Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Epidemiology of work-related burn injuries presenting to burn centres in Australia and New Zealand

Judith A. McInnes [a,*], Heather Cleland [b], Lincoln M. Tracy [a], Anne Darton [c], Fiona M. Wood [d], Tracey Perrett [e], Belinda J. Gabbe [f,g]

[a] Department of Epidemiology and Preventive Medicine, Monash University, Level 3, 553 St. Kilda Road, Melbourne, Victoria, 3004, Australia
[b] Victorian Adult Burns Service, Alfred Hospital, 55 Commercial Rd, Melbourne, Victoria, 3004, Australia
[c] NSW Agency for Clinical Innovation Statewide Burn Injury Service Network, Level 6, Clinical Services Building, Royal North Shore Hospital, Reserve Rd, St Leonards, NSW, 2065, Australia
[d] Burn Injury Research Unit, University of Western Australia, Perth, Western Australia, 6009, Australia
[e] New Zealand National Burn Centre, Plastic Surgery Department I Level 2 Staff Centre, Middlemore Hospital, 100 Hospital Road, Otahuhu, Private Bag 93311, Auckland, 1640, New Zealand
[f] Pre-hospital, Emergency and Trauma Research Unit, Department of Epidemiology and Preventive Medicine, Monash University, Level 3, 553 St. Kilda Road, Melbourne, Victoria, 3004, Australia
[g] Farr Institute, Swansea University Medical School, Swansea University, Singleton Park, Sketty, Swansea, SA2 8PP, UK

ARTICLE INFO

Article history:
Accepted 10 September 2018

Keywords:
Burns
Work-related injury
Burn database
Australia
New Zealand

ABSTRACT

Background: Burn injuries to workers can have a devastating impact, however knowledge of the epidemiology of work-related burn injuries in Australia and New Zealand is limited.
Purpose: To describe epidemiological characteristics of work-related burn injuries in Australia and New Zealand, and to compare these with non-work-related burns.
Methods: Adult burn injury data, 2009-2016, were extracted from the Burns Registry of Australia and New Zealand. Descriptive statistics were used to describe demographic, injury, management and outcome characteristics. Differences between work-related and non-work-related injuries were assessed using Chi-square and Wilcoxon rank-sum tests.
Results: Of 10,574 adult patients treated in burn centres in Australia and New Zealand, 2009–2016, 17% had work-related burns. Most work-related cases were male (85%), less than 35 years old (53%), and had sustained flame (33%), scald (30%) or chemicals (17%) burns. Proportions of chemical, scald and electrical burns were greater for work-related than for non-work-related burns, with this being most marked for chemical and electrical burns (17% vs. 3% and 7% vs. 1%, respectively).
Conclusions: Almost one in five cases of working-aged people admitted to Australian and New Zealand burns centres was work-related. Through identification of vulnerable groups, this study informs policy and strategies to minimise occupational burn risk.

* *Corresponding author.*
E-mail addresses: Judy.mcinnes@monash.edu (J.A. McInnes), H.Cleland@alfred.org.au (H. Cleland), Lincoln.Tracy@monash.edu (L.M. Tracy), Anne.Darton@health.nsw.gov.au (A. Darton), Fiona.Wood@health.wa.gov.au (F.M. Wood), tracey.perrett@middlemore.co.nz (T. Perrett), Belinda.Gabbe@monash.edu (B.J. Gabbe).
https://doi.org/10.1016/j.burns.2018.09.011

1. Introduction

Injuries arising out of, or during the course of, employment are a major source of human suffering and economic loss. It has been estimated by the International Labour Organisation that globally, 153 workers suffer a work-related injury every 15 s [1]. In Australia work-related injuries are estimated to have cost nearly $62 billion during the 2012–2013 financial year, equal to approximately 4% of the Gross Domestic Product (GDP) over that time [2]. Burn injuries are among the most devastating of work-related injury types. Depending on the severity of their injury, burn survivors may face prolonged periods of painful treatment and rehabilitation [3], long-term physical and psychological sequelae [4,5], and experience multiple barriers and challenges to returning to employment [6,7]. In addition, burn injuries are among the most expensive to treat [8].

Despite this, information regarding the epidemiology of work-related burn injuries is limited. Early Australian and New Zealand studies provide some information, but all are limited by small sample sizes and unclear definitions or selection criteria for work-related burn injuries, variously referred to as industrial burns [9], being industrial in origin [10], and occurring in industrial places and premises [11]. Reported proportions of hospitalised burns cases that were work-related over the period 1970-1998, ranged from 13.6% to 31% [9-14]. More recent information is found in Government and Statutory authority reports. The Australian Institute of Health and Welfare (AIHW) reported that sixteen percent of adult hospitalised burn cases in Australia from 2013 to 2014 occurred while working for income, however only a third of these cases had a specific industry recorded, and only limited information about the epidemiology of these injuries was provided [15].

Internationally, studies have been undertaken in a range of settings, including the US, Europe, Canada, South America and China, using case level data from workers compensation claims datasets [16,17], specialised burn centres [18] and emergency department records [19]. Some have reported on particular types of burns [20,21], others on fatal burn injuries only [22], with the reported proportions of work-related burns in adult burn populations ranging from 24 to 31% [18,19,23]. A systematic review of European epidemiological studies of severe burn injuries in Europe reported that overall, one third of severe adult burns were work-related [24].

