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Original Research Article

Yearly Trends in Burn Injury Outcome; A Nigerian Regional Burn Center Experience

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Abstract: Major burn injuries are an important cause of morbidity and mortality worldwide. Reports of improved outcome in developed countries may not reflect the situation in developing nations despite efforts at improving burn care. We aimed at evaluating yearly trends in burn injury outcome. The study was a retrospective study of patients who presented with burn injuries from 2011 - 2021. Information obtained included biographic data, injury characteristics, trends and determinants of outcome. Data was analyzed using SPSS version 29. A total of 866 patients were recorded with yearly average of 78.72. Incidence and severity of injury increased over the years. Some more current practices were yet to be adopted at the center. Most common complications were sepsis and renal failure. Trends of outcome measures were not consistent. Average maximum TBSA salvaged was 62.32 ±12.13 (41- 81), mean mortality rate was 15.16 ± 10.00 (0 - 36.23), mean LA_{50} was 55.25 ± 19.05 (37.36 - 95.91) while average mean TBSA in those that died was 68.37 ±10.71 (50 – 88). Age, gender, dressing agents, TBSA, inhalation and depth of injury had variable but significant effects on outcome. Adopting more current practices will improve outcome but requires funds and support.

Keywords: Burn Injury, Trends, Outcome, Regional Center.

INTRODUCTION

Major burn injuries cause significant morbidity and mortality throughout the world. Burn sepsis is the leading cause of mortality followed by burn shock. There have been reports of improved survival as a result of advances in the treatment of burns especially in developed countries. These include increased insight into the pathophysiology of burn injuries, improvement in fluid resuscitation, use of antibiotics and introduction of intensive care as well as early wound excision and provision of skin cover. [Lal S *et al.* 2012][Strassle PD *et al*. 2017][Sheridan RL et al. 2000][Abdelrahman I *et al.* 2017], This may not be the case in developing nations, especially sub-Saharan Africa though there have been efforts at improving burn care. Some studies seem to suggest that while there are changing patterns in terms of epidemiology of burn injuries and efforts at improving care, outcome has either remained the same or has not shown steady progress. [Ibeanusi S & Kejeh B, 2022][Shahmiri S *et al*. 2017][Haagsma JA *et al*. 2016], Reports in Nigeria show that mortality rate for burn injuries vary widely ranging from 3.3% to 35% depending on centers, age groups studied and severity of injuries. [Okoro PE et al. 2009][Mabogunje A *et al*, 1987][Oladele AO & Olabanji JK, 2010]. Among the factors that are known to influence outcome include age, sex, comorbidities, severity based on TBSA and depth, presence of inhalational injuries and care given. [Shahmiri S *et al*. 2017][Attia AF *et al*. 1997] [Akhtar M *et al*. 2014], The regional burn center is a 500 bedded tertiary health facility for orthopaedics, trauma, burns, plastic and reconstructive surgery. It serves as a referral center for the South-East, parts of South-South and North-central regions of Nigeria. It was designated as a regional burn center in 2010 which brought observable changes in the provision of care to burn patients particularly with regard to infection control measures and resuscitation. However there has not been any study in this region that evaluated the trends in outcome of management of burn injuries.

The aim of this study was to evaluate the trends in burn injury outcome by determining LA_{50} for burn injuries, highest TBSA salvaged each year, yearly mortality rate and mean TBSA of deceased patients as well as determinants of mortality.

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MATERIALS AND METHODS

The study was a retrospective study that covered 11-year period, January 2011 to December 2021 Ethical approval was obtained from the institutional review board of the hospital. All patients who presented with burn injuries, were managed and completed treatment in the hospital were included in the study. Those that were either referred or discharged against medical advice were excluded from outcome analysis. Information obtained included biographic data, characteristics of burn injuries, and the outcome of treatment. Highest TBSA salvaged each year, yearly mortality rate, mean TBSA of deceased patients and LA50 were calculated and recorded. Data was analysed using Statistical Package for Social Sciences (SPSS) version 29 (IBM Inc. Chicago, USA). Determinants of mortality were subjected to tests of significance using Chi square (X^2) test and values less than 0.05 were considered significant. LA50 was determined using probit regression analysis. Results are presented in prose, tables and charts.

