Int J Burn Trauma 2024;14(1):25-31
www.IJBT.org /ISSN:2160-2026/IJBT0152524

Original Article

Estimating mortality risk in burn patients admitted at Rwanda's largest referral hospital

Ian Shyaka[1], Elizabeth Miranda[2,3], Lotta Velin[2,4], Francoise Mukagaju[1], Yves Nezerwa[1], Faustin Ntirenganya[5], Charles Furaha[1], Robert Riviello[2,6], Laura Pompermaier[7,8,9]

[1]Department of Plastic Surgery, Rwanda Military Hospital, Kigali, Rwanda; [2]Program in Global Surgery and Social Change, Harvard Medical School, Boston, MA, USA; [3]Division of Vascular Surgery, University of Southern California, Los Angeles, CA, USA; [4]Centre for Teaching and Research in Disaster Medicine and Traumatology (KMC), Department of Biomedical and Clinical Sciences, Linköping University, Linköping, Sweden; [5]Department of Plastic Surgery, University Teaching Hospital of Kigali (CHUK), Kigali, Rwanda; [6]Center for Surgery and Public Health, Brigham and Women's Hospital, Boston, MA, USA; [7]Department of Hand and Plastic Surgery and Burn Center, Linköping University Hospital, Sweden; [8]Department of Biomedical and Clinical Sciences, Linköping University, Sweden; [9]Center for Teaching & Research in Disaster Medicine and Traumatology (KMC), Linköping, Sweden

Received July 31, 2023; Accepted January 17, 2024; Epub February 15, 2024; Published February 28, 2024

Abstract: Background: Burns is a disease of poverty, disproportionately affecting populations in low- and middle-income countries, where most of the injuries and the deaths caused by burns occurs. In Sub-Saharan Africa, it is estimated that one fifth of burn victims die from their injuries. Mortality prediction indexes are used to estimate outcomes after provided burn care, which has been used in burn services of high-income countries over the last 60 years. It remains to be seen whether these are reliable in low-income settings. This study aimed to analyze in-hospital mortality and to apply mortality estimation indexes in burn patients admitted to the only specialized burn unit in Rwanda. Methods: This retrospective study included all patients with burns admitted at the burn unit (BU) of the University Teaching Hospital in Kigali (CHUK) between 2005 and 2019. Patient data were collected from the BU logbook. Descriptive statistics were calculated with frequency (%) and median (interquartile range, IQR). Association between burns characteristics and in-hospital mortality was calculated with Fisher's exact test, and Wilcoxon rank, as appropriate. Mortality estimation analysis, including Baux score, Lethal Area 50 (LA50), and point of futility, was calculated in those patients with complete data on age and TBSA. LA50 and point-of-futility were calculated using logistic regression. Results: Among the 1093 burn patients admitted at the CHUK burn unit during the study period, 49% (n=532) had complete data on age and TBSA. Their median age, TBSA, and Baux score were 3.4 years (IQR 1.9-17.1), 15% (IQR 11-25), and 24 (IQR 16-38), respectively. Overall, reported in-hospital mortality was 13% (n=121/931), LA50 for Baux score was 89.9 (95% CI 76.2-103.7), and the point-of-futility was at a Baux score of 104. Conclusion: Mortality estimation indexes based on age and TBSA are feasible to use in low-income settings. However, implementation of systematic data collection would contribute to a more accurate calculation of the mortality risk.

Keywords: Burns, Baux score, mortality, low-income countries

Introduction

Burns are a global health concern and a challenge for public health, especially in low- and middle-income countries (LMICs), where over 96% of deaths due to burns occur [1]. Although most burn injuries are preventable, and despite the incidence and outcomes of burns improving in high income countries (HICs) in the last decades, in LMICs, the burden of burns remains high [1-4]. In Sub-Saharan Africa, it has been estimated that one in every five patients with burns die, with children under five years of age having a mortality more than double that their peers in the rest of the world [1, 3]. Although incidence and severity of burns are heterogeneous, the healthcare needs related to burns are universal [5].

