

# Fatal head injuries in children under the age of 5 years in Pretoria

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## Abstract

The incidence of fatal injuries in children has been reported to be highest amongst children aged 1-4 years. Major causes of head injury include road traffic accidents, falls and intentional or inflicted injury (such as non-accidental injury syndrome). This study reviewed the profile of children (under five years of age) who had been admitted to a large urban medico-legal mortuary (in Pretoria, the capital city of South Africa), after having suffered fatal head injuries. This study was conducted over a 5 year period (from January 2004 through December 2008) and a total of 107 cases were identified for inclusion. These cases constituted nearly a 5<sup>th</sup> of admissions in this age group. The male to female ratio was 56%:44% and the peak age of injury was less than 1 year. Most head injuries were sustained in road traffic accidents (70%) followed by falls (10%) and blunt force injuries (9%). Only 1 case of non-accidental injury syndrome (child abuse) was found. The great majority of deaths were deemed to have been accidental in nature (91%) with 6 (6%) homicides. Urgent review pertaining to the use of child restraint devices as well as the safety of pedestrians is required and the institution of childhood injury registers could aid in reducing childhood fatalities in South Africa.

## Introduction

Injury is one of the leading causes of mortality and morbidity in children. Feickert *et al* reported on a study conducted in Germany (for the period 1977-1994) that “the mortality of children caused by trauma and head injuries is second only to congenital disease in developed countries”.<sup>1</sup> On the other hand, Adesunkanmi *et al* in 1998 reported a study from Nigeria (for the period 1992-1995), stating that most deaths in infants were due to infectious disease

processes, but with trauma deaths (especially due to road traffic accidents as the external cause/circumstance of death) being the second most common cause of death.<sup>2</sup> This difference between developed and developing countries has however been changing, with the WHO World Report On Child Injury Prevention (2004 data) indicating that also in developing countries, an increasing number of children are now dying from injury and that head injuries are the single most common type of fatal injury sustained by children.<sup>3</sup> Danseco *et al* reported (from Maryland, USA) that injury rates increase with age and recorded higher non-fatal injuries amongst the 5-9 year old children, yet the rate for fatal injuries was higher amongst children aged from 0-4 years.<sup>4</sup>

John *et al* reviewed fatal pediatric head injuries over a 20 year period in Auckland<sup>5</sup>. This study included all children up to 15 years of age who were admitted to the Coronial Service from 1991-2010. One-hundred-and-sixty-seven cases were identified and divided into accidental and non-accidental causes of head injury. In the 126 cases of accidental head injury, the majority were due to motor vehicle accidents (including pedestrian accidents) (71%), with 9% due to falls and 4% due to blunt force trauma.<sup>5</sup> Tabish *et al* reported that in India (2003) the most common cause of head injury was due to falls (68.2%), followed by transportation accidents (28%), assault (2%) and injuries due to flying objects (2%).<sup>6</sup> Head injury as a result of falls was stated to be the third leading cause of death in children aged 1-4 years, according to a study from Chicago (Hall *et al*, 1989).<sup>7</sup>

There appears to be minimal recent published literature on the fatal head injuries in the pediatric population. More current publications report on general trauma in children. Bratu *et al* (from Canada) reported specifically on pediatric trauma in the Aboriginal children.<sup>8</sup> In the latter study which was conducted from 1996 – 2010 (in all fatal traumatic deaths in children under 18 years of age), that the Aboriginal children were over represented (30.9% of fatalities) with the most fatalities due to road traffic accidents.<sup>8</sup> Head and cervical spine injuries were present in 69% of children. (REF).<sup>8</sup> Pearson *et al* from Scotland reviewed fatal injuries in children under 14 years of age for 2002-2006.<sup>9</sup> Their findings included that pedestrian and road traffic fatalities in the 0-4 year old age group accounted for 11% and 9% of injuries respectively.<sup>9</sup>

