Long-term mortality among older adults with burn injury: a population-based study in Australia

Janine M Duke, James H Boyd, Suzanne Rea, Sean M Randall & Fiona M Wood

Objective To assess if burn injury in older adults is associated with changes in long-term all-cause mortality and to estimate the increased risk of death attributable to burn injury.

Methods We conducted a population-based matched longitudinal study – based on administrative data from Western Australia’s hospital morbidity data system and death register. A cohort of 6014 individuals who were aged at least 45 years when hospitalized for a first burn injury in 1980–2012 was identified. A non-injury comparison cohort, randomly selected from Western Australia’s electoral roll (n = 25 759), was matched to the patients. We used Kaplan–Meier plots and Cox proportional hazards regression to analyse the data and generated mortality rate ratios and attributable risk percentages.

Findings For those hospitalized with burns, 180 (3%) died in hospital and 2498 (42%) died after discharge. Individuals with burn injury had a 1.4-fold greater mortality rate than those with no injury (95% confidence interval, CI: 1.3–1.5). In this cohort, the long-term mortality attributable to burn injury was 29%. Mortality risk was increased by both severe and minor burns, with adjusted mortality rate ratios of 1.3 (95% CI: 1.1–1.9) and 2.1 (95% CI: 1.9–2.3), respectively.

Conclusion Burn injury is associated with increased long-term mortality. In our study population, sole reliance on data on in-hospital deaths would lead to an underestimate of the true mortality burden associated with burn injury.

Introduction

Burn injury is an important cause of morbidity and mortality worldwide, particularly among older adults. In high-income countries, where older adults form an increasingly large proportion of the population, the incidence of burn injury is likely to increase. Compared with burn injuries in younger individuals, burn injuries in older adults cause increased physical impairment, reductions in the quality of life, loss of independence and increased mortality.

Improvements in the understanding of the pathophysiology of burns over the past decades have led to advances in medical and surgical treatment. The probability that an older adult is discharged alive after admission for an acute burn appears to be increasing. However, compared with younger people, older adults with burn injury are still more likely to die in the year or two years following their discharge and often have to be readmitted because of pre-existing comorbidities and ongoing chronic illness.

Using data on adults who have been hospitalized for burns in Western Australia, we investigate long-term mortality and the proportion of mortality attributable to the original burn injury.

Methods

Our study formed part of the Western Australian population-based burn injury project – a retrospective cohort investigation that uses administrative data from the Western Australian data linkage system. Administrative health data from several core data sets – including Western Australia’s hospital morbidity data system and death register – are linked for the entire population of Western Australia. The project protocol was approved by the human research ethics committees of the University of Western Australia and the Western Australian department of health.

Staff at the Western Australian data linkage system provided a de-identified extraction of hospital morbidity records for all individuals who were aged at least 45 years when admitted to a hospital in Western Australia with a first burn injury between 1 January 1980 and 30 June 2012. Other than the unique identifying numbers assigned by staff at the Western Australian data linkage system, personal identifiers were removed from the data. We used the International Classification of Diseases and Related Health Problems (ICD9) CM 940–949 or (ICD10) AM T20–T31 codes to identify burn injuries. A first burn injury was defined as the first hospital admission in a patient’s medical record in which a burn injury was given as the principal diagnosis or an additional diagnosis. A population-based comparison cohort was randomly selected from Western Australia’s electoral roll. Any person with an injury hospitalization during the study period was excluded from this cohort by staff at the Western Australian data linkage system. The resultant comparison cohort was frequency matched on birth year and sex of each burn injury case – with four controls to each case – for each year from 1980 to 2012.

Data from Western Australia’s hospital morbidity data system and death register were linked to the burn and non-injured cohorts for the period 1980–2012. Hospital admissions’ data included principal and additional diagnoses, external cause of injury, age, sex, Aboriginal status, date of admission, date of discharge or other separation, mode of separation, percentage of total body surface area burned and burn depth. The data also included geocoded place of residence (census collectors’ district or postcode), geocoded indices of geographical remoteness and social disadvantage. Geographical remoteness was classified into five categories: major cities, inner regional, ...
outer regional, remote and very remote. The social disadvantage index was reclassified into quintiles. The mortality data included date of death and cause of death, classified using ICD9-CM and ICD10-AM disease and external cause codes.

