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Predictors of Mortality in Thermal Burn Injury: A Ten-Year Retrospective Review from a Major Burn Center in South Western Nigeria.

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Abstract

Background: Several factors such as age, gender, burn depth, and inhalation injury have been associated with the mortality from burn injuries. While studies have looked at the association between these factors and burn mortality with varying results, very few studies in our region have focused on which of these parameters can be used to predict burn mortalities. This study was carried out to establish the current mortality rate from thermal burn, and to identify the predictors of burn mortality.
Method: This was a ten-year retrospective review of thermal burn injuries in our burn center. statistical tests were done using Chi-square, multivariate, and multiple linear regression analysis.
Result: A total of 595 thermal burn injuries were seen in the period under review, with a mortality rate of 19%. Mortality rate was higher in females (20%) than males (18%), p=0.491. Shorter hospital stays (p=<0.001), presence of inhalation injury (p=<0.001), thermal etiology (p=<0.001), as well as increasing age (p=<0.001), Total Body Surface Area [TBSA] (p=<0.001), burn depth (p=<0.001) were associated with mortality. However, only burn depth (β=0.241, p=<0.001) and TBSA (β=0.473, p=<0.001) were found to be significant predictors of mortality.
Conclusion: Only burn depth and TBSA are significant predictors of mortality.

Keywords: mortality rate, predictors of mortality, burn depth, TBSA, LD50.

Abbreviations: WHO, World Health Organization; LOS, length of hospital stays; TBSA, total body surface area; LD50, lethal dose (burn surface area) with 50% mortality; DPT, deep partial thickness; FT, full thickness; SPT, superficial partial thickness; LPG, liquified petroleum gas; LMIC, low- and middle-income countries.

1:0. Introduction

Despite the advances in burn triage and management, burn injury remains a global challenge. The two most pressing challenges are burn morbidities for survivors, and mortality. Though burn mortality has declined globally, the annual incidence of 180,000 deaths is still a disaster (Gauglitz & Williams, 2023), (World Health Organization [WHO], 2018). A large proportion of the burn mortality is said to be in the low- and middle-income countries like Nigeria (WHO, 2018). This high proportion is unsurprising considering the observation that over two-thirds of burn injuries are said to occur in this low- and middle-income countries (Gauglitz & Williams, 2023), (WHO, 2018).

Several factors have been associated with the mortality from burn injuries. These factors include the region, age of the patient, gender (WHO, 2018), (Olaitan & Jibrum, 2006). The low- and middle-income country regions with high burn mortality are regions with low socioeconomic status, fewer facilities for adequate burn care, as well as shortage of trained man power. The patients in some of these countries such as Nigeria access health care through out-of-pocket payment, this makes both access and provision of health care to the patients challenging. The older age group are more likely to have co-morbid conditions that worsen the outcome of burn injury (Gauglitz & Williams, 2023).

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Burn mortalities are also influenced by some burn characteristics such as TBSA, burn depth, presence of inhalation injury, burn wound sepsis and other associated injuries (Olaitan & Jibrum, 2006), (Tarima, 2013). The association between increasing TBSA and mortality has been attributed partly to the complications from a large area of lost skin (Tarima, 2013).

This predisposes the patient to bacterial colonization with the lost skin barrier, increasing fluid and electrolyte disturbances from evaporative fluid loss, as well as temperature dysregulation. Inhalation injury is a major risk factor for mortality due to its effect on the respiratory system. This predisposes the patient to respiratory complications such as pneumonia, atelectasis, and acute respiratory distress syndrome (Foncerrada et al, 2018), (Dries &Endorf, 2013). These complications in addition to airway oedema, and hypoxemia worsen the outcome of burn injuries.

