Children admitted to paediatric intensive care at Red Cross War Memorial Children's Hospital with non-accidental injuries (2012 - 2020): A retrospective descriptive study

L Bowes, MB ChB, FC (Paed), MMed (Paed), DCH, Dip HIV Man; **B Rossouw,** MB ChB, DTM&H, MMed(Paed), Cert Critical Care (Paed), Cert Cardiology (Paed); **B M Morrow,** PhD; BSc Physiotherapy, PG Dip (Health Research Ethics), PG Dip (Paediatric Palliative Medicine

Department of Paediatrics & Child Health, Red Cross War Memorial Children's Hospital, University of Cape Town, South Africa

Corresponding author: *B M Morrow (brenda.morrow@uct.ac.za)*

Background. Violence against children remains common in South Africa (SA). Children sustaining severe non-accidental injuries (NAIs) may require admission to paediatric intensive care units (PICUs), however, their outcomes have not been well described in SA.

Objectives. To describe the characteristics and outcomes of patients admitted to the PICU with suspected NAIs at Red Cross War Memorial Children's Hospital (RCWMCH).

Methods. A retrospective descriptive study of routinely collected data from all children admitted to the PICU at RCWMCH with suspected NAIs from 1 January 2012 to 31 December 2020.

Results. Of 11 345 children admitted to the PICU, 42 (0.4%) patients with suspected NAI (median (IQR) age 20.3 (7.9 - 62.6) months; 61.9% male) were included in data analysis. Most patients sustained physical injury (*n*=35; 83.3%) from assaults (*n*=19; 45.2%), and head injuries were the most common injury site, while 37 (88.1%) received invasive mechanical ventilation for a median (interquartile range) of 2.0 (1.0 - 3.8) days. PICU mortality was 28.6% (*n*=12), with a risk-adjusted mortality (observed/mean predicted mortality) of 3.6. Of the 30 PICU survivors, 7 (23.3%) were discharged with long-term disability, while the functional outcome of 16 (53.3%) survivors remains unknown.

Conclusions. Children who have sustained NAI represent a small proportion of PICU admissions, with high mortality and considerable morbidity.

Keywords. non-accidental injuries; intensive care units; paediatric; hospital mortality; wounds; injuries; South Africa.

South Afr J Crit Care 2026:42(1):e3260. https://doi.org/10.7196/SAJCC.2026.v42i1.3260

Contribution of study

Children with severe non-accidental injury (NAI) represent fewer than 0.5% of paediatric intensive care unit (PICU) admissions at Red Cross War Memorial Children's Hospital over a nine-year period. PICU mortality was 28.6%, more than double the general PICU mortality rate, with a risk-adjusted mortality nearly four times the predicted rate. Head injury was the most common and most fatal injury pattern; most incidents occurred in the home, and the perpetrator was most often a family member. Nearly a quarter of survivors were discharged with long-term disability. These findings highlight the need for early clinical recognition of NAI, strict compliance with mandatory reporting obligations, and structured interdisciplinary follow-up of survivors.

The South African (SA) Children's Act No 38 of 2005 upholds the right to safety and protection of every child. [1] Despite these initiatives, it is still estimated that globally one out of two children aged between 2-17 years have experienced some form of violence.[2] Non-accidental injury (NAI) in children, also known as child abuse, is the deliberate infliction of injury with the intention to cause harm. This can be in the form of physical or sexual harm or intentional neglect,[3] with females being more affected by sexual abuse than males.[4] Perpetrators of child abuse range from strangers to extended family members, friends and parents.[5,6]

Fatal child abuse is the most severe consequence of NAI.[7] SA's homicide rate for children under five years of age, the most vulnerable age for NAI, is unacceptably more than six times the global incidence at an estimated and unacceptable 5.5 per 100 000 children.[7,8]

Early clinical suspicion is fundamental in making a diagnosis of NAI, which must be reported under SA law.[1,9,10] Key features that should alert medical practitioners towards the diagnosis of NAI include unexplained injuries, discrepant histories, delay in seeking health care, alleged self-inflicted injuries, alleged third party injuries, sexualised behaviour and repeated injuries.[11] Children with the most severe forms of NAI often require admission to the paediatric intensive care unit (PICU), where they may have substantial risk of mortality and both short- and long-term morbidity, as well as high associated financial and other costs.

