

Trampoline Park and Home Trampoline Injuries

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abstract

BACKGROUND AND OBJECTIVE: Trampoline parks, indoor recreational facilities with wall-to-wall trampolines, are increasing in number and popularity. The objective was to identify trends in emergency department visits for trampoline park injuries (TPIs) and compare TPI characteristics with home trampoline injuries (HTIs).

METHODS: Data on trampoline injuries from the National Electronic Injury Surveillance System from 2010 to 2014 were analyzed. Sample weights were applied to estimate yearly national injury trends; unweighted cases were used for comparison of injury patterns.

RESULTS: Estimated US emergency department visits for TPI increased significantly, from 581 in 2010 to 6932 in 2014 ($P = .045$), whereas HTIs did not increase ($P = .13$). Patients with TPI ($n = 330$) were older than patients with HTI ($n = 7933$) (mean 13.3 vs 9.5 years, respectively, $P < .001$) and predominantly male. Sprains and fractures were the most common injuries at trampoline parks and homes. Compared with HTIs, TPIs were less likely to involve head injury (odds ratio [OR] 0.64; 95% confidence interval [CI], 0.46–0.89), more likely to involve lower extremity injury (OR 2.39; 95% CI, 1.91–2.98), more likely to be a dislocation (OR 2.12; 95% CI, 1.10–4.09), and more likely to warrant admission (OR 1.76; 95% CI, 1.19–2.61). TPIs necessitating hospital admission included open fractures and spinal cord injuries. TPI mechanisms included falls, contact with other jumpers, and flips.

CONCLUSIONS: TPI patterns differed significantly from HTIs. TPIs are an emerging concern; additional investigation and strategies are needed to prevent injury at trampoline parks.

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WHAT'S KNOWN ON THIS SUBJECT: Trampoline use carries significant risk of injury to children. Most trampoline injuries occur on home trampolines. Multiple studies describe injury types and mechanisms on home trampolines; little is known about trampoline park injuries (TPIs).

WHAT THIS STUDY ADDS: TPIs increased significantly from 2010 to 2014. TPIs often involved lower extremity sprains and fractures. Serious injuries included open fractures and spinal cord injuries. TPIs had higher odds of hospital admission than home trampoline injuries.

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Trampoline use poses significant risk of injury to children.^{1–11} Estimates from the National Electronic Injury Surveillance System (NEISS) show that trampoline injuries result in nearly 100 000 emergency department (ED) visits a year.¹¹ Trampoline injuries can occur from falls on the trampoline mat, falls off a trampoline, impact with the trampoline frame or springs, and collisions of multiple trampoline users.^{3,4,12–15} Serious injuries including cervical spine and skull fractures have been reported.^{3,11,16,17} Because of the risks associated with trampoline use, trampoline use by children is discouraged, but its popularity persists.^{1–3,8,14} The American Academy of Pediatrics policy statement on trampoline safety recommends against recreational trampoline use by children and recommends that if trampolines are used, safety measures should include constant adult supervision, adequate protective padding, 1 jumper per trampoline, and avoidance of flips and somersaults.¹

Indoor trampoline parks typically consist of wall-to-wall connected trampolines with padded walls or angled trampoline walls. Over the past several years, indoor trampoline parks have increased in number and popularity.^{18,19} Despite the risk of injury with trampoline use, trampoline parks are popular for children and families. According to the International Association of Trampoline Parks, in 2011 there were only 35 to 40 trampoline parks in existence, compared with 280 in 2014.¹⁸ Trampoline parks continue to spring up at a rate of 5 or 6 a month, with expectations of ~450 trampoline parks in the United States by the end of 2015.^{18,19} Safety guidelines vary from park to park; some include safety guidelines such as discouraging flips and somersaults or limiting the number of jumpers per trampoline, whereas others allow flips.^{20–22} The design may include

appropriate padding and setups that prevent falling off trampolines, such as placement of trampolines at ground level and surrounding trampolines with padding or trampoline walls. However, there are often multiple jumpers, a practice associated with increased risk for injury on trampolines.^{4,8,12,15,23,24} To our knowledge, there have been no published studies focusing on injuries at trampoline parks. This study investigates national trends in trampoline park injuries (TPIs) and compares demographic features and injury characteristics between TPIs and home trampoline injuries (HTIs). These data will aid in promoting safe use and developing future policy guidelines.