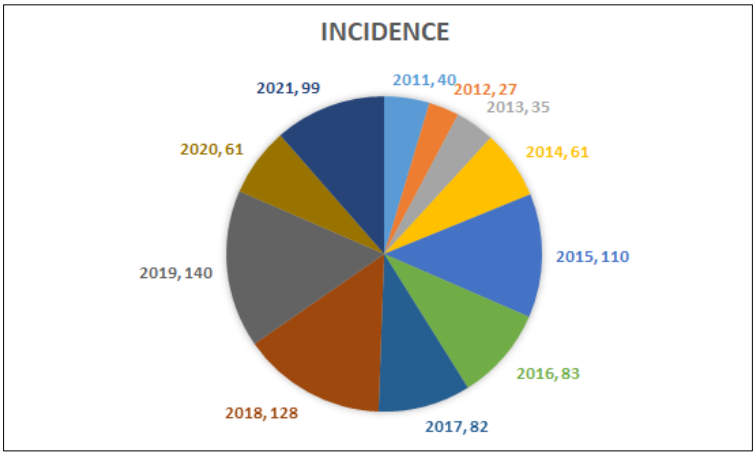

Figure 1: Pie chart showing distribution of yearly incidence of burn injury

RESULTS

A total of 866 patients were recorded over the period with yearly average of 78.72, lowest incidence in 2012 and highest incidence in 2019 (Fig. 1). There was relative but non-proportional increase in incidence over the years.

Overall, the patients were 50.5% (N=437) males and 49.5% (N=429) females. However there was a changing pattern of male to female ratio with male predominance from 2011 to 2015, and female predominance afterwards.

The patients were aged between 3 months and 88 years with mean age that ranged from 14.53 ±14.55 in 2013 to 26.14 ±23.32 in 2021.

Etiology of Injury

The commonest cause of injury over the years was flame except in 2013 when scald was recorded as the commonest. Flame constituted 522(60.63%), scald 281(32.64%), electrical 34(3.95%), chemical 17 (1.97%) and others (hot solid, bitumen and saw dust), 7(0.81%).

Presentation

An average of 46% ± 11.13% (SD) with a range of 27.5 to 61.4% of patients presented within 8 hours of injury while an average of 25.5% ± 9.4% (SD) with a range of 6.4 to 38.9% of patients presented between 8 and 24 hours. The rest which ranged from 18.6% to 40% with an average of 28.5% ± 7.7% (SD) presented after 24 hours of injury.

Characteristics of Injury

The total body surface area (TBSA) was assessed using the Wallace's [Moore RA & Waheed A] rule of nines in adults while Lund and Browder's [Lund CC & Browder NC] chart was used in children. (Table 1).

Table 1: Distribution of Mean Total Burn Surface Area

Year	Mean Tbsa (%)	Sd (%)	Range (%)
2011	19.07	±12.88	1.00 – 51.00
2012	20.52	±18.10	1.00 – 72.00
2013	16.01	±19.83	0.50 – 88.00
2014	25.61	±22.92	0.30 – 97.00
2015	22.03	±24.55	0.50 – 95.00
2016	27.28	±27.47	0.50 – 100.00
2017	34.99	±30.42	1.00 – 100 00

2018	24.46	±25.39	0.15 – 100.00
2019	18.81	±22.35	0.20 – 98.00
2020	24.75	±23.35	00 – 90.00
2021	26.22	±23.27	3.00 - 80

Superficial partial thickness injury was the most frequent depth of injury recorded all through the years. (Table 2)

