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Electrical injury and death

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Key findings

Hospitalisations

- Approximately 1,493 people were hospitalised as a result of an electrical injury during the two year period 2002–03 to 2003–04. 77 cases were identified in which lightning was associated with the injury.
- Electrical injury rates in males were much higher than in females, while for both males and females, rates of hospitalised electrical injury were highest in the young adult and adult years.
- 52% of all cases had a principal diagnosis of effects of electric current (T75.4), and an additional 26% of cases had a principal diagnosis within the range of ICD-10-AM codes describing burns.
- Of the cases where the principal diagnosis was a burn the majority (65%) were of the wrist and hand.
- A large proportion of electrical injuries were found to occur during work activities. The first and second most frequently identified locations were the home and workplace.
- Electrical injuries in children and older people were much less frequent than in other age groups. Of the 209 cases of electrical injury in 0–14 year olds, 18 cases occurred as a result of exposure to high voltage electric transmission lines.

Deaths

- Deaths occurring as a result of electrical injury were uncommon with 162 cases in a four year period between 2001 and 2004. 93% were male.
- Only 7 deaths were associated with lightning during the time period, all male.
- Very few deaths were recorded in children 0–12 years (n=6) with the majority of deaths occurring in the 25–64 year age group (n=104).
- While the incidence of injury and death associated with electricity and lightning is relatively small, reductions are still possible given the preventable nature of many of the injuries identified.

Hospitalisations, Australia, 2002–03 to 2003–04

The mechanism by which electricity can cause injury varies according to the strength of the current, the method of transmission (direct or indirect), the point at which electricity enters and leaves the body, the pathway the current takes through the body as well as the physical conditions under which the event takes place (e.g. wet environment or dry environment) (Duff & McCaffrey 2001).

Approximately 1,493 episodes in hospital occurred as a result of an electrical injury, during the two year period 2002–03 to 2003–04 (Table 1). This equated to an age-adjusted rate of 3.78 cases per 100,000 population for the period.

Table 1: Number of cases and the rates of electrical injury, Australia, 2002–03 to 2003–04

ICD-10-AM Codes T75.4, T75.0, W85, W86, W87, X33	Counts	Crude Rate (per 100,000)	Std Rate (per 100,000)
Males	1,145	5.80	5.78
Females	348	1.74	1.77
Persons	1,493	3.76	3.78

Age and sex

The age standardised rate for males was three times the rate for females and male rates were much higher than female rates for all age categories (Figure 1). For both males and females, rates of hospitalised electrical injury were highest in the young adult and adult years. Similar rates of hospitalised electrical injury occurred in children and older persons.

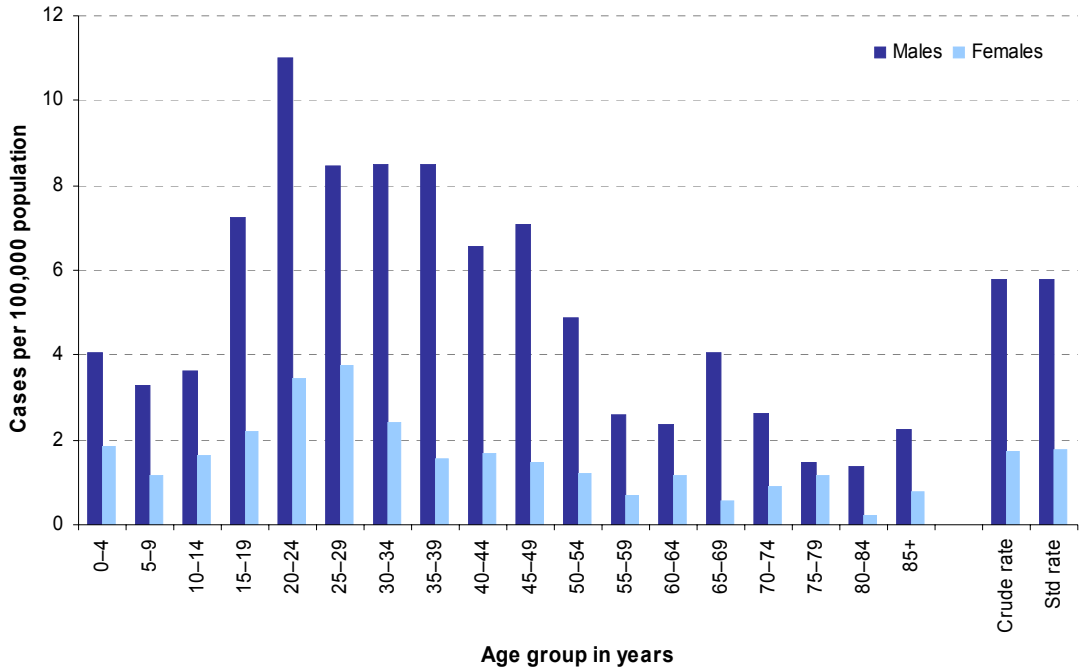


Figure 1: Rates of electrical injury hospitalisations by age and sex, Australia, 2002–03 to 2003–04

Principal diagnosis

Exposure to electricity can result in a range of injuries. For example, exposure to electricity can lead to injuries of the cardiovascular system (e.g. rhythm disturbances), cutaneous injuries and burns, nervous system disruption, respiratory arrest, as well as head injuries, fractures and dislocations (caused by being 'thrown' or 'knocked down' due to the severe muscle contractions induced by the current) (Duff & McCaffrey 2001; Koumbourlis 2002).