Geographical differences in work-related burn epidemiology are likely, reflecting differing occupational settings, regulatory environments, and industry and workforce characteristics of the various jurisdictions. Information about the epidemiology of work-related burns specific to Australia and New Zealand is needed to inform appropriate workplace policy, prevention strategies and resource allocation across this area. The aim of this study was to describe the characteristics of work-related burn injury cases admitted to burn centres in Australia and New Zealand, and to compare the characteristics of work-related burn injuries with those of burn injuries that are not work-related.

2. Method

2.1. Setting and data source

This retrospective, descriptive study of work-related and non-work-related burn injuries to working age adults (15-64 years) in Australia and New Zealand for the period 1 July 2009 to 30 June 2016, used data from the Burns Registry of Australia and New Zealand (BRANZ). This clinical quality registry, systematically collects and collates data describing burn injury cases treated in all 17 designated specialist burn centres (both adult and paediatric) in Australia and New Zealand [25]. Criteria for inclusion of burn injury cases in this registry include: (1) first admission to hospital within 28 days of the injury, (2) admission to hospital for more than 24 h, or (3) patient underwent a burns management procedure in theatre irrespective of the length of stay, or (4) the patient died within 24 h of presentation to the BRANZ hospital.

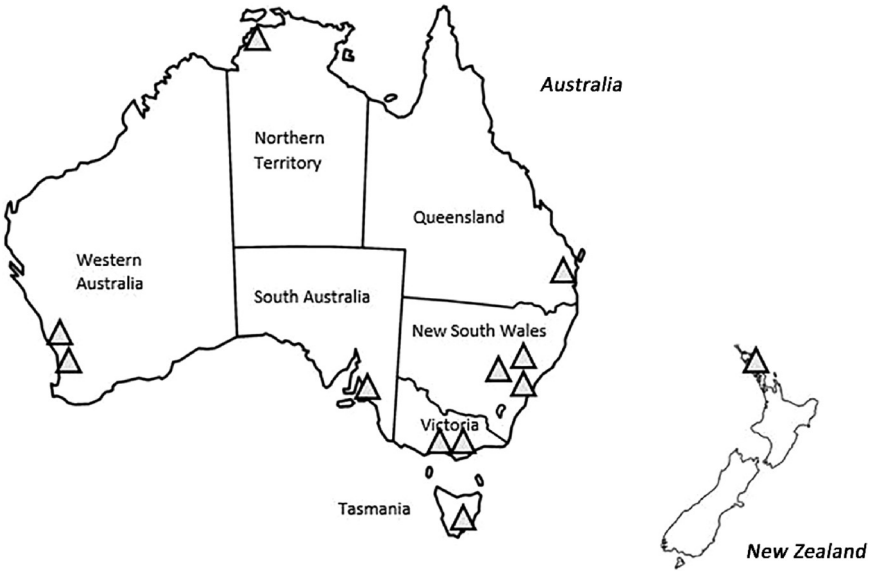

Fig. 1 – Location of the 12 burn centres in Australia and New Zealand from which data was included for this study, 2009–2016.

2.2. Participants

Eligible cases were extracted from the BRANZ, and any readmissions excluded. Only working age adults (15–64 years) were included. A case was defined as a work-related burn injury if the data field 'Activity when burn occurred' was listed as 'working for income', or if the field 'insurance or fund source' was listed as 'workers' compensation case'. For New Zealand data, all burns cases identified by the New Zealand Insurer (Accident Compensation Corporation, ACC) as being work-related were included. The 'working for income' code was applied in BRANZ data if at the time of injury, the worker was engaged in paid work for salary, bonus or other types of income, or was travelling to or from such activities.

After exclusion of four burn centres that had not contributed data consistently over the study period, and one exclusively paediatric centre, twelve burn centres provided data for this study. These included four paediatric centres that had treated a small number of adult patients during the study period. The location of these twelve specialist burn centres is illustrated in Fig. 1.

2.3. Data management and analysis

For both work-related burn cases and non-work-related burn cases, data fields were extracted that described demographic characteristics (age, gender), the burn event (cause, place, accelerants), burn characteristics (body region burnt, severity,

Table 1 – Summary statistics of demographic and injury event characteristics for work-related and non-work-related burns, 2009–2016.

