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Consumer products and activities associated with dental injuries to children treated in United States emergency departments, 1990–2003

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Abstract – *Objective*: Describe the association of consumer products and activities with dental injuries among children 0–17 years of age treated in United States emergency departments. *Design*: A retrospective analysis of data from the National Electronic Injury Surveillance System, 1990–2003. *Results*: There was an average of 22 000 dental injuries annually among children < 18 years of age during the study period, representing an average annual rate of 31.6 dental injuries per 100 000 population. Children with primary dentition (< 7 years) sustained over half of the dental injuries recorded, and products/activities associated with home structures/furniture were the leading contributors. Floors, steps, tables, and beds were the consumer products within the home most associated with dental injuries. Outdoor recreational products/activities were associated with the largest number of dental injuries among children with mixed dentition (7–12 years); almost half of these were associated with the bicycle, which was the consumer product associated with the largest number of dental injuries. Among children with permanent teeth (13- to 17-year olds), sports-related products/activities were associated with the highest number of dental injuries. Of all sports, baseball and basketball were associated with the largest number of dental injuries. *Conclusion*: To our knowledge, this is the first study to evaluate dental injuries among children using a national sample. We identified the leading consumer products/activities associated with dental injuries to children with primary, mixed, and permanent dentition. Knowledge of these consumer products/activities allows for more focused and effective prevention strategies.

Dental injuries are a common cause of morbidity among children. According to recent population-based studies, the prevalence of pediatric traumatic dental injuries ranges from 4.1 to 58.6% (1). Among children of preschool age, traumatic oral injuries account for 17% of all injuries (2). Along with the initial physical discomfort of the incident, dental injuries can have subsequent functional, social, and psychological consequences (3, 4). The direct and indirect costs of treatment of dental injuries are substantial, and these costs vary depending on the severity of the injury and whether permanent dentition is involved (5–7). The total cost of dental injuries to individuals 0–19 years of age was calculated in one prospective study to be $3.3–$4.4 million US per million individuals annually (8). Therefore, focus should be directed toward understanding the epidemiology of dental injuries in order to effectively implement preventive measures.

Historically, falls at home cause the majority of traumatic dental injuries among pre-school children and involve house structures, furniture, and stairs (9). Other etiologies of pediatric dental injuries include motor vehicle crashes, bicycle-related falls and collisions, sports, playground equipment, and being struck. Few studies have described the association of specific consumer products and activities with dental injuries among children (10–13). Furthermore, most studies have been conducted at single sites, such as a dental clinic or an emergency department (ED). The goal of our study was to describe the association of specific consumer products and activities with pediatric dental injuries treated in hospital EDs in the United States (US) using a nationally representative data set.

Methods

The US Consumer Product Safety Commission monitors consumer product-related injuries treated in US hospital EDs 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. It receives data from a network of hospitals that represent a stratified probability sample of the approximately 6100 hospitals in the US that have at least six beds and provide 24-h emergency services (14). Because data are collected daily from a statistically representative sample of hospital EDs, category weights can be applied to NEISS data to estimate the number and describe the epidemiology of

injuries associated with consumer products and activities for the entire nation (15, 16). The NEISS has been shown to be highly sensitive and accurate in identifying consumer product-related injury cases (17, 18).

Data were obtained from the NEISS regarding dental injuries reported during a 14-year period, 1990–2003. Each case includes patient information, such as age, race, gender, injured body part, diagnosis, consumer product/activity, and comments that describe the event and/or injury. Every case obtained from NEISS was categorized as body part 88 (teeth) and diagnosis 60 (dental injury). All cases aged 18 years and older were excluded from the study. When the case's descriptor was not relevant to dental injury (e.g. described as an arm fracture) or the same case was repeated (all the information provided was the same), the case was excluded. If any oral/mouth trauma was described in the comments, but it was not explicitly stated that there was a dental injury (e.g. mouth injuries, frenulum lacerations, oral mucosa injuries), the case was included because it was categorized as a dental injury and an associated dental injury could not be excluded; these cases accounted for 18 800 (6.1%) of all weighted cases. The NEISS does not include a variable regarding the severity of injury, and few of the case narratives included information about the severity of the dental injury using the Ellis classification or other descriptors (e.g. avulsion, subluxation). Therefore, the severity of dental injuries was not included in analyses in this study.