There is a paucity of recent data on the prevalence and outcomes of

children with severe NAI requiring PICU admission in SA. The present study therefore aimed to describe the proportion of children admitted to the PICU at Red Cross War Memorial Children's Hospital (RCWMCH) in Cape Town, SA, with suspected NAI, as well as their patterns and mechanisms of injury, PICU course and outcomes.

Methods

We conducted a retrospective descriptive study of routinely collected data from all infants and children admitted to the PICU with suspected NAI, as documented by a medical practitioner, between 1 January 2012 to 31 December 2020. Children who were caught in gun crossfire and unintentionally shot were not included as NAI. For the present study, all children admitted to the PICU with NAI were considered to have sustained severe NAI.

Setting and participants

The study site was the RCWMCH PICU, a 22-bed multidisciplinary PICU that admits ~1 300 patients under 13 years of age annually. As a tertiary hospital with a mixed medical and surgical PICU, RCWMCH receives all complicated trauma cases from across the Western Cape.[12] Every admission to the PICU is reviewed by the paediatric intensivist on duty. Children were eligible for inclusion in the study if they had been admitted to PICU during the study period following traumatic injury, which was suspected as being non-accidental, as documented by the attending PICU physician.

Patients were excluded if they were admitted to PICU following accidental or self-inflicted injury. Children were also excluded if they were initially suspected of having NAI at PICU admission, but the final discharge diagnosis revealed an underlying medical condition that fully explained the clinical presentation and/or where NAI was subsequently ruled out by the attending physician.

Data sources and collection

Ethical approval was obtained from the Departmental and Hospital Research Committees and the University of Cape Town's Faculty of Health Sciences' Human Research Ethics Committee (HREC ref. no. 493/2021). The requirement for written informed consent was waived given the retrospective, descriptive nature of the study, which maintained confidentiality.

Data were extracted from the PICU and social work databases as well as the National Health Laboratory Services (NHLS) database, patient medical folders and electronic discharge reports (ECCR). Radiological reports and images were viewed using the hospital's Picture Archiving and Communication System (PACS).

Demographic data included age, sex and the region in which the child lived, to describe the regional association with NAI cases. Documented admission characteristics included the Paediatric Index of Mortality Score (PIM2 or PIM3), the type of NAI, mechanism of injury, areas of the body involved, the place where NAI occurred and the perpetrator's relationship to the child (if known). Data related to the course of PICU admission included whether the child was mechanically ventilated, and the duration thereof, receipt of inopressors, blood products and the need for surgical intervention. PICU outcome measures were mortality, including the proportion of deaths occurring after withdrawal of life-sustaining therapy, and duration of PICU stay if the patient survived. Social welfare interventions were also documented, including whether the case had been documented as being reported to child protection services, completion of Form 22, as well as evidence of previous referral to social workers and/or removal from the home.

Data analysis

Data were collected in a standardised case record form after which deidentified data were entered into a password-protected MS Excel spreadsheet (Microsoft Corp., USA) and exported to SPSS Statistics (IBM Corp., USA; version 1.0.0.1406) for analysis. Descriptive data were tested for normality using the Shapiro-Wilk (W) test. Continuous variables were presented as means with standard deviations (SDs) or medians with interquartile ranges (IQRs) according to distribution, while categorical variables are presented as frequencies (*n* (%). Patient characteristics were compared between PICU survivors and non-survivors using Mann-Whitney *U*- or Chi^2 tests, as appropriate. Statistically significant and clinically relevant factors identified on univariate analysis were entered into a best-fit multivariable binary regression analysis, considering issues of collinearity, to identify any independent associative or modifiable factors for mortality. A *p*-value <0.05 was considered significant.

