

Influence of voluntary standards and design modifications on trampoline injury in Victoria, Australia

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ABSTRACT

Purpose: To examine the influence of the voluntary Australian trampoline standard (*AS 4989-2006*), and market driven design modifications, on relevant trampoline injuries

Methods: Trend and intervention analysis on frequencies and proportions of hospital treated trampoline related injury in Victoria, Australia extracted from the Victorian Emergency Minimum Dataset from 1 July 1999 and 30 June 2013. The injuries relevant to the *AS* were contact with spring and frame, and multiple user injury. Falls from trampolines were relevant for netted trampolines, a market driven modification.

Results: Frequency of all trampoline injury increased by 11.4% (95% CI 10.0%-11.7%) on average each year. Spring and frame, and fall injuries increased to a lesser extent (8.7% 95%CI 6.9%-9.8% and 7.3% 95%CI 5.8%-8.3% respectively). Multiple user injuries increased by 21.0% (95%CI 16.3%-21.9%). As a proportion of all trampoline injury, spring and frame injury and falls injury decreased, while multiple user injuries increased. The intervention analysis showed no significant change in spring and frame injuries associated with the *AS* ($p=0.17$). A significant increase was found for multiple-user injuries ($p=0.01$), in particular for the 0-4 year age group ($p<0.0001$), post-2007.

Conclusions: There was little evidence for an effect of the voluntary standard on spring and frame injury and none for multiple user injury. Netted trampolines appear to be associated with a decrease in falls from trampolines but an increase in injuries to multiple users. A mandated trampoline safety standard and a safety campaign including warnings about multiple users is recommended. Continued monitoring of injury data will be required.

INTRODUCTION

Trampoline-related injury remains a persistent injury issue in a number of countries.¹⁻⁷ The North American response to rising numbers of serious paediatric trampoline-related injuries has been advocacy for restriction of trampoline use. The American Academy of Paediatrics recommended in 1999 and again in 2012 that trampolines should not be used at home, in routine physical education classes, or in outdoor playgrounds.^{2,3} Similarly the Canadian Paediatric Society and Canadian Academy of Sports Medicine, in 2007, called for a ban on recreational use in the domestic setting.⁴ In contrast, the Australian injury prevention sector focused on revising the Australian Standard (AS) for trampolines to include measurable safety aspects designed to reduce the risk of injury.

The first voluntary AS, *AS 4989–2003*, was published in 2003 and outlined requirements for components and design, and specified information on assembly and maintenance.⁸ The revised standard published in October 2006 (*AS 4989-2006*) focused on safety aspects such as spring and frame-padding design, protection of sharp edges, safety marking and labelling, and consumer information.⁹ *AS 4989-2006* specified that all domestic trampolines on sale in Australia be supplied with frame-padding or a soft-edge system to prevent impact injury. Retrofitment of a compliant frame-padding system was recommended for existing trampolines.¹⁰ The minimum level of consumer safety information was also detailed including the need for active adult supervision, and a warning against allowing multiple users on the trampoline.

It was anticipated that these revisions to the AS would result in reductions in trampoline-related injury over time, given the lifespan of existing trampolines. Contemporaneously, trampolines that have safety enclosure ‘netting’ to minimise the risk of children falling off

were introduced onto the Australian market. Expected reductions in trampoline related injuries have not yet been seen.¹

The first objective of this study was to investigate patterns and trends in emergency department (ED) treated trampoline injury in Victoria, Australia, for the trampoline injury scenarios expected to be impacted by the AS and the new safety enclosures. The second objective was to examine whether there is an association between the occurrence of the relevant injury scenarios and the introduction of *AS 4989-2006*.

