

## **Title**

### **The epidemiology of burn injuries in an Australian setting, 2000 to 2006**

#### **Introduction**

A burn injury represents perhaps the widest spectrum of any form of trauma. Burns occur in all age groups, and may range in severity from very minor requiring no treatment, through to extremely severe when the highest levels of intensive care and surgery are indicated. This variability in severity and treatment can make it difficult to accurately describe the number of people who suffer burn injuries each year and the subsequent imposed health burden (Burd 2005).

Nonetheless, it is estimated that thermal burns constitute a significant source of morbidity and mortality. In the United States, it has been reported that 500,000 people with acute burns are treated in emergency departments (EDs) and 80,000 are hospitalised each year (Brigham 1996; Fagenholz et al 2007). Much of this data is derived from admission data from specific hospital centres, with only a few dealing with the incidence in the whole population.

In Australia, there has been no examination of burn injury incidence from multiple sources such as records of deaths, hospital admissions and ED presentations. It is purported that 1% of the Australian population sustains a burn each year, of which half are severe enough to affect daily life. Approximately 10% of burn victims require hospitalisation, of which 10% are considered to have life-threatening injuries (Greenwood et al 2007). Single burn unit studies (Greenwood et al 2007) suggest annual increases of 20% each year in hospital admissions, although conclusions drawn from these studies may not be valid because of specific variations in climate, employment patterns, or other socioeconomic factors (Fagenholz et al 2007). Similarly, studies based on data from single burn units, although invaluable for the reporting of therapeutic interventions, may not necessarily represent population-based estimates or specific treatment patterns (Fagenholz et al 2007).

Therefore, the purpose of this study was to report a population based estimate of the frequency, pattern, and mechanisms of burn injury leading to death or hospital treatment (i.e. inpatient admissions and emergency department presentations) across the state of Victoria, Australia for the years 2000-2006 inclusive.

#### **Material and methods**

##### *Aim*

A retrospective review was performed of all Victorian burn injury cases that either resulted in a fatality or warranted hospital treatment (either inpatient admission or ED presentation). Deaths data were reviewed over a six year time period from January 2000 to December 2005 while hospital admission and ED data were reviewed over seven years from January 2000 to December 2006.

### *Setting*

The estimated resident population of Victoria at 30 June 2006 was 5.13 million, an increase of 323,600 people since June 2001 at an average annual growth rate of 1.3%. The capital city, Melbourne, has 3.74 million people residing and is nearly three-quarters (73.0%) of Victoria's population (ABS, 2006). Victoria is served by three level 1 trauma centres, has 138 health care services and 38 public hospitals with 24 hour ED facilities. The state has two burns unit, with the adult unit seeing 250 acute care admissions each year that follow the criteria set out by the Australian and New Zealand Burns Association for those with acute injury requiring service of a specialised burns unit

### *Population estimates*

Population counts for Victoria including age and gender distributions were obtained from the Australian Bureau of Statistics (ABS) Census data (years 1996, 2001, 2006) (ABS, 2006). Estimates of the population size for each intervening year were calculated assuming consistent population change over the period between census years.

### *Injury data sets*

Data were provided by the Victorian Injury Surveillance Unit (VISU) from three different datasets pertaining to burn injury deaths, hospital inpatient admissions and non-admitted ED presentations. Duplicate cases (e.g. hospital admissions resulting in a fatality) were removed from the dataset to ensure that these datasets were mutually exclusive.

Fatality data were extracted from the ABS Death Unit Record File (DURF). This dataset was obtained from the Victorian State Registrars of Births, Deaths and Marriages and is coded using the World Health Organisation (WHO) International Classification of Diseases (ICD) coding system.

Hospital inpatient admissions data were obtained from the Victorian Admitted Episodes Dataset (VAED), which reports all acute hospital admitted patient information for the state. The VAED uses an Australian Modification of the ICD system (ICD-10-AM) which provides more detail than the ICD alone. Admitted cases that were transferred to other acute institutions were removed to avoid duplicative counting of cases.

