

Infant injuries treated at Red Cross War Memorial Children's Hospital, Cape Town, South Africa

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Background. Infants are entirely dependent on their caregivers, especially <6 months old when they are not yet mobile. While the epidemiology of injury among children in general has been described, the exact causes of infant injury have never been investigated in South Africa (SA).

Objective. To describe causes of injury in infants aged <12 months, stratified for the four quarters of the first year of life, in order to identify opportunities for targeted prevention strategies based on local data.

Methods. This retrospective audit study used data collected by ChildSafe SA from the Red Cross War Memorial Children's Hospital in Cape Town, SA, over a 4-year period from January 2013 to December 2016. Infants <1 year of age presenting to the hospital's trauma casualty department were included. Additionally, mortuary data on traumatic infant deaths in the hospital's catchment area were collected.

Results. A total of 2 279 injured infants were identified. More than half were male (55%; $n=1\ 250$) and the median age was 8 months (interquartile range 5 - 10 months). Leading causes of injury were falls (42%; $n=957$) and burns (32%; $n=736$). A significant association between the age group and the cause of injury ($p<0.001$) was found. From 2014 to 2016, an additional 27 infants were traumatically injured and died before arriving at the hospital.

Conclusion. Falls and burns are a significant contributor to the burden of infant injuries in Cape Town. This underlines the urgent need for targeted prevention strategies to improve safety, taking poverty into account.

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Trauma injury has a great impact on people's health, but children up to the age of 1 year are especially vulnerable^[1,2] owing to their immature anatomy, skeletal composition, cardiovascular performance and drug metabolism. Falls – from a bed, couch, baby equipment or the arms of a caregiver – are the leading cause of injury in children <1 year old.^[3,4] Burns are a second major cause of injury in infants. In Africa, the annual incidence of fire-related burns in children <1 year old is 35 per 100 000. This is more than three times the world average for this age group. Other known causes of injury in infants are interpersonal violence/assault, traffic crashes, poisonings and choking.^[5-7] Most injuries occur at home, often as a consequence of household hazards such as loose hanging kettle cables and beds without safety bars, lack of supervision, as well as the increased mobility of older infants.^[4,7,8]

Infants <6 months old are largely pre-mobile and dependent on their caregivers. When aged 6 - 12 months, they develop the ability to crawl, roll and eventually walk, and are then at greater risk for injury. Even though injuries in children <1 year old account for only 2% of all injuries in children in low- and middle-income countries (LMICs), unintentional injury death rates in this age category are highest when compared with the older age groups.^[2,3] The infant death rate from burns is highest in LMICs: 11 per 100 000 population.^[3] Standard age groupings for paediatric injury research have been developed.^[3,9] In most studies, however, children <12 months of age are taken as one group. Unfortunately, this practice may mask age-related injury trends in infants.

While the epidemiology of injury among children in general has been described, causes of infant injury have never been validly investigated in South Africa (SA). Insight into the leading causes

of injury specified for different stages of the first year of life can help to develop interventions to prevent injury.^[6,10] This study aims to describe causes of injury in children <12 months admitted to the trauma casualty department of the Red Cross War Memorial Children's Hospital (RCWMCH) in Cape Town, SA, stratified for different age groups.

Methods

Study design

This is a retrospective, descriptive audit study.

Patients and setting

ChildSafe SA is an independent non-governmental organisation, established in 1978 (www.childsafe.org.za). Since 1991, ChildSafe SA has systematically kept a computerised childhood trauma surveillance system of all injured children presenting to the RCWMCH trauma unit, which serves as a national information system for childhood injuries in SA. Funding is provided by numerous donors.

We analysed available data of children <1 year old (365 days) seen between January 2013 and December 2016. Ethical approval was obtained from the Human Research Ethics Committee, University of Cape Town Faculty of Health Sciences (ref. no. 239/2018). No recruitment or informed consent was necessary as this is a retrospective study.