Characteristics	Work-related cases n (%)	Non-work-related cases n (%)	*p*-Value[a]
Total cases	1828 (17.3%)	8746 (82.7%)	
Age group (years)			<0.001
15–24	446 (24.4)	2275 (26.0)	
25–34	510 (27.9)	2067 (23.6)	
35–44	356 (19.5)	1770 (20.3)	
45–54	321 (17.6)	1509 (17.3)	
55–64	195 (10.7)	1125 (12.9)	
Sex			<0.001
Male	1550 (84.9)	6064 (69.4)	
Female	276 (15.1)	2675 (30.6)	
Primary cause[b]			<0.001
Flame	602 (33.0)	4266 (48.9)	
Scald	553 (30.3)	2141 (24.5)	
Chemical	311 (17.0)	304 (3.5)	
Contact	153 (8.4)	1251 (14.3)	
Electrical	136 (7.4)	89 (1.0)	
Friction	39 (2.1)	435 (5.0)	
Other	33 (1.8)	237 (2.7)	
Accelerant if cause was flame[c]			<0.001
Petrol	128 (36.2)	1456 (55.9)	
Methylated spirits	25 (7.1)	278 (10.7)	
Aerosol can	16 (4.5)	157 (6.0)	
Kerosene	10 (2.8)	61 (2.3)	
Paint stripper	9 (2.5)	15 (0.6)	
Aviation gas	6 (1.7)	12 (0.5)	
Other	160 (45.2)	628 (24.1)	
Place where burn injury occurred[d]			<0.001
Trade and services area	880 (49.1)	129 (1.5)	
Industrial/construction area	512 (28.6)	28 (0.3)	
Farm	103 (5.7)	208 (2.5)	
Street/highway	81 (4.5)	834 10.0)	
Home	54 (3.0)	5263 (63.0)	
Other residence	40 (2.2)	594 (7.1)	
School/other institution	37 (2.1)	88 (1.1)	
Recreation	27 (1.5)	897 (10.7)	
Residential institution	5 (0.3)	59 (0.7)	
Other specified place	50 (2.8)	202 (2.4)	

[a] Chi-square test was used to calculate p-values.
[b] n=25 (0.3%) missing.
[c] n=48 (1.6% of flame injuries for which an accelerant was used) missing.
[d] n=431 (4.1%) missing.

Table 2 – Summary statistics of burn characteristics, severity, management and outcome for work-related and non-work-related burns, 2009–2016.

Characteristic	Work-related cases n (%)	Non-work-related cases n (%)	Comparison p[a]
Body region of burn[b]			
Lower limb			<0.001
Unilateral	293 (17.7)	1830 (23.0)	
Bilateral	266 (16.1)	1674 (21.0)	
Foot			<0.001
Unilateral	230 (13.9)	820 (10.3)	
Bilateral	64 (3.9)	503 (6.3)	
Upper limb			0.871
Unilateral	414 (25.1)	2022 (25.4)	
Bilateral	282 (17.1)	1319 (16.6)	
Hand			0.444
Unilateral	334 (20.2)	1710 (21.5)	
Bilateral	262 (15.8)	1282 (16.1)	
Perineum	39 (2.4)	307 (3.9)	0.003
Buttock	68 (4.1)	493 (6.2)	0.001
Trunk			<0.001
Front	143 (8.6)	793 (10.0)	
Back	75 (4.5)	512 (6.4)	
Front and back	68 (4.1)	506 (6.4)	
Breast	163 (10.0)	1101 (13.8)	<0.001
Neck	233 (14.1)	1074 (13.5)	0.517
Eye	90 (5.5)	244 (3.1)	<0.001
Face	501 (30.3)	2301 (28.9)	0.250
Scalp	65 (3.9)	297 (3.7)	0.698
Inhalation injury[c]			<0.001
Yes	89 (4.9)	647 (7.4)	
No	1731 (95.1)	8056 (92.6)	
Total body surface area (TBSA)			<0.001
%TBSA <10%	1509 (82.6)	6914 (79.1)	
%TBSA: 10–19%	191 (10.5)	1096 (12.5)	
%TBSA: 20–49%	110 (6.0)	563 (6.4)	
%TBSA ≥50%	18 (1.0)	173 (2.0)	
Burn depth[b]			
Superficial	540 (33.0)	2544 (33.0)	0.959
Mid dermal	819 (49.9)	3963 (51.3)	0.294
Deep dermal or full thickness	836 (50.9)	4167 (54.0)	0.025
Cooling first aid applied at scene?[d]			<0.001
Yes	1353 (80.3)	5288 (66.9)	
No	332 (19.7)	522 (33.2)	
IF YES, was this cool running water?[e]			<0.001
Yes	1258 (93.1)	4731(90.1)	
No	93 (6.9)	522 (9.9)	
IF YES, was this for ≥20 min?[f]			0.677
Yes	518 (43.7)	1961 (43.9)	
No	668 (56.1)	2508 (56.2)	
IF YES, was this ≤3 h of injury?[g]			0.775
Yes	503 (98.6)	1910 (98.5)	
No	7 (1.4)	30 (1.6)	
Patient managed in theatre[h]			0.011
Yes	1396 (77.6)	6432 (74.8)	
No	403 (22.4)	2173 (25.3)	
IF YES, was a skin graft applied?[i]			0.481
Yes	902 (65.1)	4092 (64.1)	
No	484 (34.9)	2294 (35.9)	

(continued on next page)

Table 2 (continued)

Characteristic	Work-related cases n (%)	Non-work-related cases n (%)	Comparison p[a]
IF YES, time to graft (h) median (IQR),	135.6 (76.8-223.2)	146.4 (84.0-252.0)	<0.001
Patient admitted to ICU?[j]			0.004
Yes	218 (12.0)	1265 (14.6)	
No	1603 (88.0)	7437 (85.5)	
Destination on discharge[k]			<0.001
Home	1609 (88.6)	7330 (85.2)	
Inpatient rehab	28 (1.5)	175 (2.0)	
Hospital in the home	128 (7.1)	481 (5.6)	
Other acute hospital	15 (0.8)	232 (2.7)	
Other destination	36 (2.0)	388 (4.5)	
Died in hospital	9 (0.5)	107 (1.2)	0.006
Yes	9 (0.5)	107 (1.2)	
No	1819 (99.5)	8637 (98.8)	

