

A retrospective study analysing mortality and outcomes in the paediatric burns intensive care unit at the Chris Hani Baragwanath Academic Hospital, Johannesburg

N Z Mashavave,¹ MB ChB; A Withers,¹ MB BCh; L Doedens,² MB ChB, FCPaed (SA), Cert Crit Care (SA);
B Jugmohan,¹ MB ChB, FCS (SA), MMed Surg, Cert Gastro Surg (SA); J Loveland,¹ MB ChB, FCS (SA), Cert Paed Surg (SA)

¹ Department of Paediatric Surgery, Chris Hani Baragwanath Academic Hospital and Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

² Department of Paediatric Critical Care, Chris Hani Baragwanath Academic Hospital and Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

Corresponding author: N Z Mashavave (nzxaba@gmail.com)

Background. Data on mortalities related to paediatric burns in South Africa are scarce and outcomes in transferred and direct admissions into paediatric intensive care units have not been compared.

Objectives. To describe the demographic profile, aetiology and extent of injuries in patients treated at the paediatric burns intensive care unit (PBICU) at the Chris Hani Baragwanath Academic Hospital (CHBAH), Johannesburg and to compare outcomes of direct admissions and patients transferred to the unit.

Methods. This was a retrospective cohort study of all patients younger than 10 years admitted to the PBICU at CHBAH from January 2013 to December 2017. Statistical differences between groups were analysed using log-rank analysis and Kaplan–Meier curves were used to determine survival.

Results. Of the 2 506 admissions into the general ward and ICU over the 5-year study period, 428 admissions were to the PBICU. A total of 109 deaths occurred (25.47% of PBICU admissions), with an overall mortality of 4.4%. Of the total number of deaths ($n=109$), 58 (53.21%) were among direct admissions and 51 (46.79%) among transferred patients. The mortality rate in the respective groups was 18.58% (direct admissions) and 43.97% (transferred patients). The survival rate was significantly different between the two groups ($p<0.01$).

Conclusion. A favourable outcome was more likely in direct admissions than in transferred patients. With standardised protocols for management of severe burns and stable availability of resources, improvements in outcome are expected.

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Internationally, thermal burns account for 300 000 mortalities per year, of which 180 000 are estimated to occur in low- to middle-income countries.^[1,2] In South Africa (SA), 2.8/100 000 children die annually from thermal injuries and burns remain the third most common cause of external trauma and subsequent mortality in children younger than 18 years.^[3,4] In the SA context, the incidence and patterns of burn injuries have been noted to be attributed largely to urbanisation and urban migration, disorganised development, inaccessible electrical supply, unsafe energy sources, poverty and overcrowding.^[5] A retrospective study by Jugmohan *et al.*^[6] identified the risk factors for mortality in paediatric burn victims at the Chris Hani Baragwanath Academic Hospital (CHBAH) as age below 5 years, burn injury with a total body surface area (TBSA) >30%, presence of inhalational injury and admission to the paediatric intensive care unit (PICU). Informal observations in our unit suggested that worse outcomes and higher mortality were associated with patients transferred to us from referral centres than seen in direct admissions from the emergency department. It was reasoned that this may be due to patients being transferred fairly long after the burn occurred and that burn injuries were more extensive. Literature review revealed no studies that compared the outcomes between direct admissions and patients transferred from a referral centre, which prompted us to analyse the outcomes in these patient groups formally.

Methods

The Johnson & Johnson Paediatric Burns Unit at CHBAH treats state-sector patients from Soweto and surrounds as well as from distant referral sites, often accepting patients from centres in provinces outside our referral area. The referral and admission criteria are in line with the guidelines of the American Burn Association.^[7,8]

The study aimed to compare the outcomes (defined as the proportion of mortalities versus discharges) of patients who had been admitted directly from the emergency department or referred locally from Soweto with those of patients transferred to our unit from other healthcare institutions. To this end, case data from 1 January 2013 to 31 December 2017 were retrieved from the patient registry of the paediatric burns unit.

