Consumer product-related injury: trampolines, bunk beds, button batteries

Authors: Karen Ashby, Lesley Day & Emily Kerr

This issue of Hazard provides an update on trends in injuries associated with trampolines and bunk beds, and discusses these in relation to the relevant standards. It also highlights the relatively small but potentially serious injury issue associated with button battery ingestion.

Summary

Trampolines

Each year 1,500 persons are treated in Victorian hospitals for an injury sustained while using a trampoline. Despite the strengthening of regulations, mandating of safety information for owners and users, and substantial design modifications to the trampoline, both the frequency and population rate of injury from trampoline use in Victoria continues to increase. Statistically significant increases in admission rates were observed for persons aged 0-4, 5-9, 10-14 and 15-19 years.

Falls off a trampoline remain the leading cause of trampoline-related injury, and although they are increasing in frequency, the rate of increase is significantly less than that for all trampoline injury, possibly attributable to the introduction of trampoline enclosures (nets). However, the presence of enclosures may have had an unintended effect as an increase in the number of multiple-user injuries, and injuries among younger children, is becoming apparent as parents may allow freer access when they no longer fear children falling off the trampoline. The number of multiple-user injuries is rising rapidly despite mandatory safety warnings incorporated into AS 4989-2006 against this practice. Trampolines greater than 500 mm in height are not recommended for children aged less than six years yet one-third of the injuries reported were among children aged less than 6 years.

The Victorian Injury Surveillance Unit is now an independent unit within the newly created Monash Injury Research Institute (MIRI) at Monash University, operating separately from the Monash University Accident Research Centre (MUARC) which is also part of MIRI. MUARC will now concentrate solely on research related to transport injury, whereas VISU is clustered with other centres and units working in the home, sport and leisure stream. For more information on MIRI go to: www.monash.edu.au/miri/. THE NEW WEB ADDRESS FOR VISU IS: www.monash.edu/miri/visu
Button Batteries

Button style batteries have been used in a rapidly expanding range of common household items. They are often easy for young children who may be appealing to young children who may be accessing. A third of the cases were children aged under five years old. While the ACCC generally recommend against children under nine years old from using a button battery, our study found almost three-quarters of cases (73%) and ED presentations (73%) were for children aged under nine years, and 49% and 50% respectively were for children aged under six years old.

Trampoline Injury

Karen Ashby and Lesley Day

Introduction

In the 1990s, American Academy of Pediatrics (AAP) recommended for the restriction of trampoline use in the United States to supervised training programs, in response to the rising number of serious paediatric trampoline-related injuries, especially to the head and neck. The AAP recommended that trampolines should not be used at home or in routine physical education classes and that they should have no place in outdoor playgrounds (AAP, 1999).

An updated AAP policy statement released in 2012 re-stated this same warning that, despite the implementation of safety measures such as frame-padding and netting, the risk of injury had not been substantially mitigated (AAP, 2012). In 2007, the Canadian Paediatric Society and Canadian Academy of Sports Medicine similarly called for a ban on recreational use in a domestic setting (Leonard and Joffee, 2009).

The response of the Australian injury prevention sector was more measured and focused on revising the Australian Standard for trampolines to include measurable safety aspects designed to reduce the risk of injury. An Australian Standard, AS 4999–2006 Trampolines—Safety aspects, was published in 2003. The voluntary standard set out requirements for components and design as well as specifying information on assembly and maintenance.

The Standard was revised and improved in October 2006 (AS 4999–2006: Trampolines—Safety aspects) removing specifications for frame design and focusing on safety aspects such as spring and frame-padding design, protection of upper extremities, safety marking and labeling, and consumer information.

The Standard required that all recreational trampolines offered for sale on the Australian market must be supplied with frame-padding or a soft-edge design. It was also recommended that existing trampolines purchased prior to the release of the 2006 Standard be retrofitted with a frame-padding system that meets the AS 4999 (2007). A minimum level of consumer safety information was also mandated including safety warnings on the trampoline packaging, instructions on installation, maintenance and safe use, including the need for active adult supervision and minor amendments were made in 2008 and 2010.

It was expected that the 2006 revisions to the Standard would result in a reduction in trampoline-related injury although it was not expected that the impact would be seen for several years, given the lifespan of existing trampolines. Contemporaneously, trampolines that have safety netting to minimise the risk of children falling off the equipment to the ground—one of the most common mechanisms of injury—came onto the Australian market. Unlike in the United States where the requirement for safety netting was included in their American Society for Testing and Materials ASTM standard in 2003, it was not included in the 2006 revision of the Australian Standard.

This Hazard article examines the patterns of, and trends in, hospital-treated trampoline injury in Victoria during the period July 2002 to June 2011. Both fall and non-fall injury are considered. Several aspects of trampoline injury are investigated in greater detail to explore the impact of strengthened Standards and design changes.

Methodology

Data were extracted from the Victorian Admitted Episodes Dataset [Victorian hospital admissions] and the Victorian Emergency Minimum Dataset [emergency department presentations to 39 Victorian hospitals] for the financial years 2002/3 to 2010/11. See Box 1 for details of the data sources and case selection.

Results: overview

Frequency

Over the nine-year period 2002/3 to 2010/11 there were 13,814 trampoline-related injuries treated in Victorian Hospitals. This number comprised 1,199 hospital admissions and 10,615 ED presentations with an annual average of 555 admissions and 1,179 ED presentations.

ED presentations climbed steadily in frequency each year over the study period from 639 cases in 2002/3 to 1,711 cases in 2010/11 (Figure 1a), whereas admitted cases followed a more targeted pattern but showed an overall increase from 293 in 2002/3 to 403 in 2010/11 (Figure 1b).

The majority of hospital-treated trampoline injuries were falls (97% admissions, 72% ED presentations). The predominance of children in this age group was present for both fall (i.e. collisions with other persons, over-suspension system or the frame), and non-fall (i.e. collisions with other persons, over-exertion injuries) (Table 1).

The predominant mechanism of injury for both falls and non-falls was a fall from the trampoline, falls onto the suspension system or the frame, and non-fall (i.e. collisions with other persons, over-exertion injuries) (Table 1). The mean age of the injured person was 9.0 years for admitted cases and 8.3 years for ED presentations (Table 1). Non-fall injury had a slightly higher mean age at both levels of severity.

Children aged 6-14 years were the next most commonly injured group, representing 24% of admissions and 28% of ED presentations, followed by children aged 10-14 years (22% of admissions and 23% of ED presentations). There were 1,148 injured adults, aged 15 years or older over the 9 year period, an average of 128 adults receiving hospital treatment for trampoline injuries per annum.

Males comprised 57% of admissions and 53% of ED presentations for trampoline injury, and were particularly over-represented among admissions for non-fall injury (64%) (Table 1).

Figure 1a

Source: Victorian Emergency Minimum Dataset (VEMD) – ED presentations

Figure 1b

Source: Victorian Admitted Episodes Dataset (VAED) – hospital admissions

Figure 1a

ED presentations for trampoline injury by year and broad cause, Victoria, July 1, 2002 to June 30, 2011

Figure 1b

Hospital admitted trampoline injury by year and broad cause, Victoria, July 1, 2002 to June 30, 2011

Forty-five percent of admissions and 41% of ED presentations occurred among children aged 5-9 years. The predominance of children in this age group was present for both fall (i.e. both falls from the trampoline, falls onto the suspension system or the frame) and non-fall injury (Table 1). Neither the VAED nor the VEMD data provide sufficient information to definitively determine the style of trampoline implicated i.e. rectangle or round enclosed trampoline. The VEMD narratives suggest that less than 1% of cases (n=9) were from enclosed trampolines or rebouder, although their involvement may not be consistently reported.
Figure 2 presents the trend in hospital admissions for trampoline injury and clearly indicates that the 5-9 years age group has the highest rate of admitted trampoline injury.

Rates and Trend

Rates were increasing for all age groups, except for those aged 20+ years (Figure 2). The increasing trend was apparent for males in all age groups, except age 20+ years, and for females aged 0-4 years. The average annual percentage increase was 6.5%.

Circumstances and Outcomes of Injury

The location of injury was unspecified for 70% of admissions and 8% of ED presentations. Of cases with a specified location, 87% of admissions and 88% of ED presentations occurred in a home setting (own home or other person's home). A further 6% of admissions reportedly occurred in areas for 'sport and recreation' and another 4% of admissions and 2% of ED presentations occurred in 'schools or other public buildings'.

Eighty percent of admitted cases required a stay in hospital of less than two days, 19% required a stay of between two and seven days and 1% (n=26) stayed 8-30 days. Most of the 26 patients with stays of 8-30 days (n=19, 73%) were for lower limb fracture and dislocation (range 8-24 days). A further three long-stay cases (12%) were for upper limb fracture, dislocation and open wound (range 4-11 days). One each of head, internal organ and spinal injury accounted for the rest of the longest stays.

