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# Accidental head injuries in children under 5 years of age

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**KEYWORDS**
Paediatrics; Trauma; Wounds and injuries

AIM: To evaluate the type and nature of head injuries sustained by children under the age of 5 years who present to a busy accident and emergency (A&E) department following an accidental fall.

MATERIALS AND METHODS: This study included all children under the age of 5 years, who over an 8-month period were referred to our A&E Department with head injury following an accidental fall. Data were collected regarding the height of the fall, whether or not stairs were involved, the type of surface that the child landed on and the height of the child. This was correlated with any soft-tissue injury or skull fracture.

RESULTS: A total of 72 children (aged 4 months to 4.75 years) fulfilled all the criteria for an accidental fall. The heights of the falls ranged from less than 50 cm to over 3 m, with the majority below 1 m. Of the falls, 49 were onto a hard surface and 23 were onto a soft surface. Of the 72 children, 52 had visible evidence of head injury, 35 (71%) of 49 being the result of falls onto hard surfaces and 17 (74%) of 23 onto soft (carpeted) surfaces. There was no significant difference in the type of surface that resulted in a visible head injury. A visible head injury was seen in all children who fell from a height of over 1.5 m and in 95% of children who fell over 1 m. Of the 72 children, 32 (44%) had skull radiographs performed in accordance with established guidelines and 4 (12.5%) were identified as having a fracture. Of the 3 linear parietal fractures 2 were inflicted by falls of just over 1 m (from a work surface) and 1 by a fall of 80 to 90 cm onto the hard-edged surface of a stone fire surround. The 4th was a fracture of the base of skull following a fall from more than 3 m (from a first-storey window).

CONCLUSIONS: In the vast majority of domestic accidents children do not suffer significant harm. Skull fractures are rare and probably occur in less than 5% of cases. To cause a skull fracture the fall needs to be from over 1 m or, if from a lesser height, then a small-area impact point should be considered an integral component of the injury.



## Introduction

Inflicted non-accidental head injury is a major cause of morbidity and mortality in the UK. The clinician and the radiologist both have an important role in detecting this aspect of child abuse. They also have a role in determining possible causation of the injuries and approximate timings.[1,2]

Following presentation to the medical services, the perpetrators of inflicted head injuries often suggest accidental causes for their child's head injury. The radiologist has to be able to determine, wherever possible, whether the mechanism reported by the carer could account for the radiologically detected injuries. To enable the radiologist to do this, he or she needs to be aware

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**Table 1** Indications for skull radiography

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|---|
| Boggy swelling >5 cm in diameter |
| Full-thickness laceration |
| Deep penetrating injury |
| Suspected compound or depressed fracture |
| Falls from a significant height (greater than twice the height of child) onto a hard surface or with a tense fontanelle |
| Under 18 months of age |

of which head injuries could reasonably be expected to follow domestic accidental falls and other impact injuries.[3-5]

The purpose of our study was to prospectively evaluate the type and nature of head injuries sustained by children under the age of 5 years who presented to a busy accident and emergency (A&E) department following an accidental fall.

## Materials and methods

All children under the age of 5 years, who over an 8-month period had been referred to our A&E Department with head injury following an accidental fall, were reviewed. The history and examination obtained for each child followed normal departmental protocols. None of the children reviewed experienced any alteration in clinical practice as a consequence of the study.

A fall was defined as accidental if it fulfilled all of the following criteria.

- The fall was witnessed by one of child's carers and the history was corroborated by a second reliable observer. This second observer could be another carer, friend of the witness or an older sibling.
- The child was presented to the A&E Department within hours of the incident occurring.
- The mechanism and nature of the fall was, within the opinion of the examining paediatrician, compatible with a domestic accident.

On admission to the A&E Department a full history was obtained. This included the height of the fall, whether or not stairs were involved and the type of surface that the child landed on. A hard surface was defined as one with no perceptible cushioning effect; this included all floors, apart from carpeted floors, and all outdoor falls. Carpeted floor was considered to be a soft surface, regardless of its thickness or the nature of the underlay.

At clinical examination the height of the child and the presence of any visible injury was recorded. A visible injury included any cutaneous redness or bruising to the skin, soft-tissue swelling, scratches and lacerations. The size of any swelling was recorded, as this would affect the decision to refer for skull radiography. The indications for skull radiography were based on established Trust guidelines that had been modified from those published by the Royal College of Radiologists (Table 1).[6]

The clinical outcome for all children was recorded, and if a child had to remain in hospital for clinical observation this was highlighted. All carers were advised about returning to hospital if their child developed any neurological symptoms.