The total number of admissions to the unit and also the number of admissions to the paediatric burns intensive care unit (PBICU) over the 5-year period were determined. Patients older than 10 years and re-admissions into the PBICU were excluded. Admission and demographic data were used to differentiate between patients admitted directly from the emergency department and those transferred from referral centres outside of Soweto. Direct admissions were defined as patients from within our institution's catchment area and included both patients who arrived at hospital

on own accord and those brought in by emergency medical services, without prior treatment at another institution.

Data collected from records of each group included age, gender, mechanism of injury, percentage of body surface area burned, length of stay and outcome. Outcome was based on whether the patient demised or was discharged from the PBICU.

Four age groups were defined, namely 0 - 12 months, 13 - 36 months, 37 - 60 months and 61 - 120 months. The Lund and Browder chart was used for descriptive analysis of TBSA burned in each age group (per year), with the extent of burn injuries classified as <20%, 21 - 40% and >40%. The mechanism of burns was categorised as hot water (including hot porridge and rice), hot oil, flame and electrocution.

Statistical analysis

Data were entered into a spreadsheet and analysed using Statistica version 13.0 (TIBCO Software Inc., USA) and Stata version 15.1 (StataCorp LLC., USA). Continuous variables are reported as medians, ranges and interquartile ranges (IQRs) and categorical variables as percentages. Statistical differences between groups were analysed using log-rank analysis and Kaplan-Meier curves were determined for each variable per group to determine the survival per group. A significance level $p < 0.05$ was used.

Ethical considerations

Approval for the study was obtained from the Human Research Ethics Committee of the University of the Witwatersrand prior to data retrieval and analysis of patient records (ref. no. M170411).

Results

The total number of admissions into the paediatric burns unit (inclusive of ICU admissions) over the study period was 2 506 patients. Of these, 428 were admitted to the PBICU, with 312 (72.90%) as direct admissions from the emergency department and 116 (27.10%) as transfers. A total of 109 deaths occurred, which equates to 25% of total PBICU admissions ($N=428$). Of these deaths, 58 were from direct admissions ($n=312$; 18.59%) and 51 were from transferred cases ($n=116$; 43.97%). The admission and outcome profile is shown in Table 1. The median age across all admissions to the PBICU was 23 months (IQR 12 - 36 months). The median extent of burns was 24% (IQR 15 - 30%) and the median length of stay was 14 days (IQR 6 - 26 days) in both direct admissions and transfers. The χ^2 statistic showed a significant difference in survival rate between direct admissions and transferred patients ($p < 0.01$).

As shown in Table 2, scalds accounted for most injuries ($n=338/428$; 78.97%) and were associated with 27 (7.99%) mortalities among transferred patients and 46 (13.61%) mortalities among direct admissions ($p < 0.01$). Of the 67 patients admitted with flame burns, 21 (31.34%) deaths were recorded among transferred patients and 9 (13.43%) among the directly admitted patients.

There was an increasing trend in the number of transferred admissions across the 5-year study period whereas the number of direct admissions remained more stable, except in 2015 when the number of direct admissions declined to 51 (Table 3). In the direct admissions cohort, the highest number of deaths ($n=15/65$; 23.08%) was observed in 2016, followed by a subsequent decline to prior levels. Mortalities among transferred patients were consistently and substantially higher than among direct admissions.

As shown in Fig. 1, a higher number of mortalities was reported among direct admissions between the ages of 0 and 36 months (combined numbers from the age groups 0 - 12 months and 13 - 36 months) compared with mortalities in this age group among transferred patients, with scalding reported as the most common mechanism of injury (Table 2). The highest mortality was seen in transferred patients between 61 and 120 months old, possibly owing to the nature of burns sustained.

As shown in Table 4, burns affecting >40% TBSA were associated with higher mortality among transferred patients (61.76%) than directly admitted patients (38.24%). More mortalities were recorded among the direct admissions cohort (70.00% and 53.33%) than among transferred patients (30.00% and 46.67%) when the extent of burns affected <40% TBSA. Significantly more mortalities were recorded among transferred patients across all injury extents than among directly admitted patients ($p < 0.01$).