Globally, mortality of 3% to 55% have been reported from burn injuries (Gauglitz& Williams, 2023). In Nigeria, mortality rates ranging from 14.3% to 39.5% has been reported (Isiguzo et al, 2020), (Fasika, 1997), (Iyun et al 2016), (Olawoye et al, 2014). These rates are much higher than what is obtained in the developed countries. It is therefore important to evaluate the epidemiological predictors of burn mortality in our region in order to proffer solutions to the challenge. An understanding of the predictors of burn mortality in our region will be crucial in formulating local policies and prevention programs that will help reduce the mortality rate. This study was therefore carried out to establish the current mortality rate from thermal burn injuries, identify the role of age, gender, TBSA, burn depth, inhalation injury, endotracheal intubation, and mechanical ventilation in burn mortality.

2:0. Method

2:1. Study setting and design

This was a ten-year retrospective review of all burn injury patients that presented to a major tertiary hospital in South western Nigeria between January 2013 and December 2022. Our burn unit is a 12-beded center that serves approximately 7million residents of Oyo state, as well as patients from neighboring states in the south western region of Nigerian. The tertiary hospital, a1229-beded facility, is the premier teaching hospital in Nigeria

2:2. Case definition

All patients that presented with thermal burn injury (flame, scald and contact burn) were included on the burn registry. Inhalation injury was a clinical diagnosis made from history and physical examination of the patients. It was not confirmed with fiber-optic bronchoscopy, nor graded due to unavailability of fiber-optic bronchoscopy in our burn unit. Patients with clinical features of inhalation injury were reviewed by anesthetists and prophylactically intubated as part of the burn unit protocol for management of inhalation injury. Those who showed features of respiratory failure were mechanically ventilated.

2:3. Data collection

The burn unit registry was retrospectively reviewed in line with the Helsinki declaration both in data collection and analysis. The age, gender, burn surface area, burn depth, presence of inhalation injury, etiology of the burn, ventilatory support status, mortality, and length of hospital stays were entered into the statistical package for social sciences version 23, and analyzed. Statistical test using Chi-square, multivariate, and multiple linear regression analysis were done at confidence interval of 95%. Test was statistically significant if p-value is less than 0.05.

3:0. Results

3:1. Age and gender trend in mortality

A total of 595 patients had thermal burn, comprising 351 males and 244 females with an overall mortality rate of 19% (table 1). Of the 351 males, 18% died from the injury, while 20% of females died from the burn injury (table 1), $p = 0.491$. There were 323 adults and 265 children. 26% of adults and 10% of children died from the burn injury (table 1, fig.1), $p = <0.001$. The mean age of those who died was 30.3years ±18.4, while the mean age of those who survived was 20.6years ±18.7.

Table 1: Patient's demography and burn characteristics associated with mortality

	Survivor, n(%)	Mortality, n (%)		Flame	Survivor, n (%)	Mortality, n (%)
Age, mean	20.6yrs±18.7	30.3±18.4		Kerosene	28(62)	17(38)
TBSA, mean	23.5±19.9	59.3±23.7		Petrol	108(74)	37(26)
LOS, mean	13.5±17.2	7.9±12.4		LPG Gas	89(68)	41(32)
Age group			Total, n(%)	RTA	48(87)	7(13)
Adult	238(74)	85(26)	323 (100)	Candle	2(67)	1(33)
Pediatric	238(90)	27(10)	265(100)		X^2 =9.849	p=0.043
	X^2 =24.554	p=<0.001				
Male	287(82)	64(18)	351(100)	**%TBSA**		
Female	194(80)	50(20)	244(100)	1--20	259(98)	6(2)
	X=0.474	P=0.491		21--40	116(85)	20(15)
Flame	275(73)	103(27)	378(100)	41--60	60(67)	30(33)
Scald	192(95)	11(5)	203(100)	61--80	20(37)	34(63)
Contact	14(100)	0(0)	14(100)	81--100	10(30)	23(70)
	X^2 =44.033	P=<0.001			X^2 =180.715	P=<0.001
Depth						
SPT	397(86)	67(14)		**Inhalation Injury**		
DPT	53(84)	10(16)		Yes	117(62)	73(38)
FT	31(46)	37(54)		No	364(90)	41(10)
					X^2=68.861	P=<0.001
	X^2 =61.672	p=<0.001		**Incidence of inhalation injury= 190(32%)**		
Intubation						
Yes	78(57)	58(43)		**Total burn**	481(81)	114(19)
No	402(88)	56(12)		LD50=75.6		
	X^2 =63.751	p=<0.001				