Using the consumer products/activities listed, the following four major consumer product/activity groups were created: home structures/furniture, sports, outdoor recreation, and miscellaneous. Home structures/furniture were considered to be inanimate objects that are usually part of the structure of the home or are free standing in the home – including furniture and appliances. Outdoor recreation included bicycles, playground equipment, trampolines, pools, and all-terrain vehicles. Sports included recreational and organized sports activities. Miscellaneous consumer products were any products that did not fit into each of the other three main group categories and included products such as kitchen utensils, fixed objects outside the home, musical instruments, tools, and toys (see Appendix). It should be noted that motor vehicle crashes, a known contributor to severe dental injuries, are not included in the NEISS data set.

Each individual event was assigned to one of the major consumer product/activity groups based on the product or activity listed. With falls, if two products were listed, the primary product was determined by which object initiated the event. For example, if the patient fell off the bed and landed on the floor, the primary product associated with the fall was determined to be the bed. However, if the patient was struck in the mouth and two products were listed, the primary product was determined by which object caused the injury. For example, if a ball struck a trumpet while a child was playing it, the primary product was determined to be the trumpet.

As in a previous study by Wilson et al., ages were categorized into three groups: <7, 7–12, and 13–17 years, which correspond to primary, mixed, and permanent dentition, respectively (7). Six cases in the data set had unknown ages, representing 97 weighted cases, and were not included in analyses of age.

Population data were acquired from the United States Census Bureau website (http://www.census.gov). From this website, we obtained the annual US population by age and gender from 1990 to 2003. Annual dental injury rates were then determined by dividing the average number of dental injuries per year by the average number of people in the corresponding age and/or gender category.

Data were analyzed using SPSS/PC software version 14.0 for personal computers using the weighted data for all analyses. Statistical evaluation included chi-square analysis with Yates' correction and computation of injury proportion ratios (IPRs) with a 95% confidence interval (CI). IPRs are risk ratios and are calculated the same as relative risks. P values <0.05 were considered statistically significant.

Results

Overview

An estimated 308 900 dental injuries to children 17 years of age or younger were treated in US EDs from 1990 to 2003. The average number of dental injuries was 22 000 per year, and the mean annual dental injury rate was 31.6 dental injuries per 100 000 population. Children 17 years of age and younger represented 80.6% of the dental injuries for all ages that were reported via the NEISS during this time period. There were 16 300 pediatric dental injuries in 1990 compared with 28 200 in 2003, representing a 73.1% increase in the annual number of injuries during this 14-year period.

The greatest number of dental injuries occurred among children 1–2 years of age, accounting for 24.5% of the dental injuries among children 17 years of age and younger. Children 1–2 years old also experienced the highest dental injury rates (Fig. 1). Children <7 years of age accounted for 59.6% of injuries, while the 7–12 and 13–17 year age groups made up 29.5% and 10.9%, respectively. When evaluated by age group, children <7 years had the highest annual dental injury rate (48.3 per 100 000 population), followed by 7–12 year olds (27.7 dental injuries per 100 000 population) and 13–17 year olds (12.6 dental injuries per 100 000 population).

Males sustained dental injuries more often than females in every age group and in every consumer product group (Fig. 1). Overall, males accounted for 63.5% of all dental injuries. The mean annual dental injury rate for males was 39.1 per 100 000 population. The percentage of males sustaining dental injuries was significantly higher for 7–17 year olds (55.6%) compared with <7 year olds (44.4%) (χ^2, $P < 0.01$, IPR = 1.18, 95% CI = 1.17–1.19). The male to female ratio rose from 1.45 in the <7 year age group to 2.16 and 2.84 in the 7–12 and 13–17 year age groups, respectively.