52% of all cases had a principal diagnosis of an effects of electric current (T75.4) and 1.4% of cases had a principal diagnosis of effects of lightning (T75.0) (Table 2). An additional 26% of cases had a principal diagnosis within the range of ICD-10-AM codes describing burns. Overall, 86% of cases recorded a principal diagnosis from within Chapter XIX. Males (28%) were more likely to record a principal diagnosis of a burn than females (20%) otherwise their injury profiles were very similar.

Table 2: Principal diagnosis by gender, Australia, 2002–03 to 2003–04

	Counts		
Principal diagnosis	**Males**	**Females**	**Persons**
Effects of electric current (T75.4)	587	193	780
Effects of lightning (T75.0)	15	6	21
Burns (T20-T31)*	319	68	387
Other diagnoses	224	81	305
Total	**1,145**	**348**	**1,493**

*Principal diagnoses other than effects of electric current (T75.4) and effects of lightning (T75.0) were included where an ICD-10-AM code (**T75.4, T75.0, W85, W86, W87, X33)** indicating an electrical injury was present as any external cause or within the additional diagnosis fields.

The distribution of principal diagnoses varied according to age group (Figure 2). Children were more likely to receive a principal diagnosis of a burn with no diagnoses of effects of lightning. Older persons were the least likely to receive a principal diagnosis of an electrical injury and were more likely to receive an 'other' principal diagnosis. A principal diagnosis of an electrical injury was more common among young adults and adults.

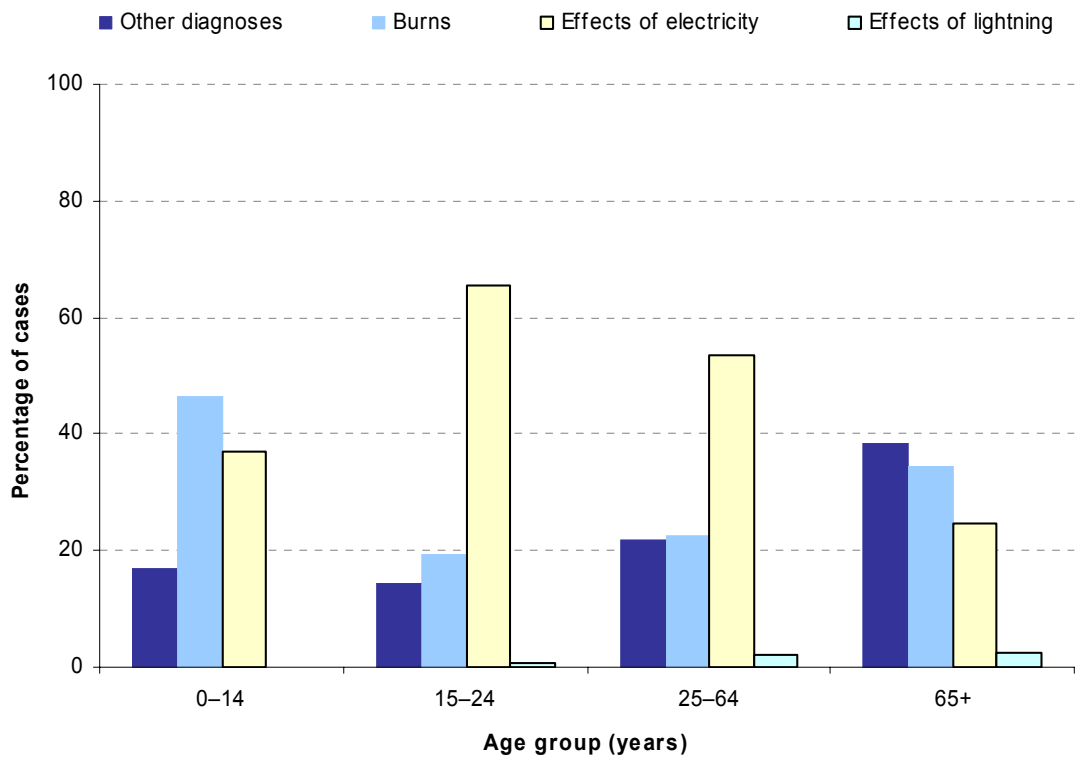


Figure 2: Electrical injury principal diagnoses by age group, Australia, 2002–03 to 2003–04

Of the cases where the principal diagnosis was a burn (N=387) the majority (65%) were of the wrist and hand (Figure 3).