Table 2: Distribution of Depth of Burn Injury

Year	Superficial Partial Thickness (%)	Mixed Thickness (%)	Deep Partial Thickness (%)	Full Thickness (%)	Superficial (%)
2011	16.00 (45.71)	13.00 (37.14)	05.00 (14.29)	01.00 (2.86)	0.00
2012	15.00 (60.00)	07.00 (28.00)	03.00(12.00)	00.00	01.00 (4.00)
2013	21.00 (68.57)	07.00 (25.71)	01.00 (3.33)	01.00 (3.33)	0.00
2014	33.00 (61.11)	16.00 (29.63)	04.00 (7.41)	01.00 (1.85)	00.00
2015	66.00 (61.68)	28.00 (26.17)	04.00 (3.74)	08.00 (7.48)	01.00 (0.93)
2016	41.00 (54.67)	28.00 (37.33)	02.00 (2.67)	04.00 (5.33)	0.00
2017	31.00 (44.29)	27.00 (38.57)	01.00 (1.43)	11.00 (15.71)	0.00
2018	56.00 (53.33)	29.00 (27.62)	05.00 (4.76)	09.00 (8.56)	06.00 (5.71)
2019	78.00 (60.47)	39.00 (30.23)	06.00 (4.65)	02.00 (1.55)	04.00 (3.10)
2020	41.00 (73.21)	11.00 (19.64)	03.00 (5.36)	00.00	01.00 (1.79)
2021	32.00 (36.36)	35.00 (39.77)	13.00 (14.77)	7.00 (7.95)	1.00 (1.14)

The history of burn injury to the face and/or occurring in an enclosure, coughing up of carbonaceous sputum and findings of singed nasal hairs, hoarseness, and respiratory impairment formed bases of the diagnosis of inhalation injury.

The highest percentage incidence of inhalation injury occurred in 2017, and the least was in 2011. (Fig. 2)

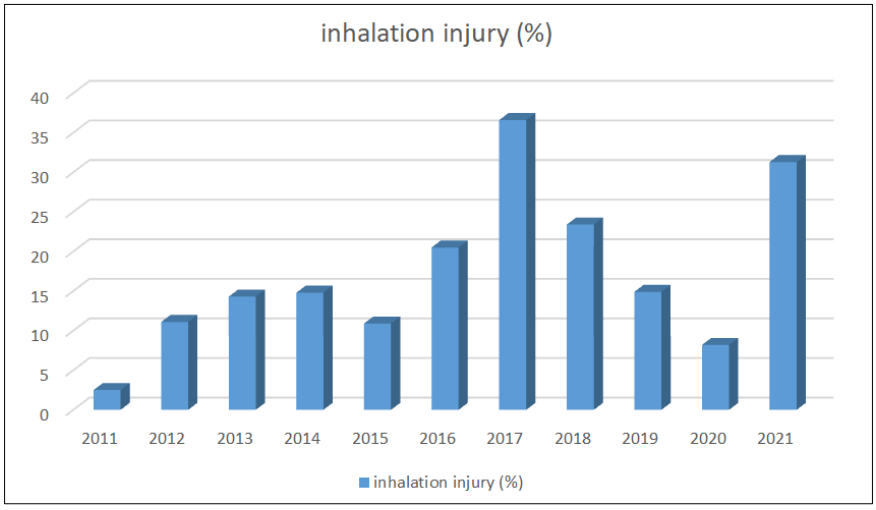

Figure 1: Bar chart showing distribution of inhalation injury

Management

Most patients were received in the accident and emergency section of the hospital. A total of 638 patients representing 73.67% with yearly variation of between 68% and 96% met the criteria for admission and were admitted to the acute burn ward while others were treated on out- patient basis. Admission criteria included more than 10% partial thickness injuries in children and the elderly, and more than 15% partial thickness injuries in others, more than 5% full thickness injuries, burns in special areas, electrical, chemical and inhalation injuries. Resuscitation was with lactated Ringers solution in most cases and normal saline in few cases using Parkland formula for the estimation. For those that presented early, half of the estimated fluid volume was administered within 8 hours of injury and the remaining over 16 hours.

Occlusive dressings were used with topical agents that included silver sulfadiazine predominantly between 2011 to 2014, povidone iodine with sufratulle predominantly between 2017 and 2021. More modern dressing materials containing any of nano-crystalline silver (Acticoat^{R}/Exalt T7^{R}), ionic silver impregnated nylon (Therabond$^{R)}$ and cellulose (Epigraft^{R}) were increasingly used between 2015 and 2018 and were predominant in 2016.

