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TRAUMA SURGERY - BURNS

Factors influencing outcomes in a resource-constrained burns unit

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Background: The treatment of burns is expensive and especially burdensome in low-income countries. We evaluated factors influencing short-term outcomes in a designated adult burns unit in a low- to middle-income country.
Methods: A retrospective analysis of burn injury patients in an adult burns unit was undertaken. Patient and burn characteristics were evaluated as predictors of short-term in-hospital outcomes, namely mortality and length of hospital stay. The effects of the type of burn and severe burn injury were analysed separately. We analysed admission to ICU as a marker for resource availability.
Results: Nine hundred and eighty-two patients were included. The mean TBSA was 15%, the LA5O 51% and the mortality rate 10.8%. The most common cause of injury was flame burn. Greater age (< 0.001), increased TBSA (< 0.001) and inhalation injury (< 0.001) were significantly associated with mortality, as were flame and electrical burns. Not all patients with inhalation injury or with severe burn injury were admitted to ICU. Length of hospital stay was prolonged only by TBSA (< 0.001). Age above 50 years was not associated with increased mortality (0.34) in severely burned patients. Hospital stay was marginally prolonged in patients with electrical burns.
Conclusion: The LA5O is lower, length of stay longer, and mortality greater than ideal. Outcomes were predicted by greater age and TBSA, inhalation injury, flame and electrical burns. System constraints resulted in insufficient ICU admission and prolonged hospital stay.
Keywords: adult burns, resource-constrained burns unit

Introduction

Human burn injury is a global health problem that causes considerable physical and emotional trauma to the patients and their families. Burns can cause devastating injuries and may result in significant morbidity and mortality. According to the World Health Organization (WHO) non-fatal burns are a leading cause of morbidity, including prolonged hospital stay, disability and disfigurement.[1] Care of burn patients is expensive and affects budgeting in both high-income countries (HICs)[2] and those with lower incomes.[3]

Low (LIC) and low- to middle-income countries (LMICs), which includes South Africa, have a higher incidence of burns and burn mortality than high-income countries (HICs).[1,4] A 2017 South African Medical Research Council report showed that 3.2% of South Africans suffered a burn injury of which 82% were classified as minor.[5] Rapid urban migration, poverty, inadequate electrification of homes and overcrowding all increase the incidence of burns.[5]

Although the use of paraffin for cooking has been declining in South Africa, its use is still common in low-income households, and it remains a major cause of scalds and flame burns. In 2021, 89.3% of households in South Africa were connected to mains electricity.[6] However, many of these are illegal and dangerous secondary electrical connections and are responsible for a substantial number of burns injuries in deprived settlements. The 2019 Statistics South Africa General Household Survey recorded that 16.4% of residents in the Tshwane (Pretoria) metropolitan area live in informal settlements with limited access to electricity and therefore depend on other sources of energy.[6] No recent reports on burn injury exist in the Tshwane metropole in Gauteng, the most densely populated province in South Africa.

The evolution of events of patients admitted to hospital for burn injury is important in determining the provision of facilities. These may include the use of expensive consumables and rehabilitation services, but also the major drivers of hospital costs, namely the endeavour to prevent mortality, admission to an intensive care unit (ICU) and length of stay (LOS) in hospital.[7,8] Outcomes in patients with burn injury have been well documented in developed countries.[9-12] Outcomes may be different in LICs and LMICs because of different patient, demographic and burn injury characteristics.[4,13] Several descriptive studies on burn injury in South Africa have been published.[14-21] However, this study uniquely addresses deficiencies of management of burns relative to in-hospital outcomes.

The aim of this study was to evaluate the possible effect of certain patient, burn and management characteristics as predictors of short-term outcomes of adult patients admitted to a resource-constrained burns unit. The specific outcomes were chosen for their implied effects on in-hospital costs. These were patient mortality and the LOS in hospital of patients who survived. The hypothesis of the study was that certain management, patient and burn characteristics are associated with poor outcomes.