In the last 60 years, HICs have developed a plethora of models based on the patient age and burn size, to estimate the in-hospital mor-

tality, and these have been used to compare and control results of the provided burn care [4-7]. Nevertheless, mortality estimation indexes based on age and total body surface area afted by burn (TBSA) are not routinely used in LMICs, although studies from middle-income countries have shown their feasibility [8-10]. Three well-known and widespread indexes are Baux score, Lethal Area (LA50), and point of futility. The Baux score estimates the mortality risk in burn patients, and is calculated by adding patient age and percentage of total body surface area affected by the burn (TBSA) [6]. Along with TBSA, the Baux score can be used to calculate the LA50, which is the Baux score or TBSA at which the risk to die is approximately 50%. "The point of futility" is the Baux score or TBSA at which mortality risk approaches 100%. These metrics reflect the local standard of burn care and have been adjusted upwards in high-income settings, parallelly to improvements in burn care treatments. We hypothesize that these prediction models might also be reliable to test outcome of burn care in resource-limited settings.

Rwanda is a low-income country in east Africa, with a population of approximately 13.2 million people [11]. The University Teaching Hospital of Kigali (CHUK) is the largest national referral hospital of the country and admits patients of all ages referred from health centers or district hospitals from all over the country. The burn unit at CHUK has the only dedicated burn ward in Rwanda, where a plastic surgeon, residents in plastic surgery, and dedicated nursing staff manage burns injuries. At CHUK, there is not a dedicated burn intensive care unit (ICU), but patients with burns requiring intensive care are transferred to the general ICU.

Previous studies have shown that burns accounted for 5% of all trauma admissions at the CHUK, and that children were the largest risk group for burns, with an alarming high in-hospital mortality above 16% reported between 2014 and 2015 [12, 13]. What remains unknown is the in-hospital mortality at the CHUK burn unit during a longer observational time, and possible changes in mortality trend. This study therefore aimed to analyze in-hospital mortality and the utility of indexes based on TBSA and age to estimate the mortality risk among patients with burns admitted at the only dedicated burn ward in Rwanda, during the last 15 years.

Methods

Study setting and design

In this retrospective study, we included all patients with burns admitted to the Burn Unit at the University Teaching Hospital of Kigali (CHUK), between January 2005 and December 2019. Patients who had burn injuries associated with other polytraumatic events were excluded. Patients without either age or TBSA recorded were also excluded from Baux Score, LA50, and point of futility analysis. The data included in the analysis were prospectively collected through patient logbooks by the nursing staff at the burn ward. The outcome of interest was in-hospital mortality which was defined as those patients who died at the Burn Unit and who had "death" recorded as outcome in the logbook. Information on patients who died after transferring to other departments, such as the ICU, are not included in this mortality count, because they were recorded as "transferred" or "deteriorated" in the Burn Unit logbook by the nursing staff. In this study, patients recorded as "discharged", "left against medical advice (AMA)", "deteriorated", or "transferred" in the Burn Unit logbook were coded as "survivors".

The following variables were coded as categorical: gender (female/male), presence of full thickness burns (yes/no), referral from different areas (Kigali/other provinces), referral from different health facilities (health centers/district hospitals), burn mechanism (scald/flame/electric/chemical), and surgical treatment (yes/no). Following variables were collected as continuous: age (years), percentage of the total body surface area burned (TBSA), and length of stay at the Burn Unit (LOS in days). Presence of inhalation injury was only documented in two patients, and therefore was not included among the considered variables.