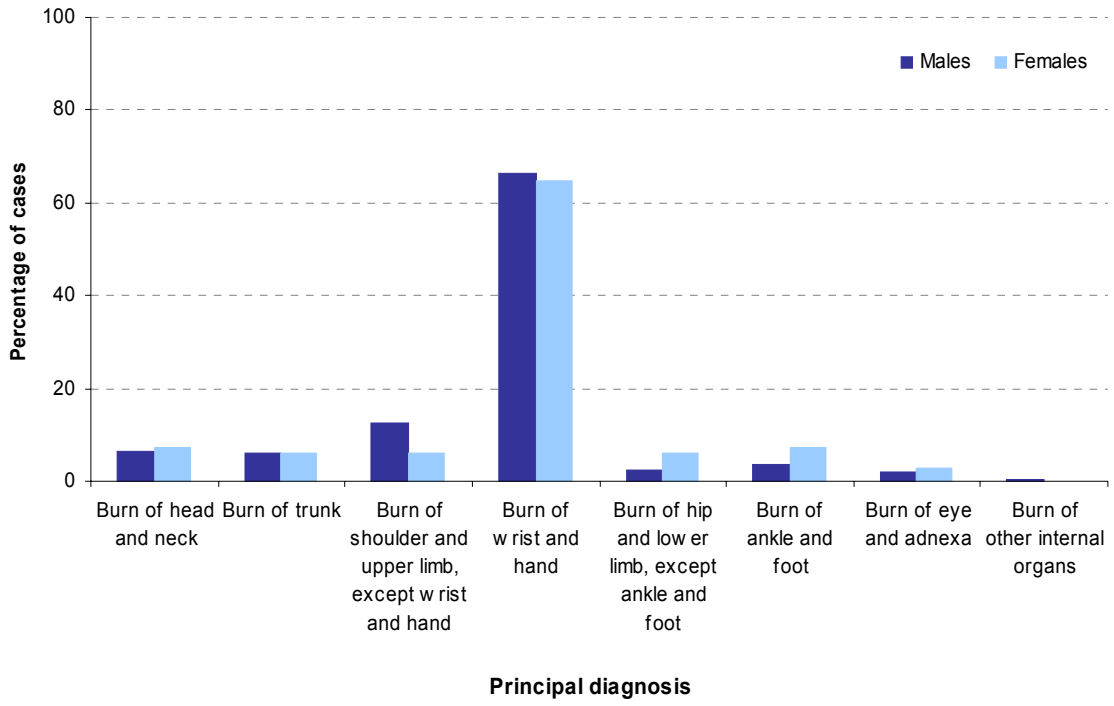


Figure 3: Location of burns associated with electrical injury, Australia, 2002–03 to 2003–04

Length of stay in hospital

Overall, the mean length of stay (LOS) for cases of electrical injuries was 2.94 days (Table 3). There was only a small difference between the mean length of stay for males and females.

45% of patients were discharged on the same day as admission. The longest length of stay was 182 days for a female with full thickness burn of the trunk.

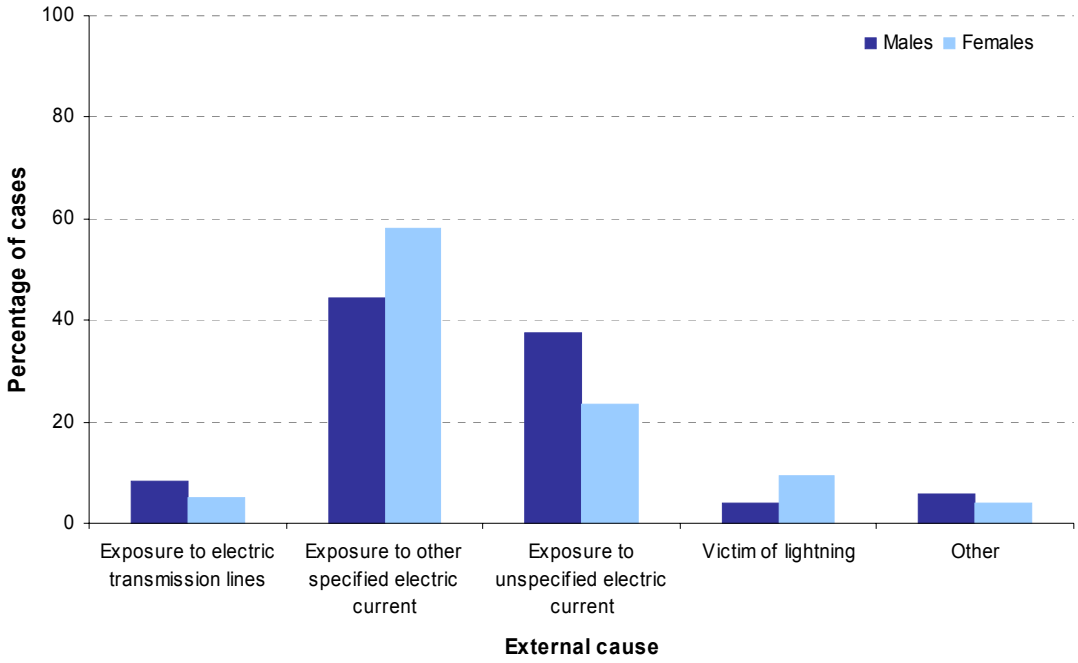
Table 3: Length of stay in hospital for electrical injuries, Australia, 2002–03 to 2003–04

