among ambulant toddlers, whereas a high percentage of fractures among infants aged less than one year are due to non-accidental reasons where Methodological diversity among studies restricts quantitative pooling, highlighting the necessity for harmonized prospective studies and finally The review offers crucial information for clinicians in discerning normative fracture patterns from those raising suspicion of abuse, as well as for public health specialists implementing targeted prevention initiatives. Standardized data collection and prospective study designs should be prioritized in future research to further delineate fracture risk factors and enhance child safety outcomes.

Keywords: Pediatric Fractures, Children Under Five, Fracture Incidence, Epidemiology, Non-Accidental Trauma, Low-Energy Falls, Systematic Review, Meta-Analysis, Fracture Patterns, Child Abuse Detection.

Introduction

Fractures in children under 5 years of age are influenced by a variety of risk factors, which include demographic, biological, and environmental elements where These factors contribute to the incidence and prevalence of fractures in this age group, highlighting the need for targeted prevention strategies and the most common risk factors identified in the literature are age, gender, socioeconomic status, and certain health conditions. Below are the key aspects of these risk factors while The incidence of fractures increases with age, particularly in children over 1 year old, with the highest rates observed in 4-year-olds (1) with Male children are more prone to

fractures compared to females, which may be attributed to higher levels of physical activity and risk-taking behaviors (2,3) according to Socioeconomic and Demographic Factors which refer to Children from certain racial backgrounds, such as Caucasian, and those living outside the US, show higher fracture rates (2,5) furthermore Socioeconomic status plays a role, with children of officers having higher fracture rates compared to those of enlisted service members (2,4,6) then Younger maternal age and higher birth order (e.g., being the fourth-born or later) are associated with increased fracture risk while Health and Lifestyle Factors refer to Low bone mineral density and high body weight are significant risk factors, as they contribute to bone fragility (8,9) in addition to Children with a history of maternal alcohol misuse are at a higher risk of fractures which Poor nutrition, particularly low calcium intake, and lack of weight-bearing exercise can lead to weaker bones and increased fracture risk also about Non-Accidental Injury (NAI) (10)

Fractures in children under 24 months, especially non-ambulant children with femur or skull fractures, may indicate non-accidental injury, necessitating careful evaluation (11) While these factors highlight the common risks associated with fractures in young children, it is important to consider that not all fractures are preventable with Some children may have underlying health conditions, such as Osteogenesis Imperfecta, that predispose them to fractures regardless of external factors (12,13,14) so Understanding these risk factors can aid in developing effective prevention strategies and interventions to reduce fracture incidence in this vulnerable age group, The relationship between falls from heights and fractures in children under 5 is significant, as falls are a leading cause of injury in this age group and through Research indicates that the height from which a child falls correlates with the severity of fractures sustained. For instance, children often experience fractures from falls off furniture or playground equipment, with younger children more likely to fall from caregivers' arms or beds (15) (16). Through Preventive measures are crucial to mitigate these risks which Fall Mechanisms and Fracture Types with Common Fall Sources Children under five frequently fall from furniture, stairs, and playgrounds, with falls from playground equipment being more common in older toddlers (17), where Fracture Patterns: Younger children tend to sustain head injuries, while older children may experience femur or humerus fractures, indicating a shift in injury patterns with age (16).

Finally, our meta-analysis of the aim of the research on the incidence of fractures in children under five, as reflected in the reviewed studies, is to systematically investigate and characterize the epidemiology, patterns, mechanisms, and risk factors associated with pediatric fractures at this young age group.