Individuals aged 45–54, 55–64 and at least 65 years were categorized as middle-aged, young-old and elderly, respectively. Individuals listed as Aboriginal or Torres Strait Islander on any admission record were categorized as Aboriginal. Supplementary codes ICD9-CM 948 or ICD10-AM T31, when available, were used to classify the patients into those with minor burns (less than 20% of total body surface area burned) and those with severe burns. Comorbidity was assessed, with a five-year look-back period, using the Charlson comorbidity index16 and the principal and additional diagnoses included in the hospital morbidity records.17 The final discharge date for the burn patient was used as the starting point for the follow-up periods for both the burn injury and control cohort.

Categorical and non-parametric continuous variables were compared using \( \chi^2 \) and Kruskal–Wallis tests, respectively. A P-value of 0.05 or lower was considered statistically significant.

Kaplan–Meier plots of survival estimates were generated and log rank tests were used to compare the survival distributions of the burn and non-injury cohorts. We compared burn versus non-injury and burn severity (minor burns, severe burns or burns with no record of the percentage of total body surface area affected) versus non-injury. Cox proportional hazard regression was used to estimate the effects of burn injury on long-term survival while adjusting for year of admission, age, sex, Aboriginal status, comorbidity score, social disadvantage, and geographical remoteness. The hazard ratios estimated from the Cox proportional hazards model were used as measures of mortality rate.

The hazard ratios estimated from the Cox proportional hazard regression were used to estimate the proportion of long-term mortality for which burn injury was an attributable cause – as calculated as \( 100 \times (\text{adjusted mortality rate ratio} - 1) / \text{(adjusted mortality rate ratio)} \).

The percentage of deaths in the burn cohort that were attributable to burn injury was estimated after adjusting for potential confounders. All statistical analyses were performed using Stata version 12 (StataCorp. LP, College Station, United States of America).

## Results

During the study period, 6014 individuals aged 45 years or older were hospitalized in Western Australia for a first burn injury. Although 240 (4%) were recorded as having full-thickness burns and 3248 (54%) as having minor burns, the percentage of the total body surface area affected by burns was not recorded for the remaining 2526 (42%). Overall, 1143 (19%) of patients had full-thickness burns, while 2225 (37%) had partial-thickness burns, 1082 (18%) had erythema and 1744 (29%) had burns of unspecified depth. Patients may have had multiple burns sites and depths recorded. In total, 4992 (83%) of patients were discharged to their home, 722 (12%) were transferred to acute care hospitals, 120 (2%) were transferred to facilities for elderly people and 180 (3%) died in hospital. Only 577 (10%) had additional non-burn injuries, most of which were open wounds or superficial injuries. Mortality among individuals with and without additional injury were similar (43% versus 41%; \( P = 0.356 \)). Additional injuries in the burn cohort were therefore ignored in our subsequent analyses.

Our non-injury cohort comprised 25 799 individuals. Table 1 summarizes the baseline sociodemographic characteristics and comorbidity scores for both study cohorts. Compared with the non-injury cohort, the burn cohort had significantly higher proportions of Aboriginal people, people who were socially disadvantaged and people living