	Minimum	Maximum	Mean	Std. Deviation	Number
Males	1	180	3.00	8.84	1,145
Females	1	182	2.75	11.32	348
Persons	1	182	2.94	7.48	1,493

External cause

Information about the source of an electrical injury is currently limited to four broad categories; exposure to electric transmission lines, exposure to other specified electric current, exposure to unspecified electric current and victim of lightning. This lack of specificity in the external cause codes makes it impossible to ascertain the source of the electrical injury (e.g. power outlet, electrical appliance) unless it involves an electric transmission line.

Exposure to other specified electric current (n=701) was the most common external cause code recorded within the hospital separations data (Figure 4). Fewer cases (n=109) of exposure to electric transmission lines were noted. There were 77 cases due to lightning in the period, 45 males and 32 females. Females were more likely to have an external cause code of exposure to other specified current or lightning than males.

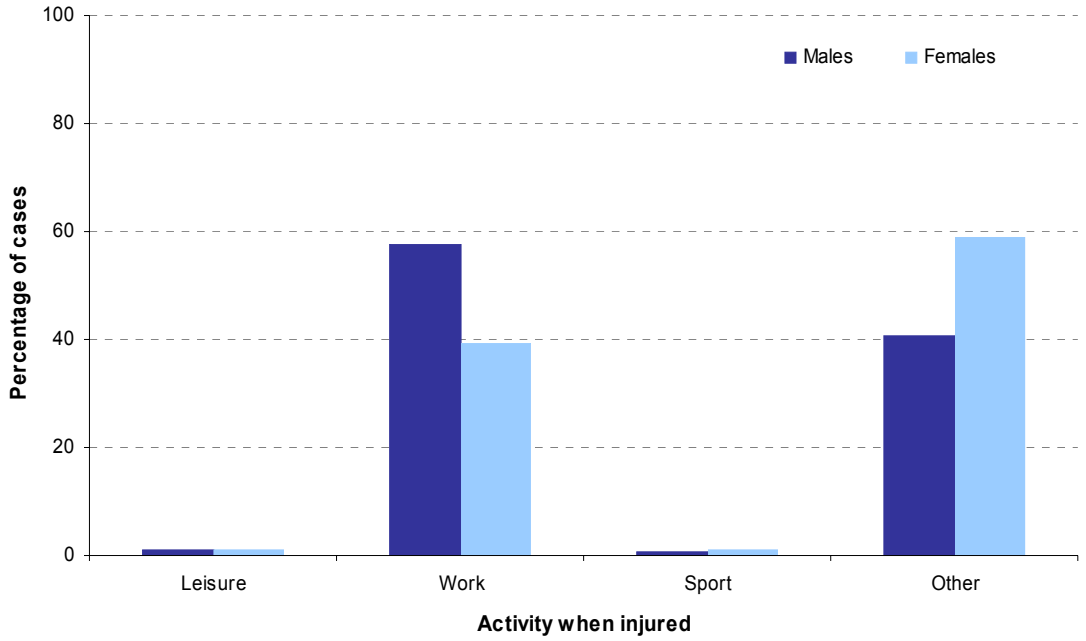


Note: 19 cases were missing an external cause code

Figure 4: External causes for electrical injuries by sex, Australia, 2002–03 to 2003–04

Type of activity

The majority of cases had an activity recorded (10 missing cases) although just under half (45%) of all cases were coded as 'while resting, sleeping, eating or engaging in other vital activities', 'other specified activity' and 'unspecified activity' (aggregated to the 'other' category in these analyses). Just over half of the activity codes indicated that the individual was working at the time of the injury (53%). Males (58%) were more likely to have activity recorded as working than females (39%) (Figure 5).