The possibility of non-accidental causes (i.e. inflicted injury) of head injury should always be considered as this has been shown to be an important cause of death<sup>10</sup>. John *et al*<sup>5</sup> reported that there were 37 cases of inflicted injury amongst the total of 167 fatal cases reviewed in New Zealand. In the latter study, children who sustained inflicted injury were younger than the children sustained accidental head injuries.<sup>5</sup> There is ongoing debate as to the validity and

premises used for differentiating between inflicted (non-accidental) injury and accidental head injuries. Goldstein *et al* (1993) stated that inflicted head injury should be considered when 1 of 3 parameters are present: inconsistency between the history and the clinical examination, retinal hemorrhages or parental risk factors.<sup>11</sup> More recently, Minns *et al* (Scotland, 2012) conducted a prospective study on children with retinal hemorrhages and concluded that “a young age and a high dot-blot count are strong predictors of inflicted traumatic brain injury”.<sup>12</sup> Controversy continues to surround the pathogenesis and nature of injuries associated with the “shaken baby syndrome”.<sup>13</sup> Scheimberg *et al* (2014) suggest that a more appropriate term would be the one initially described by Guthkelch, being that of “retino-dural hemorrhage of infancy” and that more research is needed in order to fully understand the anatomy and physiology of the dura in infancy.<sup>14</sup>

There appears to have been only one published report on severe head injury in children in South Africa, provided by Semple *et al* in 1998.<sup>15</sup> This study included 102 children younger than 14 years of age who had been admitted to the Red Cross Memorial Childrens Hospital (Cape Town) and who presented with a Glasgow Coma Scale (GCS) of less than 8. There were 57 male and 45 female patients and the majority of the head injuries were the result of transportation related accidents (83% of victims were pedestrians). Falls accounted for 11% of cases. The author then emphasized that head injury in children in South Africa can be described as “a silent or forgotten epidemic”.<sup>15</sup>

According to the official South African governmental statistics agency, the leading cause of death in infants (in the post-neonatal group) and in children aged 1-4 years in 2011, was due to intestinal infection (14.1 and 17.6% respectively).<sup>16</sup> Non-natural causes accounted for 2.7% of deaths in infants and 12% of deaths in children between 1 and 4 years of age.<sup>16</sup> In another publication from Statistics South Africa which reviewed road traffic accident deaths for the period 2002 – 2006, the age specific accident rate in the children aged 0 – 14 years was stated as 3.89 per 100 000.<sup>17</sup> It may be postulated that there is greater accuracy of statistics pertaining to cases of non-natural death, as these deaths are routinely subjected to (medico-legal) autopsy, whereas statistics regarding natural causes of death may be less reliable, as these depend almost exclusively on clinical diagnoses supplied on death notification forms.

A comprehensive search on Pubmed yielded no published articles reporting specifically on fatal head injuries in children in South Africa. The current study was undertaken in an attempt to establish a profile of fatal head injuries in children younger than 5 years of age,

who were admitted to a large urban medico-legal mortuary, situated in Pretoria (the capital city of South Africa), over a 5 year period.

## **Methods**

This study comprised a 5 year retrospective descriptive review (January 2004 through December 2008) of all children under the age of 5 years who were admitted to the Pretoria Medico-Legal Laboratory (PMLL) and in whom the attending forensic pathologist/forensic medical officer ultimately formulated the cause of death as having been due to head injury. All cases where multiple injuries had been sustained and where a head injury was part of the injuries sustained, but not specified in the cause of death, were excluded from the study.

The following data were recorded from the case files, registers and data forms (including the National Non-Natural Injury Surveillance System<sup>18</sup> forms):

- Demographic details (including race, gender and age)
- External cause/circumstances of injury (i.e. fall, road traffic accident, blunt force application, gunshot wound, etc.)
- Whether or not the deceased had been hospitalized (including the duration of hospitalization, where applicable)
- Whether or not any surgical procedure was conducted
- The pathological findings pertaining to the scalp, skull and intracranial structures.

Statistical evaluation of data was done using the SPSS<sup>®</sup> (version 17.0) program, in conjunction with the Department of Biostatistics at the Medical Research Council.

Prior approval to conduct the study was obtained from the Research and Ethics Committee of the Faculty of Health Sciences at the University of Pretoria.