Results

Study Population

A total of 11 345 children were admitted to the PICU over the study period, of which 119 patients (1.0%) were screened for inclusion after reviewing PICU and social work databases for all documented cases of suspected NAI. Fifty-five (46.2%) of these children were admitted with gunshot wounds (GSWs). After determining that the injuries sustained were accidental, 77 patients (including 47 with GSWs and 30 with other accidental mechanisms of injury including drowning and poison ingestions were excluded). A total of 42 children were therefore included in our data analysis, representing 0.4% of the PICU admissions over the study period (Fig. 1), with a median (IQR) age of 20.3 (7.9 - 62.6) months and 61.9% were male.

Most patients sustained physical injury (*n*=35;83.3%) and physical assault was the most common mechanism of injury (*n*=19; 45.2%). In 4 cases of physical injury, there was additional evidence of neglect and sexual assault (*n*=2). Many patients sustained multiple injuries

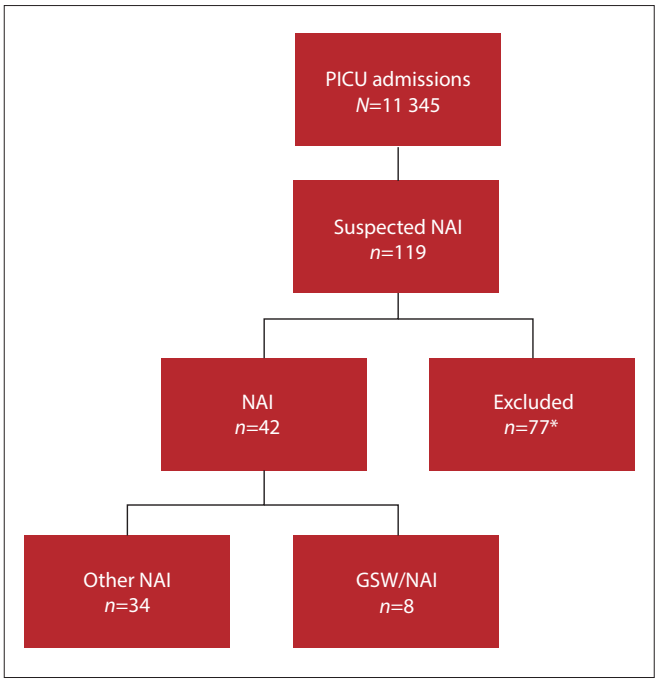

*Fig.1. Flowchart of participants in the study. (PICU = paediatric intensive care unit; NAI = non-accidental injury; GSW = gunshot wound.) (*Accidental injuries.)*

Table 1. Participant characteristics, PICU course and outcomes (*N*=42)

	All NAI (*N*=42), *n* (%)*	Survived PICU (*n*=30), *n* (%)*	Died in PICU (*n*=12), *n* (%)*	Unadjusted *p*-value
Admission characteristics				
Age (months), median (IQR)	20.3 (7.9 - 62.6)	22.8 (8.1 - 62.9)	18.6 (7.6 - 18.6)	0.86
Male sex	26 (61.9)	20 (66.7)	6 (50.0)	0.32
Risk of mortality, median (IQR)	0.06 (0.03 - 0.33)	0.06 (0.03 - 0.17)	0.42 (0.03 - 0.87)	0.13
PICU course				
Invasive MV	37 (88.1)	25 (83.3)	12 (100)	0.13
Duration of MV (days), median (IQR)	2.0 (1.0 - 3.8)	2.0 (1.0 - 3.5)	1.0 (1.0 - 5.0)	0.36
Received inopressors	11 (26.2)	5 (16.7)	6 (50.0)	0.03
Received blood products	18 (42.9)	13 (43.3)	5 (41.7)	0.92
Surgery while in PICU	23 (54.8)	19 (63.3)	4 (33.3)	0.09
Outcome				
PICU LOS (days), median (IQR)	3.0 (1.8 - 6.3)	3.0 (2.0 - 7.3)	1.5 (0 - 3.8)	0.02
NAI details				
NAI occurred at home	35 (83.3)	26 (86.7)	9 (75.0)	0.36
Type of NAI				
Neglect	5 (11.9)	4 (13.3)	1 (8.3)	
Physical	35 (83.3)	24 (80.0)	11 (91.7)	0.9
Other	2 (4.8)	2 (6.7)	0	
Mechanism of injury				
Burn	3 (7.1)	2 (6.7)	1 (8.3)	
Gunshot	8 (19.0)	8 (26.7)	0	
Physical assault	19 (45.2)	12 (40.0)	7 (58.3)	
Poisoning	2 (4.8)	2 (6.7)	0	0.03
Stab	4 (9.5)	4 (13.3)	0	
Combination	3 (7.1)	0	3 (25.0)	
Other	3 (7.1)	2 (6.7)	1 (8.3)	
Primary sites of injury (%)				
Head	25 (59.5)	14 (46.7)	11 (91.7)	0.007
Skin	23 (54.8)	13 (43.3)	10 (83.3)	0.02
Eyes	9 (21.4)	3 (10.0)	6 (50.0)	0.004
Neck	3 (7.1)	3 (10.0)	0	0.41
Chest	15 (35.7)	9 (30.0)	6 (50.0)	0.22
Abdomen	13 (31.0)	10 (33.3)	3 (25.0)	0.60
Upper limb	8 (19.0)	4 (13.3)	4 (33.3)	0.14
Lower limb	9 (21.4)	6 (20.0)	3 (25.0)	0.72
Genitourinary	1 (2.4)	0	1 (8.3)	0.29†
Spine	2 (4.8)	0	2 (16.7)	0.08†
Perpetrator (%)				
Family	24 (57.1)	16 (53.3)	8 (66.7)	
Friend	3 (7.1)	2 (6.7)	1 (8.3)	
Gang violence	3 (7.1)	3 (10.0)	0	0.81
Neighbour	1 (2.4)	1 (3.3)	0	
Unknown	11 (26.2)	8 (26.7)	3 (25.0)	

