



Access this article online

Quick Response Code:



Website:
<https://journals.lww.com/TJEM>

DOI:
10.4103/tjem.tjem_246_25

Association of total body surface area on effective surgical treatment and mortality in adult burn patients: A 5-year retrospective analysis in an Indonesian National Referral Hospital

Aditya Wardhana*, Tiara Putri Leksono, Indira Saraswati Sanjaya, Billy Sandy Handiansyah, Nadya Farhana

Department of Surgery, Plastic Reconstructive and Aesthetic Surgery Division, Burn Unit, Faculty of Medicine, Cipto Mangunkusumo Hospital, Universitas Indonesia, Jakarta, Indonesia
*Corresponding author

Submitted: 10-07-2025
Revised: 10-10-2025
Accepted: 21-10-2025
Published: 03-04-2026

ORCID:

AW: 0000-0002-7577-8357
TPL: 0000-0002-6817-7262
ISS: 0009-0000-6616-1657
BSH: 0009-0001-3004-3867
NF: 0000-0002-2332-9808

Address for correspondence:

Dr. Aditya Wardhana,
Department of Surgery,
Plastic Reconstructive
and Aesthetic Surgery
Division, Burn Unit,
Cipto Mangunkusumo
Hospital-Faculty of
Medicine Universitas
Indonesia, Jakarta,
Indonesia.
E-mail: aditya_wrdn@
yahoo.com

Abstract:

OBJECTIVES: This study evaluates the association of total body surface area (TBSA) on surgical treatment outcomes and mortality rates in burn patients.

METHODS: A retrospective cohort study was conducted on adult burn patients admitted to an Indonesian National Referral Hospital from January 2020 to November 2024. Factors associated with mortality, including age, TBSA, and surgery count, were analyzed using the SPSS software version 26.

RESULTS: This study included 595 patients, with a mean age of 41.74 ± 14.95 years and a male predominance (n = 406, 68.2%). Flame or explosion-related burns were the most common cause of hospitalization (n = 473, 79.4%). Overall mortality was 42.2%. Surgical activity and length of stay (LOS) increased with TBSA, peaking in the 21%–40% groups (median operations 3 [interquartile range 2–4]), but declined in >40% TBSA due to early deaths. Kaplan–Meier curves confirmed steep survival loss within 2 weeks among >40% TBSA patients (log-rank P < 0.001). In multivariable regression, independent predictors of mortality were age (adjusted odds ratio [aOR] 1.021, P = 0.004), male sex (aOR 1.60, P = 0.040), TBSA 31%–40% (aOR 8.27, P = 0.002), and > 40% (aOR 22.3, P < 0.001). Longer LOS (aOR 0.967, P = 0.019) and more operations (aOR 0.737, P < 0.001) were protective. Receiver operating characteristic analysis of numeric TBSA showed good discrimination (AUC = 0.813), with an optimal cutoff at ~ 33.8% (sensitivity 83.7%, specificity 66.3%).

CONCLUSION: TBSA remains the principal driver of burn outcomes, with mortality risk rising sharply beyond ~34%. Early deaths in the largest burn group explain the paradox of fewer operations despite extensive injury.

Keywords:

Burns, mortality, surgical treatment, total body surface area

Introduction

Burn injuries remain a significant public health issue in Indonesia, consistently linked with high rates

of mortality and morbidity. As a lower-middle-income country, Indonesia contributes to a large proportion of global burn-related deaths, with the World Health Organization (WHO) reporting that over 95% of burn fatalities occur in

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 License (CC BY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

How to cite this article: Wardhana A, Leksono TP, Sanjaya IS, Handiansyah BS, Farhana N. Association of total body surface area on effective surgical treatment and mortality in adult burn patients: A 5-year retrospective analysis in an Indonesian National Referral Hospital. Turk J Emerg Med 2026;26:94-101.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

Box-ED section

What is already known on the study topic?

- Total body surface area (TBSA) is a well-established predictor of mortality in burn patients
- Surgical interventions such as early excision and grafting are considered beneficial in improving survival and reducing complications
- Sepsis is a leading cause of death in severe burns, particularly in patients with larger TBSA.

What is the conflict on the issue? Has it importance for readers?

- The relationship between TBSA and surgical decision-making in real-world clinical settings remains unclear
- There is limited evidence on how TBSA influences the frequency or feasibility of surgery in lower-middle-income countries, where resources are constrained
- Clarifying this relationship is important for guiding effective surgical protocols in high-mortality burn units.

How is this study structured?

- This was a single-center, retrospective cohort study conducted at a national referral hospital in Indonesia
- It analyzed adult burn patients admitted to the intensive care unit between January 2020 and November 2024.

What does this study tell us?