The outcome of patients who had sustained scalding and flame injuries ($p < 0.01$) was significantly different in both cohorts (Table 2). Transferred patients with flame and scald burns ($n=21$; 67.74% and $n=27$; 35.53%, respectively) had a worse outcome compared with those who were directly admitted ($n=9$; 25.00% and $n=46$; 17.56%, respectively).

Discussion

Six recognised centres for managing burns of an extensive nature were available in the SA public healthcare sector in 2011, and

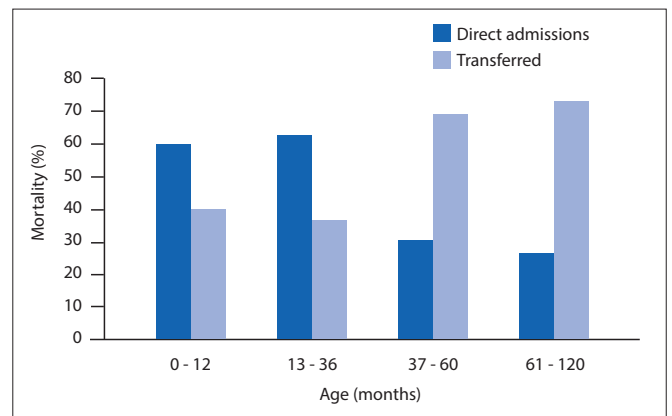


Fig. 1. Mortality of burns patients according to age group.

Table 1. Admission and outcome profile of patients admitted to the PBICU at the CHBAH, 2013 - 2017 ($N=428$)

Characteristic	Total admissions ($N=428$)	Direct admissions ($n=312$)	Transfers ($n=116$)	p -value
Age (months), median (IQR)	23 (12 - 36)	22 (15 - 48)	24 (12 - 36)	0.02
TBSA of burns (%), median	24	20	26	<0.01
LOS (days), median	14	13	15	0.75
Mortality, n (%)*	109	58 (18.59)	51 (43.97)	<0.01

PBICU = paediatric burns intensive care unit; CHBAH = Chris Hanani Baragwanath Academic Hospital; IQR = interquartile range; TBSA = total body surface area; LOS = length of stay.

*Percentages are calculated from the number of admissions per group.

Table 2. Breakdown of outcomes according to mechanism of injury per patient group

Mechanism of injury	All patients (N=428), n (%)	Direct admissions		Transfers		p-value
		Survived, n (%)	Died, n (%)	Survived, n (%)	Died, n (%)	
Hot water	338 (78.97)	216 (63.91)	46 (13.61)	49 (14.50)	27 (7.99)	<0.01
Hot oil	4 (0.94)	1 (25.00)	1 (25.00)	2 (50.00)	0 (0)	0.32
Flame	67 (15.65)	27 (40.30)	9 (13.43)	10 (14.93)	21 (31.34)	<0.01
Electrocution	10 (2.33)	6 (60.00)	0 (0.00)	2 (20.00)	2 (20.00)	0.16
Unknown	9 (2.10)	-	-	-	-	-

Table 3. Trends in burn-related admissions and mortalities between 2013 and 2017 according to admission type

Variable	2013		2014		2015		2016		2017		Total	
	D/A	T/F	D/A	T/F	D/A	T/F	D/A	T/F	D/A	T/F	D/A	T/F
Admissions, n	69	11	67	17	51	20	65	26	60	42	312	116
Mortalities, n (%)	14 (20.29)	10 (90.91)	11 (16.42)	6 (35.29)	8 (15.69)	10 (50.00)	15 (23.08)	11 (42.31)	10 (16.67)	14 (33.33)	58 (18.59)	51 (43.97)

D/A = direct admission; T/F = transfer.