An analysis was made of the type of injury the child sustained and its relationship to the height of the fall and the surface onto which the impact occurred. Follow-up of all children was for 6 to 9 months.

## Results

There were 72 children aged between 4 months and 4.75 years (mean 3.5 years) who fulfilled all the criteria for an accidental fall. The group comprised 42 boys and 30 girls. The heights of the falls ranged from less than 50 cm to over 3 m, with the majority being below 1 m. Of the falls, 49 were onto a hard surface and 23 were onto a soft surface. A total of 52 children had visible evidence of a head injury, 35 (71%) of 49 being the result of falls onto hard surfaces and 17 (74%) of 23 onto soft surfaces. There was no significant difference in the type of surface that resulted in a visible head injury. A visible head injury was seen in all the children who fell from a height of over 1.5 m and in 95% of children who fell over 1 m.

Skull radiography was performed for 32 (44%) children, all of whom fulfilled the indications documented in Table 1. In 8 (25%) of the children undergoing skull radiography, the indication was age less than 18 months, and in 24 (75%) children it was a boggy swelling greater than 5 cm in diameter. Of the remaining children, 20 had no visible injury and 20 had an injury deemed to be insignificant.

A comparison of the number of children falling

from different heights, the frequency of visible injury and the number of those undergoing radiography is depicted in Fig. 1.

Of the 32 children undergoing skull radiography, 4 had fallen less than 50 cm and were under the age of 18 months, and 6 had fallen 0.5 to 1 m, 2 of whom were under the age of 18 months. In 26 cases the child's fall involved stairs. A comparison of the number with a visible head injury with the number undergoing radiography in this scenario is shown in Fig. 2.

Of the 32 children who underwent skull radiography, 4 (12.5%) were identified as having a fracture. Of the 3 linear parietal fractures, 2 resulted from falls of just over 1 m (from a work surface). These children were aged 18 months and 37 months, respectively. In the 3rd child, who was 8 months old, the fall was from 80 to 90 cm onto the hard-edged surface of a stone fire surround. All 3 children had significant soft-tissue swelling (a boggy swelling $>5$ cm in diameter) at the fracture site. The 4th child had a basal skull fracture that resulted from a fall from more than 3 m (a first-storey window). This fall was witnessed by numerous observers in the garden area into which the child fell.

In addition to the 4 children who had skull fractures, a further 4 were admitted to hospital for observation. These children all had falls from more than 1.5 m. Only the child with a fractured skull base was thought to clinically require CT.

All children were discharged within 24 h, apart from the child who had a basal skull fracture, who went home after 10 days. None of the children in the study were readmitted and no child developed any neurological symptoms following the fall.

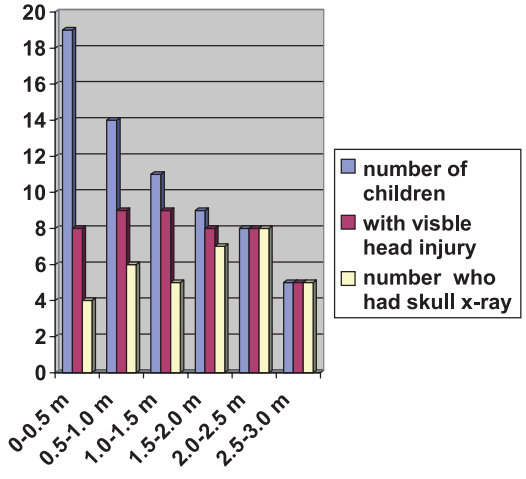


**Figure 1** Comparison between the number of children falling from different heights, the frequency of visible injury and the number undergoing radiography.

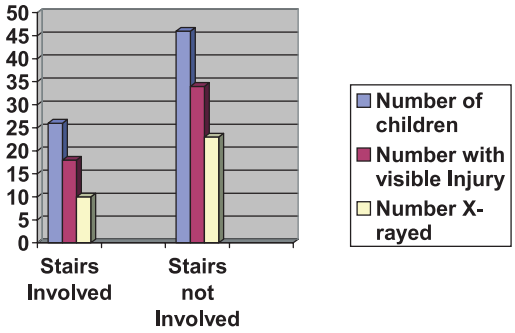


**Figure 2** Relationship between the number of children with a visible injury, the number undergoing skull radiography and whether the fall involved a flight of stairs.

## Discussion

Skull fractures are a common finding in both accidental and non-accidental injury.[1,5] Our study demonstrates that for the majority of low-impact falls from heights less than 1 m the likelihood of significant cranial trauma is minimal. If the height of the fall is below 50 cm it is extremely unlikely to cause a skull fracture.

