

# Injuries Associated With Bathtubs and Showers Among Children in the United States

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## KEY WORDS

injury, bathtub, shower, prevention, accident, slip, trip, fall, trauma

## ABBREVIATIONS

ASTM—American Society for Testing and Materials  
CI—confidence interval  
COF—coefficient of friction  
CPSC—Consumer Product Safety Commission  
ED—emergency department  
NEISS—National Electronic Injury Surveillance System

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**WHAT'S KNOWN ON THIS SUBJECT:** The most common mechanisms of bathtub- and shower-related injuries are slips and falls, hot-water scalds, and submersions. Much research pertains to scald and submersion injuries; there is relatively little research on bathtub- and shower-related slips and falls.



**WHAT THIS STUDY ADDS:** Bathtub- and shower-related injuries, particularly slips and falls, are common among children. This is the first national study on this topic. Pediatricians and caregivers should be aware of this important source of pediatric injury in the home.

## abstract

**OBJECTIVE:** The goal was to describe the epidemiological features of injuries associated with bathtubs and showers, especially those related to slips, trips, and falls, among US children.

**METHODS:** A retrospective study was performed by using nationally representative data from the US Consumer Product Safety Commission National Electronic Injury Surveillance System from 1990 through 2007 for children  $\leq 18$  years of age.

**RESULTS:** There were an estimated 791 200 bathtub- and shower-related injuries among children  $\leq 18$  years of age who were treated in US emergency departments in 1990–2007, with an average of 43 600 cases per year or  $\sim 5.9$  injuries per 10 000 US children per year. The largest number of injuries involved children 2 years of age; children  $\leq 4$  years accounted for 54.3% of injuries. The most common diagnosis was laceration (59.5%). The most common mechanism of injury was a slip, trip, or fall, accounting for 81.0% of cases or 4.6 injuries per 10 000 US children per year. The most frequently injured body part was the face (48.0%), followed by the head/neck (15.0%). The majority (71.3%) of injuries occurred in a bathtub. Of the cases with a known place of injury, 97.1% occurred at home. An estimated 2.8% of patients were admitted, transferred to another hospital, or held for observation.

**CONCLUSIONS:** This is the first study on bathtub- and shower-related injuries using nationally representative data. Slips, trips, and falls in bathtubs and showers are a common cause of injury among children, especially children  $\leq 4$  years of age. The incidence of these injuries may be decreased by increasing the coefficient of friction of bathtub and shower surfaces. *Pediatrics* 2009;124:541–547

The importance of bathtub injuries, particularly submersions and scalds, has long been recognized. The US Consumer Product Safety Commission (CPSC) found that, in 2002–2004, bathtubs were the primary locations of nonpool drownings and near-drownings.<sup>1</sup> Hot-water scalds represent the most common and most severe type of burns in young childhood.<sup>2,3</sup> Importantly, slips and falls are the most common mechanisms of injury in bathtubs and showers, accounting for >80% of injuries.<sup>4</sup> This proportion may be even greater because slips and falls may contribute to other mechanisms of injury, such as submersions and scald burns.<sup>5,6</sup>

The pediatric population is at particular risk for bathtub- and shower-related injuries because young children lack control of their bodies and surroundings.<sup>2,5,7</sup> In 1975, children <5 years of age accounted for nearly one third of all injuries, approximately three fourths of all deaths, and 65% of the social costs associated with bathtub- and shower-related injuries, although they constituted only 8.4% of the total US population.<sup>8</sup> Bathtub injuries associated with tap water burns and submersions have generated much research, but bathtub slips and falls have garnered relatively little attention.<sup>4</sup> Notably, one third of unintentional injury deaths in the home in 1992 through 1999, and an even larger proportion of residential nonfatal injuries treated in the emergency department (ED), resulted from slips, trips, and falls, including substantial proportions that occurred in the bathtub.<sup>9,10</sup> Interest in bathtub scalds and submersions may be attributable to the relative severity of these injuries.<sup>8</sup> However, bathtub slips and falls should not be overlooked; they are responsible for the majority of bathtub- and shower-related injuries, as well as

great societal cost<sup>8</sup> and much litigation.<sup>9</sup>

The purpose of this study was to investigate the epidemiological features of bathtub- and shower-related injuries among children ≤18 years of age who were treated in EDs throughout the nation, with an emphasis on injuries attributable to slips, trips, and falls. No previous studies on bathtub- and shower-related injuries using nationally representative data have been published.

