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Gary A. Smith

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# Injuries to Children in the United States Related to Trampolines, 1990–1995: A National Epidemic

Gary A. Smith, MD, DrPH

**ABSTRACT.** *Study Objective.* To describe the epidemiology of trampoline-related injuries among children in the United States.

*Design.* A retrospective analysis of data for children 18 years old and younger from the National Electronic Injury Surveillance System of the United States Consumer Product Safety Commission for 1990 through 1995.

*Results.* There were an estimated 249 400 trampoline-related injuries [95% confidence interval (CI), 166 300–332 500] to children 18 years old and younger treated in hospital emergency departments in the United States during the 6-year study period. The number of injuries increased by 98% from 29 600 in 1990 to 58 400 in 1995, with an average of 41 600 (95% CI, 27 700–55 500) injuries per year, or 59.4 injuries per 100 000 United States children per year (95% CI, 39.6–79.3). The median age of injured children was 10 years, and 50% were males. Ninety-three percent of injuries occurred at home. Injuries to the extremities predominated among children of all ages and accounted for more than 70% of all injuries. This study identified several age-specific injury patterns. There was an inverse relationship between age versus the relative frequency of upper extremity injuries, and fractures and dislocations; and there was a direct relationship between age versus lower extremity injuries and soft tissue injury. There was also an inverse relationship between age versus facial injuries, head and neck injuries, and lacerations. Annually, an estimated 1400 children (95% CI, 800–2000), or 2.0 per 100 000 United States children (95% CI, 1.1–2.9), required hospital admission or interhospital transfer because of a trampoline-related injury. This represented 3.3% of all children with a trampoline-associated injury. Fractures or dislocations accounted for 83% of injuries among admitted or transferred children, and children with a fracture or dislocation were more likely to be admitted or transferred to another hospital (8.4%) than children with other types of injury (relative risk, 10.80; 95% CI, 9.40 < relative risk < 12.29). Among children released home from the emergency department, soft tissue injuries (53%), fractures or dislocations (30%), and lacerations (14%) were the most common injuries treated.

*Conclusion.* Injuries related to trampolines, especially backyard trampolines, are an important cause of pediatric morbidity. These injuries have also resulted in death. The rapid increase in the number of trampoline-related injuries to children during recent years is evidence that current prevention strategies are inadequate. Children should not use trampolines at home, and the

sale of trampolines for private recreational use should be stopped. *Pediatrics* 1998;101:406–412; *trampoline, pediatrics, children, injury epidemiology, prevention, trauma.*

ABBREVIATIONS. CPSC, Consumer Product Safety Commission; NEISS, National Electronic Injury Surveillance System; CI, confidence interval; RR, relative risk; AAP, American Academy of Pediatrics.

The trampoline was first introduced in the United States by the circus acrobat George Nissen in 1936. During World War II, the United States and Britain used trampolines to train fighter pilots. The use of trampolines became more popular among the civilian population in the United States and Europe during the 1950s and 1960s.<sup>1–5</sup> The first reports of trampoline-related injuries were by Zimmerman<sup>6</sup> in 1956, and by Ellis and coworkers<sup>7</sup> in 1960. Subsequent studies have continued to identify injuries associated with trampolines, including quadriplegia and death.<sup>1–5,8–19</sup>

Although trampoline-related injuries have been reported in the literature for decades, relatively few studies have focused on these injuries among children.<sup>1,8–12</sup> This report describes the epidemiology of trampoline-related injuries requiring emergency department treatment among children in the United States from 1990 through 1995 using data collected by the US Consumer Product Safety Commission (CPSC).

## METHODS

The CPSC monitors consumer product-related injuries treated in US hospital emergency departments through the National Electronic Injury Surveillance System (NEISS). The NEISS was established in 1972 with revisions made in its sampling frame in 1978 and 1990. The NEISS receives data from a network of hospitals that represent a stratified probability sample of the approximately 6100 hospitals in the United States that have at least six beds and provide 24-hour emergency services.<sup>20</sup> Because data are collected daily from a statistically representative sample of hospital emergency departments, weights can be applied to NEISS data to estimate the number and describe the epidemiology of injuries associated with 15 000 consumer products for the entire nation.<sup>21,22</sup> The NEISS has been shown to be highly sensitive and accurate in identifying consumer product-related injury cases.<sup>23–26</sup>

Data were obtained from the CPSC regarding trampoline-related injuries (product code 1233) reported through the NEISS during the 6-year period, 1990 through 1995. Calculation of a 95% confidence interval (CI) for the estimated number of injuries is based on the sampling error and the relative sampling error for NEISS data provided by the CPSC. The relative sampling error is a measure of the sampling error of the estimated number of injuries expressed as a percent of the injury estimate, and is also referred to as the coefficient of variation of the estimate.<sup>27</sup> Trampoline-related injury rates per 100 000 US children 18 years old

From the Department of Pediatrics, Ohio State University College of Medicine, Columbus, Ohio.