Abbreviations: IQR, interquartile range; ICU, intensive care unit
[a] Chi-square and Wilcoxon rank tests were used to calculate p-values.
[b] Percentage values do not add up to 100 as multiple responses may apply for individual cases.
[c] n=51 (0.5%) missing.
[d] n=979 (9.3%) missing. (Includes 54 cases for whom water first aid was not appropriate).
[e] n=37 (0.6%) missing.
[f] n=334 (5.6%) missing.
[g] n=29 (1.2%) missing.
[h] n=170 (1.6%) missing.
[i] n=75 (0.7%) missing.
[j] n=51 (0.5%) missing.
[k] Cases that died in hospital have been excluded from analysis.

inhalation injury), burn management (first aid, intensive care, theatre, skin grafting) and burn outcome (disposition, fatalities). The data fields 'total body surface area' (TBSA) and 'burn depth' were extracted to describe burn severity. Determination of the proportion of cases receiving first aid was based on the current recommendation of the Australian and New Zealand Burn Association (20 min of cool running water within the first 3 h of a burn injury) [26,27]. In the case of work-related burns, data about employing industry at the time of injury was extracted using Activity Codes described in the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM) for both Australian and New Zealand sites, specifically U73.0 — while working for income [28].

Summary statistics were derived from the extracted data. Data field entries coded as not stated, inadequately described or not specified were considered missing and excluded from analysis. Data cells in tables were aggregated into 'other specified' if numbers of cases were less than five. Frequencies and percentages were used to describe categorical variables and continuous data was presented as medians and interquartile range. Work-related and non-work-related cases were compared using the Chi-square test for categorical variables, and the Wilcoxon rank-sum test for continuous variables demonstrating a non-parametric distribution. All analyses were conducted using Stata Version 15 (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). p-values less than 0.05 were considered statistically significant.

2.4. *Ethics approval*

Ethics approval was obtained from the Monash University Human Research Ethics Committee, (reference CF08/2431-2008001248), and from each participating site (approval numbers available on request).

3. Results

During the period July 2009 to June 2016, there were 10,574 admissions to the twelve burn centres in Australia and New Zealand for treatment of burn injuries sustained by people aged 15–64 years. A total of 723 cases (6.8%) were treated in New Zealand, and 9851 cases (93.2%) were treated in Australia. Of these admissions combined, 1828 (17.3%) were work-related burn injury cases. The percentage of all admissions to burn centres for treatment of burns that were work-related did not change significantly over the study period (X^2_6=2.86, p=0.83). Summary statistics describing and comparing work-related and non-work-related burn injuries are provided in Tables 1 and 2.

3.1. *Demographic characteristics*

3.1.1. *Age and gender*

The highest proportion of work-related burns occurred in the 25–34 years age group, while the highest proportion of non-work-related burns occurred in the 15–24 years age group

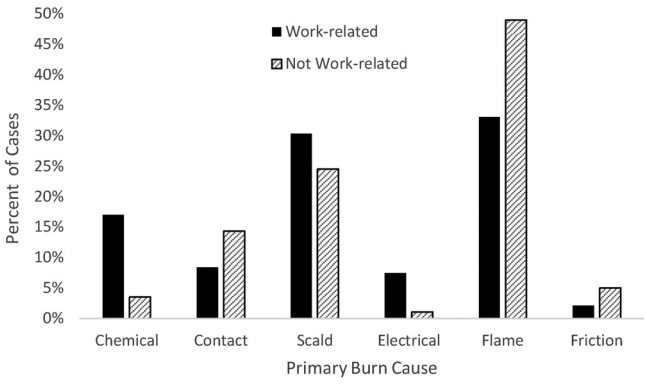

Fig. 2 – Comparison of main causes of work-related and non-work-related burn injuries, 2009–2016.

(Table 1). More than half of the work-related burns were of workers aged less than 35 years (52.3%). For work and non-work related burns, the majority of cases were male, with the ratio of male to female being greater for work-related burns (6:1) than for non-work-related burns (2:1).

3.2. *Injury event characteristics*

3.2.1. *Primary cause*

The most common primary causes of work-related burns were flame, scald and chemicals (Table 1, Fig. 2). For non-work-related burns, these were flame, scald and contact with hot objects. While the most common cause of injury for both groups was flame, this affected a greater proportion of non-work related burns, as did contact and friction burns. The proportion of work-related burns caused by chemicals was almost five times greater than that for non-work-related burns (Table 1, Fig. 2). The proportion of work-related burns that were electrical burns was more than seven times than that for non-work-related burns (Table 1, Fig. 2). For both groups, the most frequently specified accelerant in a flame burn injury was petrol (Table 1).

3.2.2. *Sub-cause*

Sparks or open flames generated by welding, using an angle grinder to cut metal or an oxyacetylene torch were the most frequent sub-causes of a work-related flame burn, while the largest proportion of non-work-related flame burns were caused by campfires, bonfires and burn offs (Table 3a). For both work-related and non-work-related burns, the predominant sub-cause for scalds was hot fat or oil, and hot water from a saucepan, kettle, urn, jug, billy or thermos (Table 3a). Work-related contact burns most commonly arose from contact with hot metal, molten plastic or glue and molten bitumen (tar), whereas for non-work-related burns this was vehicle exhaust, and hot ashes or coals (Table 3a).