## METHODS

### Data Source

This study used the National Electronic Injury Surveillance System (NEISS) of the CPSC for the years 1990 through 2007. The NEISS database was established in 1972 and has experienced 3 sampling frame revisions, most recently in 1997. The NEISS collects data from 100 EDs in the United States and its territories, representing a stratified probability sample of all US hospital EDs. These hospitals must have 24-hour emergency services and ≥6 beds. The NEISS collects data on injuries associated with ~15 000 consumer products and includes sampling weights to make national estimates. NEISS data include variables for age, gender, diagnosis, disposition from the ED, body part injured, and place of injury, as well as a short narrative describing the incident.<sup>11</sup>

Bathtub- and shower-related injuries among children ≤18 years of age were identified on the basis of their NEISS consumer product codes (codes 0611, 0609, 0610, and 4030, which include bathtubs, showers, and fixtures within them, bath mats, and enclosures). In addition, injuries associated with faucets and towel racks (codes 0699 and 0657, respectively)<sup>12</sup> were reviewed, to identify relevant cases. Data were “cleaned” for miscoding, and cases

were excluded if they were unrelated to bathtubs or showers, were sustained from outside a bathtub or shower, or were related to preexisting conditions (such as epilepsy), as described in their NEISS narratives. Injuries attributable to direct contact with chemicals, such as bleach burns, and cases of extreme horseplay that resulted directly in injuries, such as siblings throwing things at one another or swinging on a shower curtain, also were excluded.

### Variables

Through review of the NEISS narratives, information was obtained to create 2 new variables, that is, mechanism of injury and type of bathing facility. Mechanisms of injury were coded into 5 groups, that is, (1) slip, trip, or fall; (2) burn; (3) submersion; (4) user impact (hitting, striking, bumping, stepping on, or being cut on something); and (5) other (something fell on the user, the user was caught in the door, and miscellaneous mechanisms). Bathing facilities were divided into bathtubs and showers. Combination shower-bathtub facilities were categorized as bathtubs. Injuries were grouped as lacerations, soft-tissue injuries (contusions, abrasions, crushing, hematomas, strains, and sprains), burns, fractures, and other injuries (poisoning, nerve damage, ingested or aspirated foreign objects, dermatitis, conjunctivitis, amputations, electric shock, foreign-body injuries, anoxia, hemorrhage, dental injuries, internal organ injuries, avulsions, punctures, concussions, dislocations, and submersion). Body parts injured were grouped as face (including eyeball, mouth, and ear), head/neck, upper extremity, lower extremity, trunk (including shoulder, trunk, and pubic region), and other (NEISS categories for internal, 25%–50% of body, and ≥50% of body). Disposition from the ED was classified into 2 groups, namely, re-

leased or left (treated and released from the ED or left against medical advice) and admitted, transferred, or held (treated and admitted to the hospital, transferred to another hospital, or held for observation). Fatalities were not subanalyzed because of the small number of cases and because the NEISS does not capture injury deaths well.

### Analyses

Analysis was performed by using SPSS for Windows 15.0.1 (SPSS Inc, Chicago, IL), SAS 9.1 (SAS Institute, Cary, NC), SUDAAN 9.0 (Research Triangle Institute, Research Triangle Park, NC), and Epi Info 6.04 (USD, Stone Mountain, GA). Analysis was not performed for unweighted sample sizes of <20 because of the potential instability of these estimates. Injury rates were calculated by using US Census<sup>15</sup> population estimates for the years 1990–2007 and taking the average of yearly injury rates. Analyses included linear regression analyses,  $\chi^2$  tests of independence with Yates' correction, and calculation of 95% confidence intervals (CIs). Significance for all tests was determined by using  $\alpha = .05$ . All analyses were performed with data weighted to represent national estimates. All data are reported here as national estimates unless otherwise specified and are rounded to the nearest 100, except when included in parentheses to indicate how exact percentages were calculated.