Data collection

ChildSafe has developed a data collection form that consists of six major domains: (i) patient demographics; (ii) cause of injury; (iii) place of occurrence; (iv) severity of injury; (v) suspicion of abuse;

and (vi) discharge destination. This ChildSafe form is completed by the attending physician for every child presenting at the trauma casualty department of the RCWMCH. The causes of injury are classified as assault, birth injury, bites, burns, caught [between objects], falls, foreign bodies, pulled up/lifted, struck, transport, miscellaneous or unknown. We translated the different causes of injury into ICD-10-CM codes for external causes of morbidity and mortality according to the International Classification of Disease. The ICD-10-CM codes classified under the main causes of injury are shown in Table 1. The place of occurrence contains the following options: own home; road/pavement; other home; public place; school/creche; sport; other; and unknown.

The severity of injury is classified with the use of the RCWMCH's four-point abbreviated injury score (AIS) as 'mild', 'moderate', 'severe' or 'mortal'.^[11] Suspicion of abuse is represented by the abuse code on the ChildSafe form, and is classified as 'no abuse', 'possible abuse' or 'abuse'.

All variables were checked for missing or incorrect values in the database. If missing or incorrect values were identified, additional information was obtained from the medical records and processed in the database by the principal investigator (KKS). For the analysis we created four age groups (0 - 2 months old, 3 - 5 months old, 6 - 8 months old and 9 - 11 months old), corresponding with the different levels of child development and mobility.

Mortuary data on traumatic infant deaths (<1 year old) in the hospital's catchment area for the study period were collected from the University of Cape Town Division of Forensic Medicine and Toxicology. This way we additionally included fatal injuries in which the infant did not make it to the hospital. Collected data included cause of injury and manner of death (intentional v. non-intentional) in infants who had died before arrival at the hospital.

Outcomes

The primary outcome is cause of injury. Secondary outcomes are place of occurrence, severity of the injury and the nature of fall injuries and burn injuries.

Data analysis

Normally distributed variables are presented as mean (standard deviation), and non-normally distributed variables as median (interquartile range (IQR)). Descriptive statistics (frequencies and cross-tabulations) were used to characterise injuries by cause for each age group. Age-related injury patterns were compared with published norms for child growth and development. Differences in categorical variables between age groups were tested with χ^2 or Fisher's exact tests, as appropriate. If exact test was not computable, we applied Monte Carlo. A p -value <0.05 was considered statistically significant. All data management was conducted in Excel (Microsoft Corp., USA) and statistical analyses were performed in SPSS for Windows, version 24.0 (IBM SPSS Statistics, USA).

Results

According to the trauma surveillance registry, 2 279 infants <1 year old presented at the RCWMCH's trauma casualty department between January 2013 and December 2016. Table 2 gives the background characteristics of this patient group. More than half were male (55%; $n=1\ 250$) and the median age was 8 months (IQR 5 - 10).

Most injuries were classified as moderate (51%; $n=1\ 170$) or minor (47%; $n=1\ 084$). Burn injuries in particular were frequently classified as moderate (83%; $n=614$). One infant had died at the

trauma casualty department and therefore scored 'mortal' on the AIS. This was a 9-month-old female with a gunshot wound in her head.

Causes of injury

Table 3 provides details of the occurrences of the various causes of injury for the total group and the different age groups. Falls were the most frequent cause of injury, comprising 42% ($n=957$) of all injuries. This holds true for the three youngest age categories as well. The proportions of falls in the three youngest age groups were comparable, but in the oldest age group this proportion was lower than that in the three youngest age groups. In the oldest age group, burns were the most common injury (44%). Of all injuries, 70% had occurred in the two oldest age groups ($n=1\ 604$). A significant association between the age group and the cause of injury ($p<0.001$) was found, in that assault was more frequent in younger infants. Older infants were more likely to be injured from burns and foreign bodies or caustic ingestion. In the two youngest age groups, the cause of injury was more likely to be unknown than in the two oldest age groups.