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Reprint requests to (G.A.S.) Emergency Medicine, Children's Hospital, 700 Children's Dr, Columbus, OH 43205.

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and younger were calculated using US population projections from the US Bureau of the Census for January 1993, the midpoint of the 6-year study period.<sup>28</sup> These population-based rates were annualized.

The type of injury was grouped into categories during study analyses. Soft tissue injuries included the NEISS categories of contusions, abrasions, crushing injuries, hematomas, and strains or sprains. Lacerations included the NEISS categories of lacerations, punctures, and avulsions. The other injuries category included the NEISS categories of foreign bodies, nerve damage, internal organ injuries, hemorrhage, burns, dermatitis or conjunctivitis, and other injuries. The NEISS categories of fractures and dislocations were combined during analyses. The NEISS categories of dental injuries and concussions were each included as separate study categories without regrouping. When injuries to various parts of the body were categorized, facial injuries were grouped separately from injuries to the rest of the head and neck. The NEISS category of home, describing where the injury event occurred, included injuries occurring at the child's home, someone else's home, and included areas in and around the home such as a patio, yard, garden, and driveway.

Data were analyzed using PCSAS<sup>29</sup> software. Statistical evaluation included  $\chi^2$  analysis with Yates' correction and computation of relative risk (RR) with a 95% CI. *P* values < 0.05 were considered statistically significant.

## RESULTS

There were an estimated 249 400 trampoline-related injuries (95% CI, 166 300–332 500) to children 18 years and younger treated in hospital emergency departments in the United States during the 6-year period from 1990 through 1995. These injuries represent 88% of trampoline-related injuries to persons of all ages reported by the NEISS during this time period. The number of injuries to children 18 years and younger increased by 98% from 29 600 in 1990 to 58 400 in 1995, with an average of 41 600 (95% CI, 27 700–55 500) injuries per year, or 59.4 injuries per 100 000 US children per year (95% CI, 39.6–79.3). The median age of injured children was 10 years, and 50% were males (Fig 1). Eleven percent of children were younger than 5 years, 64% were 5 to 12 years old, and 25% were 13 to 18 years old. During the 6-year period, there was an increase of 114% in the number of trampoline-related injuries among children less than 5 years of age compared with an 85% increase among 5- to 12-year-old children and a 127% increase among children 13 to 18 years old (Fig 2).

Seasonal variation was seen with the number of injuries peaking during warm weather months (Fig 3).

Injuries to the extremities predominated among children of all ages, accounting for more than 70% of injuries (Fig 4). The relative frequency of the body part injured varied with the age of the child. With increasing age, there was a decrease in the relative frequency of injuries to the upper extremities. Among children younger than 5 years of age, upper extremity injuries accounted for 34% of all injuries, compared with 18% among children 13 to 18 years old. The opposite trend was seen for lower extremity injuries, which accounted for 30% of injuries among children less than 5 years old and 58% of injuries among children 13 to 18 years old. There was also a decrease in the relative frequency of head and neck injuries (12% vs 7%) and facial injuries (19% vs 7%) when 0- to 4-year-old children were compared with 13- to 18-year-old children.

The type of injury varied by the body part injured. Upper extremity injuries tended to be fractures or dislocations, whereas lower extremity injuries tended to be soft tissue injuries. Fractures or dislocations accounted for 64% of upper extremity injuries compared with 26% of lower extremity injuries. Soft tissue injury accounted for 32% of upper extremity injuries and 69% of lower extremity injuries. Head and neck injuries tended to be to the soft tissues (51%), and fractures or dislocations (1%) were uncommon. The most common facial injury was a laceration (66%). Fractures or dislocations accounted for an additional 9% of facial injuries and dental trauma accounted for 3%. There was a significant association between upper extremity injury and fractures or dislocations ( $\chi^2$ , *P* < .00001; RR = 3.42; 95% CI, 3.33 < RR < 3.51); lower extremity injury and soft tissue injuries ( $\chi^2$ , *P* < .00001; RR = 1.76; 95% CI, 1.74 < RR < 1.81); and facial injury and lacerations ( $\chi^2$ , *P* < .00001; RR = 9.44; 95% CI, 9.07 < RR < 9.83).

