Stair-Related Injuries to Young Children Treated in US Emergency Departments, 1999–2008

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KEY WORDS
stairs, injury, children, falls, prevention

ABBREVIATIONS
CI—confidence interval
CPSC—US Consumer Product Safety Commission
ED—emergency department
NEISS—National Electronic Injury Surveillance System
RR—relative risk

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WHAT'S KNOWN ON THIS SUBJECT: Stairs are a common source of injury to children. Most injuries are minor soft tissue injuries, with the head and neck region being injured most commonly.

WHAT THIS STUDY ADDS: This is the first nationally representative study of stair-related injuries to young children in the United States. A child aged <5 years is treated in a US emergency department, on average, every 6 minutes for a stair-related injury.

abstract

FREE

OBJECTIVE: The objective of this study was to investigate the epidemiologic characteristics and secular trends of stair-related injuries among children aged <5 years treated in US emergency departments.

METHODS: A retrospective analysis was conducted of data from the National Electronic Injury Surveillance System of the US Consumer Product Safety Commission from 1999 through 2008 by using sample weights to estimate national numbers and rates of stair-related injuries.

RESULTS: An estimated 931 886 children aged <5 years were treated for stair-related injuries from 1999 through 2008, averaging 93 189 injuries per year and 46.5 injuries per 10 000 population annually. The number of injuries per year decreased significantly by 11.6% from 1999 to 2008. The rate of stair-related injuries also decreased significantly from 53.0 to 42.4 per 10 000 population from 1999 to 2008. Soft tissue injuries accounted for 34.6% of cases. Approximately three-fourths (76.3%) of children had injuries to the head and neck region, and 2.7% of patients were hospitalized. Children who were being carried at the time of injury accounted for 24.5% of injuries among children <1 year and were more than 3 times more likely to be hospitalized than children injured by other mechanisms.

CONCLUSIONS: Stair-related injuries are on the decline but still represent an important source of injury to young children. Increased prevention efforts are needed, including parental education and improved stairway design, to decrease stair-related injuries among young children. *Pediatrics* 2012;129:721–727

Stairs are a common feature of houses and yet can pose substantial injury risk to those who use them, usually from a fall. Although there is extensive literature on stair-related injuries as a major cause of mortality and morbidity among older adults,[1–4] little has been published on stair-related injuries among young children. An emergency department (ED)-based study showed that stairs were among the top 10 causes of injury to children aged <1 year during each month of life and that the incidence of those injuries rose as infant mobility increased, with stairs being the most common cause of injury at 12 months of age.[5] By better understanding these injuries and their causes, recommendations can be made to prevent injuries.

Before the mid-1990s, the majority of stair-related injuries to children involved baby walkers and usually resulted in minor soft tissue injuries with 3% requiring hospitalization.[6,7] Head and neck injuries accounted for the majority of cases with extremity injuries predominating in the remainder of cases. Since the introduction of stationary activity centers as an alternative to mobile baby walkers in 1994 and the implementation of the revised American Society for Testing and Materials F977 voluntary infant walker standard in 1997, injuries due to baby walkers have decreased significantly; 1 study identified a 76% decrease in baby walker–related ED visits between 1990 and 2001.[8] Given that the vast majority of the >20 000 annual infant walker–related injuries before 1994 involved falls down stairs, this decrease resulted in changes in the pattern of injuries to children associated with stairs. One study identified more serious injuries occurring when the child fell with a caretaker,[6,9] highlighting this as an important mechanism of injury for prevention efforts.

Investigation of stair-related injuries after introduction of the 1997 revised baby walker standard is needed, because patterns of stair-related injuries to children have changed, and previous studies were based on data from single EDs. To our knowledge, this is the first study to investigate the epidemiologic characteristics, mechanisms of injury, and secular trends of stair-related injuries among US children aged <5 years by using a nationally representative sample.