Table 4. Outcome according to extent of burn injuries per admission group (N=428)

Extent of burn injuries*	All admissions (N=428), n (%)	Direct admissions		Transfers		p-value
		Survived, n (%)	Died, n (%)	Survived, n (%)	Died, n (%)	
<20% TBSA	215 (50.23)	159 (85.95)	21 (70.00)	26 (14.05)	9 (30.00)	0.16
21 - 40% TBSA	157 (36.68)	83 (74.11)	24 (53.33)	29 (25.89)	21 (46.67)	0.15
>40% TBSA	47 (10.98)	7 (53.85)	13 (38.24)	6 (46.15)	21 (61.76)	0.57
Total	428	249 (58.18)	58 (13.55)	61 (14.25)	51 (11.92)	<0.01

*The extent of the burn injuries was unknown in 9 of the 428 total admissions (2.10%).
TBSA = total body surface area.

17 centres by 2018.^[9] These facilities provided 511 beds, with reported annual admissions exceeding 8 140.^[2,5,9] At CHBAH, a seven-bed PBICU caters for an estimated population of 1.58 million (both adults and children), as well as for patients referred from various institutions elsewhere in the Gauteng province and its surrounds.^[10] In our unit, the number of direct admissions was significantly higher than transferred patients ($n=312$ v. $n=116$), although the mortality of transferred patients was significantly higher (18.59% among direct admissions v. 43.97% among transfers, $p<0.01$). These differences may be attributed to various factors, including delays in presentation to the hospital, patient referral, ambulance transport, wound cover and treatment of underlying sepsis, and fluid resuscitation with resultant hypothermia, acidosis and shock.^[11] The current study did not focus on analysing the effects of these factors on patient outcomes, but literature suggests that they may be associated with negative effects.

The process of interhospital transfer of critically ill patients carries a risk of morbidity.^[8,12] In addition, long transfer distances and other transport-related challenges often result in a prolonged time between acceptance of patients to arrival at the tertiary institution, which is often associated with less favourable outcomes.^[13] Scribante and Bhagwanjee^[11] reported significant differences in transfer of critically ill patients to intensive care units (ICUs) in SA (0.3 - 6 hours on average), highlighting the need for improvement in this regard.^[11,13] We observed an upward trend in the number of transferred patients admitted to our unit over the 5-year study period, which may be attributed to a lack of specialised burns and critical care facilities being available or a lack of skills or resources to manage such patients elsewhere.^[14] In an audit by Rode *et al.*,^[14] secondary hospitals in

the Western Cape reported a lack of surgical time, problems with equipment (often old or dysfunctional), a shortage of ICU facilities and no access to burn wound technology and dressings in treating burns patients, compounded by no capacity to isolate patients and both adults and children having to be accommodated in a common surgical ward. Similar observations were noted in other studies in developing countries in Africa, which reported that patients admitted into general wards in primary or secondary healthcare institutions will most likely experience compromised burns care owing to a lack of isolation, a risk of infection, a shortage of drugs, delayed skin grafting and a lack of resuscitation equipment.^[3,15] These resource constraints lead to poorer outcomes.^[2]

Age, extent of the burn injuries, mechanism of injury, burn depth, presence of inhalational injury, sepsis and clinical status at the time of referral are all individually associated with mortality.^[6,16] Age below 5 years is a risk factor for mortality in our unit,^[6] which is supported by observations from international studies citing age below 4 years as a considerable risk factor.^[3,17-19] In our study, higher mortality was seen among directly admitted patients with hot-water burns who were younger than 36 months than among transferred patients in this category. It is well documented that serious burns render the paediatric patient more susceptible to various infection-related complications, whether brought on by local or systemic factors.^[19] Local factors such as thinner skin, open wounds, incompetent gut barriers, invasive devices (e.g. endotracheal intubation, central venous catheterisation, arterial lines and transurethral catheters) potentiate this risk.^[15,19] Systemically, there is an overall reduced cellular immunity associated with burns, especially in the younger population.^[19]

Sepsis has been reported as the leading cause of mortality in burns patients.^[1,19,20] Although septic complications were not analysed in this study, we noted that sepsis management, especially of drug-resistant bacteria, is a challenge in our unit. Other risk factors related to mortality in the paediatric population may include delay in fluid resuscitation, which is measured as time to intravenous fluid administration.^[15] A lesser physiological reserve, technical difficulties with intravenous access and a smaller margin for error in fluid administration have also been identified as contributing factors in increased mortality.^[15]