PICU = paediatric intensive care unit; NAI = non-accidental injury; IQR = interquartile range; MV = mechanical ventilation; LOS = length of stay.
*Unless otherwise specified.
†Fischer's exact test.

(*n*=17; 40.5%) often involving the head, chest and skin (bruising), with a high associated mortality (*n*=8; 66.7% of total deaths; *p*=0.03).The two patients categorised as 'other' types of NAI were both deliberately poisoned (Table 1). In most cases, the incidents occurred in the home (*n*=35; 83.3%) and the perpetrator was a family member (*n*=24; 57.1%). Most cases of NAI (*n*=12; 28.6%) occurred in the Klipfontein health district, followed by Mitchell's Plain health sub-district (*n*=8; 19%) (Fig. 3). Most cases (n=35; 83.3%) were referred to Social Work for the first time during their incident admission; 7 (16.7%) children were previously known to the social work department and two of these patients died.

During their PICU stay, most patients (*n*=37; 88.1%) received invasive mechanical ventilation for a median (IQR) duration of 2.0 (1.0 - 3.8) days. Inopressor support was required by 11 (26.2%) patients; 18 (42.9%) received blood products and 23 (54.8%) underwent surgery (Table 1). Various surgical disciplines were involved in the co-management of the study patients, most commonly neurosurgery, where patients with severe traumatic brain injuries had intracranial pressure and brain oxygenation monitors placed to assist with maintaining neuroprotective measures. Other surgeries that were required included laparotomies (both exploratory and damage control for visceral organ damage),

vascular surgery to repair damaged bloods vessels; wound debridement for burns and orthopaedic surgery for fracture repairs.

PICU mortality was 28.6% (n=12), with a PIM2/3 risk-adjusted mortality (observed/mean predicted mortality) of 3.6. Ten of the 12 children (83.3%) died following withdrawal of life-sustaining therapy after being assessed as life limited in quantity. Of the 30 PICU survivors, seven (23.3%) were discharged with long-term disability, while the functional outcome of 16 (53.3%) survivors is not known.

A multivariable binary logistic regression was conducted to determine the effect of ino-pressors, type of NAI, mechanism of injury, injury site (head or skin injury sites – eye injuries removed from the model for reasons of collinearity), and multiple injuries on patient survival. The model was significant (p=0.001) and a good fit for the data (Nagelkerke R square 0.78) and was able to correctly predict 85.7% of cases. None of the variables in the model were found to be independently associated with survival (p>0.1 for all).