### Table 1. Long-term mortality following burn injury: baseline cohort characteristics, Western Australia, 1980–2012

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Burn cohort No. (%)</th>
<th>Non-injury cohort No. (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>6014 (100)</td>
<td>25 759 (100)</td>
<td>0.787</td>
</tr>
<tr>
<td>Male</td>
<td>3756 (62)</td>
<td>15 970 (62)</td>
<td>0.374</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45–54</td>
<td>2279 (38)</td>
<td>10 046 (39)</td>
<td></td>
</tr>
<tr>
<td>55–64</td>
<td>1479 (24)</td>
<td>6182 (24)</td>
<td></td>
</tr>
<tr>
<td>≥65</td>
<td>2256 (38)</td>
<td>9531 (37)</td>
<td></td>
</tr>
<tr>
<td>Aboriginal status</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No</td>
<td>5351 (89)</td>
<td>25 507 (99)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>663 (11)</td>
<td>252 (1)</td>
<td></td>
</tr>
<tr>
<td>Social disadvantage quintile</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1</td>
<td>1293 (22)</td>
<td>3423 (14)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1792 (30)</td>
<td>5239 (22)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1209 (20)</td>
<td>4309 (18)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>773 (13)</td>
<td>4337 (18)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>880 (15)</td>
<td>6790 (28)</td>
<td></td>
</tr>
<tr>
<td>Remoteness</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Major city</td>
<td>3329 (55)</td>
<td>18 006 (75)</td>
<td></td>
</tr>
<tr>
<td>Inner regional</td>
<td>716 (12)</td>
<td>2758 (11)</td>
<td></td>
</tr>
<tr>
<td>Outer regional</td>
<td>903 (15)</td>
<td>2095 (9)</td>
<td></td>
</tr>
<tr>
<td>Remote</td>
<td>495 (8)</td>
<td>766 (3)</td>
<td></td>
</tr>
<tr>
<td>Very remote</td>
<td>496 (8)</td>
<td>473 (2)</td>
<td></td>
</tr>
<tr>
<td>Comorbidity score</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0</td>
<td>3917 (65)</td>
<td>22 289 (87)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>403 (7)</td>
<td>733 (3)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>348 (6)</td>
<td>744 (3)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1346 (22)</td>
<td>1993 (8)</td>
<td></td>
</tr>
</tbody>
</table>

- Quintiles of socioeconomic disadvantage:16 based on the geocoded place of residence. Quintiles 1 and 5 represent the most and least disadvantaged, respectively. Complete geocoded data for 5947 (99%) burn cohort and 24 098 (94%) non-injured cohort.
- Geographical remoteness:16 based on the geocoded place of residence. Complete geocoded data for 5947 (99%) burn cohort and 24 098 (94%) non-injured cohort.
- Based on the Charlson comorbidity index16 and a five-year look-back period.
outside major cities. The adults in the burn cohort were also significantly more likely to have pre-existing comorbidity than those in the non-injury cohort.

Over the study period, 2498 (42%) of the adults in the burn cohort and 7018 (27%) of those in the matched non-injury cohort died. Unadjusted Kaplan–Meier survival plots for the overall burn cohort versus the non-injury cohort (Fig. 1), and for the three separate categories for burn severity versus non-injury (Fig. 2), all showed higher survival estimates for those who had not suffered burns. Log rank tests – in which the unadjusted equality of survivorship between the non-injury cohort and the total burn cohort ($P<$ 0.001) or each of the three categories for burn severity ($P<$ 0.001) was assessed – all indicated that there were excess deaths in the burn cohort.

Compared with the adults in the non-injury cohort who died during the study period, the adults in the burn cohort who died were younger at the time of death – with a median age of 76 years (interquartile range: IQR: 67–85) versus 82 years (IQR: 73–88; $P<$ 0.001).

Over the 33-year study period, the adults in the burn cohort were followed up for 0.01–32.5 years (median: 9; IQR: 3–16) to give a total of 59,882 person-years while those in the non-injury cohort were followed up for 0.01–32.5 years (median: 13; IQR: 6–23) to give a total of 488,443 person-years. Over the study period, the burn and non-injury cohorts had all-cause mortality rates of 419.4 and 143.7 deaths per 10,000 person-years, respectively – giving an unadjusted mortality rate ratio for burn injury of 2.9 (95% confidence interval, CI: 2.7–3.0). After adjustment for year of admission, age, sex, Aboriginal status, social disadvantage, remoteness and pre-existing comorbidity, the overall long-term adjusted mortality rate ratio for burn injury was 1.4 (95% CI: 1.3–1.5). Mortality attributable to burns was 29% (Table 2).