Most patients were given antibiotics on the day of presentation while few were given when there were signs of infection. Ceftriaxone was the commonest antibiotic used followed by co-amoxiclav all combined with metronidazole or tinidazole. Other antibiotics used were based on severity of infection or sensitivity reports.

Early in the years, intranasal oxygen was the only treatment for inhalation injuries. Nebulization with various agents like heparin and salbutamol was gradually introduced until it became the dominant treatment. There was no record of bronchoscopy and intubation in the management of inhalation injuries.

Surgical Procedures

164 surgical procedures were carried out in 132 patients, the commonest being split-skin grafting (SSG) which was 112 (68%) followed by wound debridement and escharectomy which were 37 (25%). 6 (3.7%) were amputations; 4 below knee and 2 ray amputations. 5 (3%) were escharotomy/fasciotomy. Only four (2.4%) excision and SSG were done.

Complications

The commonest complication encountered was sepsis which occurred in 109 patients with a yearly average of 9.9 ± 9.8(SD) and a range of 2 – 37. Sepsis was associated with 36 (28.1%) out of 128 deaths recorded with a yearly average of 3.6 ± 3.1(SD) and a range of 0 – 9. Between 33.7% and 100% of those that had sepsis presented after 24 hours of injury.

Acute renal failure was encountered in 42 patients with annual mean of 2.4 ± 2.8 (SD) and a range of 3 – 9. Death of 24 (18.8%) patients was associated with acute renal failure with annual average of 2.4 ±2.8 (SD) and a range of 2 – 7. Between 50% and 80% of those that had acute renal failure presented to the hospital after 8 hours of injury.

Other complications included pneumonitis, contracture, However, the association between time of presentation and complication was only statistically significant in 6 noncontiguous years.

Outcome

779 out of the total patients met criteria for outcome analysis. There was no consistency in the trends of outcome measures over the years. The average maximum TBSA salvaged 62.32 ±12.13 while mean mortality rate was 15.16 ± 10.00. The mean LA_{50} was 55.25 ± 19.05 while the average mean TBSA in those that died was 68.37 ±10.71. (Figure 3)

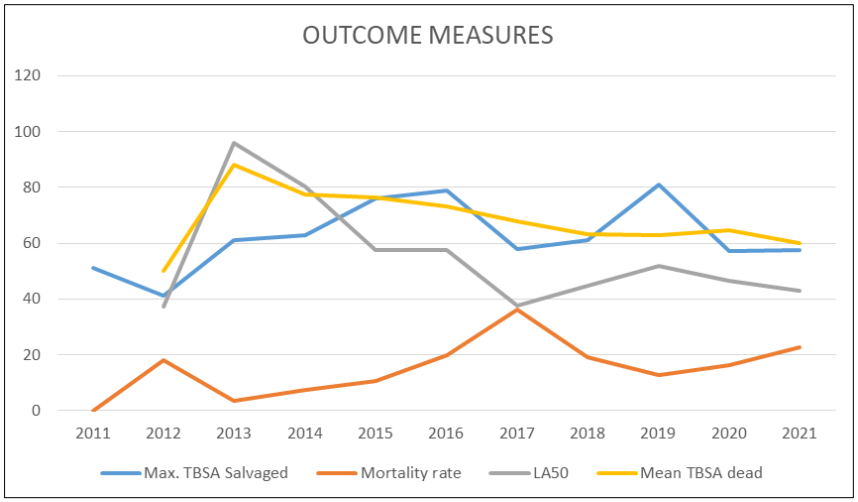

Figure 2: Line chart showing distribution of outcome measures (TBSA = total body surface area, LA_{50} = lethal area 50)

Factors That Influenced Outcome

The most consistent factor that had statistically significant effect on outcome over all the years was the depth of injury with P values that range from <.001 to .016 and a mean of .003 ± .004. Inhalation injury affected outcome, but the effect was statistically significant from 2015 to 2021 (P = <.001 - .002), while the treatment of inhalation injury had statistically significant effect from 2014 to 2021 (P= <.001 - .004). There was more survival in those that were nebulized than those that had only intranasal oxygen.