Falls

Falls from bed accounted for almost half of the fall injuries (49%; $n=471$). Other common types of fall were falls from attendants' arms (16%; $n=154$), falls from toy devices or playground equipment (8%; $n=76$), falls from stairs (6%; $n=56$) and falls from furniture (4%; $n=38$). The remaining 17% were defined as 'other falls' ($n=162$), consisting of falls while trying to walk or stand, falls out of car seats and unknown mechanisms of falls. Fig. 1 shows the distribution of age groups among the different types of falls. There was a significant association between the type of falls and the age groups ($p<0.001$), in that infants <6 months were more often dropped out of the attendant's arms, and older infants endured a greater number of other fall types. Of all falls, 22% led to a fracture ($n=210$), and 86% of the falls occurred inside the infant's own home ($n=823$).

Burns

Burn injuries were the second-most common cause of injury in the total group (32%; $n=736$), and were more often seen in male than in female infants ($p=0.007$). Burn injuries occurred more frequently in the two older age groups ($p<0.001$): the proportion of burn injuries increased from 10% in the youngest age group to 44% in the oldest age group. Hot water burns contributed to over 80% of all burns (84%; $n=615$). The distribution of age groups among the different types of burns is seen in Fig. 2. Burns were in most cases (95%) sustained at home.

Other injuries

Eighty-four infants were injured due to being struck (4%) (Table 3). Of these 84 cases, 43 (51%) resulted in tissue damage such as abrasions, lacerations and closed tissue injuries.

Of the 73 assaulted infants, 60 (82%) were physically assaulted; 10 (14%) sexually assaulted and 3 (4%) abandoned or neglected. There was a significant association between assault and age group ($p<0.001$), in that assault was mostly seen in the two youngest age groups. In addition, females were more frequently victims of sexual assault, whereas physical assault was seen more often in males ($p=0.019$).

Injuries due to foreign bodies or caustic ingestion occurred significantly more often in infants >6 months of age ($p<0.001$). In the foreign body cases, airway foreign bodies (59%; $n=43$)

Table 1. ICD-10-CM codes per cause of injury

Major category	Specific category	ICD-10-CM codes
Assault	Abandonment/neglect	T74.02, T74.32, T76.02, T76.32, Y06, Y07
	Physical assault	T74.12, T76.12, X91, X95, X97, X99, Y00, Y01, Y04, Y07
	Sexual assault	T74.22, T74.52, T76.22, T76.52, Y05, Y07
Birth injury	-	P10-P15
Bites	Dog bites	W54.0
	Rat bites	W53.11
	Other bites	W55.81, W57
Burns	Flame burns	X00-X09
	Fluid burns	X10, X12, X19
	Hot water burns	X11, X12
	Heat contact	X15, X16
	Other burns	W85, W86, X00.1, X01.1, X02.1, X03.1
Caught between objects	-	W23
Falls	Attendant's arms	W04
	Bed	W06
	Furniture	W07, W08
	Playground equipment	W09
	Stairs or steps	W10.0, W10.1, W10.2, W10.8, W10.9
	Other falls	W17-W19
Foreign body	Airway	T17, T18, W79, W80
	Ingestion	X49, Y19
	Non-airway	W45
Pulled up/lifted	-	Y93.F2
Struck	-	W20-W22
Transport	MVA	V40-V49, V70-V79
	Pedestrian	V01-V06, V09
	Other	V80
Miscellaneous		T59.3, X00.1, X01.1, X02.1, X03.1, X50, Y28, Y29, Y33, Y93.F1, Y93.F9
Unknown	-	Y34

ICD = International Classification of Diseases; MVA = motor vehicle accident.

were more common than non-airway foreign bodies (22%; $n=16$). Ingestion occurred in 13 cases (19%).

The most common transport-related injuries were motor vehicle crashes (72%; $n=46$). Seventeen infants were injured as pedestrians (27%).

In 23 cases (70%) of all infants who were injured by being pulled up or lifted, this resulted in an elbow injury. Dislocations were mostly caused by lifting up an infant (42%; $n=14$).

