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# Severe burns in Australian and New Zealand adults: Epidemiology and burn centre care

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ABSTRACT

*Introduction:* Studies describing the epidemiology of severe burns (>20% total body surface area) in adults are limited despite the extensive associated morbidity and mortality. This study aimed to describe the epidemiology of severe burn injuries admitted to burn centres in Australia and New Zealand.

*Materials and methods:* Data from the Burns Registry of Australia and New Zealand (BRANZ) were used in this study. Patients were eligible for inclusion if they were admitted between August 2009 and June 2013, were adults (18-years or older), and had burns of 20% total body surface area (TBSA) or greater. Demographics, burn characteristics and in-hospital mortality risk factors were investigated using multivariable Cox proportional hazards analysis.

*Results:* There were 496 BRANZ registered patients who met the inclusion criteria. Over half of the patients were aged 18–40 years and most were male. The median (IQR) TBSA was 31 (25–47). Most (75%) patients had burns involving <50% TBSA, 58% sustained their burn injury at home, and 86% had sustained flame burns. Leisure activities, working for income and preparing food together accounted for over 48% of the activities undertaken at the time of injury. The in-hospital mortality rate was 17% and the median (IQR) length of stay was 24 (12–44) days. Seventy-two percent were admitted to an intensive care unit (ICU) and 40% of patients had an associated inhalation injury. Alcohol and/or drug involvement was suspected in 25% of cases.

*Conclusion:* This study describes the demographics, burn injury characteristics and in-hospital outcomes of severe burn injuries in adults whilst also identifying key predictors of inpatient mortality. Key findings included the over-representation of young males, intentional self-harm injuries and flame as a cause of burns and highlights high risk groups to help aid in the development of targeted prevention strategies.

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## 1. Introduction

Burns serious enough to warrant hospital admission can be difficult to manage and benefit from input from a variety of specialist healthcare professionals [1]. Severe burn injuries (total body surface area (TBSA) of 20% or greater) account for approximately 8% of burn injury admissions to burn centres across Australia and New Zealand [1,2]. In-hospital mortality rates for severe burn injuries have been shown to range from 27% to 33% [3,4], and up to 54% for injuries of 40% TBSA or greater [5].

Despite the high levels of morbidity and mortality associated with severe burn injury, there is still a lack of published data describing the epidemiology of this patient group. Epidemiological studies are important as they help facilitate targeted burn prevention, management and organise burn care. Australian literature investigating the epidemiology of severe burns has been limited to specific regions, with some of these studies using data that is over two decades old [1,6–8]. Whilst studies investigating the epidemiology of burns based in specific geographical areas are helpful, broader nationally based perspectives using contemporary data are beneficial to best inform prevention and treatment strategies. This also provides the opportunity to analyse a relatively larger cohort of patients when compared to previously published literature. Thus, the aim of this study was to describe the epidemiology of severe burn injuries admitted to burn centres in Australia and New Zealand.

## 2. Materials and methods

### 2.1. Setting

The Burns Registry of Australia and New Zealand (BRANZ) is a clinical quality registry of burns that incorporates burn-related epidemiological, quality of care, and outcome data from patients in Australia and New Zealand [9]. The BRANZ was formed as a collaboration between Monash University and the Australia and New Zealand Burn Association (ANZBA) which aims to implement evidence-based recommendations to improve patient care, outcomes, cost-effectiveness and burn centre capacity. To be included on the registry, burns patients must be admitted to hospital for at least 24 h, be admitted for less than 24 h but undergo surgical management, or die prior to discharge. Furthermore, patients must have also been admitted within 28 days of the burn or transferred from another hospital (irrespective of the time from injury) [9].

### 2.2. Participants

Patients eligible for inclusion in this study were: adults (age of 18-years or greater) with a TBSA burned of 20% or greater who were admitted to a BRANZ participating hospital between August 2009 and June 2013. For this study 10 of 12 BRANZ sites contributed data.