Because of the decrease in upper extremity injuries with increasing age, there was a decrease in the relative frequency of fractures and dislocations among older children. Fractures or dislocations ac-

Fig 1. Estimated number of children with trampoline-related injuries by age and gender.

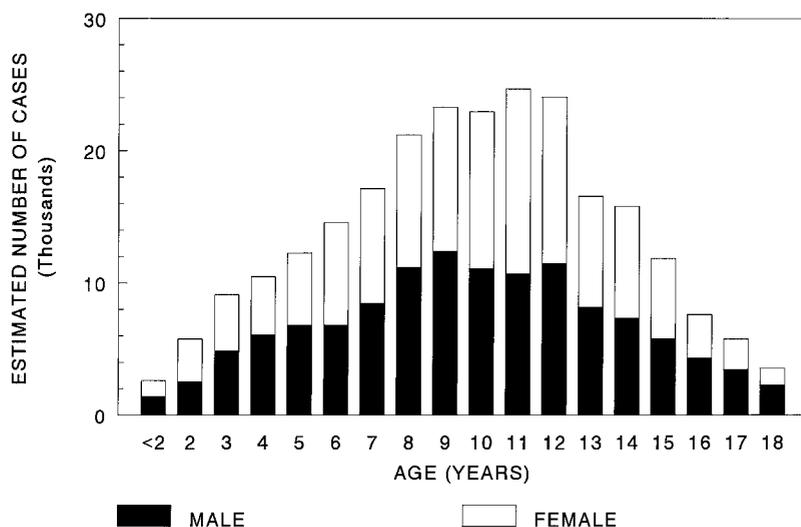


Fig 2. Estimated number of children with trampoline-related injuries by age group and year of injury.

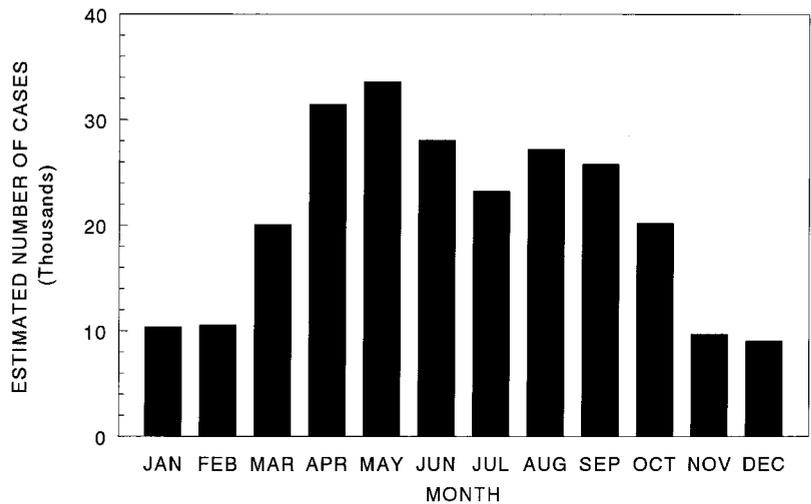
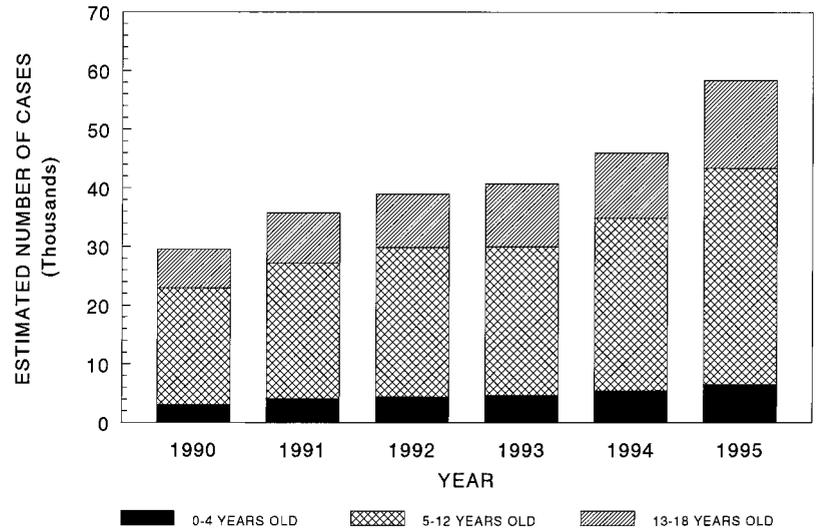
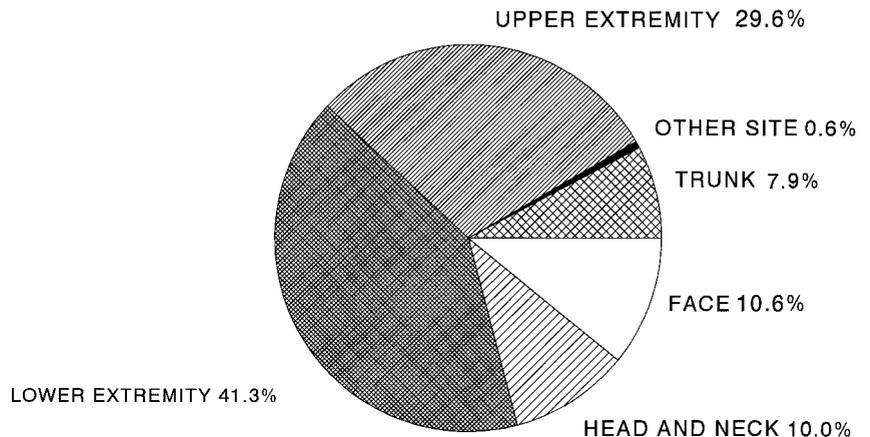