- Higher TBSA is associated with increased mortality and reduced likelihood of receiving surgical intervention
- Surgical treatment may be underutilized in patients with extensive burns despite its potential benefit, highlighting the need for TBSA-guided protocols.

low- and middle-income nations. Globally, burns are responsible for an estimated 195,000 deaths each year, with nearly two-thirds of these occurring in Africa and Southeast Asia. In Indonesia, flame and gas explosion injuries are common and often lead to extensive total body surface area (TBSA) involvement. TBSA remains one of the most critical prognostic factors in burn management, guiding clinical decisions and correlating closely with patient survival.^[1]

Despite advancements in burn care, national referral centers in Indonesia continue to report high mortality rates. For instance, the Burn Unit at Cipto Mangunkusumo General Hospital recorded a 25% mortality rate between 2013 and 2015; Dr. Soetomo General Hospital in Surabaya reported 43.2% between

2012 and 2016; and Hasan Sadikin Hospital in Bandung saw a 52% mortality rate among burn patients with sepsis from 2015 to 2017.^[2-4] These statistics reflect a critical need for improved treatment strategies. Since 2013, early tangential excision and skin grafting have been introduced in our center for hemodynamically stable patients, with additional surgical approaches including debridement, amputations, escharotomy, and flap surgeries. These procedures aim to reduce infection, sepsis, and ultimately mortality. However, burn wounds continue to pose a major risk for multidrug-resistant infections and systemic complications, especially with prolonged hospital stays and extensive antibiotic use.^[5-7]

This study aims to evaluate the impact of TBSA on the effectiveness of surgical interventions and mortality in adult burn patients. We hypothesize that higher TBSA is associated with lower rates of surgical intervention and increased mortality. Our primary objective is to assess the relationship between TBSA, the number of surgical procedures performed, and inhospital mortality outcomes over 5 years (January 2020 to November 2024) at the Cipto Mangunkusumo Burn Center in Jakarta. The findings of this study are expected to inform surgical decision-making and help develop TBSA-based protocols for improving burn care outcomes in Indonesia.

Methods

Study design and setting

This was a retrospective cohort study conducted using anonymized secondary data collected from the medical records. The objective was to examine the association between TBSA, surgical intervention, and in-hospital mortality in adult burn patients. It adheres to the STrengthening the Reporting of OBservational studies in Epidemiology guidelines for observational cohorts [Supplementary File 1].

The study was conducted at a tertiary-level national referral hospital in Jakarta, Indonesia. Data were collected over 5 years, from January 2020 to November 2024. The hospital serves as a central facility for acute burn treatment and surgical intervention across the region.

Selection of participants

Adult patients aged 18 years or older admitted with acute burn injuries during the study period were included. Exclusion criteria were age under 18 years and presentation with chronic or nonacute burns. The eligible population consisted of 595 patients and data on demographic characteristics, TBSA, number of surgical procedures, and mortality outcomes were extracted from the electronic medical records.

Study size

As a retrospective study, no formal sample size calculation was conducted. The study included all eligible patients over the defined 5-year period.

Data sources and measurement

All the variables were sourced from the institutional electronic medical records. TBSA was estimated by attending plastic surgeons using the rule of nines. Surgical procedures included debridement, escharotomy, fasciotomy, tangential excision, grafting, and other relevant interventions. Mortality outcomes were verified through discharge status. Measurement and data entry procedures were consistent across the cohort, ensuring comparability of data.

Bias

To address the potential sources of bias, we applied clear inclusion and exclusion criteria, limiting the study population to adult patients with acute burn injuries. Data extraction was conducted using a standardized protocol from electronic medical records, and all entries were independently cross-checked by four investigators to reduce information bias. Potential confounding variables, including age, sex, and TBSA, were considered in the statistical analysis.

Outcome measures

Primary outcomes were in-hospital mortality and the number of surgical procedures. Secondary outcomes included cause of death and length of stay (LOS). These were measured against TBSA categories ($\leq 10\%$, 11%–20%, 21%–30%, 31%–40%, and $>40\%$). The categorization was based on previously published literature from our institution^[3] and aligns with international evidence recognizing $>40\%$ TBSA as a critical threshold associated with significantly increased morbidity and mortality, often used to define major burns.

Statistical analysis

Categorical variables were reported as frequencies and percentages and compared using the Chi-square test. The continuous variables were reported as a mean \pm standard deviation (SD) if normally distributed or as median (interquartile range [IQR]) if not. Data normality was checked using the Shapiro–Wilk test. To allow between-group comparisons, Kruskal–Wallis tests were performed.

Mortality associations were evaluated by logistic regression. We constructed both crude (unadjusted) and multivariable adjusted models. The multivariable adjusted model contained age, sex, LOS, number of operations, and TBSA groups (reference: $\leq 10\%$). Odds ratios (ORs) and their 95% confidence intervals (CIs) were presented. Model performance was assessed with

Nagelkerke R^2 and classification accuracy. Survival analysis by Kaplan–Meier was performed in comparing TBSA strata for time-to-discharge, for which log-rank test was employed for testing differences.

Receiver operating characteristic (ROC) analysis was conducted with numeric TBSA (%) as a continuous variable for predicting mortality. Area under the curve (AUC) with 95% CI was estimated, and optimum cutoff values were determined by maximizing the Youden index. Statistical analyses were performed using IBM SPSS Statistics for Mac, Version 26.0 (IBM Corp., Armonk, NY, USA). $P < 0.05$ was considered statistically significant. There were no missing data for the key variables analyzed in this study.