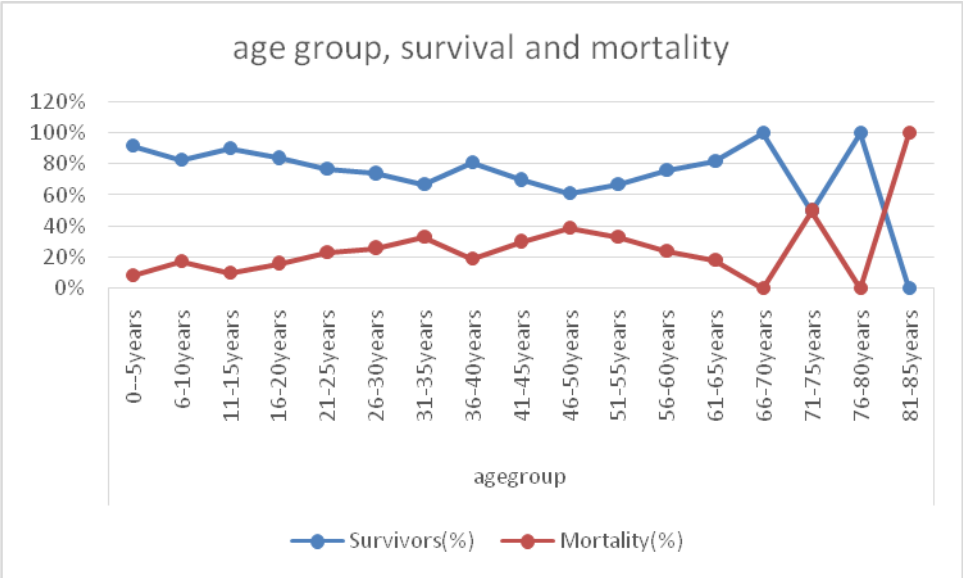

Figure 1: Relationship between age and mortality showing increasing mortality with increasing age. X^2= 42.115, p=<0.001.

3:2. TBSA and Burn depth in mortality

The mean TBSA of those who survived was 23.5% ±19.9, while those who died had a mean TBSA of 59.3% ±23.7. Most of the patients who survived had TBSA less than or equal to 20%, with mortality rate of 2%, while 30% of those who died had TBSA within 61 to 80% with a mortality rate of 63% (table 1), p = <0.001. A total of 464 patients had superficial partial thickness burn with a mortality rate of 14%, while 68 patients sustained full thickness injury with a mortality rate of 54% (table 1), p = <0.001. LD50 is 75.6% TBSA.

3:3. LOS, etiology and burn mortality

The mean length of hospital stay was longer in the survivor group (13.5 days±17.2) compared with the mortality cohort (7.9days±12.4). Of the 203 patients that had scald injury, 192 (95%) survived with a mortality rate of 5%, while 103 (27%) of the 378 with flame injury died (table 1), p = <0.001. Among the survivors, 108 (39%) of the 275 flame injuries was caused by petrol, while 41 (40%) of the 103 mortalities from flame was caused by LPG gas cookstove explosion (table 1), p = 0.043.

3:4. Inhalation injury, Endotracheal intubation and mortality in burn

Inhalation injury occurred in 190 (32%) of the 595 patients with a mortality rate of 38% (table 1), p = <0.001. The incidence of endotracheal intubation was 57% among the survivors and 43% among the mortality cohort had endotracheal intubation, p = <0.001

3:5. Multivariate and Multiple linear regression analysis

Of all the variables associated with mortality, when subjected to multivariate analysis, the length of hospital stays (p=0.019), %TBSA (p=<0.001), burn depth (p=<0.001), presence of inhalation injury (p=0.025), mechanical ventilation (p=<0.001), and endotracheal intubation (p=<0.001) were found to positively correlate with mortality. The cause of flame (p=0.734), gender (p=0.906), and age (p=0.054) were found not to be statistically significant cause of mortality (table 2). When these variables were subjected to multiple linear regression analysis, only the TBSA (β= 0.473, p=<0.001) and burn depth (β=0.241, p=<0.001) were found to be significant predictors of burn mortality (table 3).