Fig 3. Estimated number of children with trampoline-related injuries by month of injury.

Fig 4. Percent of children with trampoline-related injuries by body part injured.



counted for 43% of injuries among children younger than 5 years compared with 24% among children 13 to 18 years old ( $\chi^2, P < .00001$ ; RR = 1.76; 95% CI, 1.69 < RR < 1.85). Similarly, because of the increase in lower extremity injuries with increasing child's age, there was an increase in the relative frequency of soft tissue injury with increasing age. Soft tissue injuries accounted for 31% of injuries among children less than 5 years compared with 64% among

children 13 to 18 years of age ( $\chi^2, P < .00001$ ; RR = 2.07; 95% CI, 1.98 < RR < 2.16). The decrease in the relative frequency of facial injuries with increasing age was also accompanied by a decrease in the relative frequency of lacerations among older children. Lacerations accounted for 22% of injuries among children younger than 5 years compared with 9% among children 13 to 18 years old ( $\chi^2, P < .00001$ ; RR = 2.55; 95% CI, 2.37 < RR < 2.76).

Fractures or dislocations accounted for 32% of injuries among children of all ages. The location of these fractures was the upper extremity 59%, lower extremity 33%, trunk 4%, face 3%, and head and neck region 0.4%. Dislocations were much less common than fractures and involved the upper extremity in 65% of cases and the lower extremity in 21%.

An estimated 8100 children required admission to the hospital or transfer to another hospital for treatment of a trampoline-related injury, averaging approximately 1400 children (95% CI, 800–2000) annually, or 2.0 per 100 000 US children per year (95% CI, 1.1–2.9). This represented 3.3% of all injuries among children related to trampolines. Although there was little change in the number of children admitted or transferred to another hospital from 1990 through 1995, there was a 105% increase in the number of children who were treated and released from the emergency department during this 6-year period. Therefore, the proportion of children requiring hospital admission or interhospital transfer decreased from 5% in 1990 to 2% in 1995. Fractures or dislocations accounted for 83% of injuries among children who were admitted or transferred to another hospital (Fig 5). In contrast, soft tissue injuries (53%), fractures or dislocations (30%), and lacerations (14%) predominated among children treated and released to home from the emergency department (Fig 6). Children with a fracture or dislocation were more likely to be admitted or transferred to another hospital (8.4%) than children with other types of injury ( $\chi^2$ ,  $P < .00001$ ; RR = 10.80; 95% CI, 9.40 < RR < 12.29). Among children who were admitted or transferred to another hospital, 31% had a lower extremity injury and 53% had an injury to an upper extremity. In contrast, among children treated and released from the emergency department, 42% had an injury to a lower extremity and 29% to an upper extremity.