Note: Work category includes 'Other specified work for income', 'while working for income, unspecified', and 'while engaged in other types of work'. Other category includes 'while resting, sleeping, eating or engaging in other vital activities', 'other specified activity' and 'unspecified activity'

Figure 5: Type of activity by sex, Australia, 2002–03 to 2003–04

Place of occurence

A place of occurrence code was provided for nearly all cases (99%) although in 26% of cases the code was for unspecified place. The most common place code for all persons was in the home (35%) followed by industrial and construction locations (20%). Males were more likely than females to have been in an industrial and construction area while females were more likely than males to have sustained an electrical injury in the home (Figure 6).

Past research indicates that the majority of electrical injuries in adults tend to occur within a work environment while electrical injuries in children occur mostly in the home (Celik, Ergun & Ozok 2004; Koumbourlis 2002). In the current study children received their electrical injuries primarily in the home (77%), while young people aged 15–24 years were almost equally likely to be injured in the home (26%) and in an industrial and construction area (23%). When all work related locations are combined, 36% of young adults received their electrical injuries in a work environment. Gender differences were evident among young adults with females more likely to be injured in the home (44%) and trade and service areas (21%) than males (20% and 11%, respectively).

Adults, 25–64 years, were more likely to be injured in the work environment (29%) with 5% injured in a trade and service area and 24% in an industrial and construction area. Gender differences were also evident with females (50%) more likely to be injured in the home than males (19%), and males (28%) more likely to be injured in industrial and construction locations than females (9%).

The pattern of location of injury in older people (65+) was different to the other age groups with 65% of electrical injuries in older people occurring in the home.

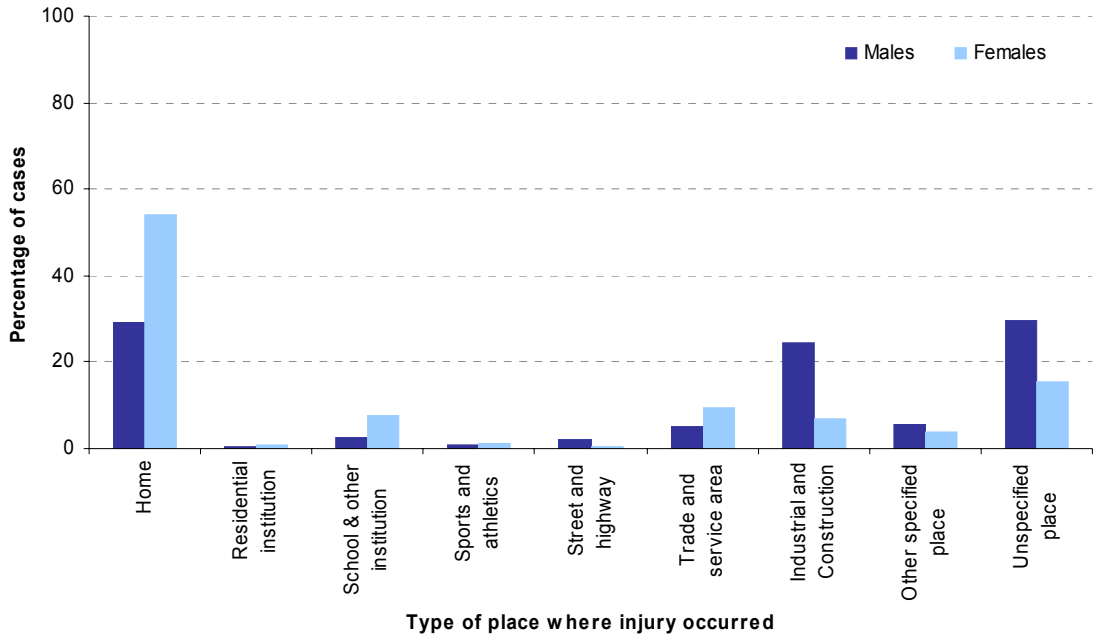


Figure 6: Place of occurrence by sex, Australia, 2002–03 to 2003–04

Injuries caused by lightning

A total of 77 cases were found where lightning was identified as a factor either through a diagnosis or external cause code. There were more males (58%) than females (42%) in the group and the injuries were more frequent among adults (25–64 years) than at younger or older ages (Figure 7).

Some information concerning the circumstances of the lightning related electrical injuries is available. However, activity at the time of injury was unspecified in 66% of cases, as was place in 30% of cases. For the activity at the time of injury 66% of cases have no detail specified, 22% of cases occurred while the person was working for income and 11% of cases occurred during participation in sport. Analysis of the location of injury reveals 30% of cases have no detail specified, 30% occurred at home, 14% in an industrial and construction location, and 10% in a sports and athletic area.