### 2.3. Procedures

Factors used to describe the demographic profile of the population included age, gender, and comorbidities. Comorbidities were based on the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM). The ICD-10-AM is a coding scheme for diseases and external causes of injury. Comorbidities reported in this study based on ICD-10-AM codes were the presence of type 1 or type 2 diabetes mellitus, obesity, chronic obstructive pulmonary disease (COPD) or asthma and ischaemic heart disease (IHD). Chronic kidney disease was not included because of low numbers (less than five). Codes were also used to calculate a Charlson Comorbidity Index (CCI) for each patient. The CCI predicts the 10-year mortality for patients based on the presence of certain conditions. Patients were assigned a score of 0, 1, 2, 3, or 6 based on the conditions present, with a higher score representing the risk of less favourable outcomes. Nineteen Charlson conditions were mapped from ICD-10-AM codes to assign CCI scores to each patient [10]. Fund sources for admission were also reported. These were categorised as Australian public healthcare (i.e. Commonwealth state funding agreement), private health insurance (Australia), self-funding (Australia), workers compensation (Australia), motor vehicle third party personal claims (Australia), Department of Veterans Affairs (Australia), reciprocal health care agreements (with other countries), other sources (e.g. travel insurance), motor vehicle compensation (Australia), Accident Compensation Corporation (no-fault personal injury cover in New Zealand), surgical services contract and other private insurance (New Zealand).

Burn injury event characteristics included the activity being performed when the burn occurred, the place of injury, the primary cause, intent of burn injury (i.e. unintentional, intentional self-harm or assault), and if alcohol or drugs were confirmed or suspected to be a factor in the occurrence of the burn. The burn injury was further characterised by the %TBSA, body area involved, whether an inhalation injury was sustained and the burn depth. A patient was recorded as having an inhalation injury if this was documented during the admission. Alcohol and/or drug involvement was recorded if clinical documentation indicated there was confirmed, or a suspicion of, alcohol and/or drug use contributing to the patient sustaining a burn.

The 'rule of nines' was used to assess %TBSA [11] by the most senior burns clinician within 72-h of admission. Categorisation based on quartiles (20–25%, 26–30%, 31–49% and $\geq$50%) was used to describe the %TBSA given the skewed distribution of this variable. Burn depth was assessed clinically and classified as superficial dermal, mid-dermal, deep dermal and full thickness at the time of assessment [12]. For this study these terms were then simplified to three groups: superficial partial thickness burns (superficial or mid dermal), deep partial thickness/full thickness burns (deep dermal or full thickness) and combination burns (where a patient had been assessed as having areas of superficial partial thickness burns *and* deep partial/full thickness burns). The following in-hospital measures were also reported; mortality, length of stay and admission to an intensive care unit (ICU).

### 2.4. Data analysis

Descriptive statistics were used to summarise the characteristics of the included patients. Frequencies and percentages were used for categorical variables and an assessment of

normality was undertaken for all continuous variables. The mean and standard deviation (SD) were reported for normally distributed variables, otherwise median and inter-quartile range (IQR) were used. Chi-square tests were used to compare categorical variables. Mann–Whitney U tests or Kruskal Wallis tests were used to compare groups using continuous variables.

A Cox Proportional Hazards regression model was used to model time to in-hospital death [13]. For this survival analysis the time of admission was designated the time of origin (t0) and survivors were censored at the time of discharge. Potential risk factors for mortality were analysed and included age, gender, comorbidities, cause, injury intent (i.e. self-harm), % TBSA, the presence of an inhalation injury, body region involved and whether the patient had a surgical procedure performed. Factors showing a significant association on univariate testing were included in the multivariable model. The hazard ratio, and corresponding 95% confidence intervals, were then reported and represent a measure of how often an event (i.e. death) occurred in one group compared to the other over time. A p-value of less than 0.05 was considered significant and statistical analyses were performed using STATA (version 13).