METHODS

A retrospective study of TPIs and HTIs from the NEISS database from January 1, 2010 to December 31, 2014 was performed. This start date was chosen because only 1 TPI was reported to NEISS before 2010. The study was approved by our institutional review board.

Data Source

The NEISS database of the US Consumer Product Safety Commission provides data on consumer product-related injuries treated in US EDs by using a stratified probability sample of EDs from across the country with 24-hour emergency service and at least ≥6 beds.²⁵ At the 100 hospitals that make up this statistically representative sample of US EDs, injury-related ED visits are entered in the database daily with injury information including age, gender, race, injury type, body part injured, disposition from the ED, location where the injury occurred, and a brief narrative description of the injury event for each case. Cases in the database are given a weight based on the inverse probability of

selection, which can be applied to estimate national injury frequency.

Study Design

Product code 1233 for trampoline was used to identify trampoline-related injuries from 2010 to 2014 in the NEISS database. Injury location is coded in 9 categories: home, farm or ranch, street or highway, other public property, mobile home, industrial place, school, place of recreation or sports (hereby referred to as recreational facilities), and unknown location. The study control group consisted of injuries occurring at home (sustained at a home or in a yard). All cases with location “home” were included in the control group ($n = 7933$). We identified TPI cases ($n = 330$) by searching narrative comments of cases with a location of “recreational facility” (which also includes bowling alleys, parks, amusement parks, sports fields, and other facilities) or other public property. Cases were included if the narrative included “trampoline park,” “trampoline place,” “trampoline playground,” “trampoline center,” “trampoline gym,” “indoor trampoline party,” playing dodgeball on a trampoline, the name of a trampoline park, or a redacted facility name that was confirmed by the NEISS to be a trampoline park. Cases documented as occurring at a “park” or “gym” rather than “trampoline park” or “trampoline gym” were excluded. Other exclusion criteria included gymnastics or competitive trampoline injuries and cases occurring at a facility that does not typically have wall-to-wall trampolines (eg, YMCA). A second reviewer reviewed TPI cases for inclusion and agreed with assignment in all cases.

Sample weights were applied to cases to estimate national number of TPIs and show trends in injuries over time. Unweighted cases were used to compare features of TPIs and HTIs

because of the small number of TPI cases.

Variables

TPIs and HTIs were compared by demographics, injury type, body part injured, and disposition. Several injury types were grouped together for analysis into the following categories: concussion (concussion, internal organ injury to head, headache), contusion or abrasion (contusion or abrasion, hematoma, crush injury), fracture (fracture, nerve damage with fracture), laceration (laceration, puncture wound, skin avulsion), pain (pain or injury to a certain body part without other specified injury), sprain (sprain or strain), and other (all remaining injuries not previously specified). Body parts were grouped in the following categories: head (head, eyeball, face, mouth, ear), upper extremity (shoulder or clavicle, arm, elbow, hand, wrist, finger), lower extremity (ankle, toe, foot, leg, knee, hip), neck, chest or trunk, and other (internal injury or affecting whole body). Mechanism of injury was determined from narrative comments for TPI cases. Injury type, body part injured, and disposition were analyzed by age group, with pediatric patients divided by age <6 years and 6 to 17 years, because previous studies have shown higher risk for certain types of trampoline injuries in children <6 years of age.¹³ Comparison of TPI and HTI features (injury type, body part injured, and disposition) was also conducted with adult patients excluded; significant findings did not differ, with the exception of a lack of significance in the rate of concussions ($P = .087$) and ED discharges ($P = .075$).