Being caught between two things was the cause of injury in 31 infants (1%).

Birth was the cause of injury in 30 cases, accounting for 1% of all injuries.

The 32 bites were classified as rat bites ($n=10$; 44%), dog bites ($n=7$; 30%), human bites ($n=2$; 9%) and other bites ($n=4$; 17%).

Cases were grouped under miscellaneous if the injury was caused by a sharp or a blunt object, massage, washing, crawling, pepper spray or smoke inhalation.

Mortuary data

Mortuary data on infants in 2013 were missing. Over the years 2014 - 2016, a total of 27 infants <1 year of age died before arrival in the hospital. Of the deceased infants, 14 (52%) were <6 months and 13 (48%) were >6 months of age. The related causes of injury in these infants were assault (30%; $n=8$), drowning (26%; $n=7$), burns (26%; $n=7$), road traffic accidents (7%; $n=2$), choking (7%; $n=2$) and falls

(4%; $n=1$). Eighteen died unintentionally and 9 were murdered. The methods of murder were assault in 8 cases and drowning in 1 infant.

Discussion

The aim of this study was to describe the characteristics of injuries in children <1 year old in Cape Town, SA. We found that most injured infants were >6 months of age. The following may serve as an explanation: with increasing age, the child's mobility gradually advances from being only able to roll over at 4 months, but sit up at 6 months, pull up to a standing position at 9 months and eventually start walking at the age of 12 months.^[12]

Previous research into paediatric injuries found that two-thirds of injuries were of minor severity in children aged <13 years.^[10] Strikingly, the severity of more than half of the injuries in the present study was classified as moderate. This suggests that infants <1 year of age are more likely to be injured more seriously after experiencing a trauma than children of other ages.

Falls

Between 2013 and 2016, falls were the most frequent cause of injuries in infants presenting to the RCWMCH, and were the leading cause of injury in infants aged ≤ 9 months. Other research likewise cites falls as the most common cause of paediatric injury.^[2,7,13] Owing to infants' rapid growth and developmental changes, the frequency and mechanism of falls change with increasing age. A higher proportion

of children >6 months of age presented to the trauma unit as a result of falls. In previous research, younger children were found to be more likely to be dropped from a caregiver's arms or to fall from furniture.^[12] Our findings support this, and suggest that infants <6 months of

age are at particular risk of being dropped. Parents should therefore be educated about the fast development of mobility in infants, to create more awareness of the hazards in the infant's first year of life.

It is striking that even though infants <3 months old are usually not able to roll over, almost half of the infants aged 0 - 2 months who had experienced a fall were reported to have fallen out of bed. This raises some serious concerns about the veracity of the history provided, and should be considered a marker for child abuse until proven otherwise. It will help to educate providers that (i) inconsistent and developmentally implausible history and (ii) injury pattern requiring mobility in a non-mobile child are highly suspicious for child abuse.

In concordance with our study, other research has also indicated that the majority of non-fatal fall injuries occur in the home environment.^[10] The significant burden of fall injuries highlights the urgent need for targeted interventions to improve the safety of infants, especially within the home. Mechanisms of falls are highly dependent on context, but in SA there is currently a lack of evidence-based research on risk factors and effective interventions to prevent falls in this specific age group. In the search for effective prevention strategies, poverty should be taken into account, since social class and childhood falls have shown a strong relationship.^[3] Not only are not all interventions applicable in poor-quality housing, but also, in poor families, children are more often left unsupervised.^[3]

Burns

The second leading cause of injury in the present study was burns. We found a predominance of burn injuries in males compared with females. Previous research conducted in SA showed the same predominance,^[9] but in the global literature burns occur more often in females. Similarly to the global literature,^[3] our study found that most burns had been sustained in the home environment. Flame burns were more frequently seen in the youngest age groups, while hot water burns occurred more frequently in infants >6 months old. Overall, hot water burns accounted for most of the burn injuries in infants. The increased vulnerability for burns with older age can be explained by the fact that when a child is able to stand upright, (s)he can more easily reach for hot objects and loose hanging kettle cables.