### RESULTS

There were an estimated 791 200 bathtub- and shower-related injuries (95% CI: 673 108–909 200 injuries) among children  $\leq 18$  years of age treated in US EDs during the 18-year study period of 1990–2007. On average, there were 43 600 cases per year (95% CI: 42 242–45 664 cases per year) or  $\sim 5.9$  injuries per 10 000 US children per year. There were no secular

trends; the greatest number of injuries occurred in 2006 (48 500 cases) and the smallest number in 1990 (36 200 cases). There was a statistically significant, positive, linear trend in the number of cases from February to August ( $P < .001$ ) and a statistically significant, negative, linear trend from August to December ( $P = .002$ ). Boys accounted for 55.5% of the injuries (Table 1). The mean age of injury was 6.0 years (SD: 5.2 years), the median age was 4.0 years, and the mode was 2 years (123 258 cases [95% CI: 103 679–142 837 cases]). Children  $\leq 4$  years of age accounted for 54.3% of all injuries or 12.2 injuries per 10 000 US children  $\leq 4$  years of age per year. Five- to 9-year-old children accounted for

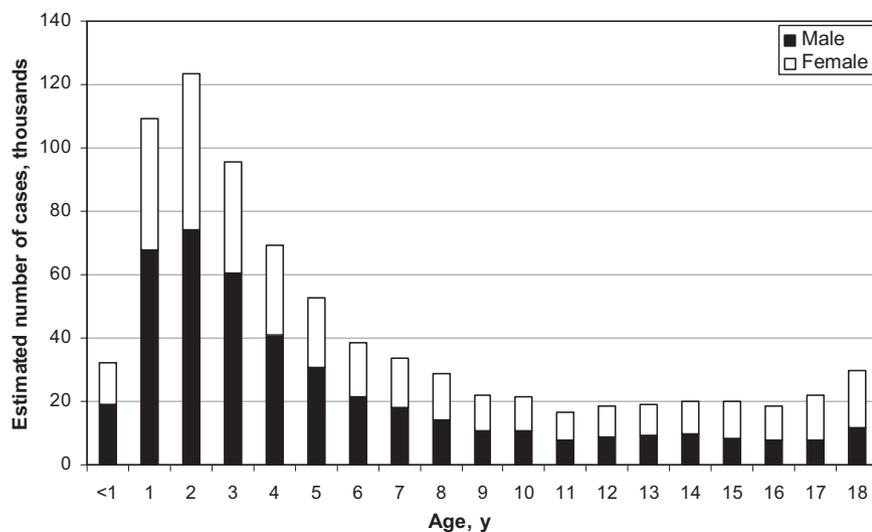
22.2% of the injuries, 10- to 14-year-old children accounted for 12.1%, and 15- to 18-year-old youths accounted for 11.4% (Fig 1).

### Type of Injury, Mechanism of Injury, and Body Part Injured

The most common diagnosis was laceration (59.5%), followed by soft-tissue injury (21.6%) (Table 1). The number of submersion diagnoses was small (1.4%; 11 015 of 790 209 cases); therefore, these injuries were included in the "other" category. Children  $\leq 9$  years of age were treated in the ED for lacerations (68.3%; 412 952 of 604 968 children) 2.2 times (95% CI: 2.0–2.4 times) more frequently than were 10- to 18-year-old children (30.8%; 57 143