Statistical Analysis

SPSS software (IBM SPSS Statistics, IBM Corporation) was used for statistical analyses. We compared estimated TPIs for yearly variation by using linear regression. Demographics, injury features, and

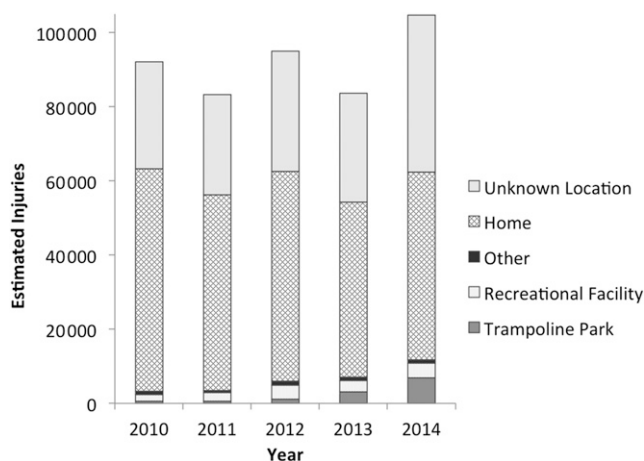


FIGURE 1

Estimated US ED visits for trampoline injuries by location. In 2009 no TPIs were reported to the NEISS. "Other" includes schools, farms, and public properties.

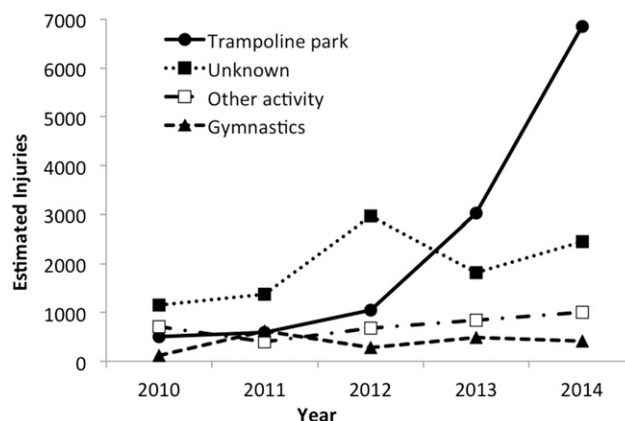


FIGURE 2

Trampoline injuries at recreational facilities: injuries at trampoline parks versus trampoline injuries during other recreational activities. Other activities include trampoline injuries in cheerleading, dance, karate, playgrounds, parks, and camps. In some cases the type of activity could not be determined.

hospital admission were compared via t tests, χ^2 , or 2-proportion z tests, and odds ratios (ORs) with 95% confidence intervals (CIs). Statistical significance was set at $\alpha = 0.05$ for all analyses.

RESULTS

ED Visit Trends

Estimated yearly US ED visits for trampoline injuries did not vary significantly during the study period ($P = .44$), with an average of 91 750 injuries per year from 2010 to 2014 (Fig 1). The majority of these injuries

occurred at homes; the yearly number of HTIs did not significantly vary ($P = .13$). TPIs increased significantly during the study period ($P = .045$), with 6932 TPIs in 2014, accounting for 11% of all trampoline injuries that year (among injuries where the location was known). Since 2011, trampoline parks have been the most common location of recreational facility trampoline injuries (Fig 2).

Home Versus Trampoline Park Injuries

Demographic features of patients with TPIs ($n = 330$) and HTIs ($n = 7933$)

are summarized in Table 1. Patients with TPI were older than patients with HTI, with a mean age of 13.3 years (median 12.0 years, range 19 months–44 years) versus 9.5 years (median age 8.0 years, range 4 months–76 years) for HTI ($P < .001$). For both TPIs and HTIs, a higher percentage of patients were male (58.8% and 53.5%, respectively).