Data analysis

De-identified data were transferred from the patient logbooks into an excel spreadsheet. Baux scores were calculated for all patients who had recorded age and TBSA. Descriptive statistics were calculated with frequency (%) for categorical variables and median (interquar-

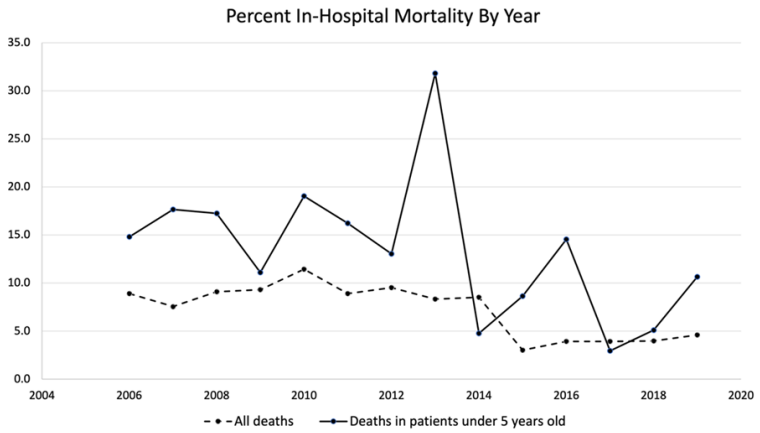

Figure 1. In-hospital death in the study population and in children under 5 years, between 2005 and 2019.

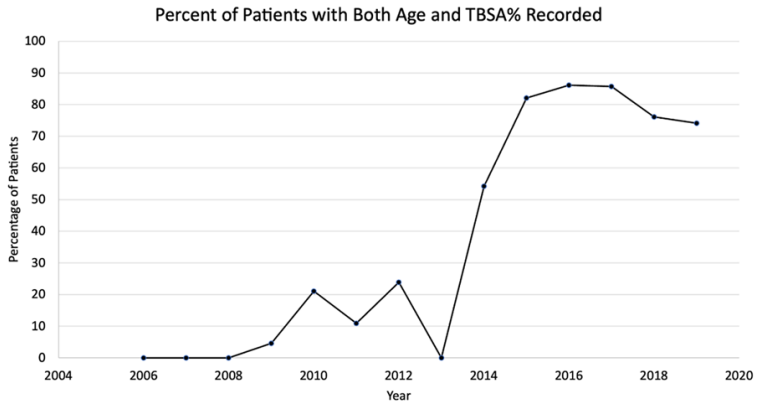

Figure 2. Percentage of patients with both data recorded on age and TBSA%, over time.

tile range, IQR) for continuous variables. Significant associations between patient demographics and clinical characteristics and in-hospital mortality were tested with Fisher's exact test for categorical variables, and Wilcoxon rank sum tests for continuous variables. We used the recorded patients' age and TBSA to calculate the Baux Score, LA50 and point of futility which were analyzed to estimate the risk of death of these burn patients. LA50 for Baux score and TBSA were calculated using logistic regression. The point of futility for Baux score was defined as the highest calculated Baux score after which mortality was 100%. Baux score, LA50, and point of futility were retrospectively calculated for those patients with complete data on age and TBSA. All analyses were performed using StataIC 16.0 (Software7).

Ethical approval

Ethical approval for this study was obtained from the CHUK Ethics Review Committee (Ref:EC/CHUK/007/2020) and from the Partners IRB Committee (Ref:2020P001096).

Results

A total of 1,093 patients were admitted to the CHUK burn ward during the study period; male sex was predominant (n=597), and median age was 3.3 years (IQR 1.8-15.4), with 643 patients (61%) being younger than 5 years. Seventy percent of patients were referred from other facilities within Kigali (n=735), while 329 came from other provinces, with district hospitals being the most common referring facility (62.2%, n=410). Burn size was recorded in 726 patients and for them, median TBSA% was 17% (IQR 12-25). Information on burn thickness was collected in 511 patients, of which 199 (39%) had full-thickness burns. The most common burn mechanism was scald (n=639), followed by flame (n=121), electric injury (n=25) and chemical burn (n=4). Of those with available information on burn management (n=712), 15.7% (n=112) underwent one or more surgical interventions, including surgical debridement (n=56), skin grafting (n=54), or amputation (n=2). Median length of stay was 32 days (IQR 10-143 days) and in-hospital mortality was 13% (n=121/931). **Figure 1** shows overall mortality and mortality in children under 5 years, by year, during the study period. LA50 by TBSA was 47.5% and the widest TBSA% at which a patient survived was 75%.