Dressing agents used had statistically significant effect on outcome in six nonconsecutive years, three of which coincided with when more modern dressing agents were predominantly used. More deaths were recorded where conventional dressing agents were used.

More deaths resulted from flames than other causes of burn injury. However, effect of cause of injury on outcome was significant in five nonconsecutive years (P= <.001 - .043). The effect of TBSA on outcome was significant statistically in four years (P= <001 - 0.019). Gender had statistically significant effect on outcome in

four years (P<001 - 0.002). 58.6% (75) of those that died were females.

The least effect on outcome was recorded with patients' age which was significant only in three years where no death was recorded in children who sustained mostly scald injuries.

DISCUSSIONS

The results show an increase in incidence as well as severity of burn injuries over the years. This may be as a result of increasing awareness and referral to the facility as a regional burn center. It may be a reflection of actual increase in the incidence of burn injuries as there have been similar reports of changing epidemiology of burn injuries in sub-Saharan Africa as we continue to modify our environment. [Ibeanusi S & Kejeh B, 2022] [Fasika M, 1997].

This changing epidemiology manifests in our finding of male preponderance early in the period of study and female preponderance in later years. Male preponderance is in keeping with most previous reports in the country and beyond. [Fasika M, 1997][Nnabuko REE *et al.,* 2009][Asuquo ME & Ekpo R, 2008][Olaitan PB *et al.,* 2007] [Abikoye F *et al*,2012][Mehta K *et al*., 2018] Female predominance though not a common occurrence has been documented in literature [Lal S *et al*., & Bhansali CA *et al*.,] and may be a reflection of changing exposure to sources of fire which can be explained by increasing domestic fire accidents from gas in our environment. However, further review of the epidemiology of burn injuries is needed to make valid conclusions. We found an association between gender and poor outcome with more female deaths. Moore *et al*., [Moore EC *et al*., 2013] reported female sex as one of the independent risk factors for death. Other authors [Lal S *et al.* 2012,][Bhansali CA *et al.,* 2017] similarly found higher mortality in female burn victims than males. The reasons for this trend are not clear but more abdominal fat resulting in graft loss after excision has been suggested. However, we performed very few excisions and grafting which could not have been responsible for our observation. In a previous study at the same center, more male deaths were recorded. [Nnabuko REE *et al*., 2009].

The average age of the patients ranged from about 14 to 26 years. Most patients are young and although the effect of age on outcome was only significant in 3 years, the long-lasting physical and psychological effects of burns will be enormous. Burn injury and management are among the most painful experiences in human existences, and the attendant psychosocial effects which are frequent debilitating post burn complications are most often overshadowed by struggle for survival. [Dalal PK *et al*. 2010][Wiechman SA & Patterson DR, 2004]

Flame was the commonest cause of burn injury followed scald. This finding is in line with findings in several similar studies [Ibeanusi S & Kejeh B,2022] [Asuquo ME & Ekpo R, 2008] [Abikoye F *et al.,* 2012][Bhansali CA *et al*., 2017] except in studies of burn injuries in paediatric age group where scald is usually the most frequent cause of injury. [Okoro PE *et al*., 2009][Mabogunje A *et al*., 1987][Nduagubam OC *et al.,* 2022]. In this series, burn aetiology significantly affected outcome with flame burns being associated with more deaths than other causes of injury. Similar findings have been documented by other authors. [Bhansali CA *et al*., 2017] [Nduagubam OC *et al.,* 2022] [Kalayi GD, 2006] This is understandable as flame usually results in more severe injury in terms of TBSA, depth and inhalation injury all of which negatively influence outcome.

Most of our patients presented late as less than 50% presented within 8 hours of injury. This is similar to finding by Abikoye *et al*., [Abikoye *et al.,* 2012] in Lagos. This may be as a result of the fact that a good percentage of our patients are referred from peripheral hospitals and there are no effective emergency ambulance services in our region which could aid quick evacuation of burn injury victims from the scene to the burn center. The implication of late presentation is that prompt resuscitation cannot be guaranteed, and this is critical in determining the occurrence of complications and the final outcome. This could explain why 50 to 80% of those that had acute renal failure were among those that presented after 8 hours of injury while about 33 to 100% of those that had sepsis were those that presented after 24 hours of injury. Burn sepsis followed by shock are the leading cause of mortality following burn injury [Lal S *et al*. 2012][Greenhalgh DG, 2017][Emara SS & Alzaylai AA, 2013][Ibrahim AE *et al*. 2013] as has been demonstrated in this study.