Strengths and limitations

A strength of this study is the distinction made between different age groups. Where other research used standard age groupings for paediatric injury, and infants <1 year of age are taken as one group,

Table 2. Background characteristics of the study population (N=2 279)

Characteristic	Frequency	Percentage
Age		
0 - 2 months	317	14
3 - 5 months	358	16
6 - 8 months	690	30
9 - 11 months	914	40
Median (IQR) age, months	8 (5 - 10)	
Sex		
Male	1 250	55
Female	1 029	45
Severity of injury*		
Minor	1 084	47
Moderate	1 170	51
Severe	22	1
Mortal	1	<1
Suspicion of abuse†		
No	2 157	95
Possible	77	3
Yes	35	2
Place of occurrence		
Own home	1 993	87
Road/pavement	61	3
Other home	48	2
Public place	41	2
School/creche	39	2
Sport	3	<1
Other	18	1
Unknown	75	3

IQR = interquartile range; GP = general practitioner; ICU = intensive care unit.
 *For 2 patients the severity of injury was not completed on the data collection form.
 †For 10 patients the abuse classification was not completed on the data collection form.

Table 3. Distribution of causes of injuries by age

Injury cause	Total (N=2 279), n (%)	0 - 2 months (n=317), n (%)	3 - 5 months (n=358), n (%)	6 - 8 months (n=690), n (%)	9 - 11 months (n=914), n (%)
Falls	957 (42)	150 (47)	168 (46)	317 (45)	322 (35)
Burns	736 (32)	32 (10)	66 (18)	235 (34)	403 (44)
Struck	84 (4)	19 (6)	17 (5)	26 (4)	22 (2)
Assault	73 (3)	22 (7)	20 (6)	14 (2)	17 (2)
Foreign bodies	73 (3)	2 (1)	6 (2)	18 (3)	47 (5)
Transport	64 (3)	10 (3)	20 (6)	17 (3)	17 (2)
Pulled up/lifted	33 (2)	6 (2)	8 (2)	11 (2)	8 (1)
Caught	31 (1)	4 (1)	7 (2)	4 (1)	16 (2)
Birth injury	28 (1)	27 (9)	1 (<1)*	0 (0)	0 (0)
Bites	23 (1)	6 (2)	3 (1)	5 (1)	9 (1)
Miscellaneous	42 (2)	10 (3)	7 (2)	10 (1)	15 (2)
Unknown	135 (6)	29 (9)	35 (10)	33 (5)	38 (4)

Fisher's exact test = 347.179; p<0.001. The category 'miscellaneous' includes injuries caused by a sharp object, machinery and other injuries.
 *Birth injury in older infant was discovered later.

RESEARCH

we were able to relate injuries to the level of development. This way we reduced the risk of masking small injury trends. Another strength is the use of mortuary data on traumatic infant deaths, which has increased the accuracy of the results.

A possible limitation of this study is the severity of injury assessment. We have tried to standardise severity assessment through the use of the RCWMCH's AIS,^[11] yet the severity of injury might have been subjectively assessed in some cases owing to the time pressure