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The pattern of injury across all body sites was similar among admissions and ED presentations. Fall-related injury at both levels of severity were mostly associated with injury to the upper limbs (67% admissions and 46% ED presentations), while non-fall-related injury was mostly associated with lower limb injury (38% of admissions and 56% of ED presentations) and the head and face (26% of admissions and 18% ED presentations).

The single leading injury for fall admissions was fracture of the elbow and forearm (n=1,300, 42% of all fall admissions). For non-fall admissions fractures of the knee and lower leg were the single leading injury (n=20, 25% of non-fall admissions). For ED presentations the fall-related leading injury was the same as for admissions, fracture of the elbow and forearm (n=1,097, 14% of all fall non-admissions) and for non-falls the leading injury was dislocation, sprain and strain of the ankle (n=503, 17%).

Table 1

<table>
<thead>
<tr>
<th>Age</th>
<th>N=3,118</th>
<th>N=7,598</th>
<th>N=10,615</th>
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<tr>
<td>Falls</td>
<td>Non-fall</td>
<td>Total</td>
<td>Falls</td>
</tr>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>0-4</td>
<td>757</td>
<td>24.3</td>
<td>13</td>
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<tr>
<td>5-9</td>
<td>1,424</td>
<td>45.7</td>
<td>25</td>
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<tr>
<td>10-14</td>
<td>680</td>
<td>21.8</td>
<td>19</td>
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<tr>
<td>15-19</td>
<td>126</td>
<td>4.0</td>
<td>12</td>
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<tr>
<td>20+</td>
<td>131</td>
<td>4.2</td>
<td>12</td>
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<tr>
<td>Mean age</td>
<td>8.9 years</td>
<td>Median</td>
<td>7.4 years</td>
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</tbody>
</table>

Source: Victorian Admitted Episode Dataset (VAED - hospital admissions)
Victorian Emergency Minimum Dataset (VEMD – ED presentations)

*Suppressed due to small cell sizes

Table 2

<table>
<thead>
<tr>
<th>Cause</th>
<th>N=3,118</th>
<th>N=7,598</th>
<th>N=10,615</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>Non-fail</td>
<td>Total</td>
<td>Falls</td>
</tr>
<tr>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Fall</td>
<td>3,118</td>
<td>100</td>
<td>NA</td>
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<tr>
<td>Collision with object</td>
<td>NA</td>
<td>21</td>
<td>26.0</td>
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<tr>
<td>Collision with person</td>
<td>NA</td>
<td>20</td>
<td>24.7</td>
</tr>
<tr>
<td>Over-exertion</td>
<td>NA</td>
<td>21</td>
<td>25.9</td>
</tr>
<tr>
<td>Other or unspecified</td>
<td>NA</td>
<td>19</td>
<td>23.5</td>
</tr>
<tr>
<td>Nature of Mal Injury</td>
<td>2,493</td>
<td>80.0</td>
<td>42</td>
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<tr>
<td>Fracture</td>
<td>154</td>
<td>4.9</td>
<td>8</td>
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<tr>
<td>Dislocation, Sprain/Strain</td>
<td>152</td>
<td>4.7</td>
<td>10</td>
</tr>
<tr>
<td>Intracranial/injury</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Superficial injury</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Injury to muscle or tendon</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Other and unspecified</td>
<td>237</td>
<td>7.6</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: Victorian Injury Surveillance Unit (VISU)

Table 3

<table>
<thead>
<tr>
<th>% Change (95%CI)</th>
<th>Annual % increase</th>
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</thead>
<tbody>
<tr>
<td>27 (10, 44)</td>
<td>2.7%</td>
</tr>
<tr>
<td>501 (46, 158)</td>
<td>8.3%</td>
</tr>
<tr>
<td>71 (14, 160)</td>
<td>6.1%</td>
</tr>
<tr>
<td>649 (22, 143)</td>
<td>10.7%</td>
</tr>
</tbody>
</table>

Source: Victorian Injury Surveillance Unit (VISU)

The single leading injury for fall admissions was fracture of the elbow and forearm (n=1,300, 42% of all fall admissions). For non-fall admissions fractures of the knee and lower leg were the single leading injury (n=20, 25% of non-fall admissions). For ED presentations the fall-related leading injury was the same as for admissions, fracture of the elbow and forearm (n=1,097, 14% of all fall non-admissions) and for non-falls the leading injury was dislocation, sprain and strain of the ankle (n=503, 17%).
Table 3  ED treated trampoline injury by detailed cause group and severity, Victoria, July 1, 2002 to June 30, 2011

<table>
<thead>
<tr>
<th>Detailed Injury Cause Categories</th>
<th>Fall off</th>
<th>Fall on</th>
<th>Jump off</th>
<th>Fall NES</th>
<th>Non-fall</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEMD admissions</td>
<td>1,021</td>
<td>61.7</td>
<td>260</td>
<td>15.7</td>
<td>39</td>
<td>4.4</td>
</tr>
<tr>
<td>N %</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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</tr>
<tr>
<td>ED presentations</td>
<td>4,641</td>
<td>43.7</td>
<td>2,013</td>
<td>18.9</td>
<td>219</td>
<td>2.2</td>
</tr>
<tr>
<td>N %</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>5,662</td>
<td>46.2</td>
<td>2,271</td>
<td>18.5</td>
<td>258</td>
<td>2.1</td>
</tr>
<tr>
<td>N %</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

| Source: Victorian Emergency Minimum Dataset (VEMD – ED presentations including admissions) |

*Note: NES = Not elsewhere specified.*

**Detailed external cause analysis**

Since falls are the major external cause of hospital treated trampoline injury further analysis was undertaken to elucidate more detail about the circumstances of the falls. The VEMD contains a free text narrative that allows further breakdown by detailed cause groups including the type of fall and categories for non-fall injury. VEMD narrative analysis was undertaken on both ED presentations and VEMD cases admitted to hospital. There is no narrative associated with the VAED so this could not be performed for this dataset. Note that the number of ED admissions (n=1,653) does not match the VEMD number of admissions (n=1,199) as the VEMD is collected from a sample of 38 hospitals and the VAED is a statewide collection. Thirteen percent of VEMD cases overall required an admission to hospital.

Table 3 shows that falls off the trampoline remain the leading cause of injury for both VEMD admissions (62%) and presentations (44%). For admitted cases, ‘fall on’ the trampoline accounted for another 16% of injuries and non-falls for 13%. For presentations, non-falls represented 28% of cases and ‘fall on’ injuries 19%.

Figures 3a & 3b show these cause categories broken down by year and indicate that:

- All hospital treated trampoline injuries have increased quite consistently over the study period, particularly those treated in the ED but not admitted to hospital.
- The trends in falls off the trampoline differ from the trends for all trampoline injuries. For ED cases admitted to hospital, there has been a departure from the same overall increasing trend from 2006/7 after which there has been a slight declining trend. For ED cases not admitted to hospital, the rate of increase has been much slower than that for all trampoline ED cases not admitted to hospital, particularly from 2006/7.

- Although in smaller numbers, increases in “falls on” and “non-fall” injuries are noticeable from 2005/6, especially in ED cases not admitted to hospital.

Further analysis of fall-related trampoline injury is presented in a later section on the impact of the Australian Standard. The remainder of this section deals with non-fall and other trampoline related injury issues.

There were 3,237 injuries for causes other than falls in the VEMD (220 admissions and 3,017 presentations) in the 9-year period 2002/3 to 2010/11. The majority of these were for injuries associated with over-exertion while using the trampoline, including awkward landings (n=1,498, 46% of non-fall injury and 12% of all trampoline injury) (Figure 4). The age pattern of over-exertion injury is similar to other trampoline injury (37% aged 5-9 years), however the gender pattern is quite different with females accounting for 56% of over-exertion injury. The most common over-exertion injuries were sprains and strains (n=816, 55% of all over-exertion injury) and the ankle was the most commonly injured body region (n=677, 45% of all over-exertion injury).

There were an increasing number of injuries occurring while attempting acrobatic manoeuvres, steadily increasing from 7 cases in 2003/4 to 53 cases in 2010/11. Injury whilst undertaking acrobatic manoeuvres mostly occurred among males (69%) and persons aged 10-14 years (46%, mean age = 12.8), and almost exclusively while doing a flip or tumble (96%). More than a third of the injuries sustained when attempting such moves were neck injuries (n=73, 36%), of which three-quarters were sprains or strains or other muscular injuries (n=55).