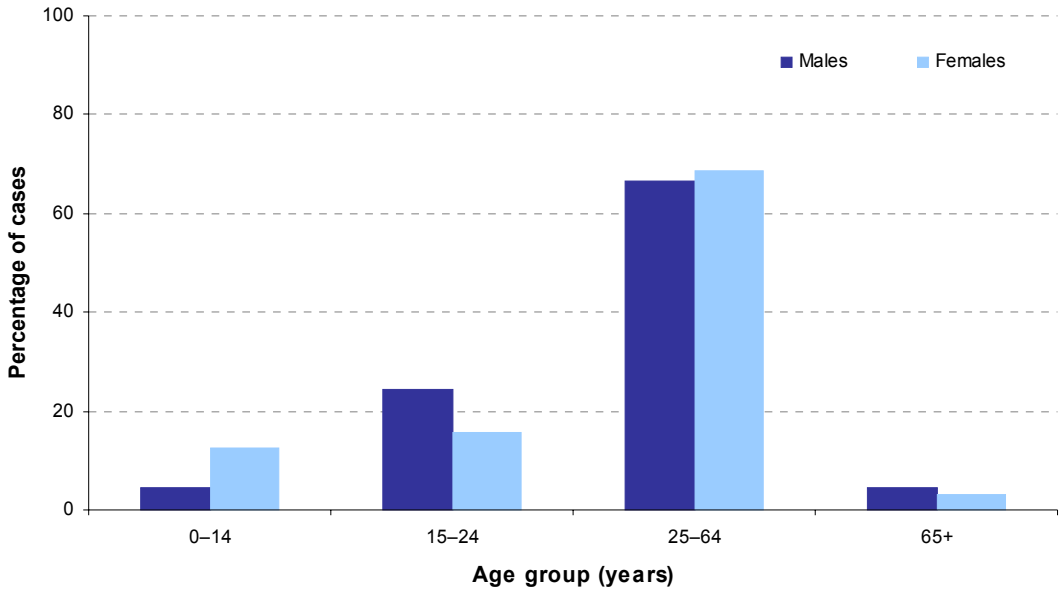


Figure 7: Lightning related electrical injury by sex and age group, Australia, 2002–03 to 2003–04

Electrical deaths, Australia, 2001–04

This section reports deaths registered in Australia during the four years 1 January 2001 to 31 December 2004. Note that this period differs from the two years covered by the section on hospitalisations. The reporting period for deaths overlaps the hospital reporting period and allows for the capture of more cases. Of the 162 deaths attributed to an electrical injury in 2001–04, the overwhelming majority were male (Table 8). The overall age-adjusted rate was 0.20 cases per 100,000 population for the 4 year period. The majority of deaths occurred in the 25–64 year age group (64%), the next highest proportion of deaths occurred in the 15–24 year age group (16%) and the older persons 65+ group (15%). Children 0–14 years had the fewest deaths with 4%.

Table 4: Number of cases and the rates of electrical injury related deaths, Australia, 2001–04

ICD-10 Codes T75.4, T75.0, W85, W86, W87, X33*	Counts	Crude Rate (per 100,000)	Std Rate (per 100,000)
Males	150	0.38	0.38
Females	12	0.03	0.03
Persons	162	0.20	0.20

*Includes cases where at least one of the codes was recorded as the Underlying Cause of Death or a Multiple Cause of Death.

External cause

As with the hospitalisations data, specific information about the cause of a fatal electrical injury is currently restricted to four broad categories; exposure to electric transmission lines, exposure to other specified electric current, exposure to unspecified electric current and victim of lightning.

As can be seen in Figure 8, the majority of cases (34%) were associated with exposure to an unspecified electric current. A total of 7 (all male) deaths were associated with lightning during the four year period. A total of 51 (31.5%) cases were identified in which the underlying cause of death was not associated with an electrical injury but for which an electrical injury was listed in the multiple causes of death. In 44 of these cases the underlying cause of death was intentional self-harm by other specified means (X83).