Results

Patient characteristics

After excluding patients aged under 18 years and those with chronic or nonacute burns, 595 adult patients with acute burn injuries were eligible for the analysis. The selection process is summarized in Figure 1. The mean age was 41.74 ± 14.95 years, with a median of 41 years. Among the patients, 406 (68.2%) were male, and 189 (31.8%) were female. The average number of surgical operations per patient was 2.22 ± 2.05 , and the mean LOS was 14.58 ± 10.57 days.

Regarding burn severity, the distribution based on TBSA revealed that most patients sustained extensive injuries. The largest proportion (263 patients; 44.2%) had burns involving more than 40% of TBSA. This was followed by 115 patients (19.3%) with TBSA of 21%–30%, 99 patients (16.6%) with TBSA of 11%–20% and 96 patients (16.1%) with TBSA of 31%–40%. Only 22 patients (3.7%) had TBSA involvement of 10% or less.

Among the cohort, 251 patients (42.2%) died during hospitalization. The predominant cause of death was sepsis, accounting for 194 cases (69.04%), underscoring its critical role as a complication in burn injuries. Other notable causes of mortality included acute respiratory distress syndrome (ARDS) in 28 patients (9.96%), inhalation injury in 21 patients (7.47%), and acute kidney injury (AKI) in 17 patients (6.05%). In addition, cardiac arrest caused 12 deaths (4.27%), and other causes accounted for 9 deaths (3.20%). Further description of patient demographics, clinical characteristics, and burn severity is presented in Table 1.

Surgical treatment and hospital stay

The mean number of operations per patient was 2.22 ± 2.05 , while the median was 2 (IQR 1–3). LOS averaged 14.6 ± 10.6 days, median 17 (IQR 10–26). The longest stays were observed in the TBSA 31%–40%

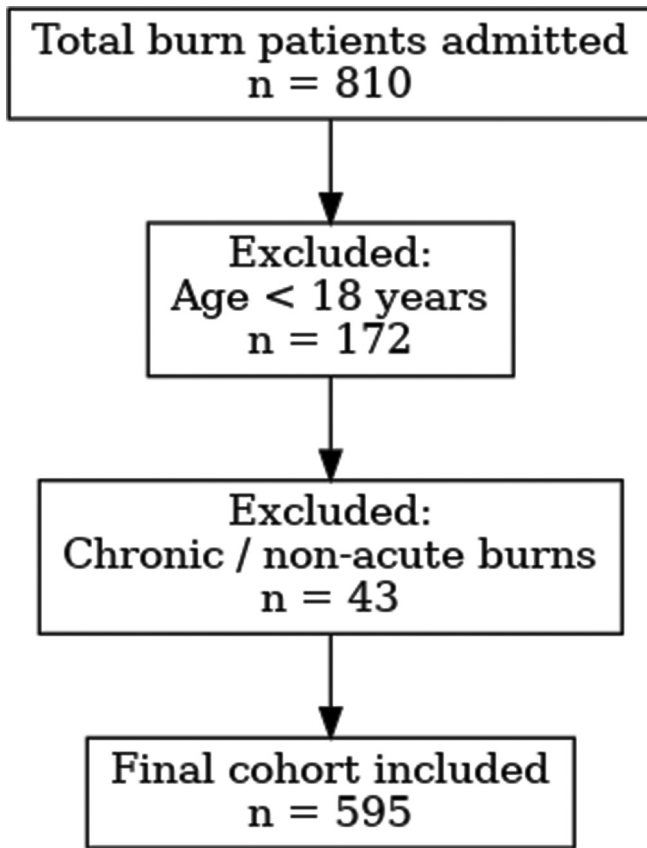


Figure 1: Patient selection

group (17.88 ± 13.31 days), while the shortest occurred in the $\leq 10\%$ group (7.18 ± 5.54 days).

To account for skewed distributions, Kruskal-Wallis testing was performed, confirming significant between-group differences in the number of operations ($H = 42.739$, $df = 4$, $P < 0.001$). Median operations peaked at 3 [IQR 2–4] in 21%–40% TBSA, then declined to 2 (IQR 1–3) in $> 40\%$ TBSA, consistent with the impact of early mortality limiting opportunities for surgery [Table 2].

Mortality and predictors

Burn severity, as reflected by TBSA, was strongly associated with in-hospital mortality. Mortality rates increased markedly with higher TBSA. Patients with TBSA $\leq 10\%$ had the lowest mortality rate at 13.6%, followed by 13.1% in the 11%–20% group and 15.7% in the 21%–30% group. A notable rise was seen in the 31%–40% group, with a mortality rate of 39.6%. The highest mortality rate was observed in patients with TBSA $> 40\%$, of whom 68.1% died. This trend was statistically significant (Chi-square test, $P < 0.001$).