In the age group 6 - 120 months, more admissions and associated mortalities were noted among transferred patients than in direct admissions and mostly among those affected by flame injuries. This pattern was also described by Van Niekerk *et al.*^[21] at the Red Cross War Memorial Children's Hospital, noting an 'over-representation' of flame burns among older children. Aggressive resuscitative and ventilatory requirements, a greater extent or depth of injury, and a need for earlier and multiple surgical interventions are often associated with flame-induced burns.^[16,22,23] In the acute phase, these injuries may require prompt intervention, including escharotomy or early excision with subsequent grafting.^[23] Inhalational injury, which is often associated with flame burns, results in an inflammatory cascade predisposing to pneumonia and which directly affects the circulatory response, leading to increased resuscitative fluid requirements and subsequently morbidity and mortality.^[22]

In 2012, Jugmohan *et al.*^[6] concluded that at the PBICU at CHBAH, significant risk factors for burn-associated mortality included age <5 years, presence of inhalational injury, extent of burn injuries exceeding 30% and admission into the PBICU. Admission into the ICU itself is a risk factor due to the substantial associated severity of burns (with regard to total extent and depth), inhalational injury (which may require mechanical ventilation), acute respiratory distress syndrome, multi-organ dysfunction syndrome, sepsis and more aggressive operative intervention.^[6] In our study, more flame-induced burns (with possible inhalation components) and a greater extent of injury (measured as TBSA affected) were seen in transferred patients compared with directly admitted patients and were most likely to require critical care services and surgical intervention. This can be translated to the significant number of mortalities observed among transferred patients. It has been documented, both in our unit and in the literature, that patients with burns affecting >60% TBSA have a 100% mortality rate, irrespective of whether there is an associated inhalational component.^[6,24] Similarly high mortality rates have been reported in a study from Brazil (80% mortality in patients with burns affecting >50% TBSA)^[25] and Nepal (95% mortality in patients with burns affecting >40% TBSA).^[26] These reports are in line with findings from a prospective analysis in a tertiary paediatric burns centre in India, in which Dhopte *et al.*^[27] concluded that the greater the extent of burn injury (expressed in terms of TBSA), the higher the risk of mortality. This was also observed in our study among transferred patients.

However, a higher risk of mortality was seen among directly admitted patients with burns affecting <40% TBSA than in the transferred group. Patients younger than 48 months and with burns affecting >30% TBSA have been reported to have a higher mortality risk and do not tolerate such burns well.^[15]

In our unit, multidisciplinary team involvement is paramount in improving outcomes and includes general surgery, plastic surgery, physiotherapy, speech therapy, occupational therapy, dietetic consultation and services by allied healthcare professionals.

Study limitations

The data reported here are from a single centre and the numbers in some categories were too small for drawing definitive conclusions. The higher mortalities seen among transferred patients were not analysed in relation to factors such as transport, resuscitation, early presence of systemic inflammatory response syndrome, sepsis or ventilatory factors, as it was not an objective of this study. However, we argue that the findings from this high-volume centre may reflect trends in other burns units nationally.

Conclusion

Our study showed a statistically significant difference in the outcomes between patients admitted directly from the emergency department and those referred from other institutions. Among transferred patients, those older than 60 months, presenting with burns affecting >40% TBSA or who had flame-induced burns were at higher risk for mortality. This contrasts with risk factors for mortality seen among directly admitted patients, namely age <36 months, extent of injury <40% TBSA or burns caused by scalding. Sepsis has a critical role in the outcome of patients, in addition to treatment delay.

Burn-related injuries are devastating, with lifelong consequences, and are largely preventable in the home environment. Intervention is required at this level, as well as at various levels of healthcare to avoid poor outcomes in patients who present with burn injuries. Further studies are required to identify individual risk factors for targeted intervention to improve these outcomes.

Declarations. None.

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Conflicts of interest. None.

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