The location where the injury occurred was known in 67% of cases. Among these cases, 93% of injuries occurred at home, 3% at a place of recreation or sports, 2% at school, and 2% on other public property. The proportion of injuries occurring at home decreased with increasing age, accounting for 94% of injuries among 0- to 4-year-old children compared with 89% among 13- to 18-year-old children. Conversely, the proportion of injuries occurring at school

or at a place of recreation or sports increased with age.

There were comparatively more soft tissue injuries and fewer fractures or dislocations occurring at school than at other locations. Soft tissue injuries accounted for 69% and fractures or dislocations accounted for 20% of trampoline-related injuries occurring at school, compared with 50% and 32%, respectively, of trampoline-associated injuries occurring at home.

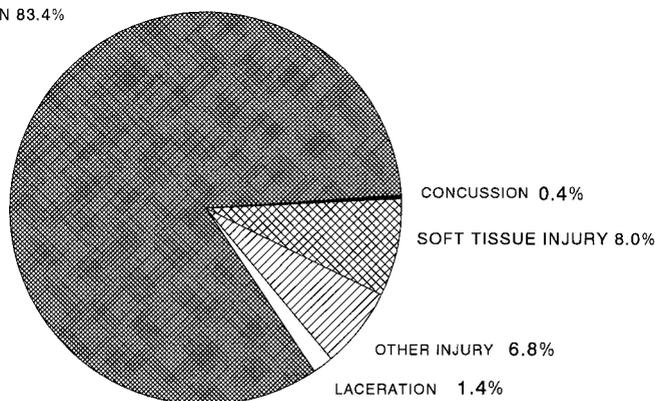
## DISCUSSION

This study identified several age-specific injury patterns related to trampolines. Injuries to the extremities predominated among children of all ages and accounted for more than 70% of all injuries. With increasing age, there was a decrease in the relative frequency of injuries to the upper extremities and a concomitant increase in the relative frequency of injuries to the lower extremities. Because of the association of fractures and dislocations with injury to the upper extremities and the association of soft tissue injuries with injury to the lower extremities, there was a decrease in fractures and dislocations and an increase in soft tissue injuries with increasing age. There was also a decrease in the relative frequency of head and neck injuries and facial injuries with increasing age. Because of the association of lacerations with facial injury, there was a decrease in the relative frequency of lacerations among older children.

Fractures or dislocations accounted for 83% of injuries among the children requiring hospital admission or interhospital transfer, and children with a fracture or dislocation were more likely to be admitted or transferred to another hospital than children with other types of injury. Because of the greater relative frequency of fractures and dislocations among younger children, hospital admission or interhospital transfer occurred more often among the young. The 3.3% rate of admission or interhospital transfer from the emergency department in this study is similar to rates seen for other pediatric injuries.<sup>30,31</sup>

There were comparatively more soft tissue injuries and fewer fractures or dislocations occurring at school than at other locations. Because older children

FRACTURE OR DISLOCATION 83.4%



**Fig 5.** Percent of children with trampoline-related injuries admitted to the hospital or transferred to another hospital by type of injury.

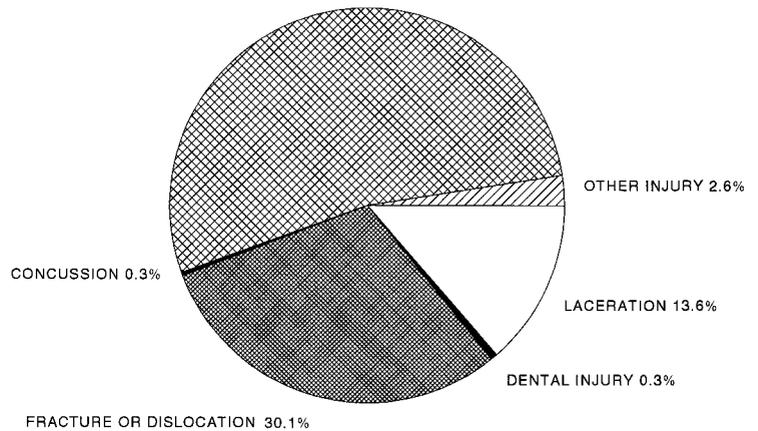


Fig 6. Percent of children with trampoline-related injuries treated in the emergency department and released to home by type of injury.

are more likely to spend time at school, this observation is consistent with the increase in the relative frequency of soft tissue injuries and the decrease in the relative frequency of fractures or dislocations with increasing age.