Unadjusted logistic regression showed higher odds of death with increasing TBSA, significant from 31% to 40% (OR 4.15, 95% CI 1.15–15.0, $P = 0.030$) and $> 40\%$

Table 1: Patient characteristics

Characteristics	Cases (n=595; 100%), n (%)
Age (years)	
Mean	41.74±14.95
Median	41 (9–83)
Sex	
Male	406 (68.2)
Female	189 (31.8)
TBSA (%)	
≤ 10	22 (3.7)
10–20	99 (16.6)
21–30	115 (19.3)
31–40	96 (16.1)
> 40	263 (44.2)
Cause of burn	
Flame	473 (79.4)
Electrical	66 (11.1)
Scald	31 (5.2)
Chemical	25 (4.2)
Length of stay (days)	
Mean	14.58±10.57
Median	12 (1–73)
Total operations	2 (0–14)
Mortality	
Alive	344 (57.8)
Dead	251 (42.2)
Cause of death	Causes (n=281), n (%)
Sepsis	194 (69.0)
ARDS	28 (10.0)
Inhalation injury	21 (7.5)
AKI	17 (6.1)
Cardiac arrest	12 (4.3)
Others	9 (3.2)

ARDS: Acute respiratory distress syndrome, AKI: Acute kidney injury, TBSA: Total body surface area

Table 2: Number of operations by total body surface area

TBSA (%)	n	Median operations (IQR)
≤ 10	22	1 (1–2)
11–20	99	2 (1–3)
21–30	115	3 (2–4)
31–40	96	3 (2–4)
> 40	263	2 (1–3)
Total	595	$H=42.739$, $P<0.001$

Statistical test used: Kruskal-Wallis. TBSA: Total body surface area, IQR: Interquartile range

TBSA (OR 13.5, 95% CI 3.89–46.9, $P < 0.001$), compared with $\leq 10\%$. In multivariable analysis [Table 3], TBSA remained a strong independent predictor: adjusted OR 8.27 (95% CI 2.16–31.7, $P = 0.002$) for 31%–40% and 22.3 (95% CI 6.16–80.8, $P < 0.001$) for $> 40\%$. Older age increased mortality (adjusted OR [aOR] 1.021 per year, $P = 0.004$), while male sex conferred modest excess risk (aOR 1.60, $P = 0.040$). More operations (aOR 0.74 per procedure, $P < 0.001$) and longer LOS (aOR 0.97 per day, $P = 0.019$) were associated with lower odds of death,

reflecting survivorship bias. The final model demonstrated good performance (Nagelkerke $R^2=0.441$, accuracy 80%).

Survival analysis

Kaplan–Meier survival curves [Figure 2] demonstrated significant differences by TBSA (log-rank $P < 0.001$). Patients with $>40\%$ TBSA had rapid declines in survival within 2 weeks, while those with $\leq 20\%$ TBSA maintained survival above 85% throughout hospitalization. This pattern suggests that fewer operations in the largest burn group reflect early mortality rather than treatment limitation.

Receiver operating characteristic analysis of total body surface area

With TBSA (%) as a continuous variable predictor, ROC analysis had strong discrimination for in-hospital death [Figure 3] with an AUC level of 0.813 (95% CI 0.777–0.848, $P < 0.001$). This implies that TBSA in numeric form alone accounts for a large percentage of risk for mortality.

Optimum cutpoint by Youden index was 33.8% TBSA with 83.7% sensitivity and 66.3% specificity. Such a threshold allows for balanced accuracy in risk stratification. With a broader triage definition, a lower cutpoint of $\sim 30.8\%$ TBSA increased sensitivity at 86.5% but decreased specificity (59.3%) in comparison. These findings are in keeping with clinical experience, whereby mortality sharply increases above one-third involvement of TBSA.

Discussion

As a lower-middle-income nation, Indonesia bears a significant burden of burn-related mortality,

contributing notably to the global toll. According to the WHO, over 95% of burn fatalities occur in low- and middle-income countries.^[1] Numerous investigations have aimed to characterize the epidemiological profile of burn injuries within their respective institutions and assess the outcomes of current therapeutic strategies. Burn injuries can lead to critical systemic disturbances and remain a major cause of morbidity and mortality. The disruption of the skin – our primary barrier against external threats – triggers both local and systemic inflammatory responses. In the present study, which analyzed 595 adult acute burn cases from 2020 to 2024, the overall mortality rate was 42.2%. Notably, mortality was the highest among patients with a TBSA burn exceeding 40%, with 68.1% of this subgroup succumbing to their injuries. These results are consistent with earlier data from our center (2013–2017), which also identified TBSA $>40\%$ as the strongest predictor of mortality.^[3]

Infection-related complications, particularly sepsis, have been widely reported as a leading cause of death in severe burn patients, accounting for over half of burn-related fatalities in multiple studies.^[8,9] Consistent with this, our study found that sepsis was the primary cause of death in 194 cases (69.04%), reinforcing its role as a critical complication in burn care. Thermal burns continue to be the predominant cause of admission to burn centers, constituting approximately 86% of all burn cases globally. These injuries commonly result from exposure to flame, scalding liquids, steam, or electrical sources. Known risk factors include male sex, younger age, and unsafe home environments, such as the absence of smoke detectors.^[10] Our findings align