Sprains and fractures were the most commonly reported injury types at trampoline parks and homes (Fig 3). Patients injured at trampoline parks were more likely to have sprains (OR 1.61; 95% CI, 1.28–2.02) and dislocations (OR 2.12; 95% CI, 1.10–4.09). Patients with TPI were less likely to have concussions (OR 0.49; 95% CI, 0.26–0.93), lacerations (OR 0.45; 95% CI, 0.27–0.75), and contusions or abrasions (OR 0.59; 95% CI, 0.41–0.85).

The distributions of body parts injured in TPIs and HTIs are depicted in Fig 4. Compared with HTIs, TPIs were less likely to involve head injury (OR 0.64; 95% CI, 0.46–0.89) and upper extremity injury (OR 0.40; 95% CI, 0.29–0.54) and more likely to involve lower extremity injury (OR 2.39; 95% CI, 1.91–2.98). The most common injury types of each body part at trampoline parks were as follows: chest or trunk: sprains (57%) and contusion or abrasions (23%), head: lacerations (39%) and concussions (24%), lower extremity: sprains (46%) and fractures (35%), neck: sprains (71%) and fractures (21%), and upper extremity: fractures (64%) and sprains (21%). Among head injuries, facial bone fractures were also common (10%).

Injury types at trampoline parks showed several differences by age. At trampoline parks, fractures were significantly more common in younger children than in adolescents and adults, accounting for 47.8%

TABLE 1 Demographic Features and ED Disposition for TPIs and HTIs

Characteristics	TPIs, n (%)	HTIs, n (%)	P
Number of cases	330	7933	
Age			
<6 y	46 (13.9)	2405 (30.3)	<.001
6–17 y	221 (67.0)	4921 (62.0)	.07
≥18 y	63 (19.1)	607 (7.7)	<.001
Gender			.06
Female	136 (41.2)	3685 (46.5)	
Male	194 (58.8)	4248 (53.5)	
Race			.07
White	182 (55.2)	4863 (61.3)	
Black	28 (8.5)	463 (5.8)	
Other	47 (14.2)	972 (12.3)	
Unknown	73 (22.1)	1635 (20.6)	
Ethnicity			.94
Hispanic	35 (10.6)	851 (10.7)	
ED disposition			
Admitted	29 (8.8)	411 (5.2)	.004
Observation	1 (0.3)	33 (0.4)	.75
Transferred	0 (0)	56 (0.7)	.13
Other ^a	2 (0.6)	30 (0.4)	.51
Discharged	298 (90.3)	7403 (93.3)	.03

^a "Other" includes left without being seen or against medical advice.

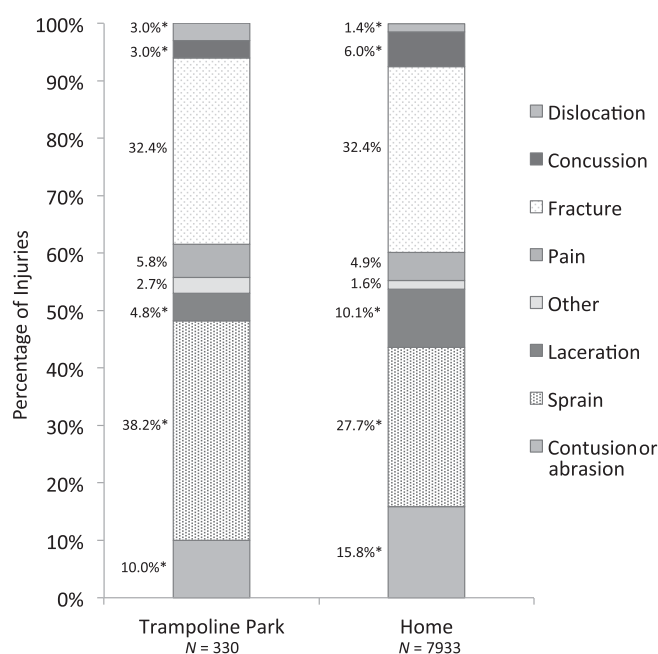


FIGURE 3

Injury types for TPIs versus HTIs. *Significant difference $P < .05$.