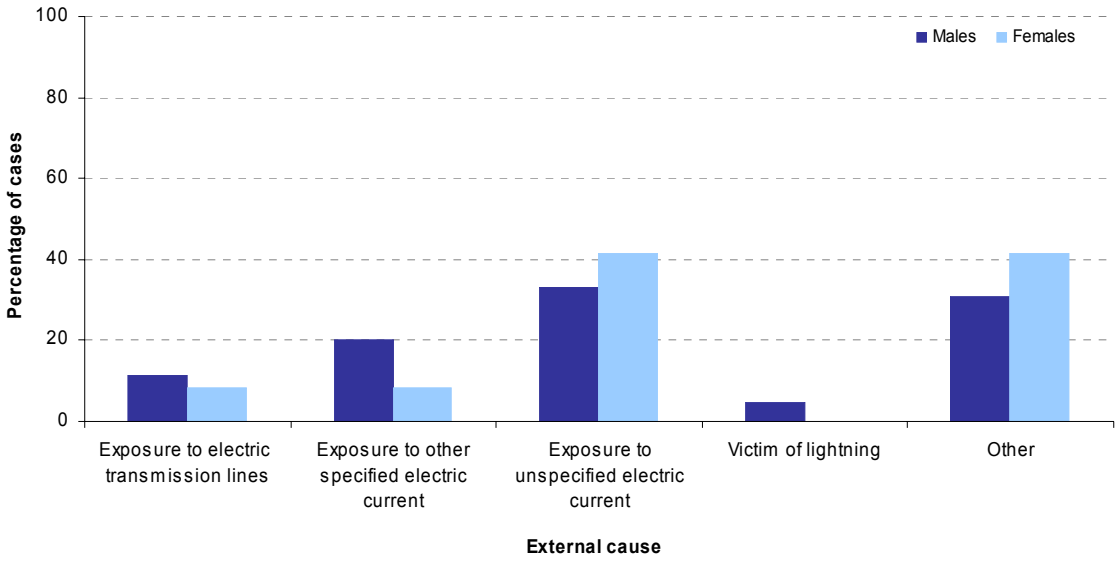


Figure 8: Distribution of external causes for electrical injury related deaths, Australia, 2001–04

A search of the National Coroners Information System identified 5 of the 7 *other* cases. One of these cases was clearly a miscode as the police report and coroners finding point to drowning as the cause of death with no reference to electricity or lightning. Three cases were classified as intentional self-harm of which 2 were intentional self-harm by hanging, strangulation or suffocation and all three involved electricity. The fifth case was coded as unintentional and involved a fall from a ladder associated with an electrical shock.

Deaths of children and young adolescents are comparatively rare. The literature suggests that cases are primarily associated with exposure to electricity within the home often as a result of playing with or near faulty appliances (Byard et al. 2003). In the present study, of the 33 deaths identified in people aged between 0–24 years the most common underlying cause of death occurred as a result of exposure to an unspecified electric current (36%).

Only a small proportion of deaths in this age group involved exposure to high voltage wires. The literature suggests that such episodes are generally confined to adolescent and early adolescent boys (Byard et al. 2003; George et al. 2005; Nguyen et al. 2004). In the present study 8 cases were identified in the 0–24 year age range, all but one were male and 5 occurred in children and adolescents less than 18 years of age.

Type of activity & place of occurence

Of the 162 deaths within the reporting period information on type of activity and place where the death occurred is only available for deaths registered between 2001 and 2002 (n=90). Information on place of occurrence was available for 89 of the 90 cases, of these cases 23 were coded as *other specified* or *unspecified*. The majority of deaths occurred at home (42%) and there were less than 6 cases in each of the other location categories.

All 90 cases had information about the type of activity engaged in at the time of death. Again the majority of activities were coded as *engaged in other specified* or *unspecified activities* (50%). The next highest proportion of deaths occurred while working for income (26%). Research suggests that adult deaths associated with electrical injury including lightning are primarily associated with the workplace (Duff and McCaffrey 2001). While information on place and activity were limited in the present study the findings tend to support this suggestion. An investigation by Driscoll et al. (2003) examining unintentional fatal injuries resulting from unpaid work at home found that the second most common mechanism of death was contact with electricity. After reviewing coroners' files the authors concluded that a common scenario associated with electrical deaths was a person (typically male) carrying out maintenance in the home using faulty electrical equipment.

Deaths caused by lightning

There were 7 deaths identified during the period which occurred as a result of lightning. All the victims were male ranging in age from 16 years to 57. Information was only available on 5 cases as a result of a search of the National Coroners Information System. All of the men were working in an outdoor environment during a lightning storm at the time of the death.

Discussion

Serious electrical injuries are relatively infrequent and injuries occurring as a result of lightning are extremely rare events. Over the two year period examined only 1,493 people were hospitalised as a result of an electrical injury at an age-adjusted rate of 3.78 cases per 100,000 population. In comparison, in 2001–02 alone more than 5,000 people were hospitalised for fires, burns and scalds at an age-adjusted rate of 27.6 cases per 100,000 population (Berry & Harrison 2006). Deaths occurring as a result of electrical injury or lightning are even rarer with 162 cases in the four years examined.

The relatively small number of cases of serious injury due to contact with electricity, despite its lethal potential and the nearly ubiquitous provision of mains supply to Australian homes and workplaces, provides a basis for thinking that current preventative measures are largely successful.

While the rates of electrical injury and death are low compared to other causes of injury there is still scope for a reduction in numbers due to the preventable nature of many of these injuries. For example, recent advances in electrical safety equipment in the home (e.g. electrical safety switches) and rigorous standards for electrical appliances have afforded a degree of protection to individuals from electrocution injury.

An investigation into deaths as a result of electrocution in children and early adolescents identified faulty electrical equipment in the home or at school as the major cause of death (Byard et al. 2003). These authors highlighted the problem of carers continuing to use electrical appliances known to be faulty, and not preventing ready access to those appliances by children. In the present study, 77% of electrical injuries in children occurred in the home. However, due to the lack of specificity in the external cause codes describing electrical injuries we are unable to say whether or not these injuries occurred as a result of faulty appliances or any other mechanism.