House structures/furniture

Consumer products that are part of house structures and/or furniture were the most common products related

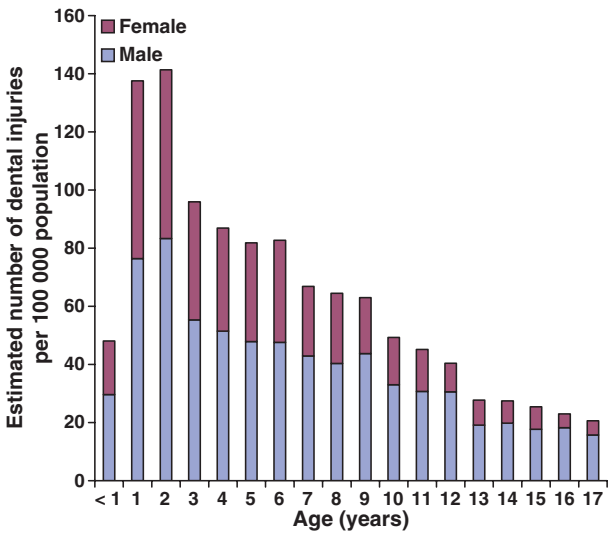

Fig. 1. Estimated number of dental injuries per 100 000 by age and gender treated in US emergency departments, 1990–2003.

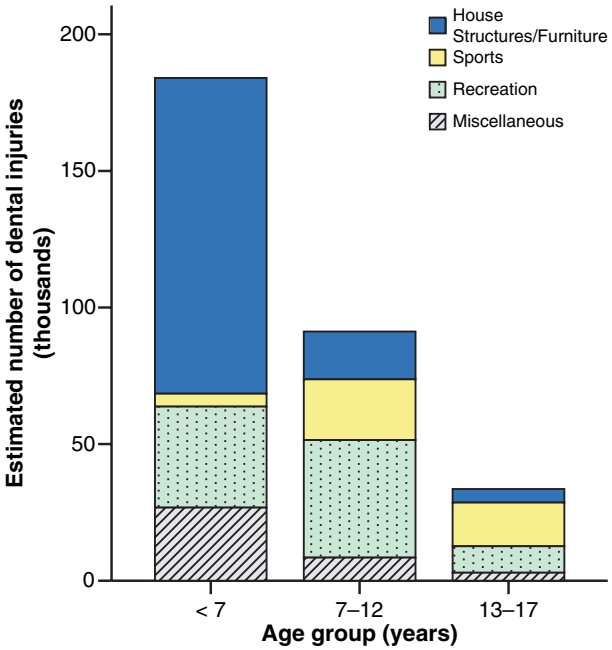

Fig. 2. Estimated number of dental injuries associated with consumer product/activity categories by age group treated in US emergency departments, 1990–2003.

to dental injuries, accounting for 44.8% of the total number of dental injuries to children (Table 1). Among this product group, falls associated with floors (20.8%), steps (16.3%), tables (13.9%) and beds (13.8%) were the most common.

House structures/furniture was the leading consumer product group associated with dental injuries in the < 7 years old age group, accounting for 62.8% of dental injuries (Fig. 2) in this age group compared with 18.0% among children 7–17 year olds (χ^2, $P < 0.01$, IPR = 3.51, 95% CI = 3.47–3.56). Furthermore, the peak years in which house structures/furniture were associated with dental injuries were 1–2 years of age. In this age group, they accounted for 76.2% of dental injuries.

Males sustained 58.0% of the injuries involving house structures and/or furniture. The male to female ratio was 1.34 in the < 7 year old age group compared with ratios of 1.59 and 1.63 in the 7–12 and 13–17 year age groups, respectively.