Data on emergency department presentations were extracted from the Victorian Emergency Minimum Dataset (VEMD), which gathers demographic, clinical and administrative details for every episode of care occurring in participating Victorian hospital EDs (Cassell et al 2004). The number of participating hospitals increased during the study period, from 28 in 2000 to 38 in 2006. It is estimated that 80% of ED presentations in the state of Victoria are represented in this data set (Stokes et al 2000). The VEMD data are coded to Level 1 National Data Standards for Injury Surveillance (AIHW, 1998) which is related to the more extensive ICD codes.

The final dataset therefore included all fatal and hospital admitted burn injuries and a significant majority of non-admitted ED presentations for burn injury across the state of Victoria.

#### *Inclusion criteria*

Fatality (ABS) and hospital admission (VAED) burn and scald data were extracted using the ICD-10 External Injury Cause Codes in the ranges X00-X19, X76-X77, X97-X98 and Y26-Y27 incorporating 'Exposure to Smoke, Fire and Flames' and 'Contact with Heat and Hot Substances' that were unintentional, self-harm, assault and of undetermined intent.

Burn and scald data for non-admitted ED presentations were extracted from the VEMD using the injury cause codes: *14* Fire, flames, smoke; *15* Scalds (hot drink, food, water, other fluid, steam, gas or vapour); and *16* Contact burn (hot object or substance). A check of narrative data for each case found that there were some misclassifications of burns under the scalds code and vice versa. Cases were then manually re-assigned and then grouped according to the ICD-10 coding system for the purposes of comparison with hospital admissions.

#### *Data analysis*

All data were managed and analysed using the Statistical Package for Social Science (SPSS) Version 12.0 and Microsoft Excel. Descriptive statistics such as age, gender, intent, site of injury, external cause and injury location were used to summarise the profiles of all burn injury cases. All statistical differences were tested with the level of significance set at 0.05. Population-based incidence rates were calculated for age, gender and each 12-month period of fatality and hospital admitted data, and Taylor series risk ratios were calculated to compare risk differences between age and gender sub-populations.

Although the non-participation of a number of Victorian ED's in the data surveillance meant that it was not possible to calculate the true population incidence of burn injury resulting in non-admitted ED presentation, an approximate incidence rate was calculated using the available data. This was done in order to illustrate the magnitude of non-admitted burn injury presentations relative to hospital admissions and fatalities, with the understanding that the estimated rates would be an under-representation of the true incidence.

## **Results**

### *Fatal burn injuries*

During the years 2000-2005, 178 people died following a burn injury (Table 1). The population incidence of burn injury mortality was significantly higher among males compared with females, and increased consistently with age. One quarter of all burn injury deaths were intentional, and three quarters of these were self-inflicted. All intentional deaths were caused by exposure to smoke, fire or flame, whereas nearly one fifth of unintentional deaths were due to contact with heat and hot substances.

INSERT TABLE 1

### *Non-fatal hospital admissions and ED presentations*

Data were available for 36,430 patients treated in hospitals for non-fatal burn injury between January 2000 and December 2006, comprising 7,543 hospital admissions and 28,887 non-admitted ED presentations. Table 2 shows the distribution of non-fatal hospital treated burn injury by gender, age-group and intent. Also displayed is the average annual incidence rate of hospital admission and ED presentation (based on available data) for burn injury over the seven years. Males were 1.64 (95% CI: 1.57, 1.72) times more likely to be hospitalised and 1.43 (95% CI: 1.40, 1.47) times more likely to present to an ED with a burn injury than females.

INSERT TABLE 2

During the seven year study period 2,805 children (aged 19 years and below), were admitted to hospital and a further 10,654 presented to an ED with a burn injury, accounting for approximately one third of all burn injury presentations (both unintentional and intentional). The youngest children (0-48 months) were over-represented in hospital admissions and ED presentations compared to other ages groups (Table 2). The frequency of paediatric burns decreased as age increased; although this trend reversed itself with a rise in both hospital admissions and ED presentations for those aged 20-24 years (Figure 1). The elderly ( $\geq 65$  years of age) shared similar hospital admissions rates with the children less than 48 months although ED presentations that did not require hospital admission were markedly lower among older people (Table 2).

## INSERT FIGURE 1

### *Intent of burn injury*

Intentional burn injury represented 24.1% of all deaths, 3.2% of all hospital admissions and 1.2% of ED presentations. The majority of intentional burn injuries were self-inflicted, although assaults accounted for 23% of intentional deaths, 22% of intentional hospital admissions and 49% of intentional ED presentations.