METHOD

Data

Data were extracted from the Victorian Emergency Minimum Dataset (VEMD) for the period 1 July 1999 and 30 June 2013. The VEMD is an administrative dataset comprising six coded and one free text fields (the ‘injury surveillance fields’). Data are collected by ED staff during, or shortly following, the injured person’s first ED attendance for a particular injury. All 39 Victorian public hospitals with a 24 hour ED contribute data to the VEMD, which captures approximately 80% of ED presentations in the state.¹¹

Cases were injured persons treated in one of the VEMD participating EDs where the free text field included one of the following text strings: “trampoline”; “tramp”; “rebounder” (including derivatives and spelling variations). This includes trampoline use in any setting. Cases were manually checked. Only incident cases were retained by excluding return visits to the same hospital for follow-up. However subsequent treatment at another hospital for the same injury cannot be identified in this dataset. The final dataset included both cases treated

and discharged to home (non-admissions), and cases subsequently admitted for inpatient care (admissions) as the result of their injury.

Cases were recoded manually as either a fall or non-fall event. Falls were further coded into three sub-categories: 1 - falls from or off the trampoline; 2 - falls on the trampoline mat or frame; and 3 - other falls (typically those with insufficient detail to categorise to 1 or 2). Injuries arising from mechanisms other than falls (non-falls) were grouped into the following subcategories: collision with object; collision with person; over-exertion; other and unspecified.

Once reassignment was completed three injury scenarios were flagged for more detailed review. Each scenario matched changes in the AS or trampoline design described above. These three scenarios were: 1 - contact with spring and frame; 2 – multiple user injury; and 3 - falls from/off trampolines. Categorisation for these three scenarios was based on review of free text data. Trampoline injury can be multi-factorial so some cases may be represented in more than one sub-group.

Trends in frequency for each injury scenario, and for all trampoline related injury, were determined using a log-linear regression model of the rate data assuming a Poisson distribution of injuries. The estimated annual percentage change and 95% confidence interval were calculated using the regression model using the SAS/STAT[®] statistical analysis software.¹²

Intervention analysis

An intervention analysis was conducted to examine whether there was an association between trends in the relevant injury scenarios (contact with spring and frame, and multiple user injury) and the introduction of *AS 4989-2006*. In order to build a robust model, only data of the highest quality both in terms of narrative and data consistency was used. Therefore, the intervention analysis was based on data from the Royal Children's Hospital (RCH), the main paediatric treatment centre in Victoria, as this hospital provided consistently high quality narratives with good details on factors contributing to injury, and accounted for 15% of cases.

Separate logistic regression models were built for spring and frame injury and multiple user injury. In addition, multiple user injury in the 0-4 year old age group was examined. In order to adjust for general trends in trampoline injury, the outcome variable was the number of injury events of interest recorded at the RCH as a proportion of *all* Victorian trampoline injury. The intervention analysis tested whether a statistically significant change in the proportion of injury occurred from 1 January 2007 to 30 June 2013 compared with the period 1 July 1999 to 31 December 2006. The data were analysed using the SAS/STAT[®] statistical analysis software.¹² The intervention date of January 2007 was chosen to coincide with the publication of *AS 4989-2006* in October 2006, with major sales associated with the Standard likely occurring prior to Christmas and any discernible effects on the number of injury events potentially occurring from 2007.

RESULTS

Injury patterns and trends

Over the 14 years investigated there were 18,514 ED treated injuries with a steady increase in annual frequency (Figure 1). Injuries were predominantly associated with falls (73.1% of

injuries), most of which occurred when the injured person fell off/from the trampoline (61.4% of fall injury). The frequency of the falls from trampolines levelled off in the last year. In contrast, falls on the trampoline have increased.

Non-falls increased as a proportion of all injury over time (Figure 1), from 19.0% of trampoline injury in 1999/00 and peaking at 33.2% in 2011/12. Non-falls were mostly from over-exertion (44.1% of non-falls) or multiple user injury; most commonly when multiple users collided or the injured person was double bounced (32.6% of non-falls).

Table 1 shows further comparison of fall and non-fall injury. Sixteen percent of persons injured in a fall required inpatient care compared with 6.6% injured in non-fall events. Children aged 5-9 years were most represented in both fall (42.3%) and non-fall injury (38.5%). The mean age for persons injured in a fall event was 8.0 years and was slightly older for non-fall events (9.1 years). Males predominated for both fall and non-fall injury.

Table 1: Emergency Department treated trampoline injury, Victoria by age, gender and cause, July 1, 1999 to June 30, 2013.