Table 1. Leading consumer products/activities in each consumer product group associated with dental injuries in children < 18 years of age treated in US emergency departments, 1990–2003

Consumer products	Actual sample	Estimated number	Category %	% of Total
House structures/furniture	6466	138 197	100.0	44.8
Floors	1367	28 726	20.8	9.3
Steps	1072	22 496	16.3	7.3
Tables	882	19 173	13.9	6.2
Beds	897	19 079	13.8	6.2
Other structures/furniture	2248	48 723	35.2	15.8
Outdoor recreation	3864	89 628	100.0	29.0
Bicycles	1943	44 484	49.6	14.4
Playground equipment	739	17 035	19.0	5.5
Non-bicycle riding	671	14 834	16.6	4.8
Trampoline	175	4320	4.8	1.4
Other outdoor recreation	336	8955	10.0	2.9
Sports	1844	42 880	100.0	13.8
Baseball	561	17 253	40.2	5.6
Basketball	397	8661	20.2	2.8
American football	245	5354	12.5	1.7
Softball	119	3243	7.6	1.0
Other sports	522	8369	19.5	2.7
Miscellaneous	1716	38 194	100.0	12.4
Total	13 890	308 900	–	100.0

Outdoor recreation

Consumer products associated with outdoor recreation accounted for 29.0% of dental injuries among children 17 years of age and younger (Table 1). Within this group of consumer products, bicycles were associated with almost half (49.6%) of the dental injuries. Combined, playground equipment (slides, see-saws, monkey bars, and swings) accounted for 19.0% of dental injuries in this product group. Outdoor riding equipment other than bicycles (skateboards, scooters, roller skates, in-line skates, and tricycles) accounted for 16.6%, and trampolines accounted for 4.8% of all dental injuries associated with outdoor recreational consumer products.

Children 7–12 year olds were significantly more likely to experience dental injuries associated with outdoor recreation when compared to the other age groups (χ^2, $P < 0.01$, IPR = 2.20, 95% CI = 2.04–2.37) (Fig. 2).

Males were involved in 64.9% of dental injuries related to outdoor recreational activities. The largest male to female ratio was seen in the 7–12 year age group (1.85); the male to female ratio was 1.49 and 1.68 in the < 7 and 13–17 years old age groups, respectively.

Bicycles

Overall, the bicycle was the single most common consumer product associated with dental injuries

(Table 1). Bicycles accounted for 14.4% (44 500) of all dental injuries. These injuries were especially common among the 7- to 12-year-old age group; bicycles were associated with 24.3% of dental injuries in this age group – significantly more than the 10.9% seen in the <7 and 13- to 17-year-old age groups combined (χ^2, $P < 0.01$, IPR = 2.23, 95% CI = 2.19–2.27). Almost half (48.3%) of the bicycle-related injuries occurred among 7–12 year olds. Males accounted for 67.0% of all bicycle-related dental injuries.

Sports

The number of sports-related dental injuries was higher among children 7–12 years of age (22 200) than among children 13–17 years of age (16 000). However, sports-related dental injuries represented a higher proportion of injuries among the 13- to 17-year-old age group compared with that among younger children (χ^2, $P < 0.01$, IPR = 4.86, 95% CI = 4.32–5.47) (Fig. 2).

Baseball accounted for 40.2% of sports-related dental injuries, followed by basketball (20.2%), American football (12.5%), and softball (7.6%) (Table 1). During the 14-year study period, sports-related dental injuries more than doubled (112% increase), which was the largest increase among the main product categories. Males experienced 76.6% of the dental injuries associated with sports. The ratio of injured males to females was highest (3.8:1) among 13–17 year olds. The male to female ratios of sports-related dental injuries in the 7–12 and <7 year-old groups were 2.3:1 and 3.3:1, respectively.

Baseball

Baseball was the sport most frequently associated with dental injuries. A significantly higher percentage (47.6%) of baseball-related dental injuries were seen in the 7–12 year age group (Fig. 3) than in the other age groups combined (32.3%; χ^2, $P < 0.01$, IPR = 1.47, 95% CI = 1.27–1.72). Baseball was also the second leading cause (31.8%) of sports-related dental injuries in the 13–17 years age group.