Gender comparisons showed that more females than males were the victim of intentional burn injury treated in hospitals and EDs and females were more likely to sustain an intentional burn injury through self-harm whereas males were more frequently the victims of burn injury related assault. Figure 2 shows the frequency of intentional (assault and self-harm) burn injury leading to death, hospital admission and non admitted ED presentation across the life-span. Hospital admissions and ED presentations peak in early adulthood, whereas deaths have a higher incidence at age 60-64 years.

## INSERT FIGURE 2

The characteristics of non-fatal burn injuries requiring hospital admission are shown in Table 3. Admitted patients with self inflicted burn injuries were more likely to be injured due to exposure to smoke, fire and flame than were patients hospitalised with either assault related (Risk Ratio (RR) 1.57, 95% CI: 1.17, 2.11) or unintentional burn injuries (RR 2.04, 95% CI: 1.86, 2.25). Consequently, self inflicted burn injury was responsible for longer hospital stays with patients more than five times more likely to remain in hospital for longer than 31 days compared patients with unintentional burn injuries (RR 5.77, 95% CI: 4.25, 7.84). The anatomical distribution of burn injuries varied according to intent. More than half of self-inflicted burn injuries affected the upper extremity whereas assault related injuries were more likely to have affected the head and face or trunk of the victim. In contrast, upper and lower extremities were mostly affected in victims of unintentional burn injury.

## INSERT TABLE 3

### *Major causes of burn injuries*

Exposure to smoke, fire and flames was responsible for 82% of all burn related deaths. In contrast, the majority of non-fatal burn injuries (64% of hospital admissions and 90% of non-admitted ED presentations) were caused by contact with heat and hot substances (Figure 3). The

higher proportion of deaths and hospital admissions due to smoke, fire and flame exposure however indicates the more serious nature of these injuries and more intensive treatment requirements. The serious nature of these injuries is also reflected by the extent of the body surface area affected among victims admitted to hospital. Twenty-three percent of burn patients hospitalised due to exposure to smoke, fire and flames had a burn injury that covered more than 10% of the body compared with only 9% of patients hospitalised due to contact with hot substances.

### INSERT FIGURE 3

#### *Body site injured*

The most frequently injured body site for hospital admissions was the extremities (57%), although males sustained more injuries to their neck (22.6% vs. 13.5%), and in a reverse situation, a higher proportion of women sustained trunk injuries than men (21.9% vs. 14.5%). The pattern of injury was similar in ED presentations with the extremities accounting for 63%, and upper extremities accounting for nearly half (47%), of all ED presentations.

#### *Place of injury*

The place of injury occurrence was not specified for a large number (36%) of hospitalised cases, however of those that were specified, 75% occurred in the home or a residential institution, 7% occurred in schools and 8% occurred in trade, service or industrial areas. Available data also indicated that the majority of burns and scalds presenting to ED occurred in the home (67%).

#### *Length of hospital stay*

Over half of the hospital admissions (51%) were in hospital for less than two days, whilst 26% stayed for 2 -7 days and the remainder (27%) stayed for 8 days or more. Women stayed in hospital slightly longer than men.

#### *Temporal trends in burn injury*

No changes in the overall population rate of burn injury deaths or hospital admissions were observed during the study period. The number of Victorian emergency departments contributing data to the VEMD database increased during the study period and hence a corresponding increase in the frequency of emergency department presentations was observed.

### **Discussion**

This epidemiological study has presented data from multiple sources to illustrate the public health problem of burn injuries in the state of Victoria. During the study period, 178 burn injury

related deaths were recorded along with over 37,000 episodes of care provided either in a hospital ward or emergency department. The serious nature of burn injuries was attested to by the finding that one quarter of all hospitalised patients (nearly 2000 individuals) remained in care for at least one week.

#### *Temporal trends*

The data did not reveal any changes to burn injury related deaths and hospital admissions during the study period. Although non-admitted emergency department presentations did increase during the study period, this was due to a greater number of EDs contributing data to the injury surveillance system capturing these events. This finding of stable burn injury rates was in contrast to previous reported Australian studies which reported a general increase in 'all cases' admission rates to hospitals since 2001 (Pegg 2005; Greenwood 2007). However, this trend in itself is in contradiction to international trends in developed countries such as the United States and Sweden where hospital admission rates and ED presentations due to burn injuries have decreased over time (Akerlund et al 2007; Fagenholz et al 2007).