It was possible to calculate Baux score only in those patients (n=532), who had both TBSA and age recorded. **Figure 2** shows improvement in completeness of collection of data on age and TBSA over time, and **Figure 3** shows the distribution of Baux scores in the 532

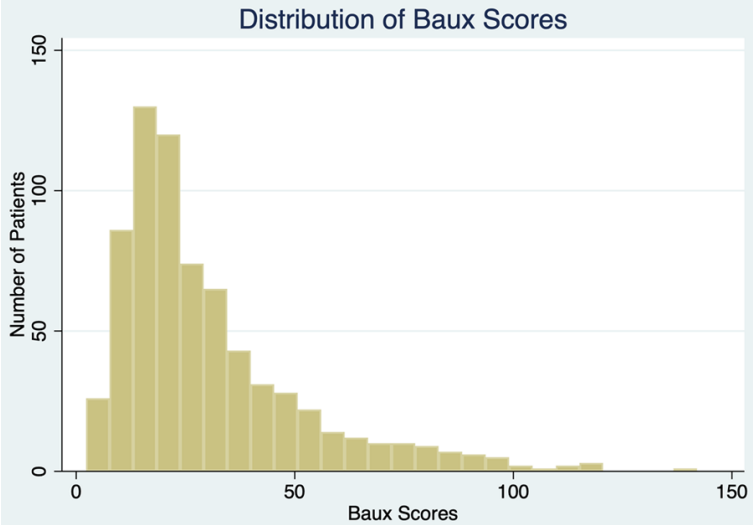

Figure 3. Baux score distribution in the group of patients (n=532) with recorded data on age and TBSA%.

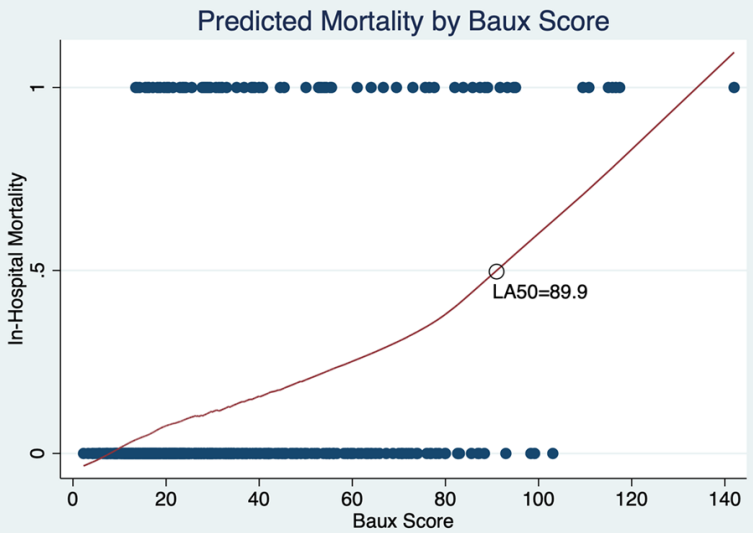

Figure 4. Estimated Baux curve.

patients. The median Baux score during the study period was 23.5 (IQR 16-38.3). **Figure 4** shows the estimated Baux curve, which represents the correlation between in-hospital mortality and Baux score with 0 representing no in-hospital mortality and 1 representing 100% in-hospital mortality recorded. The LA50 for Baux score was 89.9 (95% CI 76.2-103.7), which means that the mortality risk of patients with this Baux Score was approximately 50%. The point of futility was determined to be at a Baux score of 104, which means that all patients with Baux scores over 104 died.