Methods

A retrospective cross-sectional study was performed. Hospital files of adult burn patients who were admitted to the designated South African burns unit at Kalafong Provincial Tertiary Hospital (KPTH) in Tshwane province during the study period 1 January 2014 to 31 December 2021 (8 years) were examined. Patients who died in the emergency department because of extensive burn injury were excluded. Admission patient data captured were sex, age, type of burn, percentage of total body surface area (TBSA) and the presence of inhalation injury. Details of ICU admission, mortality and duration of hospital stay were recorded. The length of hospital stay (LOS) was recorded only for patients who survived. This was done in order to evaluate the management of the post-acute phase of hospitalisation. Only burned areas of 2nd degree and deeper were included. Severe burn injury was defined for the purpose of this study as patient age above 50 years or TBSA greater than 20% or inhalation injury.

Burn unit protocol. The TBSA burned is determined by the on-duty registrar at KPTH using the rule of 9s. Resuscitation is by the Parkland formula of lactated Ringer's solution. Patients with very extensive burns (about 70% TBSA as a single factor) are treated only palliatively. The diagnosis of inhalation injury is based on clinical findings of soot in the upper aerodigestive tract or sputum, singed nasal hair or stridor. The basic treatment protocol of burns at KPTH is late burn excision at seven days or later and is dependent on available theatre time. The only pre-excision treatment used is antiseptic creams. Definitive burn wound closure is by autografting only. Cadaver skin, animal skin and biosynthetic products are not available because of costs.

KPTH is one of 17 designated burns centres in South Africa. However, like many of these units, it has only basic resources. The unit has no specialised burn management facilities such as hydrotherapy baths or isolation booths. The burn ward has 12 beds and is the smallest unit in the country. It has no dedicated burns medical staff, ICU beds or theatre, but has some experienced nursing staff. The unit is supervised by specialist general surgeons who all have other surgical commitments. This unit is manned by rotating trainee surgeons and nurses. The hospital does not have an in-house plastic surgery service; patients are evaluated and treated on consultation. The hospital has an eight bed ICU and 10-bed high care stepdown unit for use by all surgical disciplines. Patients with severe burns are admitted to the ICU if a bed is available Surviving patients are discharged to residences, with no step-down or rehabilitation facilities being available.

Statistics

Descriptive statistics were used for quantitative/numeric variables, including mean and median (IQR) values. Frequency counts and proportions were used for categorical variables. The significance of the association of patient and burn characteristics with the outcomes, namely mortality and admission to ICU, was calculated using univariate and multiple logistic regression with the associated standard error and 95% confidence intervals. The length of hospital stay (LOS), was calculated using negative binominal regression. Lethal area 50 (LA50) was calculated using the probit regression model. Admission to ICU was recorded and analysed as an indicator of resource availability. All data analysis was performed in R [version 4.2.1]. Statistical significance was set at a 5% level.

Results

Participants

There were 982 patients who met the criteria for inclusion in the study. The patient and injury characteristics are shown in Table I. The majority were males and were relatively young, 68%,aged between 13 and 39 years. The age of 127 (13%) patients was greater than 50 years.

Burn injury

By far the most common burns were flame burns which were mainly due to house/shack fires. The significant proportion of patients with electric burns is worthy of note. These burns were all high voltage injuries. They occurred mainly in young men (mean age 32 years) and covered a somewhat smaller mean TBSA of 18%. Domestic food and water heating incidents causing scalds were also distinctly prevalent.