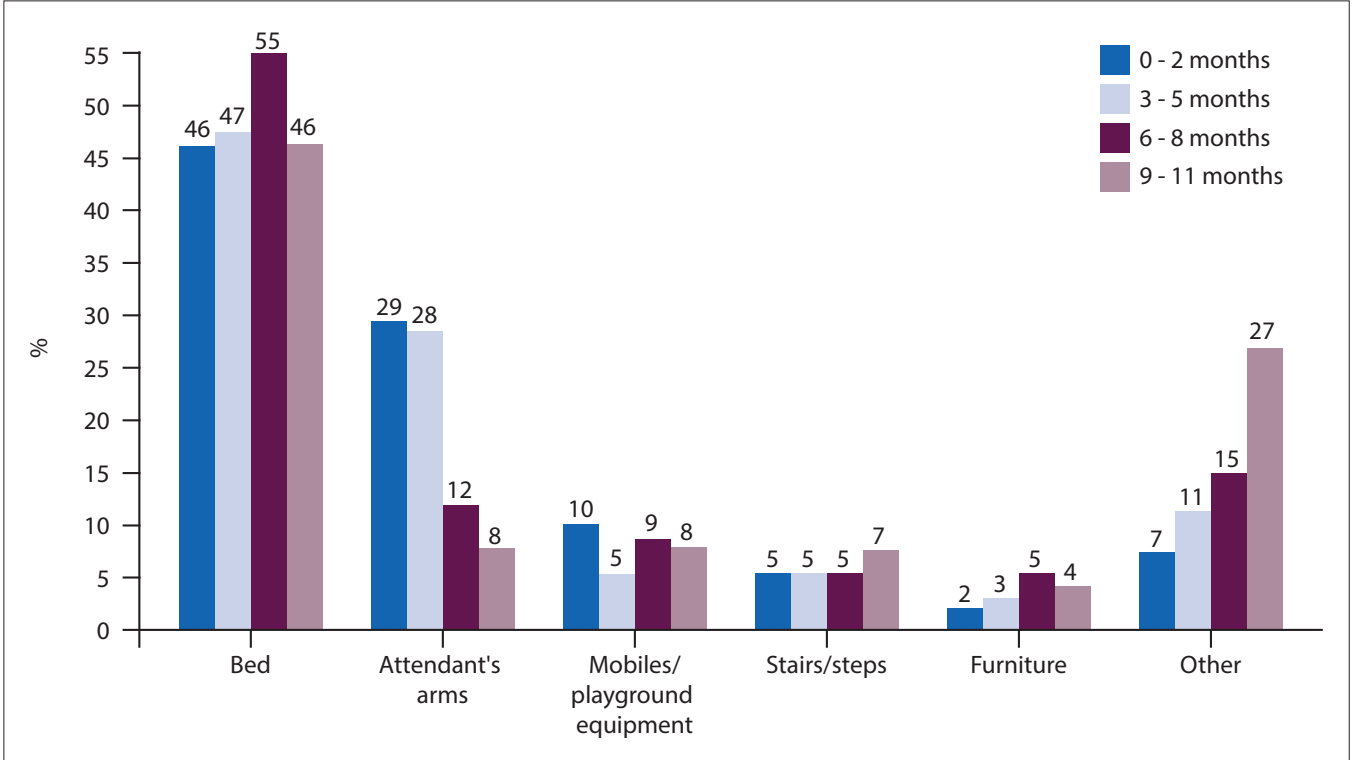


Fig. 1. Nature of fall injuries per age group in percentages (n=957).