METHODS

Data Source

The US Consumer Product Safety Commission (CPSC) uses the National Electronic Injury Surveillance System (NEISS) to monitor injuries treated in US hospital EDs. Created in 1972, the NEISS collects data from a probability sample of ~100 hospitals, selected from the population of all hospitals with EDs that have at least 6 beds and operate 24 hours a day in the United States and its territories.[10] From this probability sample, estimates of injuries that occur nationally can be made by using weighting factors provided by the CPSC. Each participating hospital submits data extracted from ED medical records regarding injuries that are associated with consumer products and sport and recreational activities on a daily basis. Several studies have shown the NEISS to be highly accurate in identifying these injury cases.[11–14]

Data regarding stair-related injuries (product code 1842, "stairs or steps") to children aged <5 years reported through the NEISS from 1999 through 2008 were retrospectively analyzed. The NEISS data set includes variables for patient age, gender, body region injured, type of injury, locale of injury, and ED disposition, in addition to a brief narrative describing the incident. Cases were excluded if the injury was caused by an object that fell down the stairs and struck a child who was not on the stairs or if the child was being pulled by the arm up the stairs by a caretaker and sustained a nursemaid's elbow. US population data from the US Bureau of the Census for 1999 through 2008[15] were used to calculate stair-related injury rates. These population-based rates are expressed as the number of injuries per 10 000 population per year.

Study Variables

On the basis of information in the NEISS case narrative, cases were categorized by mechanism of injury as follows: (1) jumped down, from, or off the stairs; (2) carried on the stairs (either in a caretaker's arms or in an infant carrier); (3) tripped on an object (not the stairs themselves) and fell; (4) fell down the stairs in a baby walker; (5) fell down the stairs in a stroller or carriage; (6) rode down the stairs on a tricycle, bicycle, wagon, or other similar product with wheels; and (7) fell down the stairs without mention of another object or action. NEISS categories for body region injured were regrouped into (1) head and neck, (2) upper extremity (including shoulder), (3) lower extremity, (4) trunk (including pubic region), and (5) >25% of the body. Subanalyses were conducted on humerus and femur fractures. NEISS categories for type of injury were regrouped into (1) dislocations, (2) fractures, (3) closed head injuries (including concussions and intracranial hemorrhages), (4) soft tissue injuries (including sprains, strains, hematomas, and contusions), (5) lacerations (including puncture wounds), and (6) miscellaneous. Disposition from the ED was categorized as (1) released (patients who were treated and released or left the ED without treatment) or (2) hospitalized (patients who were admitted, transferred to another hospital, or held for observation). The location where the injury occurred was categorized as (1) home or (2) other (including school, farm, and other public

property). If there was missing information for a category, that case was not included in analysis of data for that category.

Data Analysis

Data were analyzed by using SPSS,[16] EpiInfo,[17] SAS,[18] and SUDAAN[19] statistical software. Analysis included calculating relative risk (RR) with corresponding 95% confidence intervals (CIs), χ^2 analysis with Yates' correction, and linear regression. The level of significance for all statistical tests was $\alpha = .05$. NEISS sample weights were used in all analyses to adjust for the inverse probability of selection and generate national estimates of stair-related injuries to children. Analysis of unweighted numbers <20 was not done because estimates of this size are considered unstable by the CPSC. This study was approved by the Institutional Review Board of The Research Institute at Nationwide Children's Hospital.

RESULTS

Sample Description

During the 10-year study period (1999–2008), an estimated 931 886 (95% CI: 799 283, 1 064 490) children aged <5 years were treated in US EDs for stair-related injuries, averaging 93 189 patients annually or 46.5 injuries per 10 000 population annually. Thus, a young child is treated in a US ED, on average, every 6 minutes for a stair-related injury. Mean child's age was 2.0 years (median = 2), with the largest portion (32.4%, 301 962 of 931 886) of injuries occurring among patients aged 1 year. Injuries were slightly more common in male children at all ages, representing 56.9% (530 291 of 931 591) of cases overall. Among patients for whom locale of the injury event was recorded, 94.2% (657 661 of 698 516) occurred in the home.