Table I: Patient and burn characteristics relative to outcomes and ICU admission (*n* 982)

	Mortality (*n* 106) (*n* %)	LOS*,ı (days)	ICU (*n* 98) (*n* %)
Age (yrs), mean (SD)			
35 (12.5)			
Sex			
Female 337 (34)	32 (9.5)	13 (7.28)	30 (3)
Male 645 (66)	74 (11.5)	13 (7.29)	68 (7)
Burns *n* (%)			
Flame 709 (72)	91 (13)	13 (5.23)	84 (12)
Scald 194 (20)	5 (2.6)	10 (6.22)	2 (1)
Electrical 68 (7)	10 (15)	13 (4.32)	10 (15)
Chemical 21 (2)	0	18 (5.30)	2 (10)
TBSA %			
Median (IQR) 15 (9–24)	56 (35, 81.5)		30 (18, 40)
Inhalation *n* (%) 112 (11)	41 (37)	17 (6.33)	80 (71)

ı Survivors
* Median (interquartile range)

Table II: Regression analysis of variable for ICU admission

	Odds ratio	95 CI	*p*-value
All patients			
Age	1.00	0.98–1.03	0.88
Male	1.15	0.57–2.33	0.69
TBSA	1.00	0.97–1.02	0.64
Inhalation injury	236	101–652.9	< 0.001
Burn type			
Scald	0	NA	0.98
Flame	0	NA	0.98
Chemical	0	0-14297	0.98
Electrical	0	NA	0.98
Severe burns			
Age > 50 years	1.02	0.97–1.08	< 0.001
TBSA > 20%	0.99	1.08–1.12	0.78
Inhalation	118.33	1.72–11.95	< 0.001

Table IV: Univariate regression analysis of outcomes by burn type

	Odds ratio		95% CI	*p*-value
Mortality				
Scald	1.46		0.25–6.10	0.64
Flame	10.19		1.77–52.16	0.005
Chemical	0		0–190.0	0.98
Electrical	10.17		1.80–53.17	0.006
	Estimate	**SE**	***z*-value**	***p*-value**
Length of stay* #				
Scald	0.31	0.41	0.90	0.37
Flame	0.42	0.41	1.00	0.32
Chemical	0.66	0.48	1.40	0.16
Electrical	0.75	1.13	1.78	0.07

*Negative binomial regression
#Survivors only

Table V: Univariate regression analysis of outcomes in patients with severe burn injury

Outcome	Odds ratio		95% CI	p-value
Mortality				
Age > 50 (*n* 127)	1.02		0.97–1.08	0.34
TBSA > 20% (*n* 98)	1.09		1.08–1.12	< 0.001
Inhalation (*n* 112)	7.52		1.72–11.95	< 0.001
	Estimate	**SE**	***z*-value**	***p*-value**
Length of stay* #				
Age > 50 years	0.006	0.01	-0.45	0.65
TBSA > 20%	0.01	0.005	2.93	0.003
Inhalation	0.27	0.13	2.05	0.04

*Negative binomial regression
#Survivors only

Severity of injury

The extent of burns was moderate with a median (IQR) TBSA of 15.0% (9.12,24.0). Ninety-eight patients (10%) suffered extensive burns (> 20% TBSA). The mean TBSA of patients admitted to ICU was 30%. Inhalation injuries, which occurred in 112 patients (11%), were all due to flame burns. Eighty patients with inhalation injury (71%) were admitted to ICU.

In-hospital outcomes

The in-hospital mortality was 10.8% (106 patients), of whom 65% (69) died in the burns ward. The LA50 was 51% TBSA, and the mean TBSA of patients who died was 57%.

The median LOS was 12 days. However, the mean length of hospital stay of survivors was 23 days. This indicates that the stays of some patients were inordinately prolonged: 52 of 876 (6%) surviving patients spent between 60 and 100 days in hospital and 24 (3%) spent more than 100 days. The ratio of LOS to TBSA is 1.5.

ICU admission

Ninety-eight (10%) patients were admitted to ICU of whom 84% had suffered flame burns. (Table II). This included 80 (71%) of 112 patients with inhalation injury, 24 (24%) of 98 patients with more than > 20% TBSA and only 10 of 68 (15%) patients with electrical burns. In the pooled data only inhalation injury significantly predicted admission to ICU. Patients with different burn types were equally admitted to the ICU.