Methodology

This meta-analysis systematically pooled evidence on the incidence, trends, and mechanisms of fractures in children five years and younger by synthesizing data from seven major epidemiological and clinical studies obtained from exhaustive database searches. The methodology followed accepted standards for meta-analytic studies to ensure rigor, reproducibility, and transparency. Study Identification and Selection. The literature review covered several academic databases, mainly Google Scholar and PubMed, using search terms including "pediatric fractures," "children under five," "fracture incidence," and "epidemiology of pediatric fractures." Research was considered eligible if it:

- focused on fracture incidence among children less than five years old,
- reported primary empirical data derived from epidemiological or clinical sources.
- It was published in peer-reviewed journals. Both retrospective and prospective study types were considered, including population registry analyses, systematic reviews, and assessments of clinical records. Research was excluded if it:

A. did not report age-disaggregated data for the cohort of children under five,

B. was a case report or small case series with limited generalizability,

C. concentrated solely on particular types of fractures that were not indicative of the overall fracture incidence.

D. Was a publication in a language other than English without a readily available translation. There were no restrictions on the geographic origin of the research; nevertheless, all the included research was from high- and middle-income countries.

Where the meta-analysis. Together, these studies cover publication years from 1983 through 2024, encompassing data periods ranging from the mid-20th century up to the present decade. This broad temporal scope allows the meta-analysis to capture secular trends and evolving fracture epidemiology in young children.

Inclusion and Exclusion Criteria Summary

Criterion

Description

- ✓ Inclusion: Peer-reviewed empirical studies reporting primary data on fracture incidence in <5 children
- ✓ Studies with a clear sample size and age distribution
- ✓ Retrospective and prospective designs, registry analyses, and systematic reviews

Exclusion

Studies without specific data on the <5 age group

- ✓ Case reports/small series lacking generalizability.
- ✓ Papers focusing on rare fracture types without incidence data.
- ✓ Non-English papers lacking full-text access.
- ✓ Years Covered by Included Studies

Results

Table 1 outlines a foundational list of seven key studies underlying this meta-analytic review of the incidence of fractures in children five years and under. The table summarizes.

- ✓ Authors,
- ✓ article titles,
- ✓ and clearly stipulated research aims.

The studies included vary from large population-based cohort analyses and registry-based studies to systematic reviews and focused epidemiological investigations where Collectively, they cover a geographically diverse set of populations in addition to The research aims are all directed towards elucidating rates of fracture incidence, patterns of injury, trauma mechanisms, and the interrelation between accidental and non-accidental etiologies in young children, with particular emphasis on toddlers and infants. This strategically selected set of studies offers a firm evidence foundation for understanding age-specific fracture epidemiology in early childhood.

Table 1: Summary of Key Studies on Fracture Incidence in Children Under Five

Authors	Title	Aim
Karen Rosendahl et al.	Incidence, pattern, and mechanisms of injuries and fractures in children under two years of age	Examine incidence, pattern, mechanisms, and characteristics of fractures in 0–2 y.o.s
Rosendahl K et al.	The incidence of fractures in children under two years of age: a systematic	Systematic review of epidemiological studies on

	review	fracture incidence in <2 y.o.s
Wolfe JA et al.	Early Pediatric Fractures in a Universally Insured Population within the United States	Quantify the incidence and type of fractures among US children under 5 years.
Kemp AM et al.	Patterns of skeletal fractures in child abuse: systematic review	Review fracture patterns in abuse vs. non-abuse cases in young children
Hedstrom EM et al.	Epidemiology of fractures in children and adolescents	Provide national data on fracture epidemiology in children, with sub-data for <5 y.o.s
Brudvik C	Child injuries in Bergen, Norway: Identifying high-risk groups and activity-specific injuries	Epidemiological study of injuries, including fractures, among children in Norway

Table 2 clarifies the methodological heterogeneity and demographic characteristics of the populations studied within the included studies, The study methodologies comprise retrospective cross-sectional studies examining both radiographic and clinical records, large registry analyses, assessments of insurance claims databases, and systematic literature reviews while The sample sizes are highly variable, ranging from several hundred children (e.g., cohorts from hospital accident and emergency departments) to tens of thousands of cases derived from national registries or insurance data, which The studied populations are largely ambulatory and pre-ambulatory children under the age of five years. Collectively, these studies yield important information, including a significant increase in fracture incidence coincident with the onset of independent mobility, differences in common fracture sites by age group—most notably, the frequency of forearm fractures in toddlers—and a high percentage of fractures in infants attributable to non-accidental trauma so This table highlights the range of methodological approaches used to identify epidemiological trends, underscoring the importance of interpreting pooled findings within the context of the particular study designs and sample sources.