Injuries Sustained

Soft tissue injuries were the most common type of injury overall (34.6%, 320 141 of 926 491) (Fig 1) and also among children aged ≤2. Lacerations and puncture wounds were the next most frequent type of injury overall (26.2%, 242 983 of 926 491) and also among 3- and 4-year-olds. The most common body regions injured were

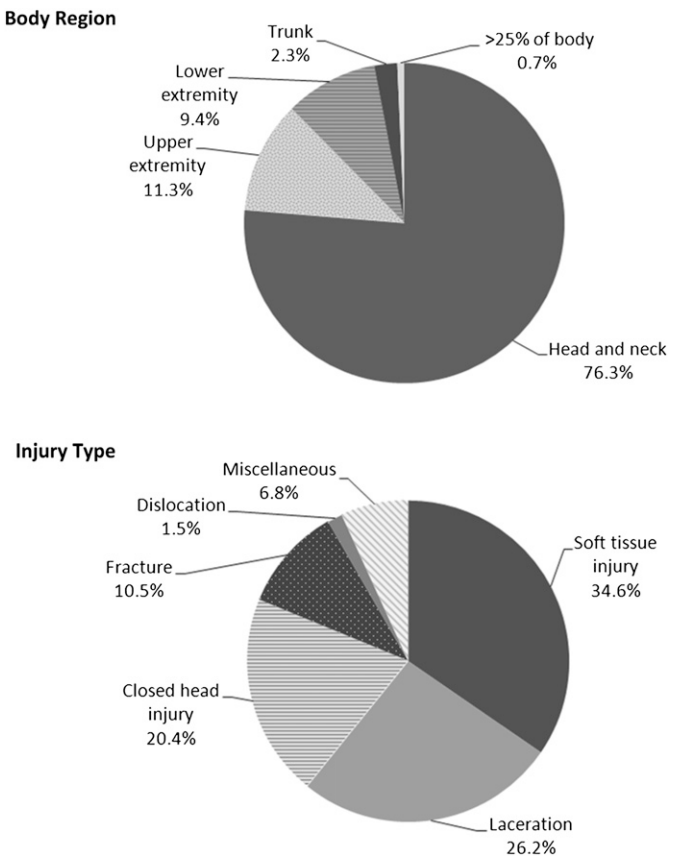

FIGURE 1
Stair-related injuries among children aged <5 years, according to injured body region and type of injury, United States, 1999–2008.

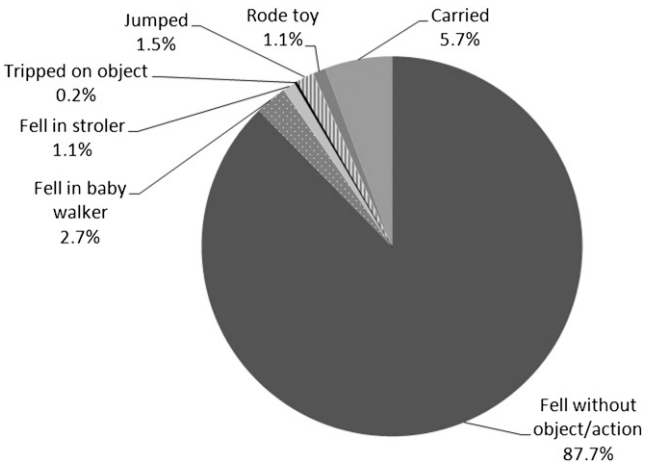

FIGURE 2
Stair-related injuries among children aged <5 years, according to mechanism of injury, United States, 1999–2008.