Discussion

The purpose of this study was to analyze the in-hospital mortality in the only dedicated burn ward of Rwanda, as well as to investigate the feasibility of burn mortality estimation indexes based on age and TBSA in a resource-limited setting. Between 2015 and 2019, the overall mortality among patients with burns admitted at the University Teaching Hospital of Kigali (CHUK) was 13%, which falls within the 9-26.8% range reported in a previous review of burn injuries in Sub-Saharan Africa [3]. It appeared that overall mortality improved over time, though it began to trend upward again in 2018. However, the causes of that are unknown and implementation of data collection, which should systematically include information on referral indications, burn severity, and time between injury and admission, might contribute to understand trends. There was also a rise in mortality in 2013, but the inaccessibility of the medical records for this period makes it impossible to explain the cause of this increase.

Baux Score is a simple and reliable index to estimate the risk of death after burns, and we expected it to be easy to calculate in most of the patients at the CHUK, as it only requires information on age and TBSA% [4]. Nevertheless, we found that TBSA was not systematically recorded in the logbooks, which allowed us to test this prediction tool in just half of the study population. However, our group has recently shown a significant improvement in the completeness of data collected at the CHUK-Burn Unit during the past years, which will allow us to use this prediction tool in a broader cohort in future studies [14]. Most studies assessing the relationship between Baux score and mortality have been performed

in HICs [4-7]. For example, in a British article analyzing patients admitted to a specialized burn service between 1982 and 2008, the LA50 for Baux score was 109.6 (CI 105.9-113.4), and the point of futility was reported as 160 [6]. In our population, we found much lower scores for both, with an LA50 for Baux Score of 89.9 and a point of futility of 104, though it is important to note that, while the UK study does not report median age or TBSA for their overall population, we assume that the burn cohort at CHUK is likely younger and perhaps presenting with larger TBSA. Additionally, as the data from the UK study was collected over 10 years ago, it is likely that burn care in that setting has improved, and the LA50 values may be even higher now than at the time of study publication. Another study performed in Iran, an upper-middle income country, used TBSA to calculate LA50 and found it to be 43.7%, slightly below that of our population (TBSA LA50 47.3%). Looking at Sub-Saharan Africa, a South African study reported findings which are similar to our own, with an LA50 for Baux score of 76 and a point of futility at 112 [15]. To date, there are few studies applying mortality prediction models in low- and middle-income settings [8, 16, 17].

Thus, the survival of burn patients in the CHUK burn unit appears to be comparable to those reported in previous studies performed in similar settings [18, 19]. However, we must consider several factors which may have influenced outcome after burn care in our population and may have falsely elevated our calculated Baux score LA50, making patient mortality risk seem lower than it truly is. For example, the burn unit at CHUK is not equipped to manage patients with intensive care needs, such as mechanical ventilation. Critically ill patients are therefore transferred to higher levels of care, such as the ICU or high dependency unit (units that can provide higher levels of care but are one step below ICUs). If patients die after transferring to these services, their deaths are not reported in the burn unit's logbooks, and these patients are coded as "transferred". Furthermore, burn patients who die at the Accidents and Emergency Department before admission to the burn unit are not recorded in the burn unit logbooks.

Frequently, there is a delay in reaching care when patients with burns are referred from health centers to Kigali, and the delay may be even larger in cases where patients try to treat the burns using traditional medicine before seeking care [20-22]. This delay leads to a natural selection of people with higher probability to survive the injury. Thus, individuals who make it through this referral process and are stable enough to be admitted to the burn unit are more likely to survive their burns, which might lead to a survival bias that can further affect the reliability of the traditional mortality prediction tools. In our opinion, in low-income settings, factors such as time between injury and admission, and use of traditional medicine before reaching care should be included in the analysis. It is also important to note that most of the burn patients in this study were children with scalds, who have been shown to have better survival as compared to their elderly counterparts [5, 23].