For both groups, alkaline substances, such as cleaning agents and cement, were the predominant sub-cause of chemical burns (Table 3b). For workers, the sub-cause of most electrical burns was contact with high voltage power sources such as overhead power lines, while most electrical burns that were not work-related were caused by contact with low voltage power sources such as exposed wiring (Table 3b).

3.2.3. *Place where injury occurred, and industry of employment*

The highest proportions of work-related burns were sustained in trade and service areas, industrial and construction sites and farms (Table 1). Non-work-related burns most commonly occurred at home, in recreational areas, and on streets and roads. Industries employing the highest proportion of workers that had sustained a burn injury were listed in the category 'other specified' (45.1%), followed by manufacturing (9.5%), construction (8.6%) and wholesale and retail trade (5.5%) (Fig. 3). For 21% of cases, the industry was 'other unspecified'.

3.3. *Burn characteristics*

3.3.1. *Body region of burn, and inhalation injury*

For both work-related and non-work-related burn injuries, the parts of the body most frequently burnt were the upper limb, hand, lower limb, and face (Table 2). The major difference between the two groups was burns to the eye, with the proportion of work-related burns that involved the eye being almost double that of non-work-related burn (Table 2). The proportion of work-related burn cases that had sustained an inhalation injury was significantly less than that of non-work-related burn cases (Table 2).

3.3.2. *Burn severity*

The proportion of non-work-related burns for which the TBSA was ≥50% was double that of work-related injuries (Table 2). For both groups, TBSA was less than 10% in a majority of cases, and more than 50% of burn injuries included a deep dermal or full thickness component.

3.4. *Management and outcome*

3.4.1. *First aid, theatre, intensive care, outcome*

A larger proportion of work-related burn cases (80%) received some type of burn cooling intervention at the injury scene than did non-work-related cases (67%) (Table 2). This intervention consisted of cool running water for over 90% of cases in both groups. Cool running water first aid was administered for at least 20 min to 44% of cases in both groups. Of these cases, almost all had received the 20 min cool running water intervention within three hours of the injury occurring.

Table 3a – Sub-causes of work-related and non-work-related burn injuries caused by Flame, scald and contact, 2009-2016.

Flame n%			Scald n%			Contact n%		
Sub-cause	Work-related burn	Non-work-related burn	Sub-cause	Work-related burn	Non-work-related burn	Sub-cause	Work-related burn	Non-work-related burn
Campfire/burn off	54 (9.0)	1526 (36.0)	Fat/oil	146 (26.5)	625 (29.4)	BBQ	n<5	14 (1.1)
Candle	n<5[a]	70 (1.7)	Molten metal	43 (7.8)	4 (0.2)	Vehicle exhaust	7 (4.6)	226 (21.5)
Fireworks	6 (1.0)	83 (2.0)	Food	54 (9.8)	201 (9.4)	Heater — unspecified	n<5	33 (2.7)
Gas/gasbottle	72 (12.0)	243 (5.7)	Steam: radiator	20 (3.6)	67 (3.1)	Coals/ashes	9 (5.9)	266 (21.5)
Electrical	51 (8.5)	26 (0.6)	Steam: vaporiser	n<5	16 (0.8)	Hot metal	66 (43.1)	170 (13.7)
Fat/oil	11 (1.8)	197 (4.6)	Steam: other	33 (6.0)	24 (1.1)	Stove top	n<5	27 (2.2)
Cigarette	10 (1.7)	168 (3.9)	Syrup/sugary liquid	14 (2.5)	14 (0.7)	Iron	n<5	11 (0.9)
Lighter/matches	10 (1.7)	338 (7.9)	Hot beverage	19 (3.4)	196 (9.2)	Molten plastic/glue	28 (18.3)	39 (3.1)
Heater — other	8 (1.3)	67 (1.6)	Water: basin, sink, bucket	29 (5.2)	94 (4.4)	Stove/oven door	n<5	16 (1.3)
Other	130 (21.7)	389 (9.1)	Water: radiator	20 (3.6)	89 (4.2)	Other	17 (11.6)	60 (4.8)
Bushfire	11 (1.8)	31 (0.7)	Water: hot water bottle	n<5	102 (4.8)	Cigarette	n<5	13 (1.0)
BBQ	n<5	276 (6.5)	Water: saucepan, kettle, urn	83 (15.0)	521 (24.5)	Heat pack	n<5	20 (1.6)
Heater — wood	n<5	36 (0.8)	Water: tap, bath shower	10 (1.8)	121 (5.2)	Hot water bottle	n<5	57 (4.6)
Heater — fireplace	n<5	62 (1.5)	Other	78 (14.1)	55 (2.6)	Bitumen (tar)	20 (13.1)	8 (0.6)
Welding, angle grinder, oxyacetylene torch	135 (22.6)	112 (2.6)				Heater — electric/gas	2 (1.3)	68 (5.5)
Vehicle/engine parts	73 (12.2)	277 (6.5)				Hair wand	n<5	13 (1.0)
Source unclear	27 (4.5)	339 (7.9)				Wax	1 (0.7)	60 (4.8)
						Heater — wood	n<5	38 (3.1)
						Hot ground	2 (1.3)	61 (4.9)

[a] If n<5 this number is included in Other.