of injuries in children <6 years old, 33.5% in children 6 to 17 years, and 17.5% in adults ($P = .003$). Children <6 years old were less likely to sustain sprains (19.6% of injuries) compared with children ages 6 to 17 years old (38.0%) and adults (52.4%) ($P = .002$). Lower extremities remained the most common body

part injured at trampoline parks in all age groups. The only significant difference in body part injured by age was an increase in neck injuries with increasing age, with neck injuries representing 0% of injuries in patients <6 years old, 3.6% in ages 6 to 17 years, and 9.5% in adults ($P = .037$).

ED Disposition

Patients injured at trampoline parks were more often admitted than patients with HTIs (OR 1.76; 95% CI, 1.19–2.61) (Table 1). Disposition, including admission, for patients with TPI did not vary significantly across age groups ($P = .78$). The most common injuries in admitted patients were lower leg fractures for TPIs (59% of admissions), compared with elbow fractures (34%) and forearm fractures (18%) for HTIs. TPIs resulting in hospital admission

included open leg fractures ($n = 4$), a skull fracture ($n = 1$), and cervical spine fractures with spinal cord injury ($n = 2$). Both patients with spinal cord injuries (ages 17 and 20 years old) sustained the injury performing a flip, with 1 landing on his head on a bar and the other jumping into a foam pit. There were no definite spinal cord injuries recorded among the 7933 HTI cases; there was 1 case of “possible nerve damage” from an upper back injury and 6 cases of cervical spine fracture

without mention of spinal cord injury from home trampolines.

TPI Mechanisms

Injury mechanisms at trampoline parks are described in Table 2. Injuries most often occurred on landing (33% of injuries), including twisting of the ankle or knee or landing on other body parts. A number of injuries at trampoline parks involved another jumper (8%), including a collision with or a fall onto another child, or another jumper caused a child to be launched into the air or to fall. Several severe injuries resulted from contact with the trampoline frame, the springs, or the ground. Multiple injuries were associated with performing flips (8%), including both cases of cervical spine fracture.

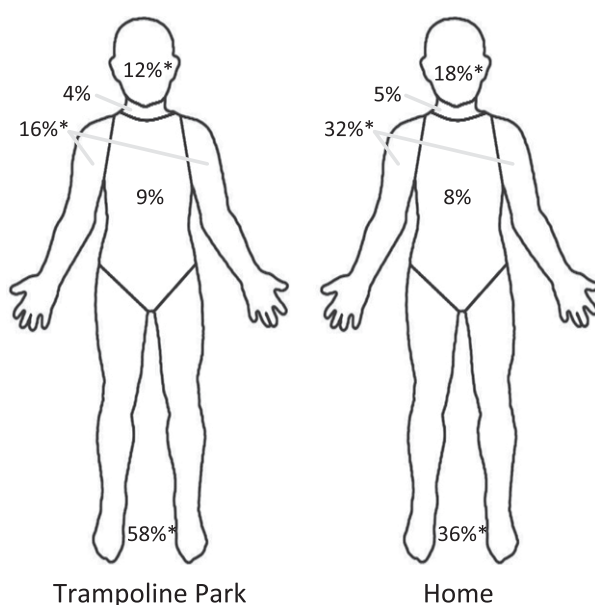


FIGURE 4

Distribution of injuries: body part injured (by percentage) at trampoline parks ($n = 330$) and home trampolines ($n = 7933$). *Significant difference $P < .05$.