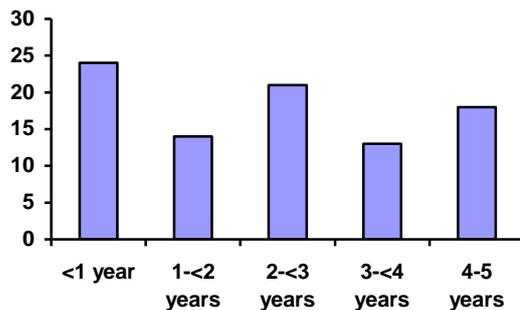
## **Results**

A total of 107 cases were identified for inclusion in this study. The number of cases per year varied from 15 to 28. Over the study period, the annual total number of children under the age of 5 years who were admitted to the PMLL varied from 93 to 150 cases (with an average of 125 cases per year). The overall total annual case load (all admissions) at the mortuary varied from 2253 to 2461 (with a cumulative total case load of 11 768). Deaths due to head injuries in children under the age of 5 years accounted for approximately 16% of children

under the age of 5 years who were admitted to the mortuary and comprized an average of approximately 1% of the total annual mortuary admission case load.

*Demographic details*

There were 60 males (56%) and 47 females (44%). The highest number of fatal head injuries were seen in children under 1 year of age (24 cases), with 50% of these children being aged between 2 and 4 months (see figure 1).



**Figure 1: Ages of children with fatal head injuries admitted to PMLL (2004-2008)**

*External cause/circumstance of death*

The external cause/circumstances of death are depicted in table I. The majority of deaths were due to road traffic accidents, being 75 cases (70%). Of these, pedestrian victims accounted for 35 cases (47%) and passenger occupants for 30 cases (40%), whilst in 10 cases (13%) the type of road traffic accident was unknown. Forty-one of these fatally injured children were less than 3 years of age (and with half [21] of this subset being vehicle occupants).

**Table I: External cause/circumstances of death**

Road traffic accidents	75 (70%)
Falls	11 (10%)
Blunt force trauma	10 (9%)
Gunshot wounds	4 (4%)
Birth related head injury	4 (4%)
Unspecified circumstance of death	3 (3%)

Head injuries due to falls ranked second, with 11 fatal outcome cases (10%). These included 6 falls (55%) from a height, 4 from a bed (36%) and 1 (9%) from a tree. Ten cases (9%) were the result of blunt force injury (including 4 cases of gates falling on children; 1 case where a wall collapsed on a child; one where a motor vehicle wreck fell on the victim; 1 victim suffering a kick by a horse and 1 assault). Gunshot wounds accounted for 4 cases (4%) of

head injury. Three of the gunshot fatalities were victims of family murders (in two separate incidents). There were 4 neonates who sustained fatal birth related head injuries. Of interest is that only 1 case was admitted to our facility as a possible victim of suspected physical abuse. In this case, the medico-legal autopsy confirmed the presence also of other injuries (of differing ages), in keeping with the diagnosis of non-accidental injury syndrome.

*Cause of death in infants under 1 year of age:*

The causes of death in the 24 infants who were under 1 year of age were as follows:

- Road traffic accidents – 13 cases (1 pedestrian, 8 occupants and 4 unspecified cases);
- Falls – 3 infants who allegedly fell from a bed;
- Birth related head trauma – 4 cases;
- Blunt force trauma – 2 cases (1 motorized gate which fell on the infant and 1 case where the father allegedly assaulted the infant);
- Unspecified – 2 cases.

*Fatal head injury due to falls*

These cases were included on the basis of initial history received at the mortuary, but with no detailed or further evaluation of the history or scenes. Table II displays the age of the infants and the height from where the fall occurred.