There are several possible explanations for the finding that hospital treated burn injury rates in Australia have either stagnated or increased. Most simply, public health campaigns aimed at decreasing burn injuries have failed either, either in their uptake by the general public, or in the lack of breadth covering all possible burn injury scenarios. There is evidence that success has been achieved for preventing hot tap water scalds among young children and the elderly, however similar achievements have not occurred to successfully prevent burn and scalds injuries from other causes. An alternative explanation for the lack of change despite burn injury prevention efforts is that burn injury victims may be bypassing other health care providers (e.g. GPs) and seeking hospital treatment for their injuries in greater numbers than previously.

#### *Age and gender*

As similarly reported in other studies (Chien et al 2003; Han et al 2005) we found ED visit rates and hospital admissions to be greater among males than females. The exception to this was for self inflicted burn injury which was seen more frequently among females. The higher proportion of males affected by burn injury has been tentatively explained by a perceived difference and attitude to risk and exposure to risk-type behaviours (Akerland et al 2007).

There was also a greater variation and different pattern in relation to age. Like similar studies (Foglia et al 2004; Sakalligolu et al 2007, Xi et al 2006), the youngest age group (0- 4 years) were over-represented in both hospital admissions and ED presentations, but not at risk of increased mortality. This was assumed to be caused by the stage of development of motor and cognitive skills, coupled with incorrect assumptions about these skills by parents (Xi et al 2006).

Males in their late teens and early twenties comprised another high risk group for hospital admission and ED presentation. This peak in burn injury came after a gradual decrease in injuries in older children, possibly due to safety regulations in schools and targeted preventative measures that would mainly affect the younger population. At the other extreme, we noted that elderly patients were far more likely to be hospitalised although they had the lowest rates of non-admitted ED presentations for burn injury. It thus appears that elderly patients who present with a burn injury are likely to be admitted to a hospital ward, most likely due to their relative frailty and higher occurrence of co-morbidities compared with younger individuals

#### *Intentional Burn Injury*

Although intentional burn compromised only 1.5% of our study population, they were responsible for a quarter of all deaths and were associated with longer hospital stays. The low detection rate of intentional burn injuries in ED department could signify that cases are misdiagnosed or improperly recorded due to patients trying to avoid embarrassment or further repercussions (Modjarred et al 2007). Among the types of intentional burns, self-harm, rather than assaults were prevalent, and the former were associated with a much poorer prognosis. According to Modjarred et al 2007, these results are reflective of observed global trends, and rationalised with arguments that patients trying to harm themselves employ fewer personal defences than those who were burnt accidentally or attacked as a result of impulse by an assailant (Tuohig et al 1995).

#### *Strengths and Limitations*

Strengths of the current study include the breadth of data available for analysis. Many other epidemiological studies, in particular, Australian studies, have been confined to small patient treated in one burn unit (Greenwood et al 2007; Duggan et al 1995;) and only a few dealing with large numbers and lengthy study period durations (Pegg 2005). In contrast, we included all fatal and hospitalised burn injury cases and a large proportion of patients presenting to an ED throughout the whole of Victoria during a seven year period.

There are, however, some limitations that must be accounted for. Firstly, our hospital admissions data was sourced from administration datasets from hospitals who report to the state-based Department of Human Services (DHS) who then provide an injury subset to VISU. The reliability of administration data is typically constrained by the fact that the data was collected at various time points with a potential for time lag and accurate reporting of actual or exact ED presentations or hospital admissions. Therefore, quantitative accuracy and reliability audits of the data collection processes may not have been performed to the same standards as expected in high quality research studies where data was collected by the researchers themselves.

Secondly, this study was a retrospective review meaning that data on patients who did not seek medical attention or who attended a health-care facility not covered by the VEMD dataset were not available for our analysis. Although perceived to be relatively small number of burn injury cases, this numerical gap may have under-estimated the true incidence in Victoria.