TABLE 1 Characteristics of Stair-Related Injuries Among Children Aged <5 Years According to Child Age, United States, 1999–2008

Characteristic	Age (y)								
	<1			1			2		
	National Estimate	95% CI	%	National Estimate	95% CI	%	National Estimate	95% CI	%
Injury mechanism									
Carried	33 531	27 285, 39 776	24.5	12 171	9657, 14685	4.0	4999	3885, 6113	2.2
Fell in baby walker	22 226	17 644, 26 809	16.2	3145	2033, 4257	1.0	[a]	[a]	[a]
Jumped	[a]	[a]	[a]	1506	927, 2086	0.5	4519	3400, 5638	2.0
Fell in stroller	6860	2869, 10 851	5.0	2704	671, 4736	0.9	381	162, 599	0.2
Rode toy	[a]	[a]	[a]	2370	1537, 3203	0.8	3791	2838, 4745	1.7
Tripped on object	[a]	[a]	[a]	547	206,889	0.2	346	113, 578	0.2
Fell without object/action	74 037	60 517, 87 558	54.0	279 519	240 960, 318 078	92.6	212 778	181 552, 244 004	93.7
Total[b]	136 988	114 042, 159 933		301 962	259 975, 343 949		226 988	194 129, 259 846	
Body region									
Head and neck	112 171	93 194, 131 148	87.5	233 491	199 530, 267 453	79.0	165 171	139 798, 190 544	73.6
Upper extremity	3538	2520, 4556	2.8	29 112	24 784, 33 440	9.9	29 944	24 733, 35 155	13.3
Lower extremity	8017	6045, 9988	6.3	26 250	21 919, 30 582	8.9	23702	19 632, 27 772	10.6
Trunk	1989	1230, 2749	1.6	4461	3405, 5517	1.5	4629	3294, 5964	2.1
>25% of body	2438	1446, 3429	1.9	2082	1378, 2786	0.7	1080	590, 1570	0.5
Total[b]	128 153	106 791, 149 515		295 396	254 155, 336 638		224527	191 906, 257 148	
Injury type									
Soft tissue injury	58 487	47 516, 69 458	43.3	115 215	95 857, 134 573	38.4	72239	59 986, 84 492	31.9
Laceration	8797	6886, 10 707	6.5	61 836	52 445, 71 227	20.6	68890	57 451, 80 330	30.4
Closed head injury	43 644	33 524, 53 765	32.3	71 166	57 031, 85 302	23.7	39299	31 779, 46 818	17.4
Fracture	10 047	7535, 12 559	7.4	24 948	20 346, 29 550	8.3	26410	21 658, 31 163	11.7
Dislocation	[a]	[a]	[a]	6557	5065, 8048	2.2	5003	3610, 6396	2.2
Miscellaneous	13 707	108 73, 16 542	10.2	20 115	16 142, 24 089	6.7	14411	10 989, 17 832	6.4
Total[b]	135 021	112 335, 157 706		299 838	258 098, 341 578		226 252	193 508, 258 997	

[a] These are unstable estimates because the unweighted number of cases is <20.

[b] The total *N* varies because missing values were omitted from analyses.

the head and neck (76.3%; 696 208 of 912 427) followed by the upper extremities (11.3%; 102 884 of 912 427; Fig 1). There were an estimated 3534 (95% CI: 2730, 4338) fractures of the humerus and 4527 (95% CI: 3404, 5650) fractures of the femur.

Among head and neck injuries, 33.9% (235 902 of 695 563) were lacerations, 33.4% (232613 of 695563) were soft tissue injuries, and 27.2% (189 303 of 695 563) were closed head injuries. The head and neck were more likely to sustain a laceration (RR: 10.34 [95% CI: 8.55, 12.50]) than other body regions. The upper extremity (RR: 11.93 [95% CI: 10.48, 13.59]) and lower extremity (RR: 3.96 [95% CI: 3.59, 4.36]) were more likely to experience a fracture than other body regions. Injury to the lower extremity was more common when the child jumped (RR: 7.37 [95% CI: 6.49, 8.37]) or was being carried (RR: 2.39 [95% CI: 2.02, 2.83]) compared with other mechanisms of injury.

Mechanism of Injury

Overall, 87.6% (816 683 of 931 886) of children fell down the stairs without mention of another object or action (Fig 2). Children aged <1 year were more likely to be injured in walkers (RR: 38.71 [95% CI: 27.85, 53.79]), in strollers (RR: 11.81 [95% CI: 9.48, 14.71]), or while being carried (RR: 9.92 [95% CI: 8.70, 11.32]) than older children. Among children in this age group, 24.5% of injuries were associated with being carried, 16.2% with a baby walker, and 5.0% with a stroller (Table 1). Injuries occurring to >25% of the body were rare (0.7%; 6271 of 912427), but were more likely to occur among children aged <1 year (RR: 3.89[95% CI: 2.65, 5.72]) than older children. Children being carried were more likely to have injury to >25% of the body (RR: 4.59 [95% CI: 2.88, 7.32]) than children injured by other mechanisms.