Discussion

SA is a middle-income country with a high unemployment rate of 32.9%.[13] Despite organisations such as Child Safe, which promotes the prevention of intentional and unintentional injuries through research, education and advocacy programmes,[14] there remains a high incidence of childhood trauma in SA associated with high levels of criminal activity, substance abuse and gang-related violence.[15] Our data confirm ~five cases of severe NAI per year warranting PICU admission, associated with substantial mortality and morbidity.

The confirmed NAI cases admitted to the PICU constituted fewer than 1% of the total RCWMCH PICU admissions over the 9-year study period. This is comparable with another SA study conducted at Chris Hani Baragwanath Academic Hospital in Johannesburg, where 1.6% of total trauma admissions to their PICU were secondary to deliberate assault.[16] Despite the relatively low proportion of NAI cases admitted to PICU, management of these cases has considerable cost implications. It is well known that PICU resources are a precious commodity in SA and the availability of beds is often a challenge to secure.[12] The average cost per day at the RCWMCH PICU is ~ZAR13 000 and the total cost for all patients admitted with NAI would therefore amount to an estimated ZAR2 899 000 (223 days) over the study period, which represents a substantial cost for a preventable condition. This cost per day is comparable with a study done by Pillay *et al.*[17] in KwaZulu-Natal, where the cost for a trauma patient in ICU was ZAR12 727.56 per day. The 223 ICU bed-days could have been utilised for curative surgical procedures thereby reducing the backlog on surgical waiting. In addition, almost a quarter of NAI survivors were known to be left with physical disability, requiring ongoing expenditure and heath resource utilisation.

It is the responsibility of and obligation of every healthcare worker to report child maltreatment and neglect and all healthcare workers should be familiar with the Children's Act (No. 38 of 2005), as well as The Amended Sexual Offenses Act, including obligatory reporting requirements for suspected NAI.[1,18] All patients in this cohort were referred to the Social Work department and appropriate forms, such as J88 and Form 22, were completed. All cases were investigated and appropriately referred to police or the Department of Social Development as indicated. Regular audits are recommended to ensure compliance with mandatory reporting is maintained.

In the present study, the average age of NAI victims was 20.3 months with the youngest patient being a 1-day old neonate. The under-5 age group is known to be most commonly affected by NAI owing to their physical inability to escape targeted injury and their high levels of dependence on adults.[19] The young age of our cohort is consistent with a 2009 SA National child homicide study, which reported that over a third of deaths due to abuse and neglect occurred in babies within the first week of life, while almost three quarters of cases were in children under 5 years of age.[8]

The proximity of RCWMCH to the Klipfontein district may explain why this district had the highest rate of NAI (28.6%) in our cohort, as most of the referrals come from this region. In the case of young children in this cohort, most fatal NAI occurred in the home and the perpetrator (most often the mother) was known to the child. Fieggen *et al.*[15] (2004) previously reported a high incidence of children who were intentionally and unintentionally used as human shields during domestic violence in SA, which may have been the mechanism for some of our cases, however this detail was not well reported in the medical files. These findings highlight the necessity for early intervention and prevention programmes targeting maternal mental health, focussed on the first 1 000 days of life.[20]

The most common type of NAI, occurring in >70% of this cohort, was physical abuse, followed by intentional neglect (9% of cases). Patients with multiple injuries had worse outcomes. This finding is similar to results from a cross-sectional cohort study conducted in Asia.[21] It is estimated by the SA Society of Psychiatrists that a third of children under 17 years of age have experienced emotional abuse or neglect, with a higher incidence of these types of abuse among children who experience other NAI types such as physical and sexual assault.[22] While physical assault was more common in our cohort admitted to the PICU, Meinck *et al.*[23] (2016) estimate that childhood victims of emotional or psychological abuse have a four-times greater risk of developing serious mental health illnesses later in life. Assessment of psychological and emotional abuse other than intentional neglect, was beyond the scope of this study. However, this aspect warrants comprehensive interdisciplinary assessment and follow-up, given the long-term mental health effects.