## 3. Results

### 3.1. *Patient demographics*

There were 496 patients eligible for inclusion in this study (Table 1). Three Australian burn centres provided care for 56% of the patients, 57% of patients were 18–40 years of age and most were male (Table 1).

**Table 1 – Demographics of the patient population.**

| Characteristics | All patients N = 496 |
|---|---|
| Age group | |
| 18-25 years | 113 (22.8%) |
| 26-40 years | 168 (33.9%) |
| 41-55 years | 107 (21.6%) |
| ≥56 years | 108 (21.8%) |
| Sex | |
| Male | 374 (75.4%) |
| Female | 122 (24.6%) |
| Comorbidities | |
| Diabetes | 32 (6.5%) |
| Obesity | 9 (1.8%) |
| COPD or asthma | 7 (1.4%) |
| IHD | 6 (1.2%) |
| Hospital Campus | |
| Hospital A | 109 (22.0%) |
| Hospital B | 105 (21.2%) |
| Hospital C | 63 (12.7%) |
| Hospital D | 62 (12.5%) |
| Hospital E | 57 (11.5%) |
| Hospital F | 53 (10.7%) |
| Hospital G | 15 (3.0%) |
| Hospital H | 13 (2.6%) |
| Hospital I | 12 (2.4%) |
| Hospital J | 7 (1.4%) |
| Insurance fund source[a] | |
| Australian health care agreements (Australia) | 331 (66.9%) |
| Accident Compensation Corporation (NZ) | 72 (14.6%) |
| Workers' compensation body (Australia) | 51 (10.3%) |
| Private health insurance (Australia) | 15 (3.0%) |
| Other[b] | 26 (5.3%) |
| Admission source | |
| Inter-hospital transfer | 279 (56.3%) |
| Via ambulance from scene of injury | 189 (38.1%) |
| Other referral source[c] | 28 (5.6%) |

[a] Insurance fund source data missing for n = 1.
[b] Funded by self, motor vehicle compensation, reciprocal health care or department of veterans affairs.
[c] From general practitioner, self-presentation or other burn centre.

### 3.2. *Burn injury event*

Most patients sustained their injuries at home. The most common activities that resulted in a severe burn were leisure activities, working for income, and preparing food or drink. Intentional self-harm injuries contributed 18% of recorded cases (Table 2). Flame burns accounted for 86% of cases and 40% of patients with a flame burn also sustained an inhalation injury (Table 2).

### 3.3. *Severity of burn injury*

The median (IQR) %TBSA was 31 (25–47) and ranged from 21 to 100 with 75% of patients sustaining burns involving <50% TBSA. Lower %TBSA burns were more commonly superficial; 31% of 20–25% TBSA burns were superficial partial thickness (Fig. 1).

### 3.4. *In-hospital outcomes*

Fifty-two percent of patients were discharged to a place of residence and there were 84 (17%) in-hospital deaths. Of the deaths, 49 (58%) had treatment withdrawn (active treatment commenced but ceased), 13 (15%) did not have active treatment instituted on admission, and 8 (10%) died without withdrawal of treatment. For 14 deaths, this information was not provided. Of the survivors, 79% were male and were younger than those who died (Table 3). The median (IQR) length of stay was 24 (12–44) days and 72% of patients were admitted to an intensive care unit (ICU). The median (IQR) length of stay in ICU was 173 (48–374) hours. Multivariable analysis revealed the presence of an inhalation injury, older age and greater TBSA were associated with increased risk of in-hospital mortality (Table 4). The presence of comorbid conditions including obesity, diabetes, COPD/asthma and ischaemic heart disease were not shown to increase the risk of in-hospital mortality. An analysis of CCI and mortality was also undertaken. A *higher* CCI (i.e. more comorbidities) was shown to be significantly associated with *survival* (P-value <0.01).

## 4. Discussion

This study provides the first epidemiological analysis of Australian and New Zealand adults with severe burn injuries.