Table 2: Title: Methodological Approaches and Study Samples in Pediatric Fracture Research

Method	Sample	Insight
Retrospective cross-sectional, radiograph review, and chart analysis	408 children, 0–23 months, Norwegian A&E department	Incidence rises 10x from <12 months to 12–24 months; forearm most common site
Systematic review of epidemiological/registry studies	12 eligible studies, 0–2 years, Europe, US, Japan	Incidence 5.3–9.5/1,000 per year for 0–2 y.o.s.
Database study (claims-based)	Over 7,000 children in the US, from birth to 5 years old	Incidence climbs from infancy to age 5; most fractures occur in limbs, especially the forearm.
Systematic review	Multiple case-control & cohort studies; abused vs non-abused	25–56% of fractures in < 1-year-olds arise from abuse; patterns differ by cause
Registry study	All pediatric fractures in a Swedish region, ages 0–16	Annual incidence data, most common sites, and causes by age group
Retrospective/registry review, survey, and medical records	Children in Bergen, Norway, including those <5 y.o.s	Identifies higher risk activities, demographics, and injury times

Table 3 synthesizes the principal findings across the included studies, presenting a consolidated overview of fracture incidence rates, anatomical fracture locations, and typical injury mechanisms in children under five years old and which The aggregate data indicate that annual fracture incidence among children under two ranges between approximately 5.3 to 9.5 per 1,000 children, with incidence increasing steadily after the first year of life as children begin walking, following by The most frequently observed fracture sites include the distal radius and ulna, tibia/fibula, and clavicle, with site-specific patterns also influenced by child age and mobility status. Falls dominate as the primary injury mechanism, particularly low-level falls from furniture or the child's own height, accounting for the majority of fractures in ambulant toddlers. Notably, greenstick and buckle fractures account for around one-third of pediatric fractures, and isolated metaphyseal lesions are considered of clinical significance, especially in the context of evaluating for potential abuse. The data also underscore that rib fractures are rare unless non-accidental trauma is suspected. Furthermore, A substantial proportion of fractures in children under one year are associated with abuse, emphasizing the importance of age-specific fracture pattern recognition for clinical and forensic assessments.

Table 3: Synthesis of Findings: Incidence and Characteristics of Fractures in Children Under Five

Results
Annual fracture incidence in children 0–2 years ranges from 5.3 to 9.5/1,000, increasing with age. Boys and girls have similar rates in the youngest age groups.
Most common fracture sites in under-2s: radius/ulna (25-40%), tibia/fibula (17-28%), clavicle (14-15%). For infants (<1 yr), the clavicle and humerus predominate.
Falls (from furniture, own height, or low elevations) account for 50–70% of fractures in the ambulant group. Crush injuries are more common in non-fracture trauma.
Greenstick/buckle fractures comprise ~32% of all fractures. Only isolated metaphyseal lesions are seen; rib fractures are rare unless abuse is suspected.
Up to 56% of fractures in children <1 year may be due to abuse; multiple and rib fractures have a higher predictive value for abuse.
National and regional data consistently support predominantly limb fractures (especially distal forearm) in children <5, with varying rates depending on activity/environment.

Table 4: Conclusions Drawn from the Meta-Analysis of Pediatric Fracture Studies

Authors	Title	Conclusion
Karen Rosendahl et al.	*Incidence, pattern, and mechanisms of injuries and fractures in children under two years of age*	Fractures are rare in non-ambulant infants, increase sharply after walking onset, and mostly affect the forearm, tibia, and clavicle.
Rosendahl K et al.	*The incidence of fractures in children under two years of age: a systematic review*	Incidence ranges 5.3–9.5/1,000 per year; heterogeneity limits pooled analysis; more prospective studies needed.
Wolfe JA et al.	*Early Pediatric Fractures in a Universally Insured Population within the United States*	Fracture incidence climbs with age up to 5 years; distal forearm fractures are most common.
Kemp AM et al.	*Patterns of skeletal fractures in child abuse: systematic review*	High proportion of fractures in infants <1 year linked to abuse; fracture patterns differ significantly between accidental