Limitations

First, this is a retrospective study which relied on manual chart review of handwritten records. This information could be difficult to read and is subject to some interpretation bias. Second, many patients had incomplete data, with both TBSA and age recorded in less than half of the patients, so that we were unable to calculate Baux scores for the entire cohort. Additionally, we were unable to calculate revised Baux score, which includes presence of inhalation injury, as this was not recorded for the burn unit patients. Previous studies have validated the revised Baux score as an index for estimating mortality among patients. Thus, in order to improve analysis of mortality in this setting, it is essential to standardize collection of the presence or absence of inhalation injury for all patients [4, 24].

Conclusion

Overall, in-hospital mortality during the last 15 years at a specialized burn unit in Rwanda was 13%, which is comparable with outcomes previously shown in similar settings, although incompleteness of data significantly limited the reliability of the findings. The use of burn mortality estimation indexes, such as Baux score, was feasible in this context, though again limited by incomplete data. Other factors relevant in this context, such as delay in reaching care, should be included to improve their reliability. Further

research is necessary to implement burn-specific and contextualized data collection, to accurately evaluate outcome after providing burn care.

Acknowledgements

The authors of this paper would like to acknowledge and thank the following burn unit nurses of CHUK for their significant contributions, both to this study and to the care of burn patients in Rwanda: Marthe Mukeshimana, Didace Mushimiyimana, Jennifer Bamurange, Belise Mukambasabire, Leoncie Uwimana, Laetitia Nayisire, Yvonne Uyisaba, Moise Mukundabantu. This work was also conducted with support from Harvard Catalyst/The Harvard Clinical and Translational Science Center (National Center for Advancing Translational Sciences, National Institutes of Health Award UL 1TR002541) and contributions from Harvard University and its affiliated academic healthcare centers. The content is solely the responsibility of the authors and does not necessarily represent the official views of Harvard Catalyst, Harvard University and its affiliated academic healthcare centers, or the National Institutes of Health.

Disclosure of conflict of interest

None.

Address correspondence to: Ian Shyaka, Department of Plastic Surgery, Rwanda Military Hospital, P.O. Box 3377, Kigali, Rwanda. Tel: +250-7858-45263; E-mail: iangashugi@gmail.com

References

[1] WHO. Burns [Internet]. [cited 2023 Sep 14]. Available from: https://www.who.int/news-room/fact-sheets/detail/burns.

[2] WHO. Burns [Internet]. [cited 2023 Sep 14]. Available from: https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/burns.

[3] Nthumba PM. Burns in sub-Saharan Africa: a review. Burns 2016; 42: 258-66.

[4] Osler T, Glance LG and Hosmer DW. Simplified estimates of the probability of death after burn injuries: extending and updating the baux score. J Trauma 2010; 68: 690-7.

[5] Jeschke MG, Pinto R, Kraft R, Nathens AB, Finnerty CC, Gamelli RL, Gibran NS, Klein MB, Arnoldo BD, Tompkins RG and Herndon DN; Inflammation and the Host Response to Injury Collaborative Research Program. Morbidity and survival probability in burn patients in modern burn care. Crit Care Med 2015; 43: 808-15.

[6] Roberts G, Lloyd M, Parker M, Martin R, Philp B, Shelley O and Dziewulski P. The Baux score is dead. Long live the Baux score: a 27-year retrospective cohort study of mortality at a regional burns service. J Trauma Acute Care Surg 2012; 72: 251-6.

[7] Dokter J, Meijs J, Oen IM, van Baar ME, van der Vlies CH and Boxma H. External validation of the revised Baux score for the prediction of mortality in patients with acute burn injury. J Trauma Acute Care Surg 2014; 76: 840-5.

[8] Christofides C, Moore R and Nel M. Baux score as a predictor of mortality at the CHBAH adult burns unit. J Surg Res 2020; 251: 53-62.

[9] Newberry JA, Bills CB, Pirrotta EA, Barry M, Ramana Rao GV, Mahadevan SV and Strehlow MC. Timely access to care for patients with critical burns in India: a prehospital prospective observational study. Emerg Med J 2019; 36: 176-82.