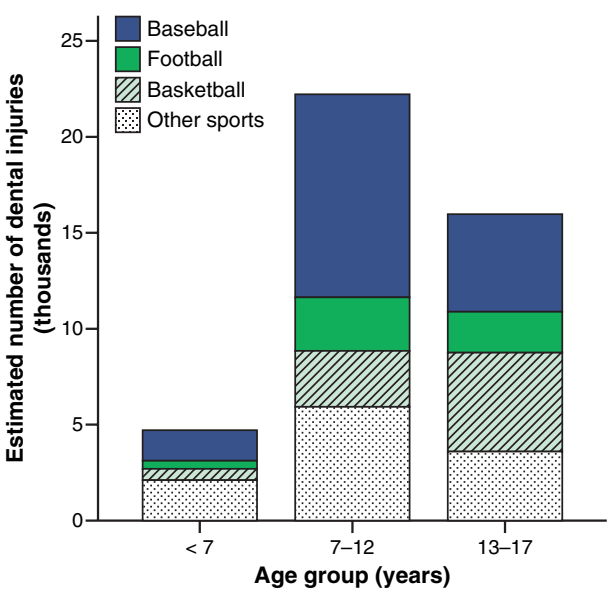

Fig. 3. Estimated number of dental injuries associated with the top three sports by age group treated in US emergency departments, 1990–2003.

Basketball

Basketball was the sport most frequently associated with dental injuries in the 13–17 year age group. It accounted for 32.3% of the sports-related dental injuries in this age group (Fig. 3), which is significantly more than among children <13 years (χ^2, $P < 0.01$, IPR = 2.48, 95% CI = 1.91–3.23).

Discussion

Overview

Dental injuries are a common cause of morbidity among children. An estimated 308 900 dental injuries to children 17 years of age or younger were treated in US EDs from 1990 to 2003. Of all reported dental injuries for all ages in NEISS, more than 80% occurred to children. Males were more likely to experience a dental injury than females with an overall ratio of 1.74:1. This is consistent with previous studies that showed a male predominance ranging from 1.43:1 to 2.34:1 (10–13). Forsberg and Tedestam (19) evaluated 1635 school age children ages 7–15 years and found that boys outnumbered girls with respect to dental trauma to deciduous dentition (1.2:1) and to permanent dentition (1.6:1). Our study also showed an increase in the male to female ratio with increasing age, from 1.45 among children with deciduous dentition to 2.84 among children with permanent dentition.

This increase is related to the types of consumer products and activities associated with the most dental injuries in each age group. Among children with primary dentition (<7 years), the leading cause of dental injuries was a fall associated with household structures/furniture. This consumer product group had a male to female ratio of 1.37:1. However, sports, the leading consumer product/activity group among 13–17 year olds, had a larger male predominance with a male to female ratio of 3.33:1.

House structures/furniture

Falls involving household structures/furniture accounted for nearly half (44.7%) of all pediatric dental injuries, and 62.8% of dental injuries among children <7 years of age. Our findings agree with previous studies, which found that falls from all causes accounted for 46–82% of pediatric dental injuries (10–12, 20). The rate of dental injury was highest among 1–2 year olds in this study, which is an age group that is developing ambulatory ability. Because young children have relatively large heads and high centers of gravity, they tend to topple head first when they fall. They are also unable to break their fall because of the immature upper extremity coordination and strength, which contributes to their observed high rate of dental trauma. House structures/

furniture are associated with falls among young children primarily because children in this age group spend most of their time in the home.

In our study, dental injuries associated with house structures/furniture mainly occurred among children with primary or mixed dentition. However, because primary teeth are anatomically close to their developing permanent successors, injuries to primary teeth are easily transmitted to the permanent dentition (1). Malformation of permanent teeth following trauma to deciduous teeth has been shown to occur in 23–69% of cases (21–23). Therefore, prevention of dental trauma at home among young children is important.