In adults, the majority of electrical injuries occurred within a work environment. While more detailed information regarding the nature of workplace electrical injury associated deaths can be found in the National Coroners Information System, as mentioned above, this similar level of detail is not available for hospitalised electrical injuries. Aside from details on the mechanism of injury, information regarding type of occupation is also unavailable. Scrutiny of occupational health and safety and compensation databases may reveal more information regarding electrical injuries in the workplace and lead to improvements in workplace safety through targeted intervention/education programs.

The majority of deaths occurring as a result of exposure to electricity occurred in the home while the person was engaged in some form of work related activity. We are limited in our knowledge of how these accidental deaths occurred as we are unable to routinely identify whether they occurred as a result of faulty electrical equipment, lapses in safety or by other means. Work by Driscoll et al. (2003) suggests that these deaths could have resulted during unsafe home maintenance activities involving the use of faulty electrical appliances. While further research using a more descriptive data source such as the National Coroners Information System may increase our knowledge of these deaths the immediate implementation of an education program warning people of the dangers of home maintenance using unsafe electrical equipment may save lives.

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Data issues

Case definition

Hospitalisations

Separations data from the National Hospital Morbidity Database were provided by the Australian Institute for Health and Welfare (AIHW). Hospital separations data used in this report are classified according to the Australian Modification of the 10th revision of the *International Classification of Diseases* (ICD-10-AM).

This study examined data for hospitalised episodes that concluded during the period from July 1st 2002 to June 30th 2004. Separations in the two years 2002–03 and 2003–04 were coded to the third edition of the International Classification of Diseases 10th Revision Australian Modification (ICD-10-AM) (NCCH 2002).

The inclusion criterion for the report was the presence of T75.4, T75.0, W85, W86, W87, or X33 codes indicating an electrical injury including being a victim of lightning, among any of the diagnosis or external cause codes assigned to a record.

Incidence rates have been calculated as cases per 100,000 of the usually resident population of Australia. Direct standardisation was employed, taking the Australian population in 2001 as the standard. Annual rates were calculated using finalised population estimates as at 31 December for each year averaged for the two year period.

Deaths

The Underlying Cause of each death (UCoD) registered in Australia is classified by the ABS according to the *International Classification of Diseases* (ICD). The *10th Revision* (ICD-10) has been used for deaths registered from 1999 onwards. All deaths registered between 1 January 2001 and 31 December 2004 and given an ICD-10 External Cause code by the ABS were eligible for inclusion in this report. As with hospitalisations, the inclusion criterion for the report was the presence of T75.4, T75.0, W85, W86, W87, or X33, codes indicating an electrical injury associated death in the Underlying Cause or Additional Cause of Death fields.

As with the hospitalisations, incidence rates have been calculated as cases per 100,000 of the usually resident population of Australia. Annual rates were calculated using finalised population estimates as at 30 June for each year averaged for the four year period.

Age adjustment

All-ages rates have been adjusted for age to overcome the effect of differences in the proportions of people of different ages (and different injury risks) in the populations that are compared. Direct standardisation was employed, taking the Australian population in 2001 as the standard. Where crude rates are reported, this is noted. Data years were aggregated as was the population data.

Data quality

Hospitalisations

This report uses data collected from state and territory hospitals. After coding and collection from the states and territories, the data is further processed by the AIHW and NISU. The geographical spread of the data and the large number of people involved in its processing increases the risk of inconsistencies across time and place in the data. Variations in reporting and coding continue to exist across jurisdictions, although standard classifications and formal coding guidelines have been in place for some years.

Incidence of hospitalisations is not equivalent to the number of hospital separations. A hospital separation refers to a single 'episode of care'. An individual may have more than one 'episode of care' or 'separation' as a consequence of the same external cause of injury. This study included all cases regardless of the mode of admission to hospital. As a result the data set contains 94 cases (6%) where the mode of admission to hospital was a transfer from another hospital. Hence, the values reported are likely to include some cases more than once, resulting in estimates that are a little higher than the number of incident cases.

Deaths

The reliability of information about cause of death depends on the reliability of ICD codes provided by the ABS. This depends largely on the adequacy of the information provided to the ABS through Registrars of Births, Deaths and Marriages, and originating from coroners and medical practitioners. Little published information is available on the quality of the data resulting from this process, particularly as it applies to injury deaths. Centralisation of mortality coding in the Brisbane office of the ABS since the mid 1990s has reduced the potential for variation due to local differences in coding practice. However, factors affecting information recording, provision, or coding could affect data in different ways for different jurisdictions, periods or population groups. Hence, apparent differences should be interpreted with caution.

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