### **Conclusion**

Burn and scalds injuries constitute an important source of mortality and morbidity which has not been reduced despite small successes at reducing the incidence of some types of burn injuries. Our findings suggest that there have been no significant change in Victorian hospital admissions or deaths over a seven year period. We believe this to be due to variations in the success made by government and health care agencies in burn injury prevention and control programs, and variations in efficient treatments and clinical practices amongst primary care providers. Therefore, educational efforts for prevention should be the keystone to minimise the incidence of burn injuries.

**Table 1**      **Distribution of Victorian burn injury fatalities, 2000-2005**

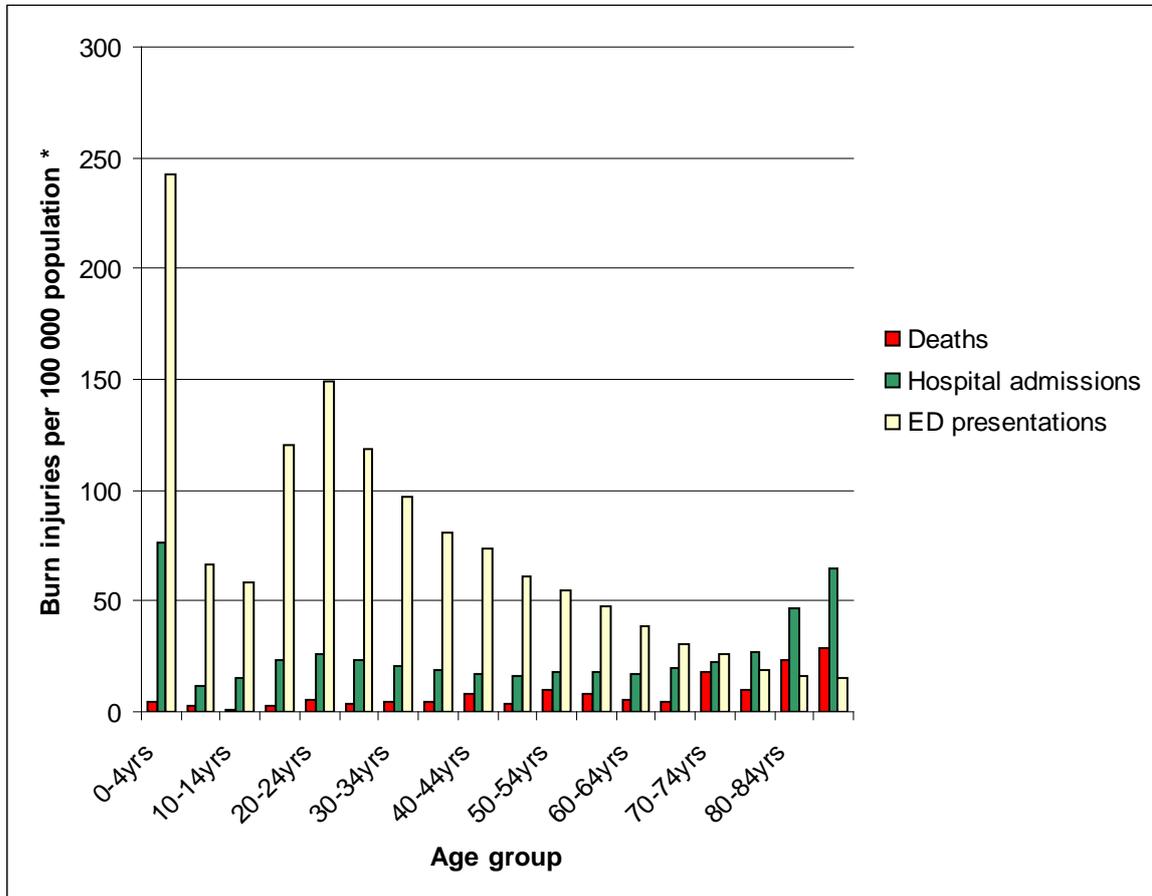
	Unintentional Deaths		Intentional Deaths		All Deaths	
	N per year	Rate per 100000 (95% CI)	N per year	Rate per 100000 (95% CI)	N per year	Rate per 100000 (95% CI)
<b>Gender</b>						
Male	15.2	0.65 (0.56 – 0.76)	4.5	0.19 (0.14 – 0.26)	19.6	0.84 (0.73 – 0.97)
Female	7.3	0.30 (0.24 – 0.38)	2.6	0.11 (0.07 – 0.16)	10.0	0.41 (0.34 – 0.50)
<b>Age-group</b>						
0-19 years	2.7	0.21 (0.14 – 0.30)	0.5	0.04 (0.04 – 0.05)	3.2	0.25 (0.18 – 0.36)
20-34 years	2.2	0.22 (0.15 – 0.33)	2.2	0.22 (0.15 – 0.33)	4.3	0.43 (0.32 – 0.58)
35-49 years	4.2	0.39 (0.29 – 0.54)	2.0	0.19 (0.12 – 0.19)	6.2	0.58 (0.46 – 0.75)
50-64 years	4.6	0.60 (0.44 – 0.78)	1.8	0.23 (0.15 – 0.36)	6.5	0.83 (0.65 – 1.06)
64-80 years	4.8	0.96 (0.78 – 1.36)	0.5	0.11 (0.05 – 0.25)	5.0	1.07 (0.81 – 1.41)
80+ years	4.3	2.61 (1.92 – 3.49)	0.2	0.10 (0.04 – 0.43)	4.5	2.71 (2.03 – 3.62)
<b>Total</b>	<b>22.5</b>	<b>0.47 (0.42 – 0.54)</b>	<b>7.2</b>	<b>0.16 (0.13 – 0.20)</b>	<b>29.6</b>	<b>0.62 (0.56 – 0.71)</b>