Figures 5a and 5b depict the nature of main injury of VEMD admissions and presentations by detailed cause of injury categories. Key findings are as follows:

- ‘Fall off’ injuries are predominantly associated with fractures for both presentations (37%) and ED admissions (81%).
- Two-thirds of ‘Fall on’ ED admissions were for fractures, whereas one-third of ‘Fall on’ presentations were for dislocations, sprains and strains. ‘Jump off’, ‘Fall NES (not elsewhere classified)’ and ‘Non-fall’ injury followed a similar pattern.
Results: impact of interventions to reduce injury

The concept of the three Es: enforcement; environment; and education are used in injury prevention to describe the range of intervention efforts used to prevent injury. The first, enforcement, describes regulatory or legislative change made to improve safety and prevent injury. Environment relates to changing the environment, and includes design modification, to make a product safer. Lastly education approaches deal with providing information to individuals in order to influence their behaviour to improve their safety. These three approaches are often most successful when used in conjunction, and indeed efforts at preventing trampoline injury have drawn on all three. Two major interventions worthy of assessment for any injury have drawn on all three. Two major approaches are intervention worthy of assessment for any injury. The concept of the three Es: enforcement; environment; and education are used in injury prevention to describe the range of intervention efforts used to prevent injury. The first, enforcement, describes regulatory or legislative change made to improve safety and prevent injury. Environment relates to changing the environment, and includes design modification, to make a product safer. Lastly education approaches deal with providing information to individuals in order to influence their behaviour to improve their safety. These three approaches are often most successful when used in conjunction, and indeed efforts at preventing trampoline injury have drawn on all three. Two major interventions worthy of assessment for any injury have drawn on all three. Two major approaches are

1) Australian Standard: AS 4989-2003

The first Australian Standard, AS 4989-2003 Trampolines—Safety aspects established requirements for components and design and specified required consumer information on assembly and maintenance. Updated in 2006, the revised Standard focused on safety aspects: spring padding; protection of sharp edges; safety marking and labelling; and improved consumer information. A key component was the requirement that trampolines be supplied with frame-padding or a soft-edge system. Retrofitting of spring and frame-padding was also recommended. A minimum level of consumer safety information was also mandated including safety warnings on the trampoline packaging, instructions on installation, maintenance and safe use, including recommendations against allowing multiple-users on the trampoline and the need for active adult supervision.

It was anticipated that the 2006 Standard would result in a reduction in trampoline-related injury, particularly injuries from contact with rigid surfaces of the trampoline, the spring and frame. It was anticipated that the 2006 Standard would result in a reduction in trampoline-related injury, particularly injuries from contact with rigid surfaces of the trampoline, the spring and frame.

2) Market-driven design modifications

Concurrent to the Standards revisions in the early 2000’s trampoline manufacturers commenced selling “new” style trampolines that had safety nets in order to reduce the risk of children falling off the trampoline to the ground. Anecdotal evidence from ED staff has suggested that an unintended outcome of this modification has been an increase in collision injury or other injury associated with multiple-users.

With these two interventions in mind, further analysis of cause of injury categories may provide insight into any effects of these interventions. Three common injury scenarios were further investigated to this end: injuries associated with frames and springs (influence of Standard AS 4989-2006), falling off the trampoline (influence of market-driven design modifications), and injuries associated with multiple-users (influence of market-driven design modifications). Since data on trampolining participation are not available, rates for the different types of trampoline injury cannot be calculated to more accurately examine the impact of the Standards and market-driven modifications. Here we examine trends in numbers of these types of injuries in comparison with the trend in trampoline injuries overall, as well as the trend in proportions.

Each of these three injury circumstances were reviewed using the available data. Given the lack of narrative in the VAEED, VEMD admissions data, as well as ED presentation data are reported. Figure 6 illustrates how these categories relate to each other and it must be noted that they are not mutually exclusive. For example, a person may collide with another user of the trampoline (and be counted as a multiple-user injury) but may also then fall off the trampoline (and hence also be counted as a ‘fall off).

Impact of Australian Standard: spring and frame injury (n=606)

The revised Standard AS 4989-2006 required that all trampolines be supplied with frame-padding or a soft-edge system that covered the frame and springs of the trampoline. Retrofitting of spring and frame-padding to existing trampolines was also recommended. Any impact of these requirements should be visible in the pattern of spring and frame injury. There were 606 injury cases (5% of all VEMD injury cases) where the free text mentioned the involvement of the springs, frame, edge or metal part of the trampoline. Most (n=566, 93%) were presentations and 40 (7%) were admissions. More than two-thirds (69%) were fall-related. Over the period 2002/3 to 2010/11 there has been an 8.6% (95% CI 5.7%-10.8%) annual average increase in the frequency of spring and frame injury, less than the overall annual average increase of 12.6% (95% CI 10.3%-13.4%) for all trampoline injury. As the confidence intervals for these estimates overlap, this difference is not statistically significant. It appears that any impact of the 2006 revision to the Standard on the trend in the frequency of spring and frame injury has been small to date. Figure 7 shows that as a proportion of all trampoline injury over time, spring and frame injuries decreased prior to the 2006 revision to the Standard and there has been no discernible trend in the proportion since the Standard came into effect.

Spring and frame presentations were most common in children aged 5-9 years (n=219, 39%), as was the case for all trampoline injury. However there was a higher proportion of injury to children aged 10-14 years among spring and frame presentations (31%, n=176) compared to all trampoline injury (Table 4). This pattern held for admitted cases where the 10-14 year old age group accounted for 35% of spring and frame admissions compared to 21% for all trampoline presentations. Males were more highly represented making up 60% of spring and frame injuries for both severity levels, compared to proportions of 57% of all admissions and 53% of all non-admissions (Table 4).

Open wounds accounted for 38% of spring and frame injury admissions and 35% of non-admissions while representing just 4% of admissions and 11% of non-admissions for all trampoline injury. Conversely there are fewer fractures and dislocation, sprain and strain injuries associated with spring and frame injuries compared to all trampoline injuries at both levels of severity (Table 4).

<table>
<thead>
<tr>
<th>Year</th>
<th>Spring and Frame Admissions</th>
<th>Spring and Frame Non-Admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002/3</td>
<td>219 (39%)</td>
<td>431 (24%)</td>
</tr>
<tr>
<td>2010/11</td>
<td>176 (35%)</td>
<td>618 (21%)</td>
</tr>
<tr>
<td>% Increase</td>
<td>8.6% (95% CI 5.7%-10.8%)</td>
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Impact of Australian Standard: multiple-users injury (n=840)

Victorian Emergency Minimum Dataset (VEMD – ED presentations, includes admissions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Multiple-User Admissions</th>
<th>Multiple-User Non-Admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002/3</td>
<td>93 (11%)</td>
<td>747 (24%)</td>
</tr>
<tr>
<td>2010/11</td>
<td>78 (9%)</td>
<td>662 (21%)</td>
</tr>
<tr>
<td>% Increase</td>
<td>10.3% (95% CI 5.7%-13.4%)</td>
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Impact of Australian Standard: multiple-users injury (n=840)

Victorian Emergency Minimum Dataset (VEMD – ED presentations, includes admissions)

<table>
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<tr>
<th>Year</th>
<th>Multiple-User Admissions</th>
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</thead>
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<td>2002/3</td>
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<td>747 (24%)</td>
</tr>
<tr>
<td>2010/11</td>
<td>78 (9%)</td>
<td>662 (21%)</td>
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<td>% Increase</td>
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<th>Year</th>
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<th>Multiple-User Non-Admissions</th>
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<tbody>
<tr>
<td>2002/3</td>
<td>93 (11%)</td>
<td>747 (24%)</td>
</tr>
<tr>
<td>2010/11</td>
<td>78 (9%)</td>
<td>662 (21%)</td>
</tr>
<tr>
<td>% Increase</td>
<td>10.3% (95% CI 5.7%-13.4%)</td>
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</tr>
</tbody>
</table>

Impact of Australian Standard: multiple-users injury (n=840)

Victorian Emergency Minimum Dataset (VEMD – ED presentations, includes admissions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Multiple-User Admissions</th>
<th>Multiple-User Non-Admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002/3</td>
<td>93 (11%)</td>
<td>747 (24%)</td>
</tr>
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<table>
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<th>Year</th>
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<td>10.3% (95% CI 5.7%-13.4%)</td>
<td>-</td>
</tr>
</tbody>
</table>
Impact of Australian Standard:

multi-user injury (n=847)

There were 847 injury cases (7% of all VEMD cases) where the free text mentioned multiple-users on the trampoline at the time of the injury. Most (n=793, 93%) were presentations and 64 (8%) were admissions. More than eighty percent (n=694, 81%) occurred when two or more, jumpers collided, another 7% occurred when the injured person was double bounced. Figure 8 shows that as a proportion of all trampoline injury over time, multi-user injuries have increased. In addition, the frequency of multiple-user injuries has increased by an average of 18.1% (95% CI 14.4%-18.8%) annually, significantly higher than the ED treated trampoline injury annual increase of 12.6% (95% CI 10.3%-13.4%).

The pattern of multiple-user-related injury shows some variation from that of all trampoline injury. Young children aged 0-4 years represented a higher proportion of multiple-user presentations (35%) compared to all trampoline presentations (28%) (Table 4).