Table 2: Multivariate analysis of factors associated with mortality

Multivariate analysis	Survivor, n(%)	Std error	p value
Factor	F		
LOS	5.601	1.779	0.019
Age	3.775	1.613	0.054
TBSA	46.207	0.1	<0.001
Inhalation Injury	5.158	0.047	0.025
Flame etiology	0.116	0.177	0.734
Gender	0.014	0.046	0.906
Ventilatory Support	16.753	0.019	<0.001
Burn depth	17.561	0.086	<0.001
Intubation	17.264	0.044	<0.001

Table 3: Multiple linear regression analysis showing Burn depth and TBSA as significant predictors of burn mortality.

Factor	Unstandardized B	Std Error	Standardized B	t	p value
Burn depth	0.098	0.015	0.241	6.332	<0.001
*TBSA %	0.152	0.015	0.473	10.021	<0.001
Gender	0.052	0.03	0.064	1.723	0.085
Age	-0.012	0.01	-0.591	-1.277	0.202
Etiology	0.006	0.034	0.008	0.179	0.858
Inhalation injury	-0.071	0.049	-0.084	-1.438	0.151
**LOS	-0.003	0.001	-0.123	-3.268	0.001

*TBSA, total body surface area; **LOS, length of hospital stays.

4:0. Discussion

Burn injury is a preventable disaster that continues to account for significant morbidity and mortality especially in many LMIC. Its consequences have been largely divided into two- morbidity, and mortality. Burn etiology, place of occurrence, and mortality follows some epidemiological pattern such as gender, and age. Most (59%) of the patients in our study were males. This is in keeping with local epidemiological studies that shows the male population to be the most commonly affected gender (Olaitan & Jibrum, 2006), (Olawoye et al, 2023), (Güldoğan et al, 2019), (Forbinake et al, 2020). With flame being the most common cause of burn, and men more often required to lead rescue operations and protect the family, it is not surprising that this gender continues to be the most at risk group in our clime. Despite the male preponderance in thermal burn injury from our study, we found that females had a higher mortality rate (20%) compared with males (18%). The finding though not statistically significant is in keeping with WHO (2018) report that females have a higher mortality rate from burns. Güldoğan et al (2019) found that most of the patients in the mortality cohort were females, though 81.7% of the burn injured patients in that study were males. Gender was however not statistically significant on multivariate and multiple regression analysis, but the slightly higher risk of mortality should merit some concern and attention in burn prevention.

Children constituted about 45% of the burn injured patients during the study. This is similar to the findings by Olawoye et al (2014), Iyun et al (2016), and Forbinake et al (2020). In terms of mortality, children had a mortality rate of 10%, compared with 26% in adults. The age-related mortality is statistically significant on univariate analysis; however, it was not significant on multivariate analysis. Multiple linear regression analysis showed that age was not a significant predictor of mortality in thermal burn injury. This age-related mortality might be due to the etiologic pattern, with children sustaining less severe injury predominantly from scald whereas adults were more likely to suffer flame burn with consequent risk of inhalation injury. The pediatric mortality rate from this study is remarkably lower than the 39.5% reported by Olawoye et al (2014) from the same institution almost a decade ago. It is a measure of improvement in burn management in this facility and offers hope for further reduction in mortality.