Injuries due to riding a tricycle or similar product down the stairs were more common among 2-year-olds than other ages (RR: 1.86 [95% CI: 1.47, 2.36]), with 74.9% (7575 of 10 117) of those injuries occurring among 2- to 4-year-olds. Children aged 4 years were more likely to be injured jumping (RR: 3.11 [95% CI: 2.36, 4.10]) than younger children. Injuries caused by jumping were more likely to result in a fracture (3363 fractures; RR: 2.32 [95% CI: 1.83, 2.92]) than other mechanisms.

Secular Trends

The number of stair-related injuries decreased 11.6% during the study period, with a significant linear trend from 101 335 cases in 1999 to 89 619 cases

TABLE 1 Continued

Age (y)								
3			4			Total		
National Estimate	95% CI	%	National Estimate	95% CI	%	National Estimate	95% CI	%
1392	806, 1977	0.9	1054	489, 1618	0.9	53 146	43 558, 62 734	5.7
a	a	a	a	a	a	25 558	20 365, 30 751	2.7
3687	2568, 4805	2.5	4355	3213, 5497	3.7	14 137	11 278, 16 996	1.5
a	a	a	a	a	a	10 232	4265, 16 199	1.1
2223	1454, 2993	1.5	1561	914, 2209	1.3	10 117	7876, 12 357	1.1
a	a	a	a	a	a	2013	1261, 2766	0.2
141 220	120 490, 161 950	94.5	109 129	93 460, 124 797	93.6	816 683	701 494, 931 873	87.6
149 383	127 477, 171 290		116 565	99 683, 133 447		931 886	799 283, 1 064 490	
105 912	90 106, 121 718	71.5	79 463	67 354, 91 571	68.4	696 208	594 052, 798 363	76.3
22 898	18 789, 27 006	15.5	17 392	14 317, 20 467	15.0	102–884	87 707, 118 060	11.3
14 000	11 477, 16 523	9.5	14 137	11 648, 16 625	12.2	86 106	73 184, 99 028	9.4
4911	3568, 6254	3.3	4967	3551, 6383	4.3	20 958	16 841, 25 075	2.3
390	161, 620	0.3	a	a	a	6271	4651, 7892	0.7
148 111	126 428, 169 794		116 239	99 366, 133 113		912 427	782 612, 1 042 242	
41 362	34 508, 48 217	27.8	32 838	26 613, 39 062	28.2	320 141	267 997, 372 286	34.6
56 269	47 195, 65 342	37.8	47 191	39 420, 54 963	40.5	242 983	206 418, 279 548	26.2
21 916	16 776, 27 056	14.7	13 277	10 292, 16 263	11.4	189 303	151 442, 227 164	20.4
19 483	15 943, 23 023	13.1	16 421	13 626, 19 217	14.1	97 310	81 754, 112 866	10.5
1527	870, 2185	1.0	571	179, 963	0.5	13 996	10 729, 17 263	1.5
8417	6590, 10 243	5.6	6107	4760, 7454	5.2	62 757	52 175, 73 338	6.8
148 975	127 102, 170 847		116 405	99 540, 133 271		926 491	794 571, 1 058 410	

in 2008 (m = −1103, P = .011). Baby walker–related injuries also decreased significantly over time (m = −472, P = .003), with 1352 injuries in 2008. In contrast, injuries occurring to children being carried on the stairs rose significantly during the study years (m = 178.3, P = .017), with 5446 injuries in 2008 (Fig 3). Overall, the rate of stair-related injury decreased significantly from 53.0 per 10 000 population in 1999 to 42.4 per 10 000 population in 2008 (m = −1.10, P < .001). The rate of baby walker–related injuries also decreased significantly, from 3.32 per 10 000 in 1999 to 0.64 per 10 000 in 2008 (m = −0.254, P = .003). When baby walker cases were removed from the overall yearly rates, the rate decrease remained significant (m = −0.847, P < .001). The increase in the rate of injury among children who were being carried on the stairs did not reach statistical significance (m = 0.059, P = .082).