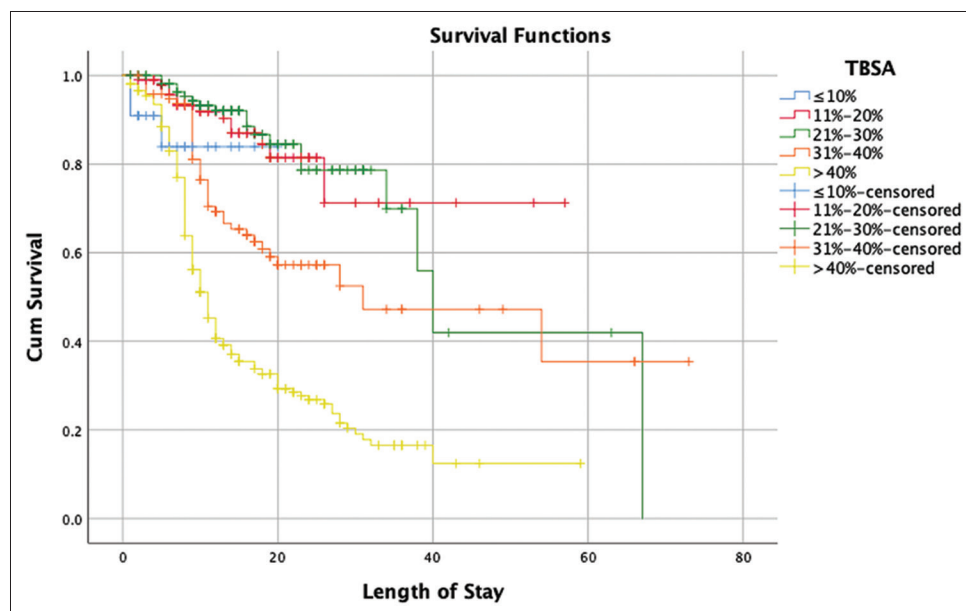


Figure 2: Kaplan–Meier survival curves by total body surface area category. TBSA: total body surface area

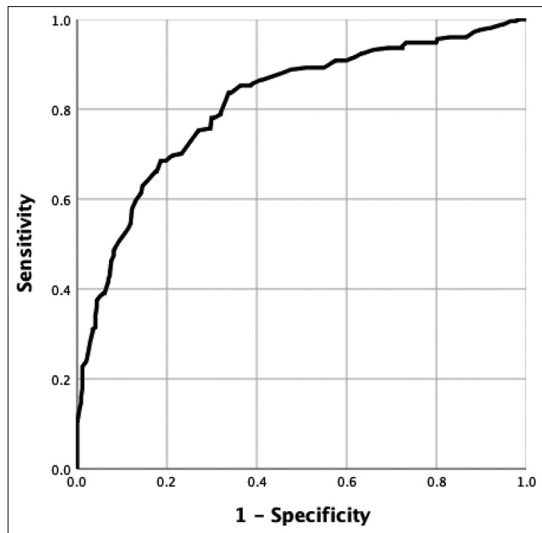


Figure 3: Receiver operating characteristic curve of total body surface area for predicting in-hospital mortality. ROC: Receiver operating characteristic

Table 3: Logistic regression for in-hospital mortality

Predictor	Crude OR (95% CI)	Adjusted OR (95% CI)	P (adjusted)
Age	-	1.02 (1.01–1.04)	0.004
LOS	-	0.97 (0.94–0.99)	0.019
Total operations	-	0.74 (0.64–0.85)	<0.001
TBSA 11%–20% versus ≤10%	0.96 (0.25–3.69)	1.53 (0.38–6.14)	0.547
TBSA 21%–30% versus ≤10%	1.18 (0.32–4.39)	2.11 (0.54–8.21)	0.283
TBSA 31%–40% versus ≤10%	4.15 (1.15–15.0)	8.27 (2.16–31.7)	0.002
TBSA >40% versus ≤10%	13.5 (3.89–46.9)	22.3 (6.16–80.8)	<0.001

Model performance: Nagelkerke $R^2 \approx 0.44$; overall accuracy $\approx 80\%$.
 TBSA: Total body surface area, OR: Odds ratio, CI: Confidence interval, LOS: Length of stay

with this pattern, identifying flame-related injuries as the most frequent etiology (79.36%), followed by electrical burns (11.07%), scalds (5.21%), and chemical burns (4.20%).