**Table II: Age of infants and height of fall**

No. of cases	Age	Height from which the child allegedly fell
1	<1 week	Bed
1	2 months	Bed
1	4 months	Bed
1	1-<2 years	Height
1	2-<3 years	Height
6	4-5 years	Bed - 1 case
		Tree – 1 case
		Height – 4 cases

*Neuropathological autopsy findings*

The most frequent anatomic injury which was recorded in the autopsy reports was that of skull fracture (seen in 80% of sample cases), followed by scalp injury (78%). In most cases there was concurrent involvement of both the vault and base of skull vault (45 cases [42%] - refer table III). The nature of recorded intracranial injuries is depicted in figure 2. Epidural

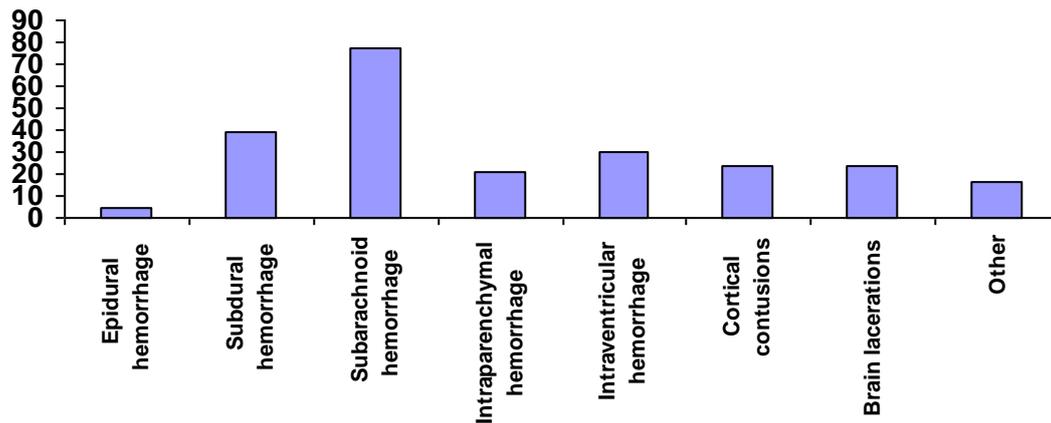


Figure 2: Intracranial injuries seen at autopsy

Table III: Case of death in comparison with type of skull fracture sustained

External cause of death	Vault fractures		Base of skull fractures		Vault <i>and</i> base of skull fractures	
	Number	Details	Number	Details	Number	Details
Road traffic accidents	13	3 pedestrians 7 passengers 3 unspecified	15	8 pedestrians 6 passengers 1 unspecified	34	16 pedestrians 14 passengers 4 unspecified
Falls	4	2 from bed 1 from height 1 from tree			3	3 from height
Birth related head injuries	2				1	
Gunshot wounds	2		1		1	
Blunt force injuries	2	1 motorized gate 1 assault	1	motor car wreck fell on child	5	3 motorized gate 1 wall fell on child 1 kicked by horse
Unspecified injuries	2				1	
Total	24		17		45	

hemorrhage was recorded in 5 cases (4.6% - refer table IV), subdural hemorrhages in 39 cases (36% - refer table V). Subarachnoid hemorrhage was seen in 77 cases (72%). The entire brain was retained in 5 cases (5%) for fixation and neuropathological evaluation, with histological examination being performed in 8 cases (7%).

**Table IV: Age and cause of death in association with epidural hemorrhages**

Age	Cause of death			Total
	Birth trauma	Fall from height	Unspecified blunt force	
1 day	1			1
1-<2 year		1	1	2
4-5 years		1	1	2
Total	1	2	2	5

**Table V: Age and cause of death in association with subdural hemorrhages**

Cause of death	Road traffic accidents			Fell			Blunt force		GSW	Unspecif	Total
	Pedestr	Passenger	Unspecif	Bed	Height	Oth	Gat	Unspecif			
Age	ian		ied			er	e	d		ied	
<1yr	1	6	4	1	1		1			2	17
1-<2yr	2	1						1	1		5
2-<3yr	2	1	1								4
3-<4yr	4			1	1	1					7
4-5 yr	3	2							1		4
Total	12	10	5	2	2	1	1	1	2	2	39

### *Hospitalization*

Most victims died at the scene of injury (51 cases; 48%). Nine cases (8%) were declared dead upon arrival at the emergency room and a further 18 patients (17%) demised in the emergency room. Twenty nine patients (27%) had hospital admission, with the duration of hospitalization ranging from 3 hours to 14 days. In 15 of the latter cases surgical (cranial) procedures were carried out (trepanation in 8 cases, craniotomies in 6 cases and fixation of the skull in 1 case).