[10] Smith MT, Allorto NL and Clarke DL. Modified first world mortality scores can be used in a regional South African burn service with resource limitations. Burns 2016; 42: 1340-4.

[11] National Institute of Statistics Rwanda. Rwanda's population reaches 13,2 million in 2022 [Internet]. Available from: https://www.statistics.gov.rw/publication/Rwanda_population_2022.

[12] Mugemana HP and Rogo T. Burns in children admitted at the University Teaching Hospital of Kigali (CHUK), Rwanda: a descriptive study. Rwanda Med J 2017; 74: 11-3.

[13] Petroze RT, Mumararungu A, Ndayiragije V, Ntakiyiruta G, Kyamanywa P, Reid J, Calland JF and Byiringiro JC. Patterns of injury at two university teaching hospitals in Rwanda: baseline injury epidemiology using the rwanda injury registry. Rwanda Med J 2014; 71: 5-8.

[14] Miranda E, Velin L, Ntirenganya F, Riviello R, Mukagaju F, Shyaka I, Nezerwa Y and Pompermaier L. Recording patient data in burn unit logbooks in Rwanda: who and what are we missing? J Burn Care Res 2021; 42: 526-32.

[15] Tyson AF, Boschini LP, Kiser MM, Samuel JC, Mjuweni SN, Cairns BA and Charles AG. Survival after burn in a sub-Saharan burn unit: challenges and opportunities. Burns 2013; 39: 1619-25.

[16] Salehi SH, As'adi K, Abbaszadeh-Kasbi A, Isfeedvajani MS and Khodaei N. Comparison of six outcome prediction models in an adult burn population in a developing country. Ann Burns Fire Disasters 2017; 30: 13-7.

[17] de Campos EV, Park M, Gomez DS, Ferreira MC and Azevedo LC. Characterization of critically ill

adult burn patients admitted to a Brazilian intensive care unit. Burns 2014; 40: 1770-9.
[18] Ready FL, Gebremedhem YD, Worku M, Mehta K, Eshte M, GoldenMerry YL, Nwariaku FE, Wolf SE and Phelan HA. Epidemiologic shifts for burn injury in Ethiopia from 2001 to 2016: implications for public health measures. Burns 2018; 44: 1839-43.
[19] Mirza Aghazadeh A, Lotfi M, Ghahramanian A and Ahadi F. Lethal area 50 in patients with burn injuries in North West, Iran. J Caring Sci 2018; 7: 53-8.
[20] Nkurunziza T, Toma G, Odhiambo J, Maine R, Riviello R, Gupta N, Habiyakare C, Mpunga T, Bonane A and Hedt-Gauthier B. Referral patterns and predictors of referral delays for patients with traumatic injuries in rural Rwanda. Surgery 2016; 160: 1636-44.
[21] Ntakiyiruta G, Wong EG, Rousseau MC, Ruhungande L, Kushner AL, Liberman AS, Khwaja K, Dakermandji M, Wilson M, Razek T, Kyamanywa P and Deckelbaum DL. Trauma care and referral patterns in Rwanda: implications for trauma system development. Can J Surg 2016; 59: 35-41.
[22] Gallaher JR, Purcell LN, Banda W and Charles A. The effect of traditional healer intervention prior to allopathic care on pediatric burn mortality in Malawi. Burns 2020; 46: 1952-7.
[23] Capek KD, Sousse LE, Hundeshagen G, Voigt CD, Suman OE, Finnerty CC, Jennings K and Herndon DN. Contemporary burn survival. J Am Coll Surg 2018; 226: 453-63.
[24] Lip HTC, Idris MAM, Imran FH, Azmah TN, Huei TJ and Thomas M. Predictors of mortality and validation of burn mortality prognostic scores in a Malaysian burns intensive care unit. BMC Emerg Med 2019; 19: 66.