The popularity of trampolines grew rapidly during the 1950s and 1960s in the United States and Europe.<sup>1-5</sup> The first world trampoline championship occurred in 1964 in Frankfurt, Germany, and the last championship was held in Tulsa, Oklahoma in 1976.<sup>16</sup> Public interest in trampolines increased in 1969 after wide television coverage of Judith Anne Ford, an 18-year-old gymnast, performing on the trampoline as part of her successful bid for the Miss America crown that year.<sup>32</sup> With increasing popularity of trampolines came more reports of injuries related to their use.<sup>1-19</sup>

In response to these reports of injuries related to trampolines, a voluntary standard was issued in 1974 by the American Society for Testing and Materials.<sup>33</sup> In 1976, the CPSC published a fact sheet on trampolines based, in part, on this voluntary standard. In 1971, a decision had also been made to eliminate the trampoline from national competition by the National Collegiate Athletic Association.<sup>3,18</sup>

The American Academy of Pediatrics (AAP) issued its first statement on trampolines<sup>34</sup> in 1977. This statement noted that during the years 1973 to 1975, spinal cord injuries with permanent paralysis were associated more frequently with trampolines than with any other gymnastic sport, and trampolines were second only to football as a sports-related cause of permanent paralysis. The statement also indicated that these injuries had often occurred while participants were engaged in supervised physical education activities. The statement concluded that, "trampolines be banned from use as part of the physical education programs in grammar schools, high schools, and colleges, and also be abolished as a competitive sport."<sup>34</sup>

This AAP statement resulted in most US schools eliminating trampolines from physical education programs. Because of decreased sales and increased product liability lawsuits, the Nissen Corporation, the largest trampoline manufacturer in the United States, halted sales of trampolines and replacement parts by the end of the 1970s.<sup>3</sup>

In 1978, the American Alliance for Health, Physical Education, and Recreation issued a statement indicating that "the use of the trampoline in physical education classes does not apparently constitute an unreasonable risk of serious injury providing that . . . controls are ensured."<sup>35</sup> The statement listed eight controls and conditions that should be met for the safe use of trampolines in physical education classes.

In 1981, the AAP issued its second statement on trampolines entitled, "Trampolines II,"<sup>36</sup> which softened its previous recommendations. The AAP stated that it "does not endorse trampoline use, but a revision of the Academy's position to allow for a trial period of limited and controlled use by schools seems appropriate."<sup>36</sup> The statement included seven precautions including that "the trampoline should never be used in home or recreational settings."<sup>36</sup> No explanation was given by the AAP for its change in position, and some authors think that the AAP was ill-advised in altering its previous stricter recommendations about the use of trampolines.<sup>4,17,18</sup>

Trampolinists can achieve heights of up to 30 feet.<sup>37</sup> The height of the bounce determines the distance that the child falls and, therefore, the amount of energy that can be transferred to the child's body upon impact with the surface. Compared with adults, children are at increased risk of injury when exposed to situations with potential for transfer of such large amounts of energy because of developmental considerations such as immature judgment, coordination, and strength, as well as open growth plates of bones.

Eleven percent of trampoline-related injuries occurred among children less than 5 years old, and the number of injuries in this age group increased by 114% during the 6-year study period. The CPSC recommends that trampolines not be used by children less than 6 years of age because of immature motor skills (interview with Ann Brown, Chairman of the CPSC, CNBC "Steals and Deals" television show, July 29, 1997). Nevertheless, a ladder is available as an accessory for some trampolines, which can facilitate access to trampolines by young children. A 3-year-old girl died in 1991 when dismounting from a residential trampoline after climbing onto the trampoline while unsupervised using such a ladder.

Beginning with the report by Ellis et al,<sup>7</sup> numerous

authors have pointed out that the center of the mat is the most dangerous part of a trampoline. This is because most severe neurologic injuries result from cervical spinal cord trauma during somersault attempts. Many of these injuries have occurred while spotters were present, because a spotter at the side of a trampoline is not in a position to prevent an injury occurring in the center of the mat.<sup>15</sup> Limiting high-risk maneuvers to advanced trampolinists also will not prevent severe neurologic injuries, because most of these injuries occur to skilled and highly-skilled trampolinists.<sup>17</sup>

Previous studies indicate that 29% to 80% of injuries result from a fall off of the trampoline.<sup>1-3</sup> In addition to the use of spotters, other strategies to prevent injuries from this mechanism include the use of a trampoline bed of adequate size, providing an energy-absorbing surface without obstructions around the trampoline, and locating the trampoline in a pit with the bed of the trampoline at ground level.