DISCUSSION

Our study confirmed that injuries at trampoline parks are increasing as trampoline parks grow in popularity (Figs 1 and 2).¹⁹ Injuries at trampoline parks increased substantially, whereas total trampoline injuries in the United States remained stable (Fig 1). Although only a fraction of trampoline-related injuries occurred at trampoline parks (11% in 2014), the trend in TPIs is alarming;

TABLE 2 Injury Mechanisms at Trampoline Parks

Injury Mechanism	Injuries, n (%)	Most Common Associated Injury Types
Fell or “landed wrong”	109 (33)	Sprain ($n = 44$), fracture ($n = 42$), pain ($n = 8$)
Twisted ankle or knee	38 (12)	Sprain ($n = 26$), fracture ($n = 9$)
Injury involving another jumper	28 (8)	Fracture ($n = 11$), sprain ($n = 6$), contusion or abrasion ($n = 4$)
Flip	27 (8)	Sprain ^a ($n = 12$), fracture ^b ($n = 9$), contusion or abrasion ($n = 2$)
Contact with structures	22 (7)	Fracture ^c ($n = 8$), sprain ($n = 5$), laceration ($n = 3$)
Fell off trampoline	14 (4)	Fracture ($n = 6$), sprain ($n = 4$), dislocation ($n = 1$)
Knee hit face	8 (2)	Laceration ($n = 5$), facial fracture ($n = 2$)
Dodgeball	6 (2)	Sprain ($n = 3$), concussion ($n = 1$), fracture ($n = 1$)
Jumping into foam pit	4 (1)	Sprain ($n = 3$), cervical spine fracture or spinal cord injury ($n = 1$)
Other ^d	9 (3)	
Unknown	117 (35)	

Some injuries had >1 mechanism and are included in multiple categories. The injury mechanism could not be determined for 117 of 330 TPI cases.

^a Includes 5 neck sprains.

^b Includes 2 cervical spine fractures with spinal cord injury.

^c Includes 3 open fractures.

^d Other includes basketball, volleyball, and jumping.

particularly concerning was the occurrence of severe and debilitating injuries such as spinal cord injuries. In addition to the 2 cases of spinal cord injuries at trampoline parks in the NEISS sample, multiple cases of spinal cord injuries have been reported in the media,^{26–30} as well as a traumatic brain injury³¹ and 2 deaths at trampoline parks.^{32,33} Trampoline parks face significant liability challenges, with a lawsuit resulting in an \$11.5-million award,³¹ multiple pending lawsuits,^{29,30} and several settled suits that led to the closure of 1 trampoline park.³⁴

TPIs and HTIs shared a number of common features but showed notable differences in several characteristics. Both TPIs and HTIs showed a male predominance, which is a common finding for other pediatric injuries as well.^{35,36} Injuries from both trampoline parks and homes often involved sprains and fractures. Young children (<6 years) more often sustained fractures, as previously reported.^{2,7,13} Fractures in young children include proximal tibia fractures from jumping with older children,^{37,38} although the frequency of this fracture type at trampoline parks could not be determined from these data. TPIs resulted in a higher prevalence of lower extremity injuries and fewer upper extremity and head injuries when compared with HTIs.

Upper extremity and head injuries often result from falls off a trampoline.^{4,5,10,39} Probably because of the wall-to-wall trampoline design, there were few falls from trampolines at trampoline parks (Table 2), which may account for the decreased proportion of head and arm injuries at trampoline parks. Lower extremity injuries were common at trampoline parks, and a number of serious lower extremity injuries were reported, including open fractures, dislocations, and

other leg fractures necessitating hospital admission. It is unclear from our study whether there is a higher inherent risk for leg injury at trampoline parks or whether this discrepancy results from a larger proportion of lower extremity injuries due to relative lack of upper extremity injuries. It is plausible that trampoline parks pose a high risk for leg injuries because of the high heights or velocities attained in jumping and the resulting increase in stress on the lower extremities. Landing on trampoline park trampoline frames also contributed to the frequency and severity of leg injuries (Table 2). Additional investigation is warranted to find ways to minimize leg injuries at trampoline parks, which could include improvements in frame padding or design.