The height of a free fall necessary to cause an injury in young children is often debated and causes some controversy among radiologists, paediatricians and other health professionals.[2-5,7-9] In cases of suspected non-accidental head injury, carers often allege that a minor domestic accidental fall is the cause of the child's injuries. Our study would suggest that in normal domestic situations the typical accidents that occur do not cause skull fractures in the majority of cases, and only very rarely result in any significant neurological damage.

We accept that not all children underwent skull radiography and it is therefore impossible to exclude the presence of skull fractures in all of them. Previous audits in our department on the use of skull radiography in head trauma have shown that the incidence of fractures is low, even in the presence of significant soft-tissue swelling. In many of the children there was little or no soft-tissue swelling, indicating that skull radiography was unnecessary. It is possible that in a few cases soft-tissue swelling may not become evident until 48 h after a head injury. As a consequence of this, on discharge all carers are advised to re-present to hospital if their child develops any neurological symptoms or new physical signs. No carers re-presented during the study period.

All children under the age of 18 months underwent skull radiography; some of these had had falls from less than 1 m. Only one fracture was detected in this group, in a child who fell onto a hard edged

surface and who had significant soft-tissue swelling. Additionally, in those children who had significant soft-tissue swelling following falls from over 1 m, the prevalence of fractures was low.

Although we were unable fully to exclude the possibility of an occult fracture in some of the children in our study, in view of the previous experience of our department of such fractures and the absence of significant swelling in those children who did not undergo radiography, we conclude that it is very unlikely.[6]

Our study confirms previously published reports that falls from below 90 cm do not, in the majority of cases, cause fractures.[7,8,10-12] We have confirmed this finding in the domestic situation rather than in a hospital environment. By confining the study to children presenting directly to an A&E department we have reflected the dilemma faced by the majority of UK radiologists. It is important that the previously published data regarding the height of fall necessary to cause a fracture are continuously questioned. The domestic environment is forever changing and evolving, putting children at different types of risk. Community-based surveys where data are derived from parental submission and postal questionnaires also support the view that the majority of domestic accidents that involve young children do not result in significant harm or cause skull fractures.[13,14]

Importantly, our study has confirmed that a fall from less than 90 cm can cause a fracture. However, this fracture occurred in a child who fell and hit his head on the sharp, hard edge of a fire surround. The impact would have been concentrated onto a small area of skull, significantly increasing the forces at the impact point. This is an important aspect of the history that must be ascertained when faced with a child with a head injury.

This study could be criticised for its definition of an accidental fall. We took the view that if the history could be corroborated by a second responsible observer, it would be unlikely, but not impossible, for it to be fabricated. Additionally, all the children in our study showed signs of relatively acute distress and were promptly presented to hospital, which would be in keeping with an acute event. Skull fractures were identified in only 4 children and no child suffered any long-term neurological damage. It would appear unlikely that in the absence of a significant head injury the carers were concealing a more sinister reason for their presentation to hospital.

The 1 child who had a significant basal skull fracture had a fall from a first-floor window (6 m). This event was witnessed by numerous observers and can, therefore, be considered to be factually correct. This height of fall is representative of the significant force required to cause major impact injuries.

All the children except the child with the basal skull fracture were discharged home within 24 h if they had needed admission to hospital. Only 9 children were admitted for observation. This confirms the widely held view that significant neurological sequelae do not result from such domestic accidents.[11,14]

The surface onto which the child falls might be expected to have an influence on the external injury, hard surfaces causing greater injury than soft surfaces. However, we did not find any significant correlation between the type of surface that the child fell onto and the presence of a visible head injury. Although this might reflect difficulty in accurately assessing during history taking the degree of elasticity of a surface, the more likely reason is that virtually all surfaces, however well carpeted, are hard because of the nature of the floor underneath. Only where it is accepted that the surface is very elastic, such as a mattress, could one assume that no visible injury should be present.

Although not specifically aimed at assessing the effect of stairway falls, our investigation does confirm previous studies that have demonstrated that it is the relatively minor fall onto the first step that causes the injury, and that subsequent multiple impacts as the child falls down further steps generate relatively minor forces.[15] In our study, only 9 of the 26 children who fell down stairs fell the entire length of the staircase. The first part of these falls was down three steps or less, i.e. a fall of less than 0.5 m.

Our study demonstrates that in the vast majority of domestic accidents children do not suffer significant harm. Skull fractures are rare and probably occur in less than 5% of cases. To cause a skull fracture the fall needs to be from over 1 m or, if from a lesser height, onto a small-area impact point which should be considered an integral component of the injury.

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