		and abusive.
Hedstrom EM et al.	*Epidemiology of fractures in children and adolescents*	National registry confirms most common fracture sites and rising incidence with age, especially after mobility begins.
Brudvik C	*Child injuries in Bergen, Norway: Identifying high-risk groups and activity-specific injuries*	Identifies fracture risk factors, including activity patterns and demographic factors; highlights the need for prevention and awareness.

Discussion

This meta-analysis pools data from seven leading studies conducted over more than four decades and offers a definitive exploration of the incidence, patterns, and mechanisms of fractures in children aged under five years. The evidence pooled identifies several consistent epidemiological trends while emphasizing important subtleties for clinical practice and research Firstly, the incidence of fractures in this age group of young children is seen to be comparatively low among non-ambulant infants (less than 12 months of age); however, it sees a significant spike as children achieve independent mobility, specifically in the 12 to 24-month age group. This rise can probably be attributed to greater exposure to environmental risks as toddlers begin to walk and partake in exploratory activities with concurrence with prevalent comprehensive epidemiological studies (Landin, 1983; Hedstrom et al., 2010), forearm fractures—more so of the distal radius and ulna—and tibia and clavicle fractures are most prevalent among ambulant children. This trend reflects the biomechanical factors involved in falls from low heights, such as those related to furniture or a child's height, which remain the leading mechanisms of injury reported (Rosendahl et al., 2020; Wolfe et al., 2019).

A significant and clinically relevant dimension is seen in the distinction between accidental and non-accidental trauma while Systematic reviews and clinical studies demonstrate that a considerable percentage of fractures in children less than one year of age can be due to abuse, with some reports estimating up to 56% (Kemp et al., 2008; Rosendahl et al., 2020) where in Fracture patterns of multiple metaphyseal lesions and rib fractures have specific diagnostic significance. Accordingly, the need for clinicians to utilize age-relevant normative fracture pattern knowledge is supreme to avoid under-recognition as well as overdiagnosis of abuse. This sensitive knowledge is crucial for protecting vulnerable children and preventing unwarranted investigations. Heterogeneity in study designs — including retrospective chart reviews, registry-based studies, insurance claims analyses, and systematic reviews — mandates a conservative stance in pooling data quantitatively furthermore Variation in fracture classification, age stratification, and reporting measures restricts the potential for large-scale pooled meta-analyses, with narrative synthesis being depended upon for synthesizing incidence trends and injury characteristics so This finding is in concordance with Rosendahl et al.'s 2024 systematic review, wherein harmonization in data collection methods and standardized reporting in future studies is called for, to allow for greater comparability and meta-analytic strength , according to The time range of the studies included, from the landmark 1980s research of Landin to more contemporary investigations by Rosendahl and colleagues, offers useful longitudinal perspective but also draws notice to changing demographic, environmental, and healthcare-related variables that could influence fracture epidemiology over time in addition to Pediatric care advances, injury prevention measures, and public health reporting improvements probably shape current fracture patterns and incidence rates differently than in previous decades, From a public health standpoint, the results highlight the need for targeted injury prevention, specifically designed for ambulant toddlers at highest risk for falls. Education for caregivers about safe home environments, fall prevention, and the early recognition of injury warning signs may be

effective. At the same time, clinical protocols must remain alert for features of abuse in infants with fractures, with prompt multidisciplinary evaluation.

Conclusion

In conclusion, this meta-analysis consolidates current knowledge regarding pediatric fractures in children under five, reaffirms established epidemiological patterns, and identifies critical gaps in methodological consistency across studies and recommended Future research endeavors should prioritize prospective, population-based designs with standardized data collection to enable more definitive incidence estimations and improved fracture classification like efforts will enhance clinical decision-making, inform prevention strategies, and ultimately improve outcomes for young children at risk of fractures.

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