### *Mechanism/mode of death*

The forensic medical practitioner specifically recorded the mechanism (mode) of death in 12 of the 29 victims who had undergone hospitalization. In a further 10 cases in this group, the mechanism/mode of death could be deduced from the post mortem report. Features of raised intracranial pressure were recorded in 17 cases (59%), bronchopneumonia was diagnosed in 4 cases (14%) and aspiration of blood and meningitis were considered to be the mechanism of death in 2 cases (7%) each. In the majority of cases where a specific mechanism of death was not recorded, the child had died at the scene of injury.

### *Manner of death*

In South Africa the manner of death is a legal function and is ultimately recorded by the presiding judicial officer at legal proceedings (inquest magistrate, judge, etc.). However, forensic pathologists are routinely asked to comment on the *apparent* manner of death, at the time of conducting the autopsy (for statistical purposes only). The majority of the cases were thus classified by the attending forensic medical practitioner as being accidents (98 cases; 91%). Six cases were recorded as homicides and included 1 case of assault, 4 firearm fatalities and 1 case of non-accidental injury syndrome (see table VI).

**Table VI: Manner of death**

Accidental	98 (91%)
Homicide	6 (6%)
Undetermined	3 (3%)

### Discussion

The World Health Organization (WHO) report on child injury prevention states that head injuries are “the single most common – and potentially most severe – type of injury sustained by children”.<sup>3</sup> The latter report indicates that intracranial injury (specifically traumatic brain injury) constitutes 16.3% of unintentional injuries sustained by children up to 15 years of age.<sup>3</sup> In our study, fatal head injuries in children under 5 years of age occurred mostly in infants (children less than 1 year of age). This correlates with the previous study done by Semple *et al.*<sup>15</sup> In the study reported by John *et al* in Auckland, the majority of inflicted head injuries were sustained in children under 2 years of age.<sup>5</sup>

Fatal head injuries in children under 5 at the PMLL accounted for nearly 1% of the total (admission) case load and comprised 16% of all admissions of children in the under 5 years age group. There was no discernible gender distinction amongst victims in the present study. In a study by Wang *et al*<sup>19</sup> it was reported that boys might be more active and may have a higher frequency of participation in different types of activities and that they may be more curious than girls, thus rendering them more susceptible to (head) injuries.

Road traffic accidents were by far the most common external cause/circumstance of death, accounting for 75 cases (70%) of fatal head injury. This correlates with the previous study done by Semple in Cape Town.<sup>15</sup> John *et al* (Auckland) also reported the majority of accidental head injuries in children to be the result of road traffic accidents.<sup>5</sup> The WHO report on “Children and road traffic injury” states that in 2004 children accounted for 21% of

all road traffic fatalities, most of these occurring in low and middle-income countries.<sup>20</sup> The latter report stated that as pedestrians in high income countries children accounted for 5-10% of all road traffic deaths and in low income countries 30-40%.<sup>20</sup> In our study more than 50% of children sustaining fatal head injury as a result of a road traffic accident were under 3 years of age, with the 50% of them being passengers in vehicles. Legislation in South Africa pertaining to the mandatory use of vehicle restraint mechanisms in children is provided by the National Road Traffic Act 93 of 1996 (in terms of the National Road Traffic Regulations, 2000), where Section 213(1)(b) defines a child as being a person aged from 3-14 years. Surprisingly, no provision is made in this legislation for the mandatory use of restraint mechanisms in children under the age of 3 years. Section 213(6) and (7) stipulate that children in motor vehicles should be in a proper child restraint, if the latter is available, otherwise the child should be on the back seat and the normal seat belt should be used as restraint. It would appear that the findings of this study (showing a high incidence of fatal head injuries in children under the age of 3 who were involved in road traffic accidents), warrant urgent review of the legislation. Many international studies (including Lennon *et al* in Australia<sup>21</sup> and Braver *et al*<sup>22</sup> in the USA) have indicated that the proper use of restraints as well as the seating position of children in motor vehicles can dramatically reduce the mortality rate in these instances. Stricter rules and more stringent application of existing measures are thus called for in South Africa.