Disposition From the ED

The majority of patients (97.3%, 905 693 of 931 120) were released home from the ED. Children aged <1 year were hospitalized 5.2% (7129 of 136 895) of the time and were more likely to be hospitalized (RR: 2.26 [95% CI: 1.90, 2.70]) than older children. Patients with fractures were hospitalized 11.6% (11 267 of 97 298) of the time and were more likely (RR: 6.89 [95% CI: 5.52, 8.60]) to be hospitalized than patients

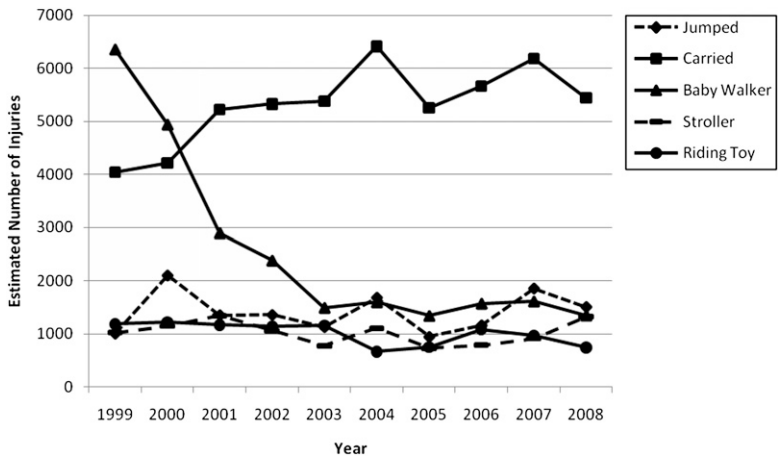

FIGURE 3
Stair-related injuries among children aged <5 years, according to mechanism of injury and year, United States, 1999–2008 Note: Falls not involving an object or action are not represented. Because of the small sample size, annual national estimates for "tripped on an object" are unstable and therefore not shown.

with other types of injuries. Closed head injuries, including concussions and intracranial hemorrhages, resulted in hospitalization 4.8% (9032 of 189 193) of the time and also were more likely (RR: 2.18 [95% CI: 1.75, 2.71]) to result in hospitalization than other types of injuries. Children who were being carried at the time of injury were also more likely to be hospitalized (RR: 3.10 [95% CI: 2.41, 3.99]) than children injured by other mechanisms.

DISCUSSION

To our knowledge, this study is the first to report national estimates and trends of stair-related injuries among young children. There were an estimated 931 886 children aged <5 years with stair-related injuries treated in US EDs during the 10-year period of this study. Although the number of injuries per year decreased 11.6% over that time period, stairs remain a common source of injury in this age group.

The findings of this study agree with those from previous studies on stair-related injuries. Like this study, previous studies demonstrated that head and neck injuries predominate, and injury severity tends to be low, with only a small percentage of patients requiring hospitalization.[6,9] In contrast to this investigation, previous studies did not report fractures to the femur and few to the humerus.[6,9] This study identified an estimated 3534 fractures to the humerus and 4527 to the femur. Research shows that femur fractures can occur from falls down stairs under certain conditions,[20,21] such as when a caretaker falls with the child; however, multiple injuries do not commonly result from stair-related falls.[21] Therefore, the presence of multiple injuries warrants more investigation to rule-out intentional injury.[6,21] In our study, less than 1% of children sustained injuries to >25% of the body (6271 of 912 426).