Our study shows that floors, steps, tables, and beds are the top four consumer products associated with fall-related dental trauma involving house structures/furniture. Possible injury prevention strategies include covering hard floors with carpeting, using stair gates, placing padded bumpers on table edges, and using side rails on beds. However, few studies have been performed that evaluate the effectiveness of these preventative strategies to reduce injuries associated with these four consumer products. One prospective study showed that head and face injuries were significantly more likely if the top bed of a bunk bed had no side rails (24). Another study showed that rolling off a bed (27 inches high) from a horizontal position presented a low risk of head injury, but did not comment on dental injury (25). Because of the large number of dental injuries associated with these consumer products and the potential for other associated injuries, future studies to evaluate the effectiveness of these preventative strategies should be performed.

Outdoor recreation

Outdoor recreation was the leading cause of dental injuries in the mixed dentition age group primarily because this consumer product group includes bicycles, the leading individual product associated with pediatric dental injuries in this study. Despite implementation of bicycle helmet laws and ordinances across the US (26), and recommendations by the American Academy of Pediatrics and other groups to wear a helmet while bicycling (27), the number of dental injuries associated with bicycles increased during the 14-year study period. This is because helmets are designed to prevent head and upper face injuries, and have been shown to have little effect on prevention of injuries to the lower face (28). Therefore, helmets with face protection or the use of mouth guards would be the most effective to prevent dental injuries associated with bicycles.

Playground equipment was the second largest product group in the outdoor recreation category associated with dental injuries. Slides, swings, and climbing equipment were the most commonly mentioned types of playground equipment associated with dental injuries. Studies have shown the importance of cushioning playground surfacing to reduce injuries from falls, because the amount of energy transferred to a child's body upon impact from a fall is determined primarily by the height of the fall and the energy-absorbing capacity of the surface struck (29).

Sports

With increased competitiveness at younger ages, a larger number of dental injuries are being experienced in youth sports (30, 31). Therefore, in its 2006 Policy on Prevention of Sports-related Orofacial Injuries, the American Academy of Pediatric Dentistry recommended, 'mandating the use of properly fitted mouth guards in other organized sporting activities with risk of orofacial injury' (32). The Academy for Sports Dentistry also supports a mandate for use of properly fitted mouth guards in all collision and contact sports (33). Compliance and cost issues related to mouth guard use prevent universal mouth guard policies from being made in every sport. Therefore, recognizing those sports in which dental injuries occur more frequently can help focus efforts to implement mouth guard policies where they are most needed.

Our study showed that, of all the sports, the greatest number of dental injuries occurred in baseball – accounting for one-third of all sports-related dental injuries (softball was measured separately and was the fourth leading sport related to dental injuries, see Table 1). Most of these occurred to 7–12 year olds, accounting for nearly 40% of sports-related dental injuries in this age group. While batting helmets with face shields may help decrease the number of injuries to batters, 89% of all ball-related facial injuries occur to players in the field (34). Governing organizations, such as Little League Baseball (LLB) and the National Federation of State High School Associations (NFHS), have attempted to decreased the ball speed on the field by setting a standard bat performance factor and/or bat exit speed ratio (formulas that measure how fast a baseball/softball comes off the bat) for non-wood bats (35). In addition, the National Operating Committee on Standards for Athletic Equipment has developed standards for softer baseballs (36). Because these are new policies, their effectiveness in preventing dental injuries has not yet been determined.

Basketball was the leading cause of dental injuries in the 13- to 17-year-old age group and the second leading sport associated with dental injuries for children of all ages. Few organized basketball programs have policies requiring mouth guard use despite the fact that orofacial injuries have been shown to account for up to 34% of injuries in basketball (37).

