BRIEF REPORT

Wheelchair related injuries treated in US emergency departments

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Objective: To characterize the trend of wheelchair related injuries over time, and describe the demographics and characteristics of wheelchair users' injuries by age group.
Methods: Data from the National Electronic Injury Surveillance System (NEISS) were analyzed.
Results: In 2003, more than 100 000 wheelchair related injuries were treated in emergency departments in the US, double the number reported in 1991. Tips and falls accounted for 65–80% of injuries across all age groups of wheelchair users. The majority of children's injuries occurred at locations outside of homes and institutions/hospitals in environments with stairs, ramps, and curbs (57.3%). In contrast, injuries among adult users were more likely to occur in homes, hospitals, and institutions (45–90%).
Conclusions: Wheelchair related injuries may have increased in the US during the past decade. Prevention efforts should address the interacting complex factors that influence risk of injury while using a wheelchair.

National data estimate that between 1.6 and 2.2 million Americans rely on wheelchairs to assist with mobility impairments.[1–3] Wheelchair users are among the most visible members of the disability community, and they often have substantial activity restrictions and functional limitations. Recent studies in the United States suggest that individuals with activity limitations are at a significantly higher risk of injury than those without mobility impairments.[4–9]

Several studies on wheelchair related injuries in the US were published more than a decade ago.[8 10 11] However, because the majority of wheelchair related injuries affect older individuals, the characteristics of wheelchair related injuries among children have been overlooked.

Data collected through the National Electronic Injury Surveillance System (NEISS)[12] were analyzed in a previous publication to describe wheelchair related injuries between 1986 and 1992 in the US.[8] However, the characteristics of wheelchair related injuries by user age group were not fully evaluated in this previous study. The objectives of this study were twofold: to present updated national estimates of wheelchair related injuries from 1991 through 2003, describing trends of wheelchair related injuries over time, and to examine characteristics of wheelchair related injuries by age group among wheelchair users based on detailed analysis of 2002 and 2003 NEISS data.

METHODS

Data source

National estimates of the annual number of wheelchair related injuries from 1991–2003 were extracted from the NEISS, which included injuries among wheelchair users, attendants, and bystanders. At the same time, wheelchair related injuries among wheelchair users treated in emergency departments in the NEISS system in 2002 and 2003 were individually reviewed and coded by one of the investigators to describe in detail the characteristics of these injuries.

Case identification

Wheelchair related injury cases were identified using the consumer product code for wheelchairs (product code = 1707) in the NEISS for all study years. For the detailed analysis of injuries among wheelchair users, a wheelchair related injury was defined as a traumatic injury event that occurred to an individual using a wheelchair; therefore, wheelchair related injury cases that involved the injury of an attendant or bystander were excluded.

Methods of measurement

Injury diagnosis

A primary injury diagnosis is assigned for each injury case in the NEISS based on the emergency department discharge diagnosis determined by the attending physician. This primary injury diagnosis was used in our study to classify injuries into five leading diagnoses. The ''other'' category groups those injury diagnosis categories that had less than 50 documented cases.

Location, external cause of injury, and primary injury triggering factor

The narrative statements often provide additional information regarding the injury circumstances. When detail was provided, these data were used in our study to describe the characteristics of injuries among wheelchair users. The location of injury includes institution/hospital, home, and other. The external cause of injury includes tips and falls, wheelchair transfer mishaps, strains of body parts, striking an object or part of the wheelchair, and other. We also identified the primary factor that triggered injury events, which is categorized as a wheelchair part, slippery or close bathroom quarters, stairs, ramps and curbs, and other.

Statistical analysis

Data analyses were conducted using SAS[13] and SUDAAN[14] software to account for the weighting structures of the NEISS.

In this study, we first generated national estimates of all wheelchair related injuries for each year between 1991 and 2003 for three age groups: children 2–17 years, working age adults 18–64 years, and adults 65 years or older. We then generated national estimates of wheelchair related injuries among users by age, sex, race, and treatment disposition from the emergency department. Percentages and 95% confidence intervals were calculated for body region, injury diagnosis, location of injury, external cause of injury, and injury triggering factor.

Abbreviations: NEISS, National Electronic Injury Surveillance System.

RESULTS

From 1991 to 2003, all injuries treated in the US emergency departments among patients aged 2–17 years, 18–64 years, and 65 years older changed by −0.9%, 22.7%, and 57.3% respectively. During the same period, however, wheelchair related injuries treated in US emergency departments increased by 69.8%, 146.8%, and 108.0% among patients aged 2–17 years, 18–64 years, and 65 years or older. The average annual number of wheelchair related injuries during the early 1990s was about 50 000 cases (fig 1). In 2003, the estimated number of wheelchair related injuries reached 102 300 cases.