**Table 2** Distribution of hospital admissions and emergency department presentations for non-fatal burn injury in Victoria, 2000-2006

	Hospital admissions		ED presentations		Total non-fatal burn injuries
	N per year	Rate per 100000 (95% CI)	N per year	Rate per 100000 (95% CI) *	N per year
<b>Gender</b>					
Male	736	31.6 (29.4 – 33.9)	2391	102.6 (98.7 – 102.7)	3127
Female	465	19.2 (17.5 – 21.0)	1735	71.7 (68.4 – 75.2)	2200
<b>Age-group</b>					
<i>Paediatric</i>					
0-4 years	230	76.1 (66.9 – 86.6)	733	242.7 (226.3– 261.1)	963
5-9 years	38	12.0 (8.7 – 16.4)	212	66.5 (58.3 – 76.2)	250
10-14 years	51	15.7 (12.0 – 20.6)	191	58.8 (51.1-67.8)	242
15-19 years	77	23.8 (18.9 – 29.5)	392	120.4 (109.0 – 132.8)	469
<i>Adult</i>					
20-34 years	232	23.1 (20.3 – 26.3)	1213	120.7 (114.1 – 127.7)	1445
35-49 years	184	17.3 (15.0 – 20.1)	764	72.1 (67.2 – 77.5)	948
50-64 years	138	17.6 (14.9 – 20.8)	376	47.9 (43.4 – 53.1)	514
64-80 years	106	22.6 (18.8 – 27.5)	120	25.7 (21.5 – 30.8)	226
80+ years	91	55.0 (44.7 – 67.3)	26	15.9 (10.7 - 22.9)	117
<b>Intent</b>					
Unintentional	1147	24.1 (22.8 – 25.6)	3980	83.8 (80.3 – 86.5)	5127
Intentional	38	0.8 (0.6 – 1.1)	49	1.0 (0.8 – 1.4)	87
Undetermined	15	0.3 (0.2 – 0.5)	97	2.1 (1.7 - .5)	112
<b>Total</b>	<b>1200</b>	<b>25.3 (23.9 – 26.7)</b>	<b>4127</b>	<b>86.9 (84.3 – 89.6)</b>	<b>5327</b>