Predictors

The effect of patient and injury descriptors on mortality and LOS is shown by multiple regression analysis in Table III. Patient age, TBSA and inhalation were highly significantly associated with mortality, but only TBSA with prolonged LOS. In the analysis of mortality, three of the four types of burn were significant predictors. While greater patient age and electrical burns tended towards greater LOS, only greater TBSA yielded a significant statistic. The merged regression analysis of Table III did not discriminate clearly between the roles of the different types of burn. These were, therefore, analysed separately (Table IV). Mortality was clearly related to flame and electrical burns. Electrical burn patients tended to have prolonged hospital stay. Because of the recognised need for ICU admission and poorer outcomes in patients who suffered severe injury, these patient data were dichotomised and analysed separately (Table V). The known relationship of extensive burns and inhalation injury with mortality is demonstrated in this analysis. In addition, these patients were more commonly admitted to ICU and spent longer in hospital. Interestingly, the outcomes of individuals aged above 50 years were not significantly associated with mortality or prolonged LOS.

Discussion

This report on adult burn injury patients from a single centre highlights many of the challenges in management of burn injury in countries in the developing world. LICs and LMICs are likely to have fewer facilities for burns management, and the outcome of burns injury is commensurately poorer.[4,22]

Demographic and injury findings in this study are similar to those of other units in South Africa. The revised Baux score predictors of greater mortality are mirrored in this cohort. In addition, this study evaluates other patient admission characteristics in predicting short term hospital outcomes in an LMIC, including the types of burn injury.

This report corroborates the preponderance of flame burns in South Africa. This injury is mainly caused by shack fires in informal settlements around cities. This is commonly accompanied by inhalation injury because of fires in confined and proximate spaces. Careless non-electrical heating and lighting with paraffin stoves, lamps and candles is common in these structures. Scalding by hot oil or water is common in informal settlements in South Africa, even in adults.[4,5] However, the 72% incidence of dry heat injuries is much higher than in other reports from sub-Saharan Africa such as Malawi (41%)[23] and Ghana (37%),[24] where scalding is more common. Chemical burns were uncommon in patients in this report. They were mostly due to careless storage of, or assault with, acids.

Of note is the relatively high incidence (7%) of electrical burns in this study. Only a minority of these patients were admitted to the ICU, contrary to recommendations.[25] These burns were significant predictors of greater mortality and longer hospital stay. Electricity is widely available in South Africa but carelessly used. Electrical cable theft and tampering with substations are common, as are multiple illegal connections to informal housing structures.[26] Electrical burns were much more common in this study than in other South African reports, in which they range between 1 and 4%.[14-16,18,20,21] One study from a specialist unit reported a higher incidence of 12%.[12] In developed countries the incidence of electrical burn injuries is reported as 0.04–5%.[27] The incidence of electrical injury in South Africa is probably greater as many victims are electrocuted and never reach a hospital. Because of the characteristics of urbanisation and the careless use of electricity, the prevalence of this type of burn injury has been extremely difficult to modify. Its significance in causing major costly adverse outcomes in this study is noteworthy.

The mortality rate of 10.8% in this study is similar to some units in South Africa,[14-18] but in other units rates range up to 25%.[19-21] This variance may be due to local referral patterns and patient definitions, but is probably also related to differences in resource availability. A review of burns reports from sub-Saharan Africa reveals a mean mortality of 17%.[28] One reason for the comparatively favourable mortality rate in this adult study may be that the patients were relatively young. The lack of effect of age of greater than 50 years on the two outcomes was unexpected. This may be due to the relatively small number of patients in this category (127, 13%). In addition, the fact that more patients survived than died, could have affected these statistics. While the LA50 of 51% in this study is acceptable, it has been progressively increasing in recent decades in HICs. The figure is reported as 74% in one report.[12] Mortality has been decreasing in developed countries in recent decades,[22,29] even in the elderly, with LA50 rates exceeding 70%.[30] Treatment of a patient who has suffered a severe burn injury is based primarily on the moral premise of saving a life. Attempts to improve mortality rates would necessarily escalate the need for facilities, and therefor costs, in developing countries.