Of the affected wheelchair users, 68.9% were individuals aged 65 years or older, and 65.0% were females. The majority of the individuals with wheelchair related injuries were treated and released (81.8%); however, 17.2% of the injuries resulted in admission to hospitals (table 1).

The characteristics of wheelchair related injuries among wheelchair users are presented in table 2. Females accounted for 60.2% and 70.8% of injuries in the 2–5 year olds and 65 year olds or older age groups respectively, while 62.1% of injuries occurred to males in the 6–17 year olds group. The most frequent injury diagnoses were fractures, contusions, and lacerations; however, a higher percentage of wheelchair related injuries among working age adults were diagnosed as strains/sprains (16.6% (95% CI 10.8% to 24.7%) for 18–34 year olds and 13.5% (95% CI 11.3% to 16.1%) for 35–64 year olds) than among non-working age patients (10.8% (95% CI 5.6% to 19.6%) for 6–17 year olds and 5.7% (95% CI 4.6% to 7.1%) for 65 year olds or older).

Figure 2 Between 1.6 and 2.2 million Americans rely on wheelchairs to assist with mobility impairments.

The leading injury cause across all age groups was tips and falls, accounting for more than 65% of wheelchair related injuries. Most wheelchair related injuries among 2–5 year

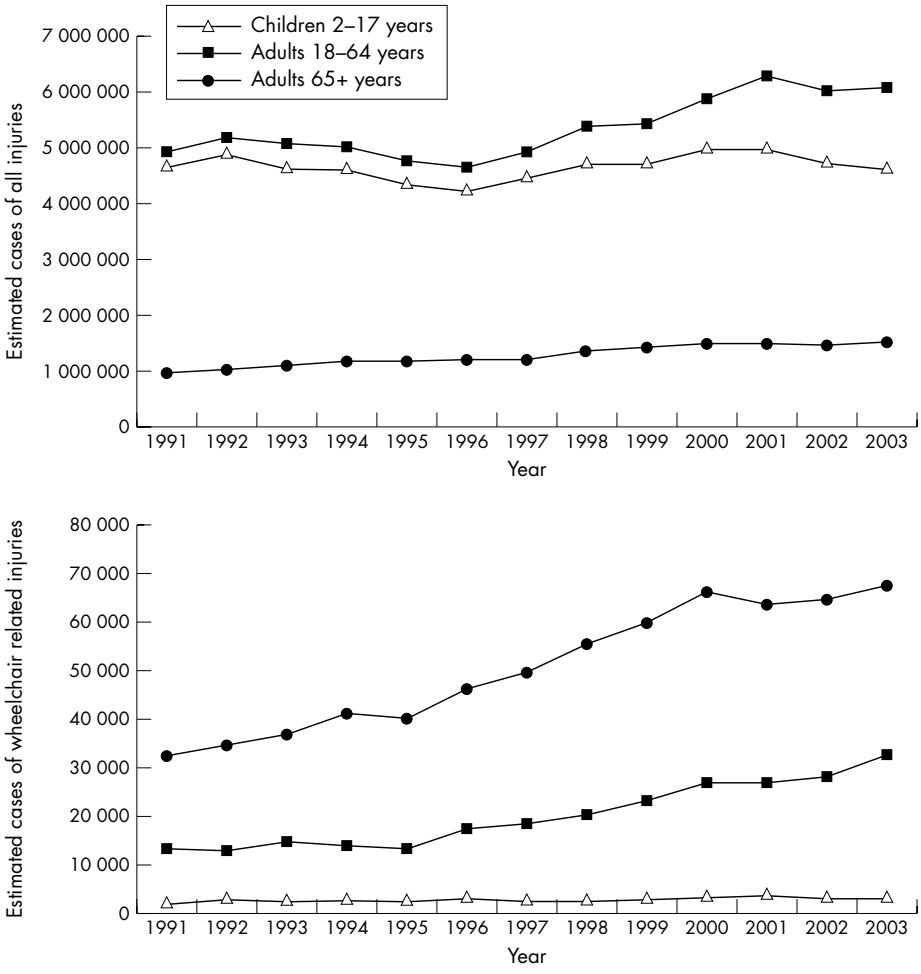

Figure 1 National estimates of all injuries and wheelchair related injuries treated in emergency departments in the US from 1991 through 2003. Source: National Electronic Injury Surveillance System, US Consumer Product Safety Commission.