Among admissions, dislocation and strain or sprain injuries, neck injuries and lower limb injuries were proportionally higher in multiple-user events compared to all trampoline injury events (Table 4).

Impact of market-driven design modifications: falls off trampolines (n=5,662)

Falls off trampolines to the ground or another surface (n=5,662) represent 46% of all cases reported in the VEMD (admissions and presentations) (Table 3). Although most (82%) were presentations, the potential for serious injury is great; they account for more than 60% of admitted cases reported on the VEMD. The AAP (2012) stated that a fall off a trampoline is the most obvious of risks as jumpers have the ability to propel themselves to greater heights off a trampoline than from a jump on the ground. The introduction of enclosed trampolines should eliminate falls off the trampoline, unless the zipper opening is not secured or the netting or zipper is compromised. In most instances a previous incident that may have led to a fall off the trampoline, should, on an enclosed trampoline, result in a more benign collision with the net with the user remaining on the surface of the trampoline instead of falling to the ground.

Figure 9 shows that falls off trampolines decreased as a proportion of trampoline injury during the study period. While the proportion has been decreasing, there has been, on average, an annual increase in the frequency of 7.9% (95% CI 5.6%-9.5%). This is significantly less than the 12.6% (95% CI 10.3%-13.4%) average annual increase in all ED-treated trampoline injury.

The mean age of persons injured by a fall off a trampoline was younger than for trampoline falls overall (7.6 years vs. 8.0 years) and for all trampoline injury (8.3 years). The sex and nature of injury patterns were comparable to all trampoline falls. ‘Fall off’ injuries were mostly associated with fractures for both admissions (51%) and presentations (37%) (Figures 5a and 5b).

There were proportionately more upper limb injuries in both admissions and presentations for falls off trampolines, compared to all trampoline injury (74% vs. 63% for admissions and 52% vs. 37% for presentations. Fractures of the elbow and forearm were the leading injuries for “falls off” for both admissions (n=39, 53%) and presentations (n=606, 17%).

**Figure 9** ED-treated falls off a trampoline injury by year as a proportion of all trampoline injury, Victoria, July 1, 2002 to June 30, 2011

**Table 4** ED-treated trampoline injury profile by selected causes, admissions and presentations, Victoria, July 1, 2002 to June 30, 2011

---

**Source:** Victorian Emergency Minimum Dataset (VEMD – ED presentations, includes admissions)
The mandatory safety information included in packaging that advises against the use of safety features. The authors of this recommendation are uncertain as to whether multiple-user injuries are vital to both identify cases and extract any knowledge and intervention regarding risk behavior with trampoline use (AAP, 2012).

The Victorian data also shows an increase in injuries sustained while attempting acrobatic manoeuvres. In the study by Bogacz et al. (2012), 73% of trampoline injuries to children aged 7-13 years old occurred when a child was performing a flip while the trampoline was in use. This is in contrast to the finding of Smith (1998) that cervical spine injuries are no more than 50 mm in height are not recommended for children aged less than six years due to their size and age. The study by Smith (1998) noted a 98% increase in child injury presenting to EDs in the United States in the period 1990-1995. Compared to the results of Smith (1998), the current investigations shows that the rate of injury from trampoline use in Victoria for children aged 0-4, 5-9, 10-14 and 15-19 years, for males in each of these age groups and among females aged 14-19 is 2004 this had decreased to 5 years. Warranties for frames and mats are consistently longer than that for padding and enclosures with the expectation that these will be replaced during the life of the trampoline. There is however no evidence to date that the children who are injured are of a reduced size. The 12 trampolines were bought a high end ‘safe’ model of trampoline. It appears that the presence of the enclosure eradicates risk of injury once again relies solely on this free text information to the contrary, parents perceive the presence of the enclosure eradicates risk of injury (Wootton and Harris, 2009). This may be attributable to the presence of nets. The 12 trampolines were bought a high end ‘safe’ model of trampoline (Eager et al., 2012a) who surveyed a customer dataset of owners of one ‘soft edge’ model of trampoline that had been designed to remove equipment-related injury. The authors of this study have found that the use of a frame-packing and enclosures in preventing injury was undertaken by Alexander et al. (2010) using US data from 2002-2007. The authors found that in the US there was no significant change in the downward trend of fall off injuries and insufficient evidence of a change in spring and frame injury, despite the above recommendations for frame packing and enclosures. This led Alexander et al. to conclude that these interventions had minimal effect, but suggests that the lack of evidence and adherence to model that finding that the median age for injury of these “safe” trampolines was younger (five years old) than for traditional trampolines (Eager et al., 2012a). Injuries from contact with the spring and frame were addressed in the design of these components directly on rectangle trampolines and combined padding and netting on enclosed trampolines. It has been little impact of the 2006 revision to the Standard on the trend in the frequency of spinal injuries. The authors of this study have found that the median age for injury of these “safe” trampolines was younger (five years old) than for traditional trampolines (Eager et al., 2012a). This trend is supported by the theory of risk compensation outlined by Morrongiello and Major (2002) where parents who believe more strongly in the efficacy of safety designs may allow greater risk-taking by their children, particularly when the children are experienced in the activity. The study by Bogacz et al. (2012) supports this suggestion as the parents who believe in the presence of nets perceived their child as safe and equally at risk of injury for one’s ‘soft edge’ model of trampoline 2012). This may be attributable to the presence of nets. The authors of this study have found that the use of a frame-packing and enclosures in preventing injury was undertaken by Alexander et al. 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Safety Features
- Ensure frame-padding is present to limit injuries from contact with the metal frame.
- Ensure netting is present and appropriately assembled.
- Consider buying models that have safety netting that assembles on the inside of the padding system. This configuration reduces the likelihood of hitting the trampoline edges in the case of a fall.

Safe Use
- Trampolines are not recommended for children under six years old.
- Before using, check that the area around and under the trampoline is free from obstacles.
- Discourage children from playing underneath the trampoline, particularly while a jumper is using the trampoline.
- Ensure netting enclosures are zipped closed while the user is on the trampoline to avoid falls through the unzipped door.

Other Things to Consider
- In-ground installation is an option to reduce fall heights and possible injury. However, digging in a trampoline will involve quite a lot of preparation (for example, pit drainage is essential).
- NSW Fair Trading state that if a child is unable to get up independently onto the trampoline then they may not be at the right developmental stage to use a trampoline, hence access via a ladder should be restricted. The opposing view is that a ladder could be a useful aid to help children get on and off a trampoline safely, but it should be removed when the trampoline is not in use as this will remove the risk of unsupervised access to the trampoline.

Further Research
While surveillance data provides us with a minimum count of the number of persons injured, further research is required to better understand the issues associated with continuing increases in trampoline injury numbers. Areas worthy of further research include: the gathering of population exposure data to apply injury rates to hours of use; and a follow-up study of people injured on trampolines to ascertain the type of trampoline, the extent to which the trampoline meets the relevant Standard and the general condition of the trampoline.

Conclusion
Trampolining is a fun way for children and adults to engage in active recreation, the need for which is becoming increasingly important, and aids in the development of coordination, balance and motor skills. Despite continuing efforts to improve the safety of trampolines for users the overall number of hospital-treated injuries continues to climb. As we do not have participation rates for trampolining we cannot compare the injury risks of trampolining injury with other forms of active recreation. Regulation and design modification have progressed; however user behaviour may adjust as a consequence with an unintended relationship between safety developments and parents allowing increased risk-taking by users as parents perceive trampolines to be safer for their children. Of particular concern is the one-third of the injured population who were younger than the recommended minimum age for use who are sustaining injuries sufficiently serious enough to require hospital treatment. The Australian Standard is currently under review and it will be important to ensure that any developments be accompanied by an intensive education campaign to raise the parental awareness of the risks associated with failing to maintain trampoline components and allowing risk-taking.

Acknowledgements
We would like to thank Associate Professor David Eager from the University of Technology Sydney for reviewing this article prior to publishing.

References


Bunk Bed Injury
Emily Kerr and Lesley Day

Introduction
Bunk beds comprise a set of components assembled into beds that are stacked one over the other, or are elevated beds where the top of the mattress base is at 800mm or more above floor level (Australian Competition & Consumer Commission (ACCC) 2012a). They are often used in children’s bedrooms, as they allow for more floor space.

Bunk beds are an injury risk for young children, in particular if the bunk bed is used inappropriately (e.g. for playing) or if it has been poorly made: Initial research into bunk bed injury came about after a number of fall-related fracture injuries were reported, as well as some cases of asphyxiation due to entrapment in the bunk bed (Watson et al 1997). Falling is the leading cause of injury hospitalisation among children in Victoria, and falls from beds or chairs are the second most frequent type of fall among young children (Ashby & Corboy 2000). Fall injuries are the most common type of bunk bed injury (Barker et al 2008), and children can suffer serious injury from falling from the top bunk. Other serious bunk bed-related injury can occur if a child gets caught between gaps in and around the bunk bed, and injury can also occur if bunk beds are placed in rooms with low ceilings, as children may hit the ceiling or be struck by fan blades (Barker et al 2008).