**TABLE 1** Characteristics of Childhood Bathtub- and Shower-Related Injuries in the United States in 1990–2007

	National Estimate, <i>n</i> (95% CI)	Proportion of Total National Estimate, %
Gender		
Male	439 321 (373 504–505 137)	55.5
Female	351 750 (298 285–405 215)	45.5
Age		
$\leq 4$ y	429 928 (365 232–494 625)	54.3
5–9 y	175 588 (145 536–205 639)	22.2
10–14 y	95 664 (79 640–111 689)	12.1
15–18 y	89 974 (75 312–104 636)	11.4
Type of injury		
Laceration	470 096 (398 087–542 104)	59.5
Soft-tissue injury	170 769 (145 120–196 418)	21.6
Burn	30 293 (21 306–39 280)	3.8
Fracture	21 991 (18 276–25 705)	2.8
Other	97 061 (76 968–117 153)	12.3
Mechanism of injury		
Slip, trip, or fall	611 295 (522 939–699 650)	81.0
User impact	70 455 (59 206–81 704)	9.3
Burn	29 852 (20 778–38 927)	4.0
Submersion	12 123 (8090–16 157)	1.6
Other	31 029 (24 868–37 190)	4.1
Body part injured		
Face	379 221 (323 162–435 281)	48.0
Head/neck	118 363 (97 486–139 240)	15.0
Lower extremity	97 124 (80 918–113 329)	12.3
Trunk	96 344 (79 969–112 718)	12.2
Upper extremity	76 583 (63 886–89 280)	9.7
Other	21 685 (15 655–27 714)	2.8
Type of bathing facility		
Bathtub	556 874 (475 546–638 202)	71.3
Shower	224 601 (181 494–267 709)	28.7
Disposition from ED		
Released or left	767 014 (651 037–882 990)	97.1
Admitted, transferred, or held	22 424 (17 078–27 770)	2.8
Died	843 (328–1358)	0.1



**FIGURE 1** Estimated numbers of bathtub- and shower-related injuries, according to age and gender, in the United States in 1990–2007.

of 185 241 children;  $\chi^2$  test,  $P < .001$ ). The most common mechanism of injury was a slip, trip, or fall, accounting for 81.0% of injuries or 4.6 injuries per 10 000 US children per year. User impact was the second most common mechanism, accounting for 9.3% of injuries. The numbers of slips, trips, and falls showed no significant linear trend over the years of the study ( $P = .132$ ), with a low of 28 300 cases in 1990 and a high of 38 600 cases in 2006. Falls also accounted for 5.7% of burns (1687 of 28 165 cases) and 9.3% of submersion injuries (1132 of 12 123 cases). The most frequently injured body part was the face (48.0% of injuries), followed by the head/neck (15.0% of injuries).

The face was injured 2.3 times (95% CI: 2.2–2.5 times) more frequently among children  $\leq 4$  years of age (65.0%; 278 794 of 428 972 children) than among children  $> 4$  years of age (27.9%; 100 428 of 360 347 children;  $\chi^2$  test,  $P < .001$ ). Among children of all ages, facial injuries were 2.7 times (95% CI: 2.5–2.8 times) more likely to be lacerations (88.3%; 334 649 of 379 126 cases), compared with other

types of injuries ( $\chi^2$  test,  $P < .001$ ). The majority of lacerations (71.2%; 334 649 of 470 030 lacerations) were to the face, 49.0% of burns (14 737 of 30 082 burns) were to the lower extremities, and 46.0% of fractures (10 112 of 21 973 cases) were to the upper extremities. Compared with older children, individuals  $\leq 4$  years of age accounted for 1.9 times (95% CI: 1.5–2.6 times) more burns (70.4%; 21 028 of 29 852 burns;  $\chi^2$  test,  $P < .001$ ) and 7.8 times (95% CI: 5.5–11.0 times) more submersions (90.6%; 10 979 of 12 123 submersions;  $\chi^2$  test,  $P < .001$ ).

#### Type of Bathing Facility and Place of Injury

The majority of injuries occurred in bathtubs (71.3%). As expected, 99.1% of submersion injuries (12 011 of 12 123 cases) occurred in bathtubs. The place of injury was unknown for 14.8% of cases (117 459 cases). Of the 85.2% of injuries (673 695 cases) with a known place of injury, 97.1% (654 168 of 673 695 injuries) occurred at home. Less than 1% of the injuries occurred at any of the other locations.