The mean TBSA of the survivors was 23.5% compared with 59.3% for the mortality cohort. It showed a statistically significant relationship between increasing TBSA and mortality, and this relationship remained significant on multivariate analysis. This is in keeping with other studies (Olaitan &Jibrum, 2006), (Olawoye et al, 2014), (Güldoğan et al, 2019), (Forbinake et al, 2020). The LD50 from our study was TBSA of 75.6%. This is remarkably higher than LD50 of 53% by Fasika (1997) and 45% by Olawoye et al (2014) from this institution earlier. Iyun et al (2016) also reported a lower LD50 of 53%TBSA in the inhalation injury cohort, and 64% in the cutaneous burn only cohort. Our finding further shows gradual improvement in the outcome of burn injury, though the mortality is still remarkably high. Multiple linear regression analysis showed that increasing TBSA was a significant predictor of burn mortality. We found that increasing burn depth correlates positively with mortality rate and was statistically significant both on univariate and multivariate analysis. The finding is similar to other studies (Tarima, 2013), (Forbinake et al, 2020). The relationship between increasing TBSA and burn depth with mortality might be due to the increase in fluid and electrolyte disturbances that ensues in such burn, as well as the increasing risk of burn wound infection and its sequalae. When this relationship between burn depth and mortality was subjected to multiple regression analysis, it was found that increasing burn depth was a significant predictor of mortality from thermal burn.

Flame was the most common cause of mortality from thermal burn injury, with LPG cookstove explosion contributing the most mortality from flame burn injury. Though both were statistically significant on univariate analysis, they were not significant on multivariate and multiple linear regression analysis. This is similar to studies from Nigeria, Cameroon, and Turkey (Olaitan & Jibrum, 2006), (Iyun et al, 2016), (Olawoye et al, 2023), (Güldoğan et al, 2019), (Forbinake et al, 2020). The mortality cohort had a shorter length of hospital stay which was significant on both univariate and multivariate analysis. This shorter length of stay indicates that most deaths occurred at about the end of the first week and might be due to the more severe nature of the burn with those in mortality cohort having larger TBSA injuries. This is a critical period post resuscitation where infection is likely to be the major challenge of burn care. This period should be an important target of burn care in order to further reduce the burn mortality in our environment. Regression analysis showed that length of stay is inversely related with mortality. This is similar to reports by Güldoğan et al (2019). Pavoni et al (2010) reported a mean length of hospitalization of 30.9days in the mortality cohort, though shorter than the survivor cohort, it is however longer than the 7.9days from our study. The study by Pavoni (2010) involved a smaller sample size than our study and involves patients admitted into the intensive care unit.

In this study, the incidence of inhalation injury was 32%, with a mortality rate of 38% among those with inhalation injury. This represents a 5% reduction in the incidence of inhalation injury, and a near 50% reduction in mortality in the inhalation injury cohort when compared with the 37% incidence and 71% mortality reported by Iyun et al (2016) from the same institution about a decade ago. Adigun et al (2001) reported a mortality of 78% from inhalation injury from the author's institution twenty-two years ago. This is another evidence of improvement in burn care, that despite the marginal reduction in incidence of inhalation injury, there was a remarkable reduction in mortality in the inhalation cohort. Inhalation injury was however not a statistically significant predictor of mortality from thermal burn injuries. The incidence of endotracheal intubation was 23%. Vagholkar et al (2021) reported an incidence of 61% and a mortality rate of 83.7% in a study in India. Similarly, Güldoğan et al (2019) reported a 67.3% mortality in those with inhalation, while 55.3% were ventilated. The incidence of inhalation injury in our study is however higher than the reports by Tarim (2013) and Olaitan & Jibrum et al (2006). There is therefore need to continue patient education on burn injury prevention which will further reduce the severity of burn thereby improving the outcome.

The overall mortality from our study is 19%. This is much lower than the earlier mortality rates from this institution (Fasika, 1997), (Iyun et al, 2016), (Adigun et al, 2001). It shows a promising result, that with more concerted efforts in burn care, a progressively improving outcome is feasible. The overall mortality rate in this report is similar to the 20.4% reported by Boissin et al (2019) from South Africa. Our mortality rate is lower than the 44.2% reported by Güldoğan et al (2019). Though the study involved patients with TBSA of 30% or larger.

5:0. Conclusion

This study found an overall improvement in burn outcome in our institution with a lower mortality rate of 19%. Though several factors such as age, gender, TBSA, burn depth, LOS, presence of inhalation injury, etiology of burn, ventilatory support status were found to be associated with mortality, we observed that age, TBSA, burn depth, inhalation injury, and etiology being flame are factors significantly correlated with mortality in thermal burn. We however found that only burn depth and TBSA are the significant predictors of mortality.

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