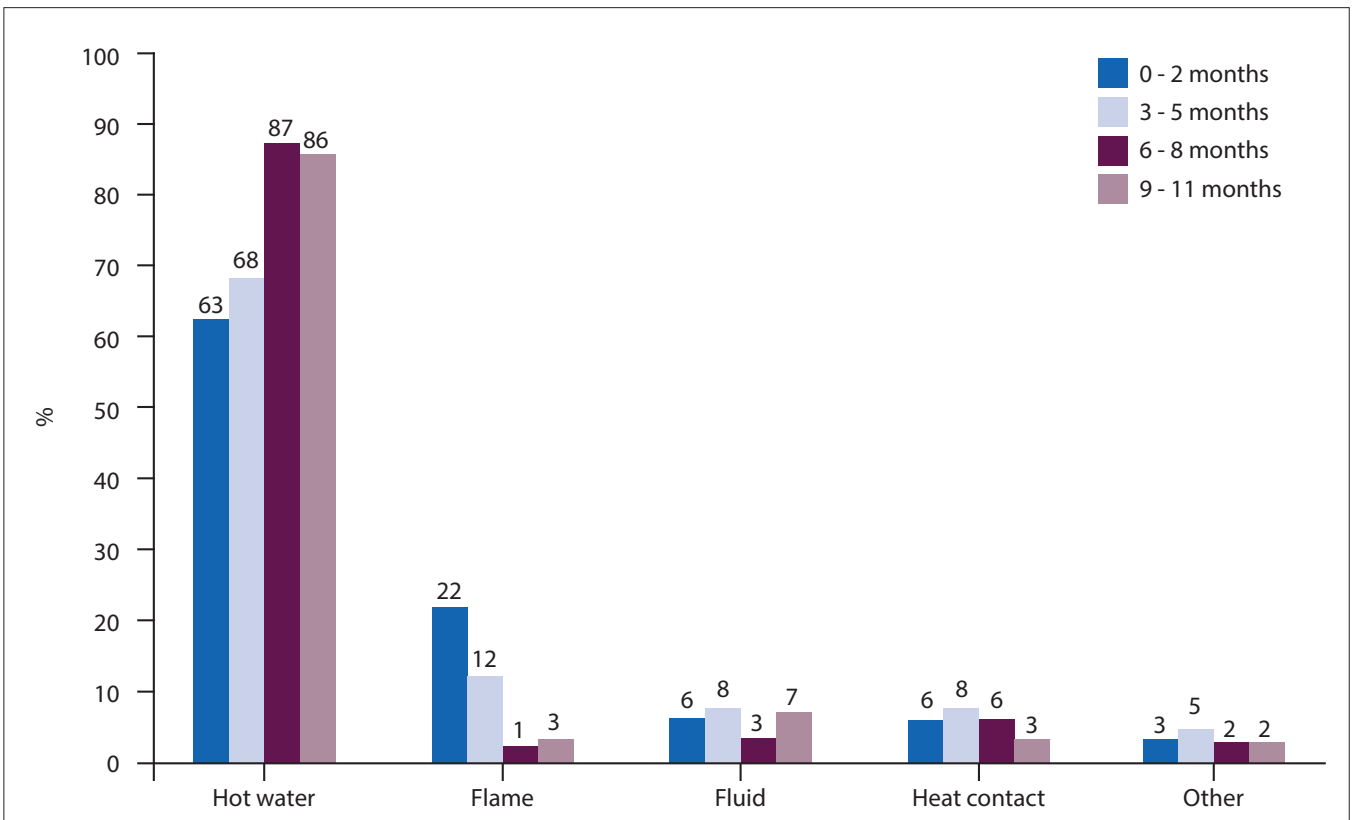


Fig. 2. Nature of burn injuries per age group in percentages (n=736).

associated with high emergency. Also, by using this RCWMCH's modified AIS, this study is limited in comparing the severity of injury with that in studies from other settings.

A further limitation is that RCWMCH's trauma registry does not follow admitted children through the course of their hospitalisation. All data collected pertained to the injured child's stay in the trauma casualty department. Outcome data, including mortality, morbidity and hospital length of stay, were therefore not available.

A final limitation of this study is the lack of information about abuse. The abuse code was collected from the ChildSafe form, which is routinely completed at the moment the child presents to the trauma unit of the RCWMCH. At that point in time, the provision of adequate healthcare is the priority, and signs and signals of abuse may be overlooked at that stage. Besides, the abuse code only indicates whether abuse was suspected at the moment of completing the ChildSafe form, not if abuse was actually confirmed. Therefore, the abuse code does not seem a reliable tool to investigate abuse in infants. Future in-depth research into determinants predicting abuse in infants is necessary.

Conclusion

The most likely causes of injury in infants <1 year of age seen in the trauma casualty department are falls or burns. The significant burden of these injuries emphasises the urgent need for targeted prevention strategies to improve infants' safety, especially within the home. Parents should be educated about the fast development of mobility in infants and the milestones they will reach in their first year of life. Interventions should be devised that take poverty into account. Findings also suggest that abuse is under-recognised: more research into determinants that predict child abuse in a standardised way is necessary. The use of a screening tool at the trauma unit should be considered.

Declaration. This study was completed as part of KKS's MMed, but changes have been made since submission.

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