	Emergency Department treated cases					
	Falls N = 13,537		Non-falls N=4,977		TOTAL N=18,514	
Age group	N	%	N	%	N	%
0-4	3,894	28.8	1,281	25.7	5,175	28.0
5-9	5,725	42.3	1,916	38.5	7,641	41.3
10-14	2,936	21.7	1,232	24.8	4,168	22.5
15-19	473	3.5	228	4.6	701	3.8
20+	509	3.7	320	6.4	829	4.4
Mean age	8.0 years		9.1 years		8.3 years	
Median	7.0 years		8.0 years		7.0 years	
Gender						
Male	7,326	54.1	2,566	51.6	9,892	53.4
Female	6,211	45.9	2,411	48.4	8,622	46.6
Cause						
Fall off	8,314	61.4	-	-	8,314	44.9
Fall on	3,600	26.6	-	-	3,600	19.4
Fall other/NS	1,623	12.0	-	-	1,623	8.8
Collision object	-	-	824	16.6	824	4.5
Collision with person	-	-	1,097	22.0	1,097	5.9
Over-exertion	-	-	2,197	44.1	2,197	11.9
Other or unspecified	-	-	859	17.3	859	4.6
Severity						
Inpatient admission	2,169	16.0	330	6.6	2,499	13.5
Treated in ED and discharged to home	11,368	84.0	4,647	93.4	16,015	86.5
Nature of main injury						
Dislocation/sprain, strain						
Fracture						
Open wound						

Impact of interventions of selected injury scenarios

Impact of AS 4989-2006 on spring and frame injury (n=893 cases)

There were 893 cases (4.8% of all cases) where the free text mentioned the involvement of the springs, frame, edge or metal part of the trampoline. Most (n=819, 91.7%) were presentations and 74 (8.3%) were admissions. Almost two-thirds (64.8%) were fall-related i.e. falls onto the component part.

Over the study period there was an 8.7% (95% CI 6.9%-9.8%) annual average increase in the frequency of spring and frame injury, significantly less than the overall annual average increase of 11.4% (95% CI 10.0%-11.7%) for all trampoline injury. As a proportion of all trampoline injury over time, spring and frame injuries have decreased (Figure 2).

The regression analysis for intervention effect found there was no statistically significant change for the proportion of spring and frame injury post-2007 compared with the previous period (Table 2).

Table 2: Change in injury scenarios as a proportion of all Victorian trampoline injury associated with the introduction of AS 4989-2006

Outcome	Odds Ratio*	Lower 95% confidence limit	Upper 95% confidence limit	<i>p-value</i>
Spring and frame	0.79	0.57	1.10	<i>0.1699</i>
Multiple user	1.35	1.06	1.72	<i>0.0143</i>
Multiple user 0-4 years	2.20	1.49	3.27	<i><0.0001</i>

*OR=1.0 means no change; OR=0.77 indicates 23% reduction; OR=1.35 indicates 35% increase

Impact of AS 4989-2006 on multiple user injuries (n=1,623 cases)

There were 1,623 injury cases (8.8% of all cases) where the free text noted more than one user on the trampoline at the time of the injury occurrence. Most (n=1,491, 91.9%) were presentations and 132 (8.1%) were admissions. Two thirds of injuries (n=1,097, 67.6%) occurred when two, or more, jumpers collided; another 26.1% were the result of a fall associated with multiple users. 7.2% of injuries occurred when the injured person was double bounced.

Multiple user injuries increased as a proportion of all trampoline injury over time (Figure 3). The frequency of multiple user injuries increased by an average of 21.0% (95%CI 16.3%-21.9%) annually, significantly higher than the all ED treated trampoline injury annual increase of 11.4% (95% CI 10.0%-11.7%).

The pattern of multiple user injury shows some variation from that of all trampoline injury. Young children aged 0-4 years represented a higher proportion of multiple user presentations (37.2%) compared to all trampoline presentations (28.0%).

The regression analysis detected a significant change in multiple user injuries associated with the period after *AS 4989-2006* came into effect. A statistically significant increase of 35% (95% CI 6%-72%) was found for the proportion of multiple user injury occurring post-2007 compared with before (Table 2). When the analysis was restricted to 0-4 year olds, this changed to a highly statistically significant increase of 120% (95% CI 49%-227%).