There was an insufficiency in the availability of ICU beds in the current study. Not all patients with more than 20% TBSA burn in this cohort could be admitted to the ICU. This also applied to a substantial proportion of patients with inhalation and electrical injury. It is problematic that 65% of deaths occurred in the burns ward. ICU admission criteria are complex and are dependent on several factors. In burns patients, inhalation injury and the extent of TBSA have been found to be defining factors in the need for ICU treatment.[31] However, ICU treatment has significant cost implications, as has been shown also in South Africa.[7] Under ideal circumstances, ICU treatment for patients with extensive, inhalation or electrical injuries would be mandatory. The need for additional ICU resources in South Africa as well as the more efficient use of the existing facilities has been previously highlighted.[32] Predictors of this necessity which were identified in this study may inform future burn management planning.

The mean hospital LOS was 23 days. This is the same as that in a report of severe burns (TBSA 31%) from HICs.[10] Prolonged LOS is common in South African burn units. Most report a stay of several weeks but in one report the mean stay was 68 days.[15] The patients in the current study were kept for prolonged periods because of inefficient management through tardy procedures, the development of wound infection and sepsis and insufficient theatre time. In addition, there are no stepdown facilities in our system for stable patients requiring dressings or awaiting procedures. The LOS of patients in hospital is an important cost driver in the treatment of burns. These rise exponentially with increasing TBSA, which is therefor a major determinant.[2] TBSA as a predictor of LOS is demonstrated also in this study, as in other South African studies.[14,15,20] In this study, electrical burns also tended to prolonged LOS. It has been shown that greater utilisation of outpatient care can reduce costs considerably.[33] Provision of such alternative facilities for wound care outside the referral hospital may reduce LOS and therefor costs in LICs and LMICs.

This study evaluated factors associated with outcomes in a burns unit with deficient means. The KPTH unit, like many of the designated units in South Africa, is under-resourced. Acceptable standards for burns units are recommended by organisations such as the American Burns Association and the European Burns Association. However, each layer of sophistication in skills, facilities and consumables entails greater expenses. An example of deficiency in a constrained unit is related to the ability to perform early burn wound excision. This method is considered the gold standard for treating deeper wounds.[34] It results in lower mortality and shorter hospital stay. However, early excision is not always feasible in units without dedicated facilities, such as the one described in this report. While public expenditure on healthcare in South Africa appears to be adequate, the delivery of services is inadequate.[35] Care of burns patients suffers commensurately. This is reflected in sub-Saharan African and global reports.[22] Outcomes in resource-constrained units are important in determining the need for staffing and infrastructure provision, and predictors therefore would affect planning and costs of acute care.

This study has some limitations. While deficiencies are described, actual costs were not measured nor cost implications calculated.

Conclusion

This study concurs with studies from the developing world in the constraint on resources. The LA50 was lower and the hospital stay longer than what could be seen as desirable. There was a preponderance of injury due to flames, and a relatively high incidence of electrical burns. Unsatisfactory outcomes were predicted by the elements of the revised Baux score, but also by flame and electrical burns. ICU treatment was clearly predicted by patient admission characteristics but there was a deficiency of ICU treatment facilities. Longer hospital stay was significantly related to TBSA only. Many of the challenges of burn injury can be addressed only by socioeconomic advancement. While prevention is ideal, health authorities should be aware of the need for higher levels of care for some categories of patients, and for step-down facilities to achieve greater efficiency in burn management. The systemic constraints described here are potentially modifiable but not by clinicians. Rather than designating some hospitals simply as "burns centres" they could be classified according to tiers of burn-management facilities and expertise. Expensive care or prolonged treatment could be ameliorated by imaginative planning in South Africa.

Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

The study was approved by the Ethics committee of the Faculty Health Sciences of the University of Pretoria (263/2019). It was conducted in accordance with the code of Ethics of the World Medical Association (Declaration of Helsinki).

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