The current mandatory Australian Standard for bunk beds (AS/NZS 4420) came into effect in April 2005 (ACCC 2007). It covers requirements for the construction, design and labelling of bunk beds and states that:

- All bunk beds must have permanently fixed guardrails on all four sides and ends, with a minimum distance of 200mm between the upper surface of the mattress base and the upper surface of the guardrail;
- There must not be any gaps large enough to trap a child’s head or limbs;
- There must be no protrusions from the bunk bed measuring over 15mm which may stick a child’s clothing;
- Bunk beds must come with a marking indicating the maximum mattress height on the upper bunk bed when the height of the guardrail is less than 350mm.

Product Safety Australia generally recommends against children under nine years old using an upper bunk bed, and definitely advises against the use of these beds for children under six years old (2012a). Changes to hospital data coding have enhanced our ability to specifically monitor bunk bed-related injury and hence, this hazard article examines the patterns of, and trends in, hospital-treated bunk bed injury in Victoria during the period July 2006 to June 2011.
Table 1: Hospital-treated bunk bed injury in Victoria by year, July 1, 2006 to June 30, 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Falls (N=362)</th>
<th>Non-fall (N=147)</th>
<th>TOTAL (N=1,129)</th>
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<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
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<td>2008/9</td>
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</tr>
<tr>
<td>2010/11</td>
<td>76</td>
<td>21.0</td>
<td>199</td>
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</table>

Annual avg. 72 196 29 226

Source: Victorian Admitted Episodes Dataset (VAED – hospital admissions)

Table 2: Hospital-treated bunk bed injury in Victoria by age and gender, July 1, 2006 to June 30, 2011

<table>
<thead>
<tr>
<th>Age</th>
<th>Falls (N=362)</th>
<th>Non-fall (N=147)</th>
<th>TOTAL (N=1,129)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
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<tr>
<td>0-4 yrs</td>
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<td>407</td>
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<tr>
<td>5-9 yrs</td>
<td>144</td>
<td>39.8</td>
<td>354</td>
</tr>
<tr>
<td>10-14 yrs</td>
<td>46</td>
<td>12.7</td>
<td>146</td>
</tr>
<tr>
<td>15-19 yrs</td>
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<td>5.2</td>
<td>55</td>
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<td>20 yrs and</td>
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<td>28</td>
</tr>
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<td>21 yrs and</td>
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<td>3.6</td>
<td>33</td>
</tr>
<tr>
<td>22 yrs and</td>
<td>14</td>
<td>3.8</td>
<td>33</td>
</tr>
<tr>
<td>23 yrs and</td>
<td>15</td>
<td>3.9</td>
<td>43</td>
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<tr>
<td>24 yrs and</td>
<td>10</td>
<td>2.8</td>
<td>16</td>
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<td>25 yrs and</td>
<td>9</td>
<td>2.5</td>
<td>12</td>
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<tr>
<td>26 yrs and</td>
<td>7</td>
<td>1.9</td>
<td>10</td>
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<td>Mean age</td>
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<td>7.7 years</td>
<td>11.7 years</td>
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</table>

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<th>Gender</th>
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<th>Non-fall (N=147)</th>
<th>TOTAL (N=1,129)</th>
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<td>231</td>
<td>58.3</td>
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<tr>
<td>Female</td>
<td>131</td>
<td>41.7</td>
<td>457</td>
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</table>

*Suppressed due to small cell sizes

Source: Victorian Admitted Episodes Dataset (VAED – hospital admissions)

Method

Data were extracted from the Victorian Admitted Episodes Dataset (Victorian hospital admissions) and the Victorian Emergency Minimum Dataset (emergency department presentations to 39 Victorian hospitals) for the financial years 2006/7 to 2010/11. See Box 1 for details of the data sources and case selection.

Results

Frequencies

Over the five-year period 2006/7 to 2010/11 there were 1,491 bunk bed-related injury cases identified in Victorian hospitals. These comprised 862 hospital admitted cases and 1,129 emergency department (ED) presentations (excluding admissions), with an annual average of 72 admissions and 226 ED presentations over the five years (Table 1).

There was a general increase in the frequency of admitted cases over the study period, while there was no clear trend for ED presentations.

The admissions (VAED) dataset only has a code for falls from bunk beds; however the ED dataset (VEMD) has a text “description of injury event” variable which can be searched for any injury involving a bunk bed and thereby allowing analysis of the type of injury event. Of ED presentations for bunk bed-related injury, 87% were fall-related, including falls from the bunk bed, jumps off the bunk bed, and being pushed or pulled off the bunk bed. Non-fall injuries included: collisions with or striking the bunk bed; being struck by part of the bunk bed or by a ceiling fan (when on top of bunk); or being caught or jammed in the bunk. For non-fall-related ED presentations, there were higher proportions of injury to the older age groups compared to the falls presentation.

Figure 1 presents the trend in the rate of hospital admissions for bunk bed injury. The 5-9 year age group had the highest rate of admitted bunk bed injury. There were no statistically significant trends in bunk bed injury admission rates over the five-year period.

Circumstances and outcomes of injury

Table 3 summarises the cause and type of injury for hospital-treated bunk bed injury for both fall and non-fall injury. Key findings are:

- The location of injury was unspecified for 23% of admissions and 4% of ED presentations. Of cases with a specified location, 90% of both admissions and ED presentations occurred in a home setting (own or other person’s home).
- Fracture was the most common injury among fall-related admissions and ED presentations, accounting for 58% of admissions and 26% of ED presentations. For non-fall-related ED presentation cases, open wounds were the most common injury type (45%).
- Among fall-related bunk bed injury admissions, the upper limb was the most commonly injured body region, accounting for 49% of admissions. Among all ED presentations, the head or face was the most commonly injured body region (36%), followed by the upper limb (35%). Among non-fall-related ED presentations, the head or face was the most commonly injured body region (57%).
- Of the 147 non-fall-related ED presentation cases, 66% were caused by being struck by or colliding with an object and 16% were caused by a cutting or piercing object.

The mean age for non-fall-related ED presentations was higher, at 11.7 years. There were 145 adults injured (aged 15 years or older) over the five-year period; on average, 29 per annum.

Rates and Trend

For non-fall-related ED presentation cases, open wounds were the most common injury type (45%).

Among fall-related bunk bed injury admissions, the upper limb was the most commonly injured body region, accounting for 49% of admissions. Among all ED presentations, the head or face was the most commonly injured body region (36%), followed by the upper limb (35%). Among non-fall-related ED presentations, the head or face was the most commonly injured body region (57%).

84% of admissions required a hospital stay of less than two days.
The single leading injury for fall-related admissions was fracture of the elbow and forearm (n=117, 32% of all fall admissions). For all (fall and non-fall-related) ED presentations, open wounds to the head were the leading injury (n=114, 12% of all fall presentations; n=52, 35% of all non-fall presentations).

**Detailed analysis: external cause**

There is no narrative available in the VAED so VEMD narrative analysis was undertaken on all ED presentations including admitted cases, to allow description of external cause to a more detailed level than that possible when relying on the routinely available external cause codes. Note that the number of ED admissions (n=169) does not match the VAED number of admissions (n=362) as the VEMD is only collected from a sample of 38 hospitals and the VAED is a state-wide collection.

Table 4 shows the detailed cause of injury categories and the associated nature of main injury of VEMD admissions and ED presentations for bunk bed-related injury. Key findings are as follows:

- Among both ED presentations (non-admissions) and admitted cases, the leading cause of injury was a fall from a bunk bed (87% overall, 80% and 91% respectively).
- Among ED presentations, falls from the bunk most commonly resulted in fractures (26%) and dislocations, sprains and strains (20%). Among ED admissions, falls from the bunk most commonly resulted in fractures (57%) and intracranial injuries.
- Among non-fall ED presentations (n=147), the specified causes of injury were colliding with or striking the bunk bed (e.g. running into the bunk bed) (65%), being struck by part of the bunk bed (e.g. part of bunk bed falling onto person) (9%), being caught or jammed in the bunk bed (7%), and being struck by a ceiling fan (5%).
- Among ED non-fall presentations, colliding with or striking the bunk bed most commonly resulted in open wounds (48%), superficial injuries (16%) and dislocations, sprains and strains (12%).