**Table 2 – Burn injury event characteristics of entire population.**

| Place, action and primary cause that resulted in severe burn injury | All patients N = 496 |
|---|---|
| Place of burn injury[a] | |
| Home | 272 (57.5%) |
| Place of recreation | 35 (7.4%) |
| Other residence | 31 (6.6%) |
| Trade or service area | 30 (6.3%) |
| Street or highway | 29 (6.1%) |
| Industrial or construction area | 29 (6.1%) |
| Farm | 17 (3.6%) |
| Other specified place[b] | 30 (6.3%) |
| Activity at the time of burn injury[c] | |
| Leisure activity (excludes sport) | 69 (17.7%) |
| Working for income | 68 (17.4%) |
| Preparing food/drink | 53 (13.6%) |
| Sleeping/resting | 35 (9.0%) |
| Suspected illegal activity | 30 (7.7%) |
| Household maintenance | 24 (6.2%) |
| Vehicle maintenance | 23 (5.9%) |
| Gardening | 21 (5.4%) |
| Other specified activities[d] | 67 (17.2%) |
| Intent of injury[e] | |
| Unintentional | 373 (77.7%) |
| Intentional self-harm | 85 (17.7%) |
| Assault or maltreatment | 22 (4.6%) |
| Primary cause of burn injury[f] | |
| Flame | 427 (86.3%) |
| Scald | 44 (8.9%) |
| Other specified cause[g] | 24 (4.9%) |
| Associated inhalation injury | |
| No | 296 (59.7%) |
| Yes | 200 (40.3%) |
| Alcohol or drugs involved[h] | |
| No | 305 (74.9%) |
| Yes | 102 (25.1%) |

[a] Place of burn injury data missing for n = 23.
[b] Residential institution, school or public administrative area, sports or athletics area, farm.
[c] Action when burn injury occurred data missing for n = 21. Leisure activities included anything with an entertainment element such as being at a cinema, a party or participating in activities of a voluntary organization.
[d] Sports activity, cleaning, near person preparing food/drink, driving, bathing, vehicle/household.
[e] Intent when burn injury occurred data missing for n = 16.
[f] Primary cause of burn injury data missing for n = 1.
[g] Contact, chemical, friction, electrical, pressurised gas/air (non-flame), radiant heat.
[h] Document confirmation or suspicion of alcohol and/or drugs involved data missing for n = 89.

The findings highlight the large number of severe burns occurring in the home which were mostly flame type injuries. The important predictors of mortality were increased age, intentional self-harm, higher %TBSA and the presence of an inhalation injury.

In our study, 4.9% of admissions to Australian and New Zealand burn centres involved burns >=20% TBSA while previous studies have reported values ranging from 8 to 31% [3,4,14,15]. Data from the National Burn Repository (NBR) in the United States of America (USA) and a study involving 1063 cases from Hong Kong each quoted severe burn injury proportions of 8% [4,15]. It is possible that in the USA, a higher proportion of smaller burn injuries were managed outside burn centres, as compared to Australia and New Zealand [16]. It was also possible that in Australia and New Zealand a greater proportion of patients were admitted with less severe injuries that could have been managed elsewhere, which may have accounted for the lower proportion of severe burns observed in BRANZ patients when compared with those from Hong Kong and the USA [15,16]. The highest proportions were seen in Brazilian (31%) and North-East China (20%) cohorts of patients [3,14]. Reasons for variability in reported proportions were multifactorial with differences between healthcare systems, models of care, referral patterns and patient populations likely contributors [3,14].

Severe burn injuries in BRANZ patients predominantly occurred in males aged 18-40 years. Our findings were consistent with data from previous Australian studies and studies undertaken in other high-income countries [16–20]. In contrast, studies undertaken in low and middle-income countries (LMIC) reported a higher proportion of severe burn injuries in women, with the most common mechanisms largely attributed to burn injuries related to cooking [21,22].