Mouth guards, when used properly, have repeatedly been shown to decrease the risk of dental injuries (38–40). Also, with the implementation of the use of faceguards and mouth guards in American football, the American Dental Association reports that more than 200 000 orofacial injuries are being prevented annually (37). The NFHS currently recommends that mouth guards be worn in the following contact sports: American football, ice hockey, men's lacrosse, field hockey, and amateur boxing. No other high school sports have mouth guard policies on the national level, but states are allowed to add their own requirements. Massachusetts, New Hampshire, and Vermont require mouth guard use in both basketball and soccer, and Maine requires mouth guards in soccer. There are no requirements for mouth guard use in softball or baseball (41). In addition, LLB (Youth Basketball of America Inc.), and US Youth

Soccer do not require mouth guards, but each allows local chapters to implement their own policies.

There is a clear opportunity to prevent dental injuries in baseball and basketball through implementation of policies requiring mouth guards. Sponsoring organizations and local dentists can work together to make mouth guards accessible and affordable to athletes in sports with increased risk of dental injury. As awareness increases about the frequency and severity of dental injuries among child athletes, coaches, trainers, parents, and children will hopefully increase the adoption of mouth guard use in those sports that present the greatest risk.

Study limitations

Information about exposure to risk of injury was not available, and therefore, true injury rates could not be calculated. However, injury rates were calculated using population data, which is an appropriate method, given the broad exposure to dental injury among the pediatric population. NEISS data are based on ED chart review by trained coders, and these data suffer from lack of documentation, mis-documentation, and errors in data extraction and coding, as do all similar surveillance systems based on patient medical records. NEISS underestimates the total number of pediatric dental injuries because it includes only injuries treated in EDs and not those treated in other types of health care facilities, private physician and dental offices, or those injuries not treated at all. For the same reason, dental injuries reported by the NEISS may be more severe than those treated in other locations, and may not be representative of all pediatric dental injuries. NEISS also does not include categories for all consumer products (most notably motor vehicles) nor all types of activities (such as organized vs recreational basketball), which limited our analyses. The type of dental injury was not consistently described in the NEISS narrative, and therefore could not be evaluated in this study. The NEISS does not include a variable regarding the severity of injury, and few of the case narratives included information about the severity of the dental injury using the Ellis classification or other descriptors (e.g. avulsion, subluxation). Therefore, the severity of dental injuries was not included in analyses in this study. Despite these limitations, the NEISS provides the most comprehensive national data available describing dental injuries.

Conclusions

To our knowledge, this is the first study evaluating dental injuries among children in the US using a national sample. The majority of dental injuries are associated with falls involving house structures and furniture during the preschool years. Reasonable prevention strategies include using carpeting or other soft non-slip floor coverings, gates for stairs, padding for edges of tables, and bed rails. Among children with permanent teeth, recreational and sports activities are the leading cause of dental injuries. Bicycles were responsible for more dental injuries than any other consumer product and, unfortunately, bicycle helmet use will not prevent these injuries. Therefore, children should be encouraged to wear mouth guards while bicycle riding. Baseball and basketball are the leading causes of sports-related dental injuries. As mouth guards have been shown to prevent dental injuries in sports, we recommend all organized baseball and basketball programs require their use.

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Appendix: List of consumer product/activity categories

House structures/furniture
Bed
Table
Chairs
Sofa/couch
Furniture
Floor
Steps
Appliances
Bathtub/shower
Porch/deck
House structure (door, walls, railing, window sill, etc)
Sports
Baseball/softball
Basketball
Football
Volleyball
Soccer
Hockey
Snowboarding
Skiing
Wrestling
Track
Badminton
Kickball
Dodge ball
Tennis
Gymnastics
Tetherball
Fishing
Ping-pong
Horseshoe
Croquet
Ice skating
Kneeboard
Wakeboard
Golf
Rugby
Lacrosse
Bowling
Boxing
Cheerleading
Dancing
Field hockey
Racquet ball
Martial arts
Weight lifting
Exercise
Outdoor recreation
Slides
Swings
Merry-go-round
Monkey bars
See saw/teeter totter
Playhouse
Trampoline
Scooter
Skating (roller and inline)
Skateboard
Dirt bike/ATV
Swimming pool
Bicycles
Tricycles