Falls accounted for 11 cases (10%), being the second leading external cause resulting in fatal head injury cases admitted to the PMLL. Hall *et al* (Chicago) reported that falls were the third leading cause of traumatic deaths in children aged 1- 4 years.<sup>7</sup> The mean age of children who died from accidental falls in the latter study was 2.3 years and 41% of these falls were considered to have been “minor” falls, with delays in seeking medical attention being present in 38% of cases.<sup>7</sup> John *et al* reported from Auckland that falls accounted for 9% of accidental fatal pediatric head injuries and 38% of inflicted pediatric head injuries in their study.<sup>5</sup> All the falls in our study were deemed to have been accidental in nature, but we were not in a position to further corroborate this and information regarding height of fall, nature of surface of impact, and versions provided by informants or investigators cannot be validated. Deaths resulting from short falls in children remain a problematic area for forensic pathologists and the differentiation between accidental and homicidal injury can be very difficult to ascertain. Fujiwara *et al* (Japan) reviewed the validity of reports provided by caregivers after children sustained short falls.<sup>23</sup> They concluded that children sustaining short falls may indeed present with severe head trauma and that the “validity of caretakers” report on infant or young child’s head trauma due to falls is low”.<sup>23</sup> Ibrahim *et al* (Philadelphia, 2012) reviewed children under the age of 4 years who had sustained accidental head injury in a fall and found that there were

age related differences in the nature of injuries sustained.<sup>24</sup> This study found skull fractures to be more common in infants (79% of cases) than in children aged 1-4 years (39%). They also indicated that in falls from a low height ( $\leq 3$  feet) resulted in primary intracranial injury without scalp or skull injury in 6% of infants and 16% of toddlers.<sup>24</sup>

We identified six cases of homicide for inclusion in our study sample: four of these fatalities were due to gunshot wounds, with 3 of these coming from 2 homicide-suicide events. Byard *et al* have reported on children involved in murder-suicide cases, stating that when the father was the perpetrator, they tended to kill the children and the adult in the relationship.<sup>25</sup> One of our homicide cases was the result of inflicted blunt force trauma, with a father striking the victim with a bottle. In 1 case, the circumstance/cause of injury was established as being related to non-accidental injury syndrome.

South Africa does not have a national register for recording of injuries to pediatric patients, in order to provide surveillance of individual cases or broader injury patterns.<sup>26</sup> A fatal outcome constitutes only a small portion of children who suffer head injuries. The WHO report on child injury prevention indicates that the severity of the problem of head injuries in children may be measured in terms of mortality, hospital admissions, emergency department visits as well as days lost from school.<sup>3</sup> Data from the Global Childhood Unintentional Injury Surveillance report indicates that nearly 50% of children under 12 years of age who sustained an unintentional head injury was left with a degree of disability.<sup>3</sup> The only specific legislation in South Africa which currently applies to the monitoring of injuries in children, is found within the Childrens' Act (Act no. 35 of 2005), which stipulates that child abuse (or suspicion thereof) must be notified to the authorities. There is no legal obligation to record or report other injuries which a child may have sustained, for purposes of implementing individual or collective preventative measures or strategies.

### Conclusion

There is a paucity of published research regarding childhood injuries in South Africa, particularly also in respect of the profile and nature of serious head injuries. This study suggests that fatal head injury in children under the age of 5 years constitutes nearly a 5<sup>th</sup> of children in this age group admitted to medico-legal mortuaries in an urban environment in South Africa. Children under the age of one year were seemingly at greatest risk. Road traffic accidents account for the vast majority of these deaths, with falls being the second most prevalent circumstance of injury. Half of road traffic fatality cases were pedestrians. Review of existing legislation regarding measures to protect young children from injury in road traffic accidents appears to be indicated. The implementation of mandatory child injury

registers may help to extend injury surveillance into clinical domains. Establishing regional or national multidisciplinary child death review programs may also contribute to our understanding of the scope and nature of this problem and may allow for the implementation of interventional programs and measures to minimize the risk of injury to these most vulnerable members of society.

#### Acknowledgements:

The authors would like to thank ms Lieketseng from the Medical Research Council who aided in the initial statistical analysis of the data. Thanks also to ms T Phasha for the preparation of the research protocol.

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