The mortality rate of adults with severe burn injuries in this study was 17%. Similar mortality rates have been described in comparable patient populations from other high-income countries throughout Europe [17]. A previous study from the USA reported a mortality rate of 27% between 2005 and 2014 [4]. Mortality rates in LMIC have not been well reported [21]. However higher rates have been observed, with one study from Brazil demonstrating a mortality rate of 33% amongst adults with severe burn injuries [3].

The important predictors of in-hospital mortality in this study were older age, intentional self-harm, higher %TBSA and an associated inhalation injury, which were consistent with previously published literature [17–19,23–27]. Comorbidities have been identified as a possible predictor of mortality in burn injuries previously [28–31]. In this study there were no significant associations found between the presence of obesity, diabetes, COPD/asthma or IHD and an increased risk of in-hospital death. A significant association between survival and *higher* CCI was found (P-value < 0.01) on multivariate analysis, despite adjusting for age, gender, injury intent, %TBSA and inhalation injury (not shown in tables). Upon further investigation it was found that close to 88% of deaths within 24-h of admission had no reported CCI conditions. Thus, it may have been that in cases of such early deaths there was no recording or collection of information about patient comorbidities, and this association may have been the result of bias in the collection of comorbidity information. While multiple studies have found women to be at increased risk of mortality [17,20,22,32–34], we found no association between gender and mortality after adjusting for age, %TBSA, CCI, intentional self-harm and inhalation injury.

Despite adjusting for %TBSA and inhalation injury, intentional self-harm injuries were still found to significantly increase the risk of in-hospital mortality when compared with accidental injuries. It is possible other confounding factors not adjusted for in this analysis, such as burn depth, may be an explanation for this association.