Table 3b – Sub-causes of work-related and non-work-related burn injuries groups: chemical and electrical, 2009-2016.

Chemical n%			Electrical n%		
Sub-cause	Work-related burn	Non-work-related burn	Sub-cause	Work-related burn	Non-work-related burn
Acid	71 (22.8)	58 (19.1)	Lightning	n<5[a]	n<5
Alkali	210 (67.5)	191 (62.8)	Low voltage (<415V)	60 (45.5)	65 (76.5)
Other	30 (9.6)	55 (18.1)	High voltage (>415V)	73 (55.3)	17 (20.0)
			Other	n<5	n<5

[a] If n<5 this number is included in Other.

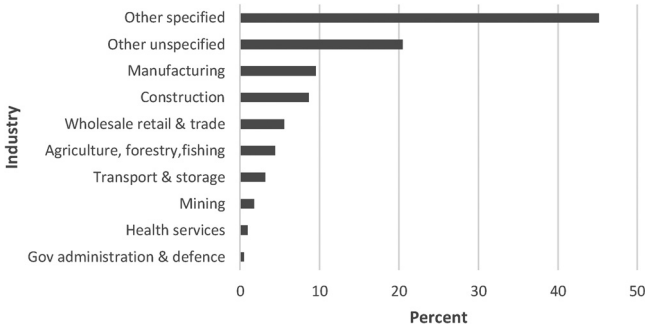

Fig. 3 – Percentage of work-related burn injuries according to industry, 2009-2016.

A higher proportion of work-related cases were managed in theatre, but no difference between groups was evident regarding the proportion of cases that received a skin graft (Table 2). A Wilcoxon-rank sum test demonstrated that time to graft (time from admission to first theatre) was significantly longer for non-work-related cases than for work-related cases

($z=3.48$, $p<0.0005$). A higher proportion of non-work-related burn cases were admitted to an intensive care unit and a higher proportion of work-related burn cases were discharged to home, or were managed by hospital in the home, than were cases of non-work-related injury. A greater proportion of non-work-related burn cases died from their injuries than did work-injury cases (Table 2)

4. Discussion

This study provides contemporary data about all work-related burn injuries admitted to burn centres in Australia and New Zealand. An understanding of the epidemiology of work-related burns in Australia and New Zealand is essential to inform prevention strategies as geographical differences in work-related burn injury characteristics are likely, due to different regulatory, industrial and regulatory settings. Over the period 2009–2016, 17% of admissions of working age adults to burn centres in Australia and New Zealand were work-related, and characteristics of work-related burns differed significantly from burns sustained in other contexts. Importantly, the proportion of burns cases that were work-related showed no sign of decline over the study period.

This comparison of work-related and non-work-related burn epidemiology has highlighted a number of differences. Work-related burn injuries were found to affect a greater proportion of men, and a slightly older cohort than non-work-related burns. Proportionally, the number of chemical, scald and electrical burns was greater for work-related than for non-work-related burns. Notably, the proportion of electrical burns sustained in the workplace was seven times greater for work-related burns than for non-work-related burns and the proportion of chemical burns was almost five times greater. Work-related burn injuries were more likely to involve the eyes than non-work-related burns, and were most commonly sustained in trade and service areas, in industrial and construction sites and on farms. By highlighting vulnerable worker subgroups, workplaces, hazards and activities, these findings provide valuable evidence to inform Occupational Health and Safety (OHS) policy and guideline development to minimise harm to workers from burn injuries in the future.

Consistent with other studies [16,29,30] we found that flame burns were most common in the work-related group. While we observed that electrical burns were more common in the work-related group when compared to non-work related burns, the proportion of electrical burns in the work-related burn group was lower when compared to other studies. A previous study of major burns treated in a burns centre in Queensland over the period 1997–2003, reported that 18% of workplace burns were electrical in origin [29]. Taylor et al. found that electrical burns accounted for approximately 20% of burns treated in a burn centre in Birmingham, USA [18], and a study of 100 work-related burn cases admitted to a specialist burn unit in Ontario, Canada, found that electrical burn was the mechanism underling 32% of cases [23]. The lower prevalence of electrical burns in our population may reflect differing definitions of an electrical burn, and the establishment of more effective regulations in Australia and New Zealand in recent years. In the BRANZ data, an electrical burn is defined as one that arises from contact with a voltage source, whereas burns caused by sparks, flames or explosions arising from faulty wiring, curds, switches or plugs are classified as flame burns. It is possible that these types of burn circumstances are regarded as electrical in other jurisdictions.

Some differences between work-related and non-work related burns were observed that are not easy to explain. The proportion of work-related burn cases that had sustained an inhalation injury was significantly less than that for non-work-related burn cases. Also, the time from admission to first graft was longer for non-work-related cases than for work-related cases. Causation underlying these discrepancies cannot be ascertained on the basis of this study alone, and further investigation is warranted.

Consistent with a previous BRANZ study [27], the overall proportion of patients received cooling first aid at the scene of the injury was 69% but this was notably higher in the work-related group when compared to the non-work related group (80% and 67% respectively). Application of cool running tap water for 20 min within the first 3 h after a burn injury, as recommended by the Australian and New Zealand Burn Association (ANZBA), is the standard first aid protocol for first responders in Australia and New Zealand [31]. Easier access to cool running water, as well as occupational health and safety first-aid education, may explain the higher proportion of work-related burns receiving any type of cooling first aid in the workplace, but highlights the importance of continuing burn first aid education for both for the community and the workplace.