Table 3: Hospital-treated bunk bed injury profile, Victoria, July 1, 2006 to June 30, 2011

<table>
<thead>
<tr>
<th>Cause</th>
<th>Admissions (VAED)</th>
<th>Emergency Dept presentations (non-admissions) (VEMD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture</td>
<td>Falls n=362</td>
<td>Falls n=82</td>
</tr>
<tr>
<td>Fall involving bunk bed</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Open wound</td>
<td>47</td>
<td>13.0</td>
</tr>
<tr>
<td>Dislocation/sprain/strain</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Intracranial injury</td>
<td>20</td>
<td>5.6</td>
</tr>
<tr>
<td>Muscle or tendon</td>
<td>*</td>
<td>31</td>
</tr>
<tr>
<td>Superficial injury</td>
<td>15</td>
<td>4.1</td>
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<tr>
<td>Other and unspecified</td>
<td>46</td>
<td>12.8</td>
</tr>
<tr>
<td>Head/face</td>
<td>118</td>
<td>32.6</td>
</tr>
<tr>
<td>Neck</td>
<td>13</td>
<td>3.6</td>
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<tr>
<td>Trunk</td>
<td>19</td>
<td>5.3</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>176</td>
<td>48.7</td>
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<tr>
<td>Lower limbs</td>
<td>85</td>
<td>23.6</td>
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<tr>
<td>Multiple body regions</td>
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<td>*</td>
</tr>
<tr>
<td>Other and unspecified</td>
<td>*</td>
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</tr>
<tr>
<td>Length of inpatient stay</td>
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</tr>
<tr>
<td>2-7 days</td>
<td>13</td>
<td>*</td>
</tr>
<tr>
<td>8-30 days</td>
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</table>

Source: Victorian Admitted Episodes Dataset (VAED - hospital admissions)

VICTORIAN INJURY SURVEILLANCE UNIT

HAZARD 75 page 18
Among the 1,146 fall-related cases presenting to the ED (including admissions), 15% of case narratives mentioned that the person struck something when they fell (n=125). Table 5 shows the agent of injury for these falls. Of these 125 cases, 50% (n=63) mentioned the person struck the floor, with 21 cases specifically mentioning it was a hard floor (e.g. floor boards, tiles) and 17 mentioning it was carpeted floor. Some children hit the bunk bed as they fell (n=17, 14%), while others hit tables (n=11, 9%), and drawers and cupboards (n=11, 9%).

Forty-eight percent of ED presentation falls case narratives (n=1,246) specifically mentioned that the person was on the top bunk when they fell (n=550), 5% mentioned the person fell from the ladder (n=61) and 0.4% of case narratives mentioned the person fell from the bottom bunk (n=5).

**Detailed analysis: activity**

Eight percent (n=106) of the 1,298 ED presentation case narratives mentioned whether the person was sleeping or playing at the time of the injury. Of these 106 cases, 61% were playing, and 39% were sleeping or resting when they were injured. Younger children were more likely to be playing at the time of the injury. 76% (n=28) of 0-4 year olds were playing at the time of the injury compared with 55% (n=27) and 56% (n=9) of 5-9 year olds and 10-14 year olds respectively.

**Discussion**

There were 362 hospital admissions and 1,125 ED presentations during the five-year period 2006/7 to 2010/11 due to bunk bed-related injury. There were no apparent trends in the injury rates over this time period. Conclusions regarding the effect of the mandatory Australian standard (AS/ NZS 4220) introduced in April 2005 on injury rates are difficult to draw. Certainly there has not yet been a reduction in the number of bunk bed related injuries associated with the introduction of the Standard. We are unable to determine if the Standard might have arrested any previous upward trend in bunk bed injury rates, as pre-2005 data are not available. Given that the Standard cannot regulate bunk bed use, or have an impact on the sometimes impulsive behavior of young children, it might not be reasonable to expect a large effect in the absence of other accompanying prevention strategies.

Children under ten years of age comprised 76% of all hospital treated bunk bed-related injury. The ACCC generally recommend against children under nine years old from using a bunk bed, and definitely do not recommend bunk beds for children under six years old (ACCC, 2012a). Our study found almost three-quarters of fall-related admissions (73%) and ED presentations (73%) were for children aged under nine years old, with 49% and 50% respectively for children aged under six years old. The proportion of children aged under nine years among non-fall-related bunk bed ED presentations was also high (55% of cases). Other studies have shown similar age patterns, with younger children being more frequently injured than older children (Mayr et al., 2000; Belcher et al., 2002; D’Souza et al., 2008; McFaul et al. 2012).

Falling predominated as the external cause. Eighty-seven percent of bunk bed-related ED presentations were fall-related. Similar patterns have been reported in the literature, with other studies using ED data describing 73% to 93% of bunk bed injuries as fall-related (Mack et al., 2007; Barker et al., 2008; D’Souza et al., 2008; McFaul et al. 2012). The nature of the injury and body region injured was also similar to other studies, with fractures and open wounds being the most common injury type, and the head and neck and upper limbs being commonly injured body regions (Belcher et al., 2002; Mack et al., 2007; Barker et al., 2008; D’Souza et al., 2008; McFaul et al. 2012).

Whether the person was asleep or at play on the bunk bed when injured is a useful factor in determining the mechanism of injury. Our study noted only 106 cases (8% of all ED presentations) that specified whether the person was sleeping or playing at the time of the injury. We found 61% of these cases were playing, with younger children more likely to be playing when injured. Barker et al. (2008) also found that young children aged 1-4 years were more likely to be injured during play rather than sleep, and compared bunk bed use similar to having a ‘playfort’ in a child’s bedroom.

There are noteworthy limitations to the injury surveillance data. For the most authoritative and complete source of hospital admission data, the VAED, the bunk bed external cause of injury code is only for falls off the top bunk, therefore we could not identify cases admitted for other bunk bed-related injury (e.g. struck by or collided with bunk bed, jammed in bunk bed). For this, we relied on admitted cases included in the VEMD (emergency department presentations) where case narrative descriptions provide an opportunity for more detailed analysis.

For ED presentations in the VEMD, case narrative descriptions were relied on to identify bunk bed injury cases. Some hospitals record post quality narratives meaning there may be an underestimate of the number of presentations. The amount of detail in each narrative also varies, with some more descriptive than others. This limits the identification of useful information such as the number of children on the bunk beds when the injury occurred, whether the child was asleep or playing at the time of the injury, and whether the child was in their own bed at the time when injured. Further, where this information is present, it has been provided by self-report which may not necessarily be completely accurate.

Although the majority of our cases were identified as occurring in the home, bunk beds are common in short-term rental accommodation, such as caravan parks, holiday homes, and school camps. The Queensland government is introducing mandatory safety standards for bunk bed use from October 2013 (Queensland Office of Fair Trading 2012).

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**Recommendations**

*Product Safety Australia (2012b)*, a part of the ACCC has made a number of recommendations for bunk bed safety and injury prevention. These include:

- **The top bunk is not recommended for use by children under nine years old (and particularly not for children under six years).**
- **Make sure the bed has guardrails or bedsides on all sides of the upper bunk, at least 160mm above the mattress, to prevent children falling off.**
- **Ensure there are no dangerous gaps in any part of the bed, including the guardrails, to prevent children from trapping their heads.**
- **The bunk bed should be set away from potential hazards to children such as ceiling fans, heaters, lights and blind cords.**
- **Ladders should be tightly fixed to the bed.**
- **Do not allow children to play on or around bunk beds and educate them about the safe use of bunk beds.**
- **Remove the bunk bed ladder when the bunk bed is not in use to stop small children from climbing up the bunk bed.**
- **Do not use overly thick mattresses which might render the guard rail ineffective in preventing children from rolling off the bunk.**
- **Check the security and stability of guard rails, mattress base components, access devices and fastenings regularly to ensure safe use.**
- **Avoid purchasing and using bunk beds with themed features designed to encourage a sense of play with the bunk.**

The ACCC is currently conducting a risk assessment process to determine whether the current mandatory standard is still effective, and is also giving consideration into regulating any hazards not properly addressed, by referencing requirements in more recent versions of the voluntary standard. They are also looking at possible educational campaigns targeted at parents and young children (3-6 years) to raise awareness of the hazards of bunk beds for small children (G. Milne, personal communication, November 30, 2012).

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**Table 5**

**Agent of injury for ED falls presentations (including admissions) bunk bed fall-related injury, Victoria, July 1, 2006 to June 30, 2011**

<table>
<thead>
<tr>
<th>ED presentations (including admissions), (n=125)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Floor</strong></td>
<td>63</td>
</tr>
<tr>
<td>Hard floor (e.g. floorboards, tiles)</td>
<td>21</td>
</tr>
<tr>
<td>Carpet</td>
<td>17</td>
</tr>
<tr>
<td>Unspecified floor</td>
<td>25</td>
</tr>
<tr>
<td><strong>Bunk bed</strong></td>
<td>17</td>
</tr>
<tr>
<td>Drawers/cupboards</td>
<td>11</td>
</tr>
<tr>
<td>Table</td>
<td>11</td>
</tr>
<tr>
<td>Toys</td>
<td>*</td>
</tr>
<tr>
<td>Window</td>
<td>*</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>125</td>
</tr>
<tr>
<td><strong>%</strong></td>
<td>50.4</td>
</tr>
<tr>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>13.6</td>
<td></td>
</tr>
<tr>
<td>20.0</td>
<td></td>
</tr>
</tbody>
</table>

*Suppressed due to small cell sizes*
Acknowledgements
We thank Gary Milne and Ian Scott from the Product Safety Branch of the Australian Competition and Consumer Commission for helpful comments and suggestions on this article.