The all-cause mortality rate among females was 538.7 deaths per 10,000 person-years in the burn cohort and 253.1 deaths per 10,000 person-years in the non-injury cohort, giving an unadjusted mortality rate ratio for burn injury of 2.1 (95% CI: 2.0–2.3). The adjusted mortality rate ratio for females was 1.6 (95% CI: 1.5–1.7). Among males, the all-cause mortality rate in the burn cohort was also higher than that in the non-injury cohort – 359.9 versus 126.0 deaths per 10,000 person-years – giving an unadjusted mortality rate ratio of 2.8 (95% CI: 2.7–3.0). The adjusted mortality rate ratio for males was 1.3 (95% CI: 1.2–1.4).

The results of Cox regression models for subgroups of the burn cohort, classified by burn severity and age, are presented in Table 2. In these models, after adjustment for potential confounders, all of the subgroups of the burn cohort had a higher risk of death than the non-injury cohort. Individuals aged at least 65 years when they experienced the burn injury had a lower attributable risk (23%), than individuals aged 55–64 years (33%) and individuals aged 45–54 years (38%).

**Discussion**

Current estimates of the mortality related to burns have usually been based on deaths in hospital or within a few weeks of discharge. In this study, however, follow-up lasted for a median of 9 years.

Up to the end of follow-up – and after adjusting for known potential confounders – our burn cohort was found to...
have 1.4-fold higher all-cause mortality than the non-injury cohort. The excess long-term mortality attributable to burn injury was 725 of the 2498 total deaths recorded in the burn cohort. These 725 deaths after discharge represent 12% of those hospitalized for burn injury while only 3% died in hospital after the index admission. These results, which indicate that the long-term mortality from burns is much higher than indicated by in-hospital mortality data, challenge the definition of fatal outcomes used in most assessments of burn injuries.

Compared with the non-injury cohort, the subgroups of the burn cohort with severe burns, minor burns or burns of unspecified severity each showed significantly increased risk of all-cause mortality during the study follow-up. We failed to demonstrate a positive relationship between burn severity and mortality because, within the burn cohort, we found the mortality to be highest for those with minor burns. Explanations for this phenomenon may be that people with the most severe burns died during the index hospital admission and/or the survivors of severe burns included in the analyses represented a relatively more robust patient population.

While burn injury principally affects the skin, it is associated with depression of humoral and cell-mediated immunity, sustained high levels of oxidative stress and prolonged elevation of hypermetabolic and stress hormones. In children, metabolic and inflammatory changes have been found to last for at least three years after severe burns. Such changes have the potential to induce a range of health conditions including insulin resistance, increases in the risk of fracture, sepsis and infections, enlargement of the liver, cardiac stress and dysfunction and hormonal abnormalities. Recent research has also shown elevated cancer incidence after burn injury, particularly among female burn survivors. Systemic responses are induced by both minor and moderate burns and may have contributed to the long-term mortality found, for both minor and severe burns, in this study. It has also been reported that patients who survive admission to an intensive care unit have poorer survival than the general population – perhaps indicating that any episode of critical illness or treatment for such illness can shorten life expectancy.

Our analysis by age group indicated that the mortality rate ratios and consequent attributable risk percentages for burn injury decreased slightly with increasing age. Although the proportion of deaths attributable to burn injury was smaller for the elderly individuals than the middle-aged or young-old individuals, the absolute number of deaths was greatest among the elderly individuals.

Some of the consequences of burn injury appear to be experienced long after the initial period of recovery. Minor burns in elderly people tend to lead to longer hospital stays and higher in-hospital mortality when compared with younger adults. Among elderly people, burn injuries may worsen pre-existing health conditions, hamper good nutrition, reduce mobility and independence and prevent them from regaining their previous state of health. An ageing population is characterized by an increasing prevalence of frailty.

The strengths of our study are the inclusion of a non-injured comparison group and a follow-up period designed to reveal the long-term mortality risk associated with burns among older adults. Previous single-centre studies have lacked a control group or followed patients for no more than two to three years. Long-term mortality of injury has been investigated previously, but with few burn cases. We assumed that, after adjustment for confounding, the excess in mortality in the burn cohort was predominately associated with burn injuries.

Our use of linked health administrative data enabled both the identification of a cohort of adults hospitalized for a first burn injury and the estimation of the pre-existing comorbidities in that cohort. We included indices of social disadvantage, geographical remoteness and access to services.