Burn injuries are complex traumatic events that can lead to a wide range of complications involving multiple organ systems. One of the most critical consequences is the systemic inflammatory response, which may progress to systemic inflammatory response syndrome, multiple organ dysfunction syndrome, and sepsis – each contributing significantly to increased morbidity and mortality. Organ dysfunction, particularly in patients with major burns, is a leading cause of death. The inflammatory cascade, initially a protective mechanism, often becomes dysregulated, resulting in immunosuppression and catabolism. This dysregulation impairs wound healing and increases the risk of secondary complications such as ARDS, cardiovascular dysfunction, and AKI.^[11,12]

Among these, renal dysfunction is particularly notable due to its frequency and prognostic significance. Extensive tissue injury and systemic inflammation commonly lead to renal impairment, reflected by elevated blood urea and serum creatinine levels. Hasibuan *et al.* emphasized that serum creatinine serves as a more accurate predictor of burn-related mortality than blood urea, underscoring its clinical relevance as a prognostic marker.^[12] Furthermore, burn severity – especially the TBSA affected and the presence of inhalation injury – remains a key determinant of patient outcomes. Higher TBSA involvement correlates with a more intense inflammatory and metabolic response, resulting in poorer prognoses and an increased risk of life-threatening complications.^[11]

This is the first study systematically analyzing the influence of the number of surgical interventions on outcomes in burn patients, covering a broad range of interventions such as amputations, debridement, treatment without excision, escharotomy, fasciotomies, and flap operations. About half of the patients, as indicated in Table 2, had a significantly different number of operations per month within a certain TBSA classification (Kruskal–Wallis $H = 42.739, P < 0.001$). Both patients with 21%–40% TBSA had the highest number of median operations (median 3 [IQR 2–4]), whereas patients with TBSA >40 had fewer operations (median 2 [IQR 1–3]), despite larger lesions. Kaplan–Meier estimation of survival identified an additional steep fall in patients with >40% TBSA within 2 weeks after their arrival, further confirming the conviction that fewer operations in such a subgroup early in-hospital deaths were indicative rather than limited therapy.

Therefore, our multivariable logistic regression confirmed TBSA as an independent predictor of death with aORs for 31%–40% TBSA and >40% TBSA compared with ≤10% TBSA of 8.27 and 22.3, respectively. Older age was a risk factor for death; longer stay and greater number of operations were inversely related to death, consistent with survivorship in patients who lived long enough for definitive operations. This inverse correlation in the >40% TBSA subgroup is best explained by the rapid clinical deterioration commonly seen in severe burn patients, which would preclude definitive surgical intervention at least a proportion of the time, instead of signaling a deliberate treatment delay. Kaplan–Meier analysis confirmed that a large majority of deaths in this subgroup were taking place within an early few weeks after admission, before which multiple operative interventions were not feasible. Such an environment highlights the importance of early aggressive resuscitative maneuvers as well as critical care support in such patients. Directed investigation in the future is warranted, particularly in patients with extensive deep-dermal and full-thickness burns, in determining if an earlier onset of surgical

intervention or adjunctive intensive care maneuvers might improve outcomes in such patients.

In this study of 595 adult burn patients, burn severity as measured by TBSA demonstrated a strong association with key clinical outcomes. As TBSA increased, both the number of surgical operations and hospital LOS rose significantly, peaking in the 21%–40% TBSA groups. Patients with TBSA >40% underwent fewer surgeries despite having the most extensive injuries, a pattern best explained by their rapid early mortality, as confirmed by Kaplan–Meier survival curves. Mortality rates increased markedly with burn severity, with the highest mortality (68.1%) observed in patients with TBSA >40%. Logistic regression confirmed TBSA as an independent predictor of mortality, with aORs of 8.27 for 31%–40% and 22.3 for >40% TBSA compared with ≤10%. These findings are in line with previous studies that have highlighted the critical role of burn severity in influencing the clinical outcomes. For instance, Alshammari *et al.* reported that partial-thickness burns significantly improved survival, increasing the likelihood of survival by ten times compared to full-thickness burns ($P < 0.003$).^[13] Similarly, Jeschke *et al.* found that a burn size between 40% and 50% TBSA was associated with a markedly increased risk of severe morbidity. Their analysis indicated that adult burn patients had threshold TBSA values of 44% for mortality, 46% for multiple organ failure, 42% for burn wound infections, and 49% for sepsis.^[14] These data collectively reinforce the current study's conclusion that TBSA is a powerful predictor of adverse outcomes in burn patients.

Other clinical factors also influenced mortality. Older age increased the risk of death, consistent with the well-known vulnerability of older burn patients. Fewer surgical procedures and shorter hospital stays were associated with mortality, reflecting the fact that severely ill patients often died early before receiving more extensive operative care or prolonged treatment. In contrast to prior reports, male sex was modestly associated with increased mortality risk in the adjusted model (aOR 1.60, 95% CI 1.02–2.51). These findings emphasize the critical role of burn severity and clinical course in determining outcomes and highlight the importance of early, aggressive management, particularly intensive support in high TBSA burns, where surgical opportunities are rapidly curtailed by early deaths.