The study has a number of strengths. Data were extracted from a large clinical registry of burn injury data. The systematic and consistent coding of data that is entered into this registry, including clear inclusion criteria, allows for pooling of a large body of data available for research purposes. In addition, a clear and consistent definition of a work-related injury has been used, ensuring consistency of this variable across contributing sites. To maximise identification of work-related burn injury cases, the BRANZ register has used the ICD-10-AM activity code and/or workers compensation claim status as inclusion criteria. This is important in light of research indicating that the activity code 'working for income' is poorly reported in hospitalisation data in Australia [32].

A number of limitations are also noted. Firstly, while it is possible that all serious burn injuries in Australia and New Zealand are captured in the BRANZ dataset, in practice this is unlikely as not all serious burn cases will be referred to a specialist burn centre. Furthermore, only 12 of a possible 17 burn centres contributed data to this study. Having data from just one New Zealand burn centre precluded any comparison between Australia and New Zealand. Secondly, by focusing on the most serious burns, this study under-represents the scope of the issue of occupational burns as many cases will not benefit from hospitalisation for treatment. Finally, ICD-10-AM codes for 'activity at time of injury' provide limited information about the industry of employment at the time of injury, with over 60% of work-related injury cases being classified as 'Other specified' or 'Other unspecified'. The

category 'Other Specified' encompasses 11 industries including 'accommodation, cafes and restaurants', childcare services', 'communication services', 'electricity, gas and water supply', and 'public order and safety services', all of which are likely to have contributed cases to the BRANZ data. Other than place or sub-cause, no other information about the occupation of the injured worker is systematically available from the BRANZ data. While a text narrative accompanies each case record in the registry, these are inconsistent in detail. These are important limitations as worker occupation and activity at the time of injury provides considerably more information about circumstances contributing to the injury event than does the broad category of industry. Further research, such as linkage of BRANZ data with a data source that includes more detailed occupational information could allow a more thorough examination of risk factors for work-related burn injury, and identification of vulnerable worker sub-groups. For instance, anecdotal evidence suggests that commercial kitchens may be a major source of work-related scald burns, however firm evidence supporting this hypothesis is currently lacking. Data is also currently lacking regarding burn-injuries to self-employed workers and to other employment category groups.

Despite these limitations, this study provides important information about the epidemiology of work-related burn injuries, and is the first to do so for the Australia and New Zealand region. Male workers, young workers and workers engaged in the manufacturing and construction industries have been identified as vulnerable groups. Hands, feet and eyes are frequent burn sites. The percentage of work-related burns to the eye was found to be almost double that of non-work-related burns, suggesting a need for addition personal protective equipment or improved protective strategies. Activities from which the highest proportions of workplace burns arise include coming into contact with high voltage power sources, use of angle grinders and welding apparatus, cooking with hot oils or fats, and spilling containers of hot water. This evidence can inform targeted prevention strategies, workplace education programs, and guidelines for workers, supervisors and employers.

5. Conclusions

This study has described the characteristics of severe work-related burn injuries in Australia and New Zealand and has demonstrated significant differences between work-related burns and burns sustained in other contexts. Further research is needed to investigate the relationship between work-related burn injury, occupation and activity at the time of injury, allowing more detailed identification of vulnerable worker subgroups, and more detailed evidence to inform occupational health and safety policy and guideline development to minimise occupational burn risk.

Declarations of interest

None.

Acknowledgements

The BRANZ is an initiative of the Australian and New Zealand Burn Association (ANZBA). Funding has been received from the Julian Burns Trust (2011–2012, 2018), the Australian Commission on Safety and Quality in Health Care (2008–2009), the Australian and New Zealand Burn Association (2008–2010), the Helen MacPherson Smith Trust (2010–2012), the Thyne Reid Foundation (2011–2013), the New Zealand Accident Compensation Corporation (2013–current), the Australasian Foundation for Plastic Surgery (2013–2016), and a HCF Research Foundation grant. Individual burn centres contribute funding to the registry to ensure the ongoing sustainability of BRANZ. We thank the BRANZ Steering Committee for supporting the project and providing data to the project. Belinda Gabbe was supported by an Australian Research Council Future Fellowship (FT170100048) during the preparation of this manuscript.