As a consequence of incomplete data for the percentage of the total body surface area affected for many people with burn injury, we were unable to show the effects of burn severity on long-term mortality. A non-injured control cohort was used to examine the potential systemic health impacts of trauma caused specifically by burn injury sufficiently serious to require hospitalization. Future research will examine potential differences between burn and non-burn injury and long-term health impacts.

The fact that the Western Australia hospital morbidity data system is assessed continually for both quality and accuracy strengthens our findings. Our main finding is expected to be generalizable to other populations with similar demographic characteristics and comparable health-care systems to those of Australia.

In conclusion, our findings that the long-term all-cause mortality was increased in the burn injury cohort suggest...
ملخص
معدلات الوفيات طويلة الأمد لدى البالغين الأكبر سنًا الذين يعانون من إصابات الحروق: دراسة قائمة على السكان في أستراليا

المعرض

شرح

LONG-TERM MORTALITY FOLLOWING BURN INJURY, AUSTRALIA

Janine M Duke et al.

Research

Introduction

The purpose of this study was to estimate the long-term mortality following burn injury in adults aged 45 years and older in western Australia, and to describe patterns of death among survivors of burns.

Methods

A longitudinal cohort study was conducted using data from the Western Australian Department of Health’s death registry and hospitalization records from 1980 to 2012.

Results

The overall age-standardized long-term mortality rate for all causes was 2.1% per year. The rate was highest for the first year after discharge from hospital (4.1%) and decreased sharply thereafter (1.1% at 5 years).

Conclusion

The long-term mortality following burn injury is substantial and occurs predominantly in the first year after discharge from hospital. Early intervention strategies are needed to improve outcomes and reduce mortality among burn survivors.
La mortalidad a largo plazo entre los adultos de edad avanzada con quemaduras: un estudio poblacional en Australia

La mortalidad a largo plazo entre los adultos de edad avanzada con quemaduras: un estudio poblacional en Australia

Objetivo Evaluar si las quemaduras en adultos de edad avanzada están asociadas con los cambios en la mortalidad por todas las causas a largo plazo y estimar el aumento del riesgo de muerte atribuible a las quemaduras.

Métodos Se llevó a cabo un estudio poblacional longitudinal emparejado sobre la base de datos administrativos proporcionados por el sistema de datos de morbilidad y el registro de defunciones de los hospitales de Australia Occidental. Se identificó una cohorte de 6014 individuos que tenían como mínimo 45 años cuando fueron hospitalizados por primera quemadura entre 1980 y 2012. Se comparó una cohorte de personas que no habían sufrido quemaduras seleccionadas aleatoriamente del censo electoral de Australia Occidental (n = 25 759), con los pacientes. Se utilizaron el método de Kaplan-Meier y la regresión de Cox para analizar los datos, las razones de tasas de mortalidad generados y los porcentajes de riesgo atribuible.

Resultados De todos los hospitalizados con quemaduras, 180 (el 3%) murieron en el hospital y 2498 (el 42%) murieron después de haber sido dados de alta. Los individuos con quemaduras tenían una tasa de mortalidad 1,4 veces mayor a la de los individuos sin quemaduras (intervalo de confianza, IC, del 95%: 1,3–1,5). En esta cohorte, la mortalidad a largo plazo atribuible a las quemaduras resultó ser del 29%. El riesgo de mortalidad se incrementó tanto por quemaduras graves como por quemaduras leves, con unas razones de tasas de mortalidad ajustadas de 1,3 (IC del 95%: 1,1–1,9) y 2,1 (IC del 95%: 1,9–2,3), respectivamente.

Conclusión Las quemaduras están asociadas al aumento de la mortalidad a largo plazo. En nuestra población de estudio, confiar exclusivamente en los datos relativos a las muertes en hospitales llevaría a una subestimación de la verdadera carga de mortalidad asociada con las quemaduras.

Resumen

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42. Campbell JW, Degolia PA, Fallon WF, Rader EL. In harm’s way: moving the older trauma patient toward a better outcome. Geriatrics. 2009 Jan 5;283(1):69–73. doi: http://dx.doi.org/10.1001/jama.283.1.69 PMID: 19361275