NAI can occur and affect any site in the body. Malki *et al.*[24] described head injuries to be the most common primary injury site and similarly these were the most common and most fatal injuries (11 out of 12 deaths) in our cohort, mostly a consequence of physical assault. The NAI study conducted at the Addenbrooke PICU in the UK found all 15 of their study participants to have 'shaken baby syndrome'.[25] In this phenomenon, rapid acceleration and deceleration of the head results in disruption of bridging veins leading to intracranial and retinal haemorrhages.[26] In our patient cohort, 7 (16%) of those screened were found to have evidence of retinal haemorrhage, which is strongly associated with shaken infant syndrome.

PICU mortality in our study of severe NAI was 28.6%. This is more than double the general RCWMCH PICU mortality of ~10%.[13] The PIM score is an internationally validated benchmarking tool to predict mortality during PICU admission.[27] In the SA setting, Solomon *et al.*[28] found that despite good discrimination with PIM 3, it was poorly calibrated, rendering the interpretation of the absolute risk difficult. More than 80% of deaths in our cohort occurred after withdrawal of life-sustaining therapy due to devastating irreversible injuries.

Ballot *et al.*[29] (2019) described the challenges faced with withdrawal of life sustaining therapies in the SA public healthcare sector. According to The Royal College of Paediatrics and Child Health, there are three sets of circumstances when treatment limitation can be considered: when life is limited in quantity with imminent death or inevitable death; when life is limited in quality with burden of treatment, burden of the condition or lack of ability to benefit; and finally informed competent refusal

of treatment.[30] In our study, all the patients in whom life-sustaining therapy was withdrawn were in the 'limited in quantity' category. The high mortality in this group PICU patients, compared with general PICU patients, warrants further investigation.

The long-term outcomes of this cohort of NAI survivors are beyond the scope of the study, but are likely to include substantial long-term debilitating sequelae such as epilepsy, cognitive dysfunction, cortical blindness, motor disabilities and psychological impairment.[23,31] Interdisciplinary clinical follow-up of NAI survivors is therefore strongly recommended to monitor and optimise long-term functional outcomes.

Lastly, we note with concern the high proportion of children admitted to PICU following both accidental and non-accidental gunshot injury. Despite many of these patients not meeting the stated criteria for NAI, and who were therefore not included in data analysis, we presented these data to highlight the problem of gun violence against children in SA. Of the patients admitted with gunshot wounds who did not meet NAI criteria, the majority (n=47; 85.4%) had been caught in crossfire shootings related to gang violence. The issue of gang violence predates democracy in SA[32] and children continue to be victims, especially in the Western Cape. Enhanced advocacy is needed to support protection of children from gun violence.

Study limitations

This study was a retrospective folder review and is therefore at risk of information and selection bias, being reliant on documentation in the medical folders and on the attending, clinician documenting a diagnosis of suspected NAI. We did not include children who died before admission to PICU. In addition, children admitted for other reasons, where NAI was later identified as an incidental finding, may not have been identified for inclusion in this study. This was a single-centre study and therefore not generalisable to other units in (or beyond) SA.

Conclusion

Children who have sustained NAI represent a small proportion of overall PICU admissions, with high mortality and considerable morbidity. Early recognition of children who may have sustained severe NAIs, based on presenting signs and injury patterns, is important to facilitate prompt referral and management. Standardised follow-up of survivors of severe NAI is recommended to determine and optimise long-term functional and psychosocial outcomes.

The ongoing violence against children has (and will continue to have) massive implications for SA's economic, physical and social health. Urgent action and policy change is needed to achieve the Sustainable Development Goal of eliminating violence against children by 2030.[33] Every effort should be made to protect the future generation, the children.

Declaration. The research for this study was done in partial fulfilment of the requirements for LB's MMed (Paed) degree at the University of Cape Town.

Acknowledgements. Carla Brown, who assisted with the patient database and Dirk Von Delft for the initial assistance with conceptualising the project.

Author contributions. LB conceived the study, collected data and wrote the initial draft. BM contributed to protocol development, data analysis, reviewed and edited manuscript drafts. BR contributed to protocol development, reviewed and edited manuscript drafts. All authors reviewed and approved the final version of the manuscript.

Funding. None.

Conflicts of interest. None.

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Received 13 March 2025. Accepted 25 November 2025.