REFERENCES

[1] International Labour Organisation. Safety and health at work international labour office. Geneva: International Labour Organisation; 2016.
[2] Safe Work Australia. The cost of work-related injury and illness for Australian employers, workers and the community: 2012–13. Canberra: Safework Australia; 2015.
[3] Summer GJ, Puntillo KA, Miaskowski C, Green PG, Levine JD. Burn injury pain: the continuing challenge. J Pain 2007;8:533–48.
[4] Reeve J, James F, McNeill R, Brown P, Cameron L, Mills S. Functional and psychological outcomes following burn injury: reduced income and hidden emotions are predictors of greater distress. J Burn Care Res 2011;32:468–74.
[5] Fauerbach JAP, McKibben JP, Bienvenu OJMDP, Magyar-Russell GP, Smith MTP, Holavanahalli RP, et al. Psychological distress after major burn injury. Psychosom Med 2007;69:473–82.
[6] Schneider JCMD, Bassi SMD, Ryan CMMD. Employment outcomes after burn injury: a comparison of those burned at work and those burned outside of work. J Burn Care Res 2011;32 (March/April):294–301.
[7] Mason STP, Esselman PMD, Fraser RP, Schomer KMA, Truitt AMPH, Johnson KP. Return to work after burn injury: a systematic review. J Burn Care Res 2012;33(January/February):101–9.
[8] Ahn CS, Maitz PKM. The true cost of burn. Burns 2012;38:967–74.
[9] Masterton JP, Pressley TA, Caird Ramsay G. A survey of adults with flame burns at a Melbourne hospital. Med J Aust 1979;1:332–6.
[10] Pegg SP, Miller PM, Sticklen EJ, Storie WJ. Epidemiology of industrial burns in Brisbane. Burns Incl Therm Inj 1986;12:484–90.
[11] Waller AE, Marshall SW, Langley JD. Adult thermal injuries in New Zealand resulting in death and hospitalization. Burns 1998;24:245–51.
[12] MacLeod A. Adult burns in Melbourne. A five-year survey. Med J Aust 1970;2:772–7.
[13] Pegg SP, Seawright AA. Burns due to cooking oils—an increasing hazard. Burns Incl Therm Inj 1983;9:362–9.
[14] Duggan D, Quine S. Burn injuries and characteristics of burn patients in New South Wales, Australia. Burns 1995;21:83–9.
[15] AIHW, Pointer S, Tovell A. Hospitalised burn injuries, Australia, 2013-2014. Injury research and statistics series no. 102. cat. no. INJCAT 178. Canberra: AIHW; 2016.

[16] McCullough JE, Henderson AK, Kaufman JD. Occupational burns in Washington state, 1989-1993. J Occup Environ Med 1998;40:1083–9.
[17] Islam SS, Nambiar A, Doyle EJ, Velilla AM, Biswas RS, Ducatman AM. Epidemiology of work-related burn injuries: experience of a state-managed workers' compensation system. J Trauma-Inj Infect Crit Care 2000;49:1045–51.
[18] Taylor AJ, McGwin GJ, Cross JM, Smith DR, Birmingham BR, Rue LW. Serious occupational burn injuries treated at a regional burn center. J Burn Care Rehab 2002;23(July/August):244–8.
[19] Müller M, Moser EM, Pfortmueller CA, Olariu R, Lehmann B, Exadaktylos AK. Aetiology of adult burns treated from 2000 to 2012 in a Swiss University Hospital. Burns 2016;42:919–25.
[20] Bunker DJ, George RJ, Kleinschmidt A, Kumar RJ, Maitz P. Alkali-related ocular burns: a case series and review. J Burn Care Res 2014;35:261–8.
[21] Ye C, Wang X, Zhang Y, Ni L, Jiang R, Liu L, et al. Ten-year epidemiology of chemical burns in western Zhejiang Province, China. Burns 2016;42:668–74.
[22] Quinney B, McGwin Jr G, Cross JM, Valent F, Taylor AJ, Rue LW. Thermal burn fatalities in the workplace, United States, 1992 to 1999. J Burn Care Rehab 2002;23(September/October):305–10.
[23] Mandelcorn E, Gomez M, Cartotto RC. Work-related burn injuries in Ontario, Canada: has anything changed in the last 10 years? Burns 2003;29:469–72.
[24] Brusselaers N, Monstrey S, Vogelaers D, Hoste E, Blot S. Severe burn injury in Europe: a systematic review of the incidence, etiology, morbidity, and mortality. Crit Care 2010;14:R188.
[25] Cleland H, Greenwood JE, Wood FM, Read DJ, She RW, Maitz P, et al. The Burns Registry of Australia and New Zealand: progressing the evidence base for burn care. Med J Aust 2016204: 195.e1–e.7.
[26] Maitz PM, Wong She R. Emergency management of severe burns (EMSB) course manual. The Education Committee of the Australian and New Zealand Burns Association Ltd. 18th ed. revised 2016/17 Sydney NSW: Australian and New Zealand Burn Association; 2014.
[27] Wood FM, Phillips M, Jovic T, Cassidy JT, Cameron P, Edgar DW, et al. Water first aid is beneficial in humans post-burn: evidence from a ni-national cohort study. PLoS ONE 2016;11:0147259, doi:http://dx.doi.org/10.1371/journal.pone.0147259.
[28] National Centre for Classification in Health. International statistical classification of diseases and related health problems, 10th revision, Australian Modification (ICD-10-AM). 9th ed. Sydney: National Centre for Classification in Health; 2015.
[29] Pegg SP. Burn epidemiology in the Brisbane and Queensland area. Burns 2005;31:S27–31.
[30] Sharma NP, Duke JM, Lama BB, Thapa B, Dahal P, Bariya ND, et al. Descriptive epidemiology of unintentional burn injuries admitted to a tertiary-level government hospital in Nepal: gender-specific patterns. Asia Pac J Public Health 2015;27:551–60.
[31] ANZBA. Care — first aid [website]. http://anzba.org.au/care/first-aid/. [Accessed August 2018].
[32] McKenzie K, Mitchell R, Scott D, Harrison J, McClure RJ. The reliability of information on work-related injuries available from hospitalisation data in Australia. Aust N Z J Public Health 2009;33:332–8.