Injury mechanisms at trampoline parks included similar mechanisms to those previously reported on home trampolines: landing wrong, contact with other jumpers, flips, falling off trampolines, and landing on the frame or springs.^{3,6,12,13} Falling off was a less common mechanism at trampoline parks (4%) than has been reported on home trampolines (27%–39%).^{3,6,12} In addition to common injury mechanisms, TPI mechanisms included novel injury mechanisms such as trampoline-based sports including trampoline dodgeball and volleyball.

Several severe injuries at trampoline parks resulted from contact with trampoline frames, springs, or surrounding structures such as poles. The most common injury from contact with support structures was fracture (36%), of which 3 out of 8 were open fractures. Although padding over trampoline frames and springs is recommended, the addition of padding has not necessarily reduced injuries on home trampolines,¹² and our study

suggests there is also room for improvements in trampoline park design. One trampoline design that has been shown to reduce injury is a “soft-edge trampoline” design that has no springs on the jumping surface and includes a netted enclosure without rigid supports.⁴⁰

Falls off trampolines have been associated with increased severity of injuries, such as fractures necessitating surgery, and higher admission rates.^{3,10,24,41} Despite the low occurrence of falls off of trampolines as the injury mechanism at trampoline parks (4% of TPIs), our study found higher admission rate for TPIs, suggesting other reasons for more severe injuries. Flips have been recognized as carrying high risk, including risk of spinal cord injury.^{3,16,17} Our data support this finding, with 2 cases of spinal cord injuries occurring from flips. Given the potential severity of neck injuries, flips should be avoided at trampoline parks, in accordance with the American Academy of Pediatrics policy statement on trampoline safety.¹

Adult supervision has been proposed to reduce trampoline injuries in children, although trampoline injuries often occur despite adult supervision.^{6,9,14} Most trampoline parks have constant supervision of jumpers by park personnel^{20,21}; whether a supervisor was present could not be determined from our data. The supervised environment may promote a sense of complacency and underestimation of risk at trampoline parks. However, dutiful supervision could be helpful to enforce trampoline park rules such as allowing only a single jumper per trampoline, because injuries resulting from multiple jumpers are problematic (Table 2).^{4,8,15,42} Some parks have a separate designated area for young children, which could increase safety for younger jumpers because studies show that a younger

child is most often the victim when multiple children are involved.^{4,8,15}

This study does have limitations. The NEISS has incomplete data including injury locations and mechanisms. Because the type of recreational facility was not known in a number of cases, our study probably underestimates the number of trampoline park injuries. Although the NEISS is a representative sample of ED visits, it does not include injuries for which care was not sought in an ED, which could exclude less severe injuries. Additionally, without knowing the frequency of trampoline park attendance, we could not determine the risk of injury during a trip to a trampoline park or compare the risks of trampoline park use with home trampoline use.

CONCLUSIONS

Trampoline use carries significant risk of injury to children, and trampoline parks are no exception. ED visits for TPIs are increasing substantially. Trampoline park use can result in severe injuries through varied mechanisms, with TPIs often involving lower extremity sprains and fractures and rarely open fractures and spinal cord injuries. Patients with TPI were more likely to need hospital admission than those with HTIs. Prevention strategies should focus on common injuries such as lower extremity sprains and fractures, as well as strategies to prevent serious injuries. As is recommended for home trampolines, flips should be restricted and contact between jumpers should be minimized. Furthermore, improved padding to provide protection from landing on trampoline frames may help prevent some injuries. Understanding features and mechanisms of TPIs is essential in forming injury prevention strategies for recreational trampoline use.

ABBREVIATIONS

CI: confidence interval
ED: emergency department
HTI: home trampoline injury
NEISS: National Electronic Injury Surveillance System
OR: odds ratio
TPI: trampoline park injury

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