Burn injury with large TBSA can lead to persistent systemic dysregulation. To accelerate wound healing, the inflammatory response increases rapidly. There are two phases, the ebb phase and the flow phase, where the ebb phase lasts for the first 72–96 h postinjury. After the initial sympathetically mediated shock, there is an ebb phase accompanied by a decrease in metabolic

rate and tissue perfusion. After that, the systemic inflammatory response becomes uncontrolled and is exacerbated by tissue and organ dysfunction, which will lead to a hypermetabolic state. The flow phase can last up to 36 h postinitial injury. Increased chronic stress mediator responses, such as catecholamines and glucocorticoids, will cause multiorgan hypercatabolism, such as lipolysis, glycogenolysis, and proteolysis, leading to insulin resistance and lipotoxic conditions, which only worsen the hypermetabolic response in a futile cycle. If hypermetabolism cannot be overcome, the patient may experience sepsis and/or multi-organ failure.^[15]

In lower-middle-income countries, healthcare systems face significant challenges in managing burn patients, including delayed referrals, limited surgical capacity, and lack of intensive care unit resources. These systemic barriers have been highlighted in a recent systematic review, which demonstrated significantly higher mortality rates and poorer outcomes compared to high-income countries.^[16] In such contexts, although excision, debridement, and skin grafting are crucial for managing full-thickness burns, they are often not prioritized due to the urgent need for initial resuscitation, infection control, and stabilization of critically ill patients. The main focus should be on hemodynamic stabilization and management of risk factors that may lead to mortality. Patients with burn areas exceeding 45% of the TBSA have limited donor sites available for grafting, thus benefiting more from allotransplantation (using split-thickness skin grafts preserved in skin banks or obtained from donors) for serial excision grafting interventions.^[17]

These findings support the concept of proactive surgical management, where excision is prioritized to improve the survival outcomes. However, in low- and middle-income countries, systemic barriers such as delayed referrals and limited surgical capacity may limit the feasibility of this approach, highlighting the need for further prospective research to adapt proactive strategies within the resource-constrained settings.

Limitations

Some limitations of this study are identified. First, its single-center design in retrospect is based on secondary medical records and so may suffer from missing or incomplete recording. Despite a few missing values, which were managed by listwise deletion, residual information bias is not excluded. Second, only adult patients with acute burns were included in our study population, so results are not transferrable for pediatric cases or other settings. Third, some clinically relevant confounding variables were absent, for example, burn depth, inhalation injury, preexisting comorbid disease, nutritional state, and referral delay. The absence of these data was primarily due to inconsistent documentation

in medical records, which limited our ability to include them in the analysis. Future prospective studies with standardized assessment are needed to address these gaps. These variables may influence both surgical decision-making and patient outcome and were not available for the construction of more detailed multivariable models (e.g., for surgical counts). Fourth, our relative lower number of operations in patients with >40% TBSA should be interpreted with caution: our examination of survival shows this is more a product of early mortality rather than systematic undertreatment at a population level, but on a retrospective dataset, definitive causal conclusions are not available. Fifth, since our unit is a national referral center, our study population is likely over-representative in severe and complex burns compared with smaller units in which it is referred; thus, our ratio is likely over-estimate relative national or Australian-wide mortality compared with smaller units.

Conclusions

Among this 5-year population of 595 adults with burns, the severity of burn by TBSA predicted the best surgical therapy opportunities as well as survival. These patients with 21%–40% TBSA had the most operations conducted in their cases, while those with >40% TBSA had fewer operations conducted, mostly due to early rapid death validated by Kaplan–Meier analysis. Multivariable logistic regression identified independently elevated mortality in greater TBSA, increased age, and male sex, while longer stay in hospital and increased operations were protective variables reflecting survivorship. On the basis of numeric TBSA, ROC analysis identified ~ 34% as a clinically significant threshold for risk for mortality with an objective discriminator for prehospital triage as well as prognostic advice. These conclusions identify critically early aggressive intervention requirements in high-TBSA patients while at the same time drawing attention to the fact that, besides burn size, outcomes are also moderated by clinical course in hospital.

Author contributions statement

Aditya Wardhana: Conceptualization, study design, data collection, data analysis, and manuscript writing.

Tiara Putri Leksono, Indira Saraswati Sanjaya, Billy Sandy Handiansyah, and Nadya Farhana: Data interpretation, critical revision of the manuscript.

All authors approved the final version of the manuscript and agree to be personally accountable for their own contributions and to ensure the integrity and accuracy of the work.

Conflicts of interest

None Declared.

Ethical approval

This study was approved by the Institutional Ethics Committee (KET-599/UN2.F1/ETIK/PPM.00.02/2024, Protocol

No. 24-04-0598; and KET-1676/UN2.F1/ETIK/PPM.00.02/2024, Protocol No. 24-11-1679). The requirement for informed consent was waived due to the retrospective design and use of fully anonymized data. Patient confidentiality was strictly maintained, and no identifiable information was disclosed. All procedures were conducted in accordance with institutional guidelines and the principles of the Declaration of Helsinki.

Funding

None.