References


Batteries have been identified by Ferrante et al., (2012): mechanisms of battery induced injury have been identified, and then focus on those cases where button batteries have been identified.

Battery a button battery is a small single cell flat round battery typically between 5 and 20 mm in diameter but refers to any battery where the diameter of the battery is greater than its height (Ferrante et al., 2012). Button style batteries have been used in a rapidly expanding range of common household items such as watches, remote control devices, calculators, hearing aids, digital thermometers, bathroom scales, reading lights, toys, games, talking and singing books, and greeting cards.

The common use of button batteries, ease of access in many devices, and small size mean they are both accessible and appealing to young children who may ingest these small items or insert them into their noses, or other body orifices.

Batteries less than 18mm in diameter often pass through to the gastrointestinal tract and are expelled without causing injury (Litovitz et al., 2010). In contrast, ingestion or insertion of larger batteries, particularly 20mm or greater in diameter, can result in the battery becoming lodged in the soft tissues of the oesophagus or other body orifices. When lodged, the battery emits an external electrical current flowing between the terminals generating hydroxide from the surrounding body fluid which may result in burns, necrosis and life threatening injury in as little as two hours (Litovitz et al., 2010; Lee & Malgelt, 2012). Two additional proposed mechanisms of battery induced injury have been identified by Ferrante et al., (2012):

1. Leakage of caustic alkaline electrolytes
2. Ischaemic necrosis caused by direct pressure

Existing literature, mostly based on data from the United States (US) indicates that 20mm, 3-volt lithium batteries are associated with the most serious outcomes (Ferrante et al., 2012; Litovitz et al., 2010), although cases of smaller batteries stuck in the oesophagus are known (Barker, personal communication, 2012). Lithium is a light metal which is used by battery manufacturers as it offers electrochemical efficiency, high energy density, long shelf life and cold tolerance.

Figure 1 ED presentations for button battery injury by year, children aged 0-4 years, Victoria, July 1, 2002 to June 30, 2011

Source: Victorian Emergency Minimum Dataset

Injury associated with Button Batteries
Karen Ashby

Background
A button battery is a small single cell flat round battery typically between 5 and 20 mm in diameter but refers to any battery where the diameter of the battery is greater than its height (Ferrante et al., 2012). Button style batteries have been used in a rapidly expanding range of common household items such as watches, remote control devices, calculators, hearing aids, digital thermometers, bathroom scales, reading lights, toys, games, talking and singing books, and greeting cards.

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Method
Data were extracted from the Victorian Emergency Minimum Dataset [emergency department presentations to 39 Victorian hospitals] for the financial years 2002/3 to 2010/11. See Box 1 for details of the data sources and case selection.

Results
In the 12-year period July 1999 to June 2011 there were 506 battery ingestions or insertion injuries among children aged 0-4 years. These were all derived from the Victorian Emergency Minimum Dataset. There were no injuries with the external cause code for choking or inhalation of a battery (W30.2) identified in the Victorian Admitted Episodes Dataset. This code has only been available since July 2008. In almost two-thirds of all cases the type of battery was identified as a button style battery (n=323, 64%). A smaller proportion (4%) were identified as cylindrical batteries and 30% did not provide any information upon which a category could be determined.

### Button batteries (n=323)

<table>
<thead>
<tr>
<th>Source</th>
<th>Victorian Emergency Minimum Dataset</th>
</tr>
</thead>
</table>

Table 1 shows the details of button battery injury. Thirty-four children (11%) required admission to hospital for further treatment. Thirty-eight percent of cases that required hospitalisation were children less than two years of age. Among non-admissions approximately one quarter of injuries occurred to each of one, two and three year olds. Male children were slightly over-represented accounting for 55% of cases.

Almost 40% of the cases mentioned the source (or use) of the battery. Most ingested batteries were described as watch batteries (n=36, 19%), while a further 14 (7%) were from toys, including games, and nine (5%) were from calculators. However the term “watch battery” may have been used by ED staff as a descriptor of the characteristics of the battery (i.e. still a button battery) rather than the source or intended source.

Discussion

The Victorian ED data identified 506 battery related injuries to children aged less than five years, of which at least 323 (64%) were associated with button batteries. This compares closely to US ED presentation data, which shows that 58% of battery-related injury cases in young children were associated with button batteries, 11% with cylindrical batteries and the remainder were undetermined (Ferrante et al., 2012).

The Victorian data provided is limited, in that we are relying predominantly on ED data and using non-standardised data elements such as triage text captured in a busy ED environment to identify and describe battery related injury events. Cases cannot be identified using ICD codes either in the ED or admitted patient data sets, as there is only one code specific to battery related foreign bodies: W30.2
Further complicating this issue is the fact that for ingestion or insertion events to be declared on presentation to the ED, they will have to have been witnessed, or have some other very convincing evidence available. On disclosure of this, the appropriate imaging will usually be done in a timely manner, and the battery will urgently be removed if indicated. Where ingestion or insertion incidents have occurred, but have not been witnessed, diagnosis does not occur until an appropriate x-ray is taken. The delay may be hours to days, and consequently, this subgroup of cases are more likely to sustain severe injury as a result of delay. These cases cannot, as stated, be identified using ED discharge or inpatient ICD codes, and as they are unlikely to be identified in the ED, will not appear in the triage text.

Litovitz et al. (2010) similarly noted that in the US the majority of the most serious cases were unwitnessed ingestions: fatalities (92%, n=12), and non-fatal cases with major outcomes (56%, n=41). Clearly, the ability of the child to access the battery readily and unnoticed requires attention to the design of not only the battery, but the battery compartment of the item in which the batteries are housed and the battery packaging. In addition, larger batteries appear to retain sufficient charge to generate hydroxyl ions when spent, so are hazardous at both ends of their lifecycle. The availability of some detailed data from the 247 US National Battery Ingestion Hotline (NBII) allowed logistic regression modeling to be undertaken to determine outcome predictors for button battery ingestion. The model showed that a battery diameter of 20 to 25 mm was the most important predictor of a clinically significant outcome (OR 24.6; P<0.001), followed by age less than four years (OR 3.2; P<0.001) and ingestion of more than one battery (OR 2.1; P=0.02) (Litovitz et al., 2010). The outcome of ingestion of small lithium cells, <20mm, was no worse than the outcome from ingestions of other small sized button batteries (Litovitz et al., 2010).

The Consumer Product Safety Commission recommends a multifaceted approach to prevention of battery injury including: increased consumer education, awareness of proper use and disposal of batteries; improved product standards for electronic enclosures and battery packaging; and advances in battery construction and design to mitigate the risk (Lee and Midgett, 2012). Other suggestions include the provision of advice to suppliers, end users and the medical fraternity (Rushton, 2012).

A joint safety campaign involving Energizer, Kidsafe, and the Australian Competition and Consumer Commission, ‘The Battery Controlled’, launched in Australia in April 2012. (http://thebatterycontrolled.com.au/) The campaign warns parents that small coin-sized lithium button batteries, when swallowed, can get stuck in a child’s throat and can cause severe burns or death. The campaign runs in numerous formats: print – brochures and posters; and electronically - websites, Facebook and Twitter. A key component is the high profile “Hunter’s Story” that uses the case of a one year old Queensland boy Hunter who sustained major injuries after ingesting a button battery.

The following summarises some of the proposed design modifications and other prevention strategies raised in this conference session:

**Design**
- Near complete encapsulation of one of the poles to prevent hydroxyl generation.
- Use of nonconductive encapsulation or modification of the terminal surface to reduce accessible electrode area.
- Addition of a protective device, such as a switch, to limit the current flow once removed from the battery compartment of a product.
- Addition of a collapsible mechanism to the outer surface that will expand when the battery is removed from its enclosure so that it will be too big for a child to swallow.
- Slowed hydroxide formation e.g. by insulating the battery until it is fitted in coordinating battery compartment.
- Child resistant closures on consumer products that use batteries.

**Other**
- Child resistant packaging for batteries.
- Packaging warnings.
- Educational literature accompanying products that use button batteries.

**Sources**: Ferrante et al., 2012; Lee & Midgett, 2012; Midgett & Lee, 2012; Babiak, 2012; Baum & Baum, 2012.

Raising parental awareness of the risk of button battery ingestion should be a co-ordinated strategy with a consistent message regarding the potential for harm. While such a strategy should consist of a number of actions, the placement of batteries in retail outlets could be readily used to re-inforce this message. It is not uncommon for button batteries, including 3V lithium batteries, to be placed on low shelves in large supermarkets. This is not to suggest that this is a source by which children ingest these batteries, but their placement within easy reach does not portray to parents the potential for serious harm. The ACCC has had discussions with suppliers (including major retailers) about the safety of packaging and warnings associated with the sale of these products (Jamieson, personal communication 2013). VISU would urge that these discussions extend to more appropriate shelf placement and point of sale warning of the risk of serious injury from ingestion/insertion of button battery.