#### Disposition from the ED

A large proportion of patients (97.1%) were released or left (Table 1), and 2.8% were admitted, transferred, or held. Most patients with slip, trip, and fall injuries (98.7%; 602 924 of 610 631 patients) or user impact-related injuries (99.1%; 69 755 of 70 397 patients) were released or left. Submersions were 26.4 times (95% CI: 19.1–36.5 times) more likely to result in patients being admitted, transferred, or held (54.6%; 6619 of 12 123 patients), compared with other mechanisms of injury ( $\chi^2$  test,  $P < .001$ ). Patients with burns were admitted, transferred, or held for observation 22.8% of the time (6678 of 29 780 patients).

#### DISCUSSION

This investigation found that more than four fifths of bathtub- and shower-related injuries resulted from slips, trips, and falls, closely mirroring the results of a 2005 study.<sup>4</sup> In addition, young children ( $\leq 4$  years of age) have especially high rates of injury and accounted for more than one half of the injuries in this study. The large numbers of bathtub- and shower-related injuries, and more specifically slip, trip, and fall injuries, remained relatively consistent during the 18-year study period, despite recognition of the problem since 1975 and a renewed call to action in 2005.<sup>4,8</sup> These findings argue for the need to increase prevention efforts with a focus on the prevention of slips, trips, and falls in the bathtub and shower, especially among young children. The high injury rate among young children is consistent with their poor coordination, lack of strength, immature judgment, and poor ability to anticipate danger. Notably, children  $\leq 4$  years of age are more likely to injure their head and face; this is attributable to their higher center of gravity, which causes them to topple head first during a fall, and their inabil-

ity to protect their head and face because of limited arm strength and coordination.<sup>14</sup> The elder population, although not included in this study, is also at higher risk for fall-related injuries; bathtub- and shower-related falls in this population deserve attention as a topic for future research.

As expected, bathtub- and shower-related burns and submersions had much higher rates of hospital admission than did slips, trips, and falls. Several measures are now in effect to help prevent scalding and drowning. As the effects of temperature and duration of exposure to hot water on scald burns became better understood, legislation and educational efforts worked together to decrease preset temperatures on water heaters, which reduced the incidence of hot-water scalds.<sup>15,16</sup> Infant bath seats were identified as contributors to bathtub drownings,<sup>17</sup> which led some advocacy groups to call for their ban in 2000.<sup>18</sup> The CPSC voted to propose a mandatory standard for infant bath seats in 2003,<sup>19</sup> which resulted in revision of American Society for Testing and Materials (ASTM) voluntary standard F1967 for infant bath seats.<sup>20</sup>

The American Academy of Pediatrics and other groups currently recommend that young children be supervised by an adult at all times while they are in the bathtub.<sup>1,10,17,21,22</sup> This is especially important for the prevention of submersion injuries. However, supervision alone is insufficient for prevention of slips and falls.<sup>4</sup> Although supervision is important, passive measures of prevention are essential for protection against slips and falls in the bathtub and shower. Passive forms of prevention do not require users to change their behavior or to take action but instead involve changes to make the environment safer (eg, through product modification). This type of automatic protection is more effective in prevent-

ing injury than are active forms of prevention such as constant vigilance by caregivers.<sup>23</sup> Patient education (an active prevention strategy) has many challenges; in addition, awareness of dangers may not be an adequate motivation to change.<sup>24</sup> A new product or product modification (a passive prevention strategy), often unknown to the user, can be more effective in preventing injury, especially when coupled with other passive or active strategies.<sup>25</sup>