Impact of market driven design modification - Falls from trampolines (n=8,314 cases)

Falls off, or from trampolines to the ground or another surface remained the single most common cause of trampoline injury representing 44.9% of all cases. The potential for serious injury appears greater; some 18.3% of falls from/off a trampoline required inpatient care, compared with 13.5% of all cases. Falls from a trampoline accounted for 60.9% of admitted cases examined.

The mean age of persons injured by a fall from, or off, a trampoline was younger than for trampoline falls overall (7.5 years vs 8.0 years) and for all trampoline injury (8.3 years). 'Fall from, or off' injuries were mostly associated with fractures (45.3%). There were

proportionally more upper limb injuries associated with falls from, or off trampolines, compared to all trampoline injury (56.5% vs 40.5%).

Falls off trampolines decreased as a proportion of trampoline injury during the study period. While the proportion has been decreasing, there has been, an average annual increase in the frequency of 7.3% (95%CI 5.8%-8.3%) (Figure 4). This is significantly less than the 11.4% (95% CI 10.0%-11.7%) average annual increase in all ED-treated trampoline injury.

DISCUSSION

Despite a voluntary Standard setting out minimum safety measures and a market driven design modification, hospital ED treated trampoline injuries continued to rise in Victoria. There were two specific trampoline injury scenarios examined to determine if modifications to the AS had an effect: spring and frame injury, and multiple user injury.

We found little evidence for an effect of the AS recommendations for frame-padding or a soft-edge system to cover the frame and springs of the trampoline, although there does appear to be a slowing in the trend relative to all trampoline injury. It may be too early to observe an effect, or there may be insufficient market penetration of compliant models. There is some evidence that at least a selection of trampoline models on the market are not compliant with this aspect of the AS. The Australian Consumers Association recently reviewed 12 trampoline models ranging in price from \$AU179 to \$AU985.¹³ The trampolines were tested against the requirements of *AS 4989-2006* for impact attenuation (padding).⁹ Only one model tested passed in terms of the effectiveness of the spring and frame-padding in preventing

injury to a child's brain, indicating that for the remaining 11 models, there is an unacceptable risk of brain injury, in the event of a fall onto the springs or frame.

It is worth noting that there was a higher representation of older children, particularly males, among spring and frame injury. Older children may jump higher increasing their injury risk should they fall onto exposed springs or frame. These injuries may also be occurring on older trampolines purchased prior to *AS 4989-2006*, bought when these children were younger, or if bought since *AS 4989-2006*, within a time frame that has seen the padding perish or be otherwise damaged and not replaced. The quality and longevity of trampoline components is particularly pertinent. The International Trampoline Industry Association estimated that a trampoline sold in 1989 had an expected life of 10 years; by 2004 this had decreased to 5 years.¹⁴ 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 as to the extent to which this occurs or whether damaged items remain in place or are discarded altogether.

Similarly, we found no evidence for an effect of the mandatory safety warnings against multiple users incorporated into *AS 4989-2006*. In fact multiple user injuries are rising rapidly and at a greater rate than all trampoline injury, suggesting that multi-use may be increasing in Victoria. The emergence of domestic trampolines with large beds and group activity at commercial trampoline parks may be encouraging multiple use in the domestic setting. In countries where falls from trampoline injuries are less prominent, multiple user injury reaches high proportions among children (80-82%).^{15,16} Multiple use is particularly hazardous for young children who have less developed coordination, lack necessary motor

skills for balance and as the lightest trampoline multi-users are subject to energy transfer during collision with other heavier users, increasing their injury risk .¹⁵⁻¹⁷

The Victorian data showed that children aged under five years were over-represented among multiple user injuries. The mandatory safety information included in trampoline packaging that advises against multiple users also states that trampolines greater than 500 mm in height are not recommended for children aged under six years. Without complete details of the injury scenario we speculate that parents perceive enclosed trampolines as safe for younger, and multiple, users as the potential to fall from the trampoline is eliminated. A survey of owners of one 'soft-edge' trampoline model found that the median age for injury of this model of "safe" trampolines was younger than that reported for traditional trampolines.¹⁸ However, purchase of this type of trampoline could be more common among families with young children.