An estimated 53 147 injuries resulted when children were being carried down the stairs by a caretaker who lost his or her balance. These falls often resulted in serious injuries, likely because of the force from the tumbling adult on the child. Caretakers should minimize stair use while carrying children by placing the child in a safe place instead of bringing the child with them if possible. Child caretakers can also reduce injuries by keeping the stairs well-maintained and free of objects that could result in tripping. Other items should not be carried in addition to the child, because this may make caretakers more likely to lose their balance; the spare hand should be on the handrail in case they do slip or trip. Caretakers should also avoid stair use when transporting a child using a stroller or other similar device. There were an estimated 10 233 injuries in which children fell down the stairs in a stroller or carriage. In many cases, the narratives indicated that the child was strapped in; however, this was not enough to prevent injury. Caretakers should not attempt to wheel the child on the stairs and should instead use an elevator, if available, or carry the child while keeping their other hand on the railing.[22]

More consideration should be given to making stairs safer and more user-friendly, such as increasing the length of stair "goings,"[23] which are the horizontal depths of stair treads between vertical lines drawn from stair nosings (lead edges), in building codes. Missteps due to overstepping are a common cause of stair-related fall injuries.[24] Lack of uniformity in and/or short stair tread dimensions are important contributing factors to these events, especially in homes. Stair nosings should all line up as one sights down a flight of stairs. A misalignment of the top flight nosing is a common and dangerous defect found in many homes and elsewhere.[25] Additionally, handrails should allow a power grip, rather than a pinch grip, for enhanced stability.[26]

Stair-related injuries involving baby walkers decreased significantly during the study period; however, there were still an estimated 1352 of these injuries in 2008. Given that baby walkers provide no essential benefit and have been shown by multiple studies to transiently delay normal motor and mental development, parents should be discouraged from letting their children use baby walkers to further reduce the number of baby walker–related injuries among children.[8]

Some injuries reported in this study resulted from children playing on or around stairs. There were an estimated 14 137 injuries caused by children jumping down the stairs, including an estimated 3363 fractures. To prevent such injuries, parents should closely monitor young children when they are using the stairs, discourage play on the stairs (including riding toys down stairs, which caused an estimated 10 115 injuries), and keep the stairs free of objects that could cause the child to slip or trip. Additionally, children should be discouraged from carrying objects down the stairs. Larger objects may cause the child to lose balance, and others can inflict wounds if the child falls.

Stair gates are an important way to prevent children from using the stairs unsupervised, but parents should not rely on them exclusively. A review of the case narratives in this study showed that the gates were often removed by another household member or the young child was able to knock or climb over the gate. One solution may be to improve stair-gate design to make gates more difficult for a child to get past. Injury-prevention theory indicates that the most effective strategies for prevention are those that do not require

frequent human effort and vigilance.[27] Built-in, wall-mounted gates would ensure that the gates are always in place and may require less effort to use. Unfortunately, only 35% of household stairs can accommodate a wall-mounted gate at the top of the stairs, and only 62% of household stairs can accommodate a pressure-mounted gate at the bottom of the stairs.[28] Clearly, there is a need for both improved housing codes and stair gates that better fit staircases. Parents should be advised about proper use of stair gates at the top and bottom of stairs but reminded that their presence is not a substitute for proper adult supervision.

This study underestimates the actual number of stair-related injuries among young children, because the NEISS only includes injuries treated in EDs. Other injuries may be treated by the caretaker, in urgent care centers, other medical facilities, or receive no medical attention. Data from the NEISS may not be representative of all stair-related injuries. The NEISS injury code for "stairs and steps" included many minor injuries with bumps on steps rather than substantial falls down the stairs, which limited our ability to identify and analyze major falls alone. In addition, the NEISS is not a good data set for determining injury intent and therefore cannot be used to identify cases of abuse. Because of inconsistent documentation in case narratives, it was difficult to determine the mechanism of the fall in a large number of patients. The amount of exposure to stairs among young children is not known; however, the use of census data is an acceptable method for calculating population-based injury rates.

CONCLUSIONS

Stair-related injuries are on the decline but still represent an important source of injury to young children. Increased prevention efforts are needed, including parental education and improved stairway design, to decrease stair-related injuries among young children.

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