The CPSC made several recommendations in its 1975 report for the prevention of injuries in bathtubs and showers.<sup>8</sup> Recommendations included handholds to reduce slipping and falling, shatterproof enclosures to prevent lacerations, cushioned and/or curved tub edges, modified shower enclosures to prevent pinching or laceration of body parts, and rounded and recessed fittings to prevent hitting of body parts. The report also noted the importance of slip resistance but did not detail any specific recommendations.<sup>8</sup>

The 2005 study on bathtub-related injuries discussed the relationship between the bathtub surface coefficient of friction (COF) and the risk of slips and falls.<sup>4</sup> The COF is a unitless ratio of normal force (force perpendicular to the surface, usually gravitational) to frictional force (horizontal force opposing movement). Our discussion focuses on COF measured at the start of motion (static), rather than during motion (kinetic). Slip resistance (measured as static COF) is a good predictor of slips,<sup>26,27</sup> with a person being less likely to fall with a higher COF. Many factors can affect friction, however, including water, sweat, dirt, oil, skin condition, and wear of the bathtub or shower floor surface.<sup>28,29</sup>

The current ASTM voluntary standard F462-07 specifies the COF for bathtub and shower surfaces as 0.04.<sup>26</sup> This value was determined by evaluating 50

existing bathtubs, both textured and nontextured, in 1976 and setting the standard at 2 times the highest tested static COF of a nontextured bathtub. This arbitrary method is clearly flawed, because the bathtubs were never tested for the likelihood of slips and falls. Therefore, it is not known whether even the bathtubs with textured finishes had COFs sufficient to prevent slips and falls. Furthermore, the value of 0.04 is >12 times lower than the widely accepted static COF for safe walking of 0.50.<sup>9,30,31</sup> For wet surfaces, this value may need to be even higher. Therefore, there is a strong need for reevaluation of the COF standard for bathtub and shower surfaces, as well as a method for testing slip resistance on slippery surfaces such as bathtubs. Standards and legislative action clearly cannot prevent injuries caused by improper use of bathing facilities.<sup>26</sup> Furthermore, factors besides COF, such as the bather's physical, behavioral, and mental condition, can affect slips and falls.<sup>4,32</sup> These other factors notwithstanding, evaluation and strengthening of the current COF standard offer the best opportunity to prevent injuries associated with slips and falls in bathtubs and showers.

This study likely underestimates the true rates of bathtub- and shower-related injuries. NEISS data represent injuries treated in US EDs and cannot indicate the number of patients who were treated in other medical settings or did not seek medical attention. In addition, the findings of this study may not be representative of injuries treated in other medical settings. Furthermore, the NEISS does not capture fatalities well, because many fatal cases are not treated in the ED. As in all retrospective studies, missing or inaccurate data in patients' ED medical charts or in NEISS narratives represented a limitation of this investigation. In addition, there was no way to

distinguish between intentional and unintentional injuries in our study. Intentional injury rates would not be reduced by improving bathtub safety; therefore, the inability to differentiate intentional and unintentional injuries might overestimate the number of injuries that prevention efforts could help. Two variables, that is, the part of the tub or shower associated with the injury and the activity at the time of injury, were created from NEISS narratives but could not be evaluated because of large proportions of missing data (66% and 72%, respectively). These variables would have provided useful information, such as identification of the parts of bathtubs and show-

ers most likely to cause injury, allowing for targeted product-modification efforts. Despite these limitations, the NEISS data set provides a large, nationally representative sample of bathtub- and shower-related injuries over an 18-year study period. This study represents the most-comprehensive investigation to date on this important topic.

## CONCLUSIONS

Bathtub- and shower-related injuries, especially those attributable to slips, trips, and falls, represent a common source of injuries for children, particularly children  $\leq 4$  years of age. The consistently high rates of these injuries over the 18-year study period un-

derscore the need for additional preventive actions. The COF specified in the current ASTM standard F462-07 for bathing facility slip resistance is inadequate and needs to be reevaluated and increased. Other safety measures, such as use of shatterproof enclosures and elimination of sharp edges in bathing environments, also should be evaluated. Pediatricians and caregivers should be aware of this important source of pediatric injuries in the home.

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