While better data is required, this is a clear case where action should proceed to address this serious injury risk to young children.
Acknowledgement

VISU gratefully acknowledge the expertise and comment provided by Dr Ruth Barker, Director of the Queensland Injury Surveillance, on this article.

References


In 1993, after five years at VicHealth, Erin took up a position as the Assistant (and later Acting) Director Injury Research and Control Section in the Commonwealth Department of Health. Erin was recruited to undertake the research, writing and liaison for injury as one of the first four areas to receive attention in the National Health Goals and Targets Program. This program was tasked with working out best practice for the prevention and treatment of injury in Australia. It was aimed at shifting the focus of the health system, at that time, to outcomes rather than activity levels. The resulting strategy “Working as a Nation to Prevent Injury”, co-ordinated and produced by Erin, was endorsed as part of the National Health Policy and launched in 1995 at the First National Conference on Injury Prevention and Control in Sydney.

In 1996, Monash University managed to tempt Erin to leave Canberra and join the Accident Research Centre (MUARC). During this period, Erin was involved in some of the first work that MUARC did in the sports injury area, and worked on a range of other injury prevention research topics including community based program evaluation, women’s injury, older person’s falls and home injuries. Erin was a key member of the team that produced the Melbourne Declaration adopted at the final session of the Third International Conference on Injury Prevention and Control in 1996. The Declaration called for a range of actions by the international network to forward injury prevention and control around the world.

In 2003, Erin became the Director of VISU. Her research management and policy development experience at both VicHealth and the Commonwealth Department of Health, coupled with research experience, meant that she was uniquely qualified for this position. Since then VISU has enjoyed continuous ongoing funding and formed the platform for a program of injury research covering a range of issues. Under Erin’s leadership, partnerships and collaborative research have been established with Marine Safety Victoria, the Victorian Taxi Directorate, the Victorian Department of Education and Early Childhood Development, and the Australian Competition and Consumer Commission. Erin established a series of call back studies on topical injury issues including football, recreational boating and dog bites. During this period, the injury surveillance system and function was enhanced with more sophisticated responses to requests which included an interpretive report in addition to the data tables, and by making this material more widely available as short reports on the web. Erin has been an author on the 22 editions of Hazard that have been produced while she has been Director and her influence can be seen in the quality of these publications. She has an extremely comprehensive grasp of the literature and current research on an impressive range of injury issues. Through this body of work, and her participation on KidSafe, the Victorian Safe Communities Network and various standard committees, the profile of VISU has increased both nationally and internationally. Importantly, lives have been saved and injuries prevented based on the work of VISU.

The VISU staff are extremely appreciative of the professional and personal support they have received from Erin over the years. Erin has been a dedicated, valued and respected colleague at Monash and within the injury sector more broadly. She leaves with our very best wishes for a fulfilling and contented retirement.

The position of Director of VISU has been taken up by Associate Professor Lesley Day. Lesley has 20 years experience and expertise in injury epidemiology, surveillance, and the design and evaluation of injury trials and interventions. Her research spans diverse topics including the association between falls prevention and disability, translational research in the falls area, identification of farm injury risk factors, and program evaluation.
**Box 1: Data sources and case selection**

**Hospital admissions**

The VAED is a statewide collection of data on all admissions to Victorian hospitals (public and private) and is coded to the International Classification of Diseases, Australian Modification (ICD-10-AM). Transfers within and between hospitals and readmissions to the same hospital within 30 days were excluded from these analyses to estimate the incidence of cases. Table cells with values less than 5 were replaced by an asterisk (*) as a privacy protection measure. The table below shows the variables and the associated parameters used to select injury cases:

<table>
<thead>
<tr>
<th></th>
<th>Trampolines</th>
<th>Bunk beds</th>
<th>Button batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years</strong></td>
<td>2002/3 to 2010/11</td>
<td>2006/7 to 2010/11</td>
<td>2008/09 to 2010/11</td>
</tr>
<tr>
<td><strong>Ages</strong></td>
<td>0-4 years</td>
<td>all</td>
<td>all</td>
</tr>
<tr>
<td><strong>Selected codes</strong></td>
<td>External cause code W06.6: fall involving trampoline or Activity code U57.06: trampoline and mini-trampoline</td>
<td>External cause code W06:0: fall involving bunk bed*</td>
<td>External cause code W06:2: choking or inhalation of a battery</td>
</tr>
</tbody>
</table>

* excludes falls from bottom bunks

**Emergency department presentations**

The VEMD is an ongoing surveillance database of injury presentations to 39 Victorian public hospital emergency departments (EDs). The VEMD collects data in accordance with National Minimum Data Standards for injury surveillance. While data is not coded using the ICD-10-AM system, the code set is similar and comparable. ED cases subsequently admitted to hospital were retained, but excluded from any analysis where VAED admissions data was also available to avoid double counting. The term “ED presentations” is used to refer to non-admitted ED cases. As only the VEMD has a free text case narrative, where the detail for VAED admissions was not sufficient, the VEMD admissions are reported and their inclusion is specified. All cases selected from the VEMD were manually screened for relevance. Table cells with values less than 5 were replaced by an asterisk (*) as a privacy protection measure. The table below shows the variables and the associated parameters used to select injury cases:

<table>
<thead>
<tr>
<th></th>
<th>Trampolines</th>
<th>Bunk beds</th>
<th>Button batteries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years</strong></td>
<td>2002/3 to 2010/11</td>
<td>2006/7 to 2010/11</td>
<td>2008/09 to 2010/11</td>
</tr>
<tr>
<td><strong>Ages</strong></td>
<td>all</td>
<td>all</td>
<td>all</td>
</tr>
<tr>
<td><strong>Selected codes</strong></td>
<td>Intent code Unintentional (i.e. accidental)</td>
<td>Intent code Unintentional (i.e. accidental)</td>
<td>Intent code Unintentional (i.e. accidental)</td>
</tr>
<tr>
<td><strong>Narrative search terms</strong></td>
<td>trampoline, tramp, mini-tramp, rebounder and derivatives and spelling variations</td>
<td>bunk</td>
<td>lithium, button battery, disc battery, battery or battery and derivatives and spelling variations.</td>
</tr>
<tr>
<td><strong>Further limitations</strong></td>
<td>Injury resulted from the ingestion or insertion of the battery into a natural orifice.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Emergency department presentations**

Trends were determined using a log-linear regression model of the rate data assuming a Poisson distribution of injuries. The statistics related to the trend curves, slope and intercept, estimated annual percentage change and the p-value, were calculated using the regression model in SAS® 9.2. A trend was considered to be statistically significant if the p-value of the slope of the regression model was less than 0.05.
VISU Staff

Director: Assoc. Prof Lesley Day
Manager Data Quality Improvement and Consumer Product Safety: Ms Karen Ashby
Manager Data Systems Data Requests & Reports: Ms Angela Clapperton
Research Officer: Ms Emily Kerr
Administration Officer: Ms Vanessa Fleming-Baille

Participating hospitals

From October 1995
Austin & Repatriation Medical Centre
Ballarat Base Hospital
The Bendigo Hospital Campus
Box Hill Hospital
Echuca Base Hospital
The Geelong Hospital
Goulburn Valley Base Hospital
Maroondah Hospital
Mildura Base Hospital
The Northern Hospital
Royal Children’s Hospital
St Vincents Public Hospital
Wangaratta Base Hospital
Warrnambool & District Base Hospital
Western Hospital - Footscray
Western Hospital - Sunshine
Williamstown Hospital
Wimmera Base Hospital

From November 1995
Dandenong Hospital

From December 1995
Royal Victorian Eye & Ear Hospital
Frankston Hospital

From January 1996
Latrobe Regional Hospital

From July 1996
Alfred Hospital
Monash Medical Centre

From September 1996
Angliss Hospital

From January 1997
Royal Melbourne Hospital

From January 1999
Werribee Mercy Hospital

From December 2000
Rosebud Hospital

From January 2004
Bairnsdale Hospital
Central Gippsland Health Service (Sale)
Hamilton Base Hospital
Royal Women’s Hospital
Sandringham & District Hospital
Swan Hill Hospital
West Gippsland Hospital (Warragul)
Wodonga Regional Health Group

From January 2005
Mercy Hospital for Women

From April 2005
Casey Hospital

From July 2011
Bass Coast Regional Health

How to access VISU data:

VISU collects and analyses information on injury problems to underpin the development of prevention strategies and their implementation. VISU analyses are publicly available for teaching, research and prevention purposes. Requests for information should be directed to the VISU Co-ordinator or the Director by contacting them at the VISU office.