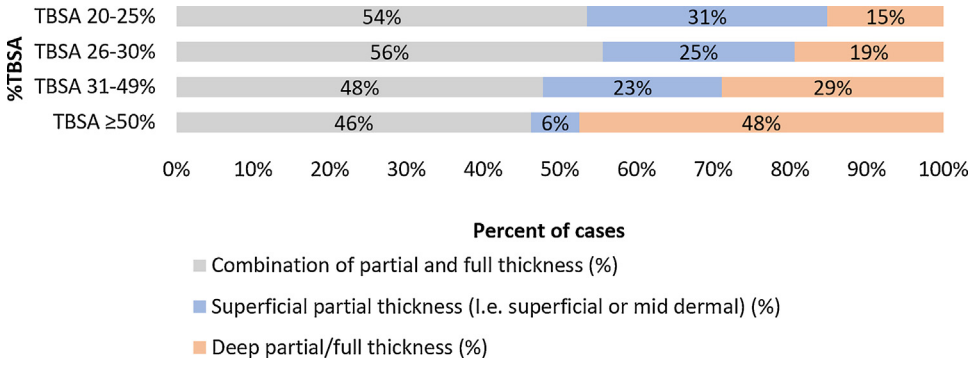


**Fig. 1 – Burn injury depth by %TBSA.**

**Table 3 – Comparison of survivors to discharge and in-hospital deaths.**

| Characteristics | Survivors to discharge N = 411 | In-hospital deaths N = 84 | P-value |
|---|---|---|---|
| Age | | | |
| Median (IQR)- years | 36 (25-50) | 53 (39-66) | <0.01 |
| Range- years | 18-84 | 19-97 | |
| Gender | | | |
| Male | 323 (86.6%) | 50 (13.4%) | <0.01 |
| Female | 88 (72.1%) | 34 (27.9%) | |
| Comorbidities[a] | | | |
| Diabetes | 26 (81.3%) | 6 (18.8%) | 0.81 |
| Obesity | 7 (77.8%) | 2 (22.2%) | 0.69 |
| COPD or asthma | 6 (85.7%) | 1 (14.3%) | 0.84 |
| IHD | 5 (83.3%) | 1 (16.7%) | 0.97 |
| Charlson Comorbidity Index[a] | | | |
| 0 | 281 (83.9%) | 54 (16.1%) | <0.01 |
| 1 | 76 (91.6%) | 7 (8.4%) | |
| ≥2 | 47 (67.1%) | 23 (32.9%) | |
| Primary cause of burn injury[b] | | | |
| Flame | 350 (82.2%) | 76 (17.8%) | 0.22 |
| Other specified cause[c] | 60 (88.2%) | 8 (11.8) | |
| Intent of injury[d] | | | |
| Unintentional | 334 (89.8%) | 38 (10.2%) | <0.01 |
| Intentional self-harm | 50 (58.8%) | 35 (41.2%) | |
| Assault or maltreatment | 18 (81.8%) | 4 (18.2%) | |
| %TBSA group | | | |
| 20-25% | 136 (96.5%) | 5 (3.6%) | <0.01 |
| 26-30% | 101 (95.3%) | 5 (4.7%) | |
| 31-49% | 115 (89.8%) | 13 (10.2%) | |
| >50% | 59 (49.2%) | 61 (50.8%) | |
| Associated inhalation injury | | | |
| Yes | 135 (67.5%) | 65 (32.5%) | <0.01 |
| No | 276 (93.6%) | 19 (6.46%) | |
| Face involved[e] | | | |
| Yes | 256 (83.9%) | 49 (16.1%) | 0.66 |
| No | 96 (85.7%) | 16 (14.3%) | |

[a] CCI and Comorbidity data missing for n = 7.
[b] Primary cause missing for n = 1.
[c] Scald, contact, chemical, friction, electrical, pressurised gas/air (non-flame), radiant heat.
[d] Intent when burn injury occurred data missing for n = 16.
[e] Face involved missing for n = 18.

**Table 4 – Predictors of time to in-hospital mortality (multivariate analysis).**

| Factor | Hazard Ratio (95% CI) N = 472 | P-value |
|---|---|---|
| Age | 1.06 (1.04, 1.07) | <0.01 |
| Gender | | |
| Male (reference) | 1.00 | |
| Female | 1.22 (0.75, 1.99) | 0.43 |
| Diabetes | | |
| No (reference) | 1.00 | |
| Yes | 0.44 (0.18, 1.09) | 0.08 |
| Obesity | | |
| No (reference) | 1.00 | |
| Yes | 0.69 (0.19, 4.09) | 0.88 |
| COPD/asthma | | |
| No (reference) | 1.00 | |
| Yes | 0.84 (0.09, 7.97) | 0.88 |
| IHD | | |
| No (reference) | 1.00 | |
| Yes | 0.65 (0.07, 5.90) | 0.70 |
| Intent of injury | | |
| Unintentional (reference) | 1.00 | |
| Intentional self-harm | 2.90 (1.76, 4.77) | <0.01 |
| Assault or maltreatment | 1.37 (0.47, 3.99) | 0.56 |
| %TBSA group | | |
| 20-25% (reference) | 1.00 | |
| 26-30% | 1.50 (0.40, 5.66) | 0.55 |
| 31-49% | 2.79 (0.89, 8.75) | 0.08 |
| >50% | 17.20 (5.93, 49.85) | <0.01 |
| Inhalation injury | | |
| No (reference) | 1.00 | |
| Yes | 2.14 (1.21, 3.78) | 0.01 |

Self-immolation burns are known to be associated with greater burn depth when compared with accidental burns [35–37]. Dousing and setting alight an accelerant is the most common method of self-inflicted burns and it is likely this is the main contributor to the increased severity, and thus higher rates of mortality, observed in these patients [37].

## 5. Conclusion

This study identified key predictors of mortality in adults with severe burn injuries and provides a comprehensive descriptive analysis of demographics, burn injury characteristics and in-hospital outcomes related to adults with severe

burn injuries in Australia and New Zealand. This study has highlighted the over-representation of young males, intentional self-harm injuries and flame as a cause of burns. Together, these findings can be used to inform prevention strategies aimed at reducing mortality and morbidity related to severe burn injuries in adults.

## Conflict of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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