References

1. World Health Organization. Burns; 2023. Available from: <https://www.who.int/news-room/fact-sheets/detail/burns>. [Last accessed on 2025 Jun 11].
2. Bowo SA, Putri AC. Bacterial pathogens and antibiotic sensitivity pattern in burn unit of Hasan Sadikin Hospital (RSHS) from January 2012–December 2015. *J Plast Reconstr* 2016;3:32-9.
3. Wardhana A, Winarno GA. Epidemiology and mortality of burn injury in Cipto Mangunkusumo Hospital, Jakarta: a 5 year retrospective study. *J Plast Reconstr* 2019;6:234-42.
4. Soedjana H, Nadia J, Sundoro A, Hasibuan L, Rubianti IW, Putri AC, et al. The profile of severe burn injury patients with sepsis in Hasan Sadikin Bandung General hospital. *Ann Burns Fire Disasters* 2020;33:312-6.
5. Syarif AN, Afira F, Wardhana A, Ramadhan A. Analyzing mortality and the effect of early excision as a preliminary treatment of acute burn patients in a limited resource setting using LA50 as an outcome measurement. *Ann Burns Fire Disasters* 2022;35:125-36.
6. Rose JK, Herndon DN. Advances in the treatment of burn patients. *Burns* 1997;23 Suppl 1:S19-26.
7. Mosier MJ, Gibran NS. Surgical excision of the burn wound. *Clin Plast Surg* 2009;36:617-25.
8. D'Avignon LC, Hogan BK, Murray CK, Loo FL, Hospenthal DR, Cancio LC, et al. Contribution of bacterial and viral infections to attributable mortality in patients with severe burns: An autopsy series. *Burns* 2010;36:773-9.
9. Sharma BR, Harish D, Singh VP, Bangar S. Septicemia as a cause of death in burns: An autopsy study. *Burns* 2006;32:545-9.
10. Szymanski KD, Tannan SC. Thermal Burns [Internet]. Treasure Island (FL): StatPearls Publishing; 2023. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK430773/>. [Last accessed on 2025 Sep 27].
11. Wertz PW, Zwierello W, Piorun K, Skórka-Majewicz M, Maruszewska A, Antoniewski J, et al. Burns: Classification, pathophysiology, and treatment: A review. *Med Sci Rev* 2023;24:3749.
12. Hasibuan MI, Moenadjat Y. Prognostic and predictive factors of mortality in burn patients at dr. Cipto Mangunkusumo General Hospital, Indonesia. *New Ropanasuri J Surg* 2021;6:11-4.
13. Alshammari SM, Almarzouq S, Alghamdi AA, Shash H. Mortality and survival analysis of burn patients admitted in a critical care burn unit, Saudi Arabia. *Saudi J Med Med Sci* 2022;10:216-20.
14. Jeschke MG, Pinto R, Kraft R, Nathens AB, Finnerty CC, Gamelli RL, et al. Morbidity and survival probability in burn patients in modern burn care. *Crit Care Med* 2015;43:808-15.
15. Knuth CM, Auger C, Jeschke MG. Burn-induced hypermetabolism and skeletal muscle dysfunction. *Am J Physiol Cell Physiol* 2021;321:C58-71.
16. Nițescu C, Calotă DR, Florescu IP, Lascăr I. Surgical options in extensive burns management. *J Med Life* 2012;5:129-36.
17. Wong L, Rajandram R, Allorto N. Systematic review of excision and grafting in burns: Comparing outcomes of early and late surgery in low and high-income countries. *Burns* 2021;47:1705-13.

Supplementary File 1: STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*: Checklist for cohort, case–control, and cross-sectional studies (combined)

Section/Topic	Item number	Recommendation	Reported on page number
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State-specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of the study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(a) Cohort study – Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4
		Case–control study – Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	
		Cross-sectional study – Give the eligibility criteria, and the sources and methods of selection of participants	
		(b) Cohort study – For matched studies, give matching criteria and number of exposed and unexposed	NA
		Case–control study – For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4–5
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	4–5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	5
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	5
		(d) Cohort study – If applicable, explain how loss to follow-up was addressed	NA
		Case–control study – If applicable, explain how matching of cases and controls was addressed	
		Cross-sectional study – If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study – e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	5
		(b) Give reasons for non-participation at each stage	5 and 17
		(c) Consider use of a flow diagram	17
Descriptive data	14*	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders	5
		(b) Indicate number of participants with missing data for each variable of interest	5
		(c) Cohort study – Summarise follow-up time (e.g., average and total amount)	NA
Outcome data	15*	Cohort study – Report numbers of outcome events or summary measures over time	5–6
		Case–control study – Report numbers in each exposure category, or summary measures of exposure	NA
		Cross-sectional study – Report numbers of outcome events or summary measures	NA

Contd...

Supplementary File 1: Contd...

Section/Topic	Item number	Recommendation	Reported on page number
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	5–6
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done – e.g., analyses of subgroups and interactions, and sensitivity analyses	6
Discussion			
Key results	18	Summarize key results with reference to study objectives	7–9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both the direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results, considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	NA
Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for cases and controls in case–control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies. An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Websites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org