The notion that netted trampolines may be perceived as safer is consistent with the theory of risk compensation which suggests that parents who believe more strongly in the efficacy of safety designs erroneously assume that injury risk has been eliminated and allow greater risk taking by their children, particularly when the children are experienced in the activity.¹⁹ Applied to trampolines, parents who have bought a high end 'safe' model of trampoline may contravene mandatory warnings as they are falsely assured of the complete safety of the product. The AAP expressed concerns over supervision complacency, particularly when safety measures are in place, as well as lack of adult knowledge and intervention regarding risk behavior with trampoline use.³

In contrast to our findings for injuries targeted by the AS, we found strong evidence for an effect of netted trampolines on injuries associated with falls from trampolines. While falls from trampolines remained the single leading cause of injury, they comprised a decreasing proportion of all trampoline injury and the frequency increased at a slower rate than all trampoline injury.

As this article goes to print Standards Australia are about to publish the third revision of AS 4989. This document was written specifically to be used by the Australian Consumer and Competition Commission (ACCC) as a mandatory Standard. It includes new and more focused safety interventions such as the mandation of safety enclosures, UV degradation testing of all plastic components, structural integrity testing, an easier frame padding test, and an enclosure test. It is expected that the mandation of minimum safety requirements will in time lead to a lowering of trampoline associated injuries. In particular, the mandation of enclosures to ensure that they meet minimum performance requirements should lead to a further reduction in falls off trampolines, the largest source of equipment related injuries. Nevertheless, the full effect of these progressive interventions will not be observed immediately. The retirement of old and less safe trampolines will take several years.

Limitations

Identification of cases on the VEMD was reliant solely on the inclusion of a good free text narrative collected in the busy ED by staff for whom data collection is a secondary duty to patient care. The ability to classify identified cases into a 'type' of trampoline injury again relied solely on this free text field. Common spelling mistakes were included in the search strategy to try account for typographical errors. Cases identified in the VEMD are expected to be an underestimate of the true number of cases presenting to EDs.

There is a lack of good information on trampoline sales, lifespan of backyard trampolines, owner maintenance and uptake of, and adherence to, safety measures outlined in educational campaigns and mandatory safety warnings on packaging. Exposure data, to determine the proportion of the increase in frequency related to increased exposure alone, is also absent. We were not able to include other factors such as socio-economic status in our analysis.

CONCLUSION

This paper provides a historical record of trampoline injury rates from 2000 to 2013. Two trampoline safety Standards intended as interventions to limit the frequency and magnitude of trampoline related injuries were published in this period. As there was little evidence for an effect of these voluntary standards, it is recommended that the ACCC mandate the third revision of *AS4989*.

The observed decrease in falls from trampolines, probably due to increased availability of netted trampolines, was accompanied by a worrying increased trend in injury associated with multiple users. It is recommended that in addition to mandating the trampoline safety Standard that the ACCC conducts a safety campaign that includes multiple user danger warnings.

Continued monitoring of hospital injury data is required to assess any impact of the technical provisions contained within the new Standard, the influence of product mandating, and potential adverse effects from changes in consumer behaviour.

What is already known

- Trampoline-related injury remains a persistent issue in many countries
- The effect of a voluntary Australian Standard on trampolines introduced in 2003 and revised in 2006 is not clear

What this study adds

- There may be some effect of the voluntary standard on spring and frame injury, but there was no effect for multiple user injury.
- Netted trampolines, a market driven modification, appeared to be associated with a decrease in falls from trampolines but an increase in injuries to multiple users.

Statement of contributorship

KA and LD conceived the study and interpreted the data. DE contributed to the study design and interpretation of the data. AE conceived, conducted and interpreted the intervention analysis. KA drafted the paper, and all authors contributed to revising the intellectual content and approved the final version.

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Competing interests

D. Eager and L. Day are members of the Standards Australia CS-100 Trampolines Committee. D. Eager is the immediate past Chair of the Committee. There are no other competing interests.

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