Simultaneous use of a trampoline by multiple individuals has been identified as a risk factor for injury. The studies by Woodward et al<sup>1</sup> and Larson and Davis<sup>3</sup> found that more than one person was on the trampoline at the time of injury in 77% and 64% of cases, respectively. Small children may be particularly at increased risk when trampolining with a heavier partner because of the amount of force with which a trampoline mat recoils after a bounce by the heavier individual.<sup>10</sup>

The doubling of trampoline-related injuries among US children during the 6-year period covered by this study to more than 58 000 annually in 1995 indicates a concerning epidemic trend. Ninety-three percent of injuries occurred at home, which underscores the necessity of focusing prevention efforts on backyard trampoline use. Data from New Zealand indicate that 59% to 71% of trampoline-related injuries occur at home in that country.<sup>2</sup> In addition to the AAP,<sup>36</sup> a number of authors have recommended against the recreational use of backyard trampolines.<sup>1,2,9,15,16</sup>

Injury prevention theory indicates that prevention strategies requiring increased human effort or action are least likely to succeed in preventing injuries.<sup>38</sup> Education of parents about consumer product-related hazards and the use of warning labels have not been effective in preventing pediatric injuries related to other consumer products,<sup>31,39,40</sup> and are unlikely to be effective strategies in preventing trampoline-related injuries. In compliance with the voluntary standards established by the American Society for Testing and Materials,<sup>41</sup> trampoline manufacturers currently provide cautionary labeling and instructions with their products. Adult supervision also cannot be relied upon to decrease trampoline-related injuries. Even supervision by trained spotters has been ineffective in preventing serious trampoline-related injury.<sup>15</sup>

The number of injuries treated in US emergency departments associated with trampolines is more than twice the number attributable to baby walkers.<sup>39</sup> Injuries related to both these consumer products occur primarily to children and are almost entirely

because of falls.<sup>31,39,42</sup> The American Medical Association and the AAP have joined with other groups calling for a ban on the sale of baby walkers in the United States, and the American Medical Association has called infant walkers a "lethal form of transportation."<sup>43</sup> Commensurately strong positions are needed from these and other health and child advocacy organizations calling for a halt to the sale and use of backyard trampolines, especially given the rapidly increasing number of trampoline-related injuries occurring at home among US children. The skills and enjoyment obtained from trampolining by children can be acquired through other safer recreational activities and sports, including other forms of gymnastics.

The reasons for the observed doubling of the number of trampoline-related injuries during the study period cannot be determined from study data. Increasing numbers of backyard trampolines, resulting in increased exposure of children to these devices, is likely to have been an important contributing factor. Trampoline sales offer an indirect measure of the number of trampolines in use and trampoline usage. As many as 500 000 trampolines intended for backyard use are sold annually in the United States, representing \$125 million in retail sales (A. C. Homan, "Trampolines," Directorate for Economics, CPSC, February 16, 1995). Backyard trampolines are widely available in stores carrying sporting goods, and can be purchased for less than \$250. A leading trampoline manufacturer reports an estimated 5-fold increase in sales during the approximate time period covered by this study (CNBC "Steals and Deals" TV show, July 29, 1997). The observed increase in the number of trampoline-related injuries treated in emergency departments could also be attributable to changes in the rate or severity of these injuries, changes in patients' use of emergency departments as a source of care, or a combination of these factors. Further research is needed to elucidate the relative contribution of these and other factors to the observed trend.

A limitation of the NEISS is the potential selection bias inherent in who receives emergency care for an injury. NEISS data cannot be used to estimate the number of trampoline-related injuries treated in settings outside of emergency departments, or the number of injuries not receiving medical attention.

## CONCLUSION

Injuries related to trampolines, especially backyard trampolines, are an important cause of pediatric morbidity. These injuries have also resulted in death. The rapid increase in the number of trampoline-related injuries to children during recent years is evidence that current prevention strategies are inadequate. Children should not use trampolines at home. The sale of trampolines for private recreational use should be stopped, and a trade-in campaign should be conducted nationally to decrease the number of existing backyard trampolines.

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Gary A. Smith

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