\* Based on available data from participating ED's only

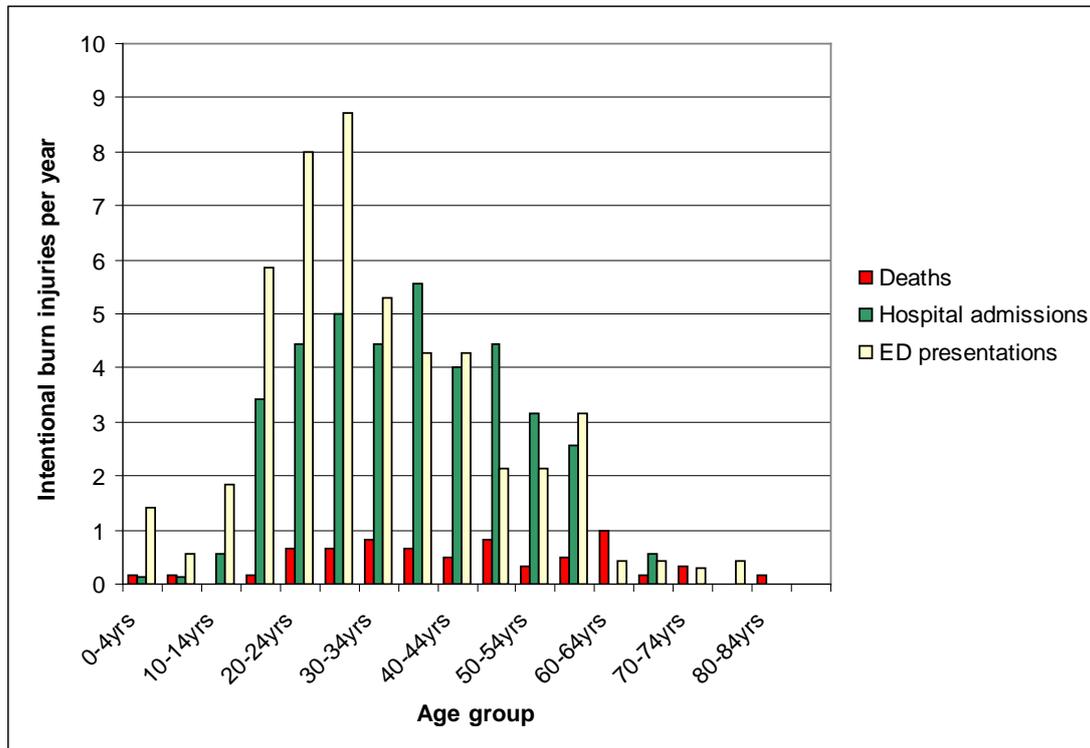
**Figure 1 Population incidence of burn injury related deaths, hospital admissions and ED presentations by age group, Victoria, 2000-2006**



\* Incidence of burn injury deaths is per 10 000 population.

\* ED incidence based on available data from participating ED's only

**Figure 2 Annual frequency of intentional burn injuries across the life-span in Victoria, 2000-2006**



\* ED incidence based on available data from participating ED's only

**Table 3 Intent characteristics of non-fatal burn injuries admitted to Victorian hospitals, 2000-2006**

	Intentional burn injuries - self harm*		Intentional burn injuries - assault*		Unintentional burn injuries *	
	N	%	N	%	N	%
<b>Gender</b>						
Male	51	29%	40	71%	4495	62%
Female	127	71%	16	29%	2726	38%
<b>Age group</b>						
0-19 years	13	7%	10	18%	2445	34%
20-34 years	60	34%	27	48%	1523	21%
35-49 years	67	38%	17	30%	1201	17%
50-64 years	34	19%	2	4%	880	12%
64-80 years	4	2%	0	0%	660	9%
80+ years	0	0%	0	0%	512	7%
<b>External cause</b>						
Exposure to smoke, flame and fire	130	73%	26	46%	2575	36%
Contact with heat / hot substances	48	27%	30	54%	4646	64%
<b>Anatomical location</b>						
Head / face /neck	16	9%	16	29%	1363	19%
Trunk	26	15%	17	30%	1205	17%
Upper extremity	93	52%	15	27%	2441	34%
Lower extremity	29	16%	6	11%	1935	27%
Multiple body regions	2	1%	0	0%	32	0%
Body region not relevant	8	4%	2	4%	374	5%
<b>Length of Stay +</b>						
< 2 days	51	29%	21	38%	3879	54%
2 – 7 days	40	22%	11	20%	1844	26%
8 – 30 days	49	28%	9	16%	1231	17%
> 31 days	38	21%	4	7%	267	4%

\* Totals differ due to missing data

Figure 3 Proportion of burn injury deaths, hospital admissions and ED presentations by major cause category