In this study, we observed a wide variation in TBSA burned over the years ranging from 0% to 100%. TBSA is an important parameter in determining outcome with a number of outcome measures such as LA_{50}, maximum TBSA salvaged and mean TBSA dead being based on it. A number of studies have shown that mortality is significantly related to TBSA burned. [Ibeanusi S & Kejeh B, 2022][Nduagubam OC *et al*. 2022][Tan H *et al*. 2019][Taylor SL. 2015] This is corroborated by the findings in our series.

Depth of injury had significant effect on outcome with full thickness and deep dermal injuries being associated with more mortality especially in 2017 when they were high. Although depth of injury is known to affect mortality, early excision and grafting have been shown to attenuate the effects and positively influence outcome. [Pavoni V *et al.* 2010][Ziegler B *et al.* 2020] However, excision and grafting constituted only 2.4% of surgical procedures recorded in this study despite high incidence of full, deep dermal and mixed thickness injuries. To be of value, early excision has to be followed

by immediate provision of skin cover. [Atiyeh B *et al*. 2009] We often rely on autografts which is not usually feasible in severe burn injuries and facilities for skin banks, cadaveric allografts, zenografts and skin substitutes are not available. In addition, blood loss following excision in major burn could be difficult to cope with as blood and blood products are often in short supply.

Inhalation injury and its treatment had significant effect on outcome with nebulization using bronchodilators and anticoagulants improving survival from inhalation injuries. Many authors have reported similar findings. [El-Helbawy RH & Ghareeb FM, 2011][Walker PF *et al*. 2015][Dries DJ & Endorf FW, 2013] Other measures useful in the management of inhalation injuries include bronchoscopy which could be diagnostic or therapeutic, and early endotracheal intubation with ventilation[El-Helbawy RH & Ghareeb FM, 2011][Walker PF *et al.* 2015][Dries DJ & Endorf FW, 2013] There was no record of these for our patients due to lack of requisite facilities coupled with late presentation of a good number patients.

We observed that dressing agents had statistically significant effect on outcome only in those years when high percentage of the newer materials were used. However, their use was not sustained probably because of cost which was often beyond our average patients. Similarly, several studies have demonstrated the usefulness of these newer agents in burn wound care in terms of infection control, reduction in frequency of dressing and pain as well as improvement in re-epithelialization and post burn scars. [Fong J & Wood F, 2006][Woodmansey EJ & Roberts CD,2018][Argirova M & Hadjiiski O, 2011] Shanks LA *et al*., 2020][Qureshi MA *et al.* 2021].

Our study revealed lack of consistency in outcome over the period reviewed despite improvement in fluid resuscitation and infection control measures. There was no recorded mortality in 2011 while among other years, overall best outcome measures were obtained in 2013 when mortality rate was lowest, LA_{50} and mean TBSA of those that died were highest, and maximum TBSA salvaged above yearly average. The worst outcome was recorded in 2017 when mortality rate was highest and other parameters were below yearly average. Although the mean mortality rate in this study was less than what was recorded at the same center more than a decade earlier, [Jiburum BC & Olaitan PB. 2005] we recorded much higher values within some years.

CONCLUSIONS

Despite observable efforts at improving services, improvement in outcome has not been consistent. Adoption of measures that are known to improve outcome such as early burn wound excision, use of newer dressing materials, as well as bronchoscopy, endotracheal intubation and ventilation for inhalation injuries will have sustained positive effects on outcome. This will require funds and support for both the burn center and the patients.

Limitations

The yearly sample size appear small and any variance in outcomes may be related to normal fluctuation in burn size. However, we used multiple outcome measures to overcome this limitation.

Conflict of Interest: The authors have no conflict of interest to declare.

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