Table 1 National estimates of wheelchair related injuries by demographics of injured wheelchair users treated in US emergency departments, 2002–03

Demographics	Injury cases in sample	National estimates*	Weighted %*
Age (years)			
2–5	32	902	0.5
6–17	157	3413	2.0
18–34	229	7858	4.5
35–64	1108	42208	24.1
65+	2870	120904	68.9
Sex			
Male	1612	61274	35.0
Female	2784	114011	65.0
Race			
White	2695	108373	61.8
Black	546	18952	10.8
Hispanic	82	1756	1.0
Other/not stated	1073	46204	26.4
Outcomes			
Treated and released	3615	143419	81.8
Admitted to hospital	739	30043	17.2
Held for observation	26	1245	0.7
Left without treatment	9	375	0.2
Death	5	191	0.1
Other/not stated	2	12	0.0

*Statistical weights were used in calculations of weighted percentage to account for survey design; thus, there are slight variations from what would be calculated directly from the number of cases in the actual sample.
Sources: National Electronic Injury Surveillance System, US Consumer Products Safety Commission.

olds (84.1%) and 65 year olds or older (94.0%) occurred in homes and institutions/hospitals. However, 57.3% of injuries among 6–17 year olds occurred at other locations.

DISCUSSION

Major findings

In 2003, more than 100 000 wheelchair related injuries were treated in emergency departments in the US, double the number reported in 1991.[8] Additionally, in-depth analysis of injuries among wheelchair users indicated that the leading cause of injuries across all age groups was tips and falls. Most wheelchair related injuries among individuals 2–5 years of age (84%) and individuals 65 years of age or older (94%) occurred in homes and institutions/hospitals. However, wheelchair related injuries among children 6–17 years old did not follow this pattern.

The finding from this and previous studies that tips and falls is the leading mechanism of wheelchair related injury across all age groups underscores the priority of prevention efforts focusing on tips and falls among wheelchair users. Based on general systems theory, a conceptual model has been proposed and evaluated by other researchers to assess wheelchair related injuries and potential risk factors.[8–11] This conceptual model classifies potential risk factors into four broad categories: engineering factors (for example, manual *v* powered wheelchair, wheelchair occupant restraint systems, anti-tips, and wheel locks), characteristics of wheelchair users (for example, age, sex, and type of disabling conditions), physical environment (for example, uneven terrain, bathroom and home modifications), and social environment

Table 2 Characteristics of wheelchair related injuries among wheelchair users by age group treated in US emergency departments, 2002–03

	2–5 years		6–17 years		18–34 years		35–64 years		65 years	
	n	%* (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Sex										
Male	16	39.7 (21.9–60.7)	98	62.1 (47.9–74.5)	124	52.1 (43.1–60.9)	537	46.1 (42.0–50.2)	836	29.1 (26.8–31.5)
Female	16	60.2 (39.2–78.0)	59	37.8 (25.4–52.0)	105	47.8 (39.0–56.8)	570	53.9 (49.8–57.9)	2034	70.8 (68.5–73.1)
Body region injured										
Head	6	14.3 (4.3–37.8)	29	14.2 (9.2–21.3)	32	15.4 (10.2–22.6)	163	13.6 (11.7–15.8)	640	21.4 (19.2–23.8)
Face, eyeball, mouth	14	48.4 (28.7–68.7)	31	21.8 (12.1–36.3)	19	8.1 (4.4–14.2)	95	9.4 (7.7–11.5)	514	19.6 (16.8–22.7)
Neck and trunk	1	0.7 (0.1–5.0)	14	13.1 (7.2–22.7)	61	28.9 (22.8–36.0)	296	24.3 (21.2–27.6)	763	26.8 (24.3–29.4)
Upper extremity	5	17.4 (6.0–41.0)	25	17.2 (10.9–25.9)	38	15.3 (10.6–21.4)	157	16.4 (13.7–19.4)	335	11.9 (10.4–13.7)
Lower extremity	6	19.0 (6.1–45.7)	54	31.1 (21.4–42.8)	70	30.1 (22.6–38.8)	341	31.3 (28.0–34.8)	514	17.1 (15.0–19.4)
Other	0†		4	2.3 (0.4–11.0)	9	2.0 (0.9–4.4)	55	4.8 (3.4–6.7)	102	2.9 (2.1–4.0)
Injury diagnosis										
Fracture	4	5.0 (1.0–20.7)	34	23.6 (13.9–37.2)	24	7.6 (4.3–13.1)	217	20.6 (17.4–24.2)	619	21.0 (18.7–23.6)
Contusion	10	40.0 (19.1–65.2)	39	31.8 (21.1–45.0)	79	37.1 (29.2–45.7)	337	31.5 (27.6–35.7)	792	27.9 (24.4–31.6)
Laceration	8	36.4 (18.0–59.9)	18	11.7 (5.2–24.1)	21	10.4 (6.4–16.5)	135	12.6 (10.0–15.9)	652	24.5 (22.2–26.8)
Internal organ injury	3	3.0 (0.8–11.1)	20	9.9 (5.7–16.7)	16	7.1 (3.4–14.0)	73	5.8 (4.2–8.0)	268	8.3 (6.4–10.7)
Strain/sprain	0†		19	10.8 (5.6–19.6)	43	16.6 (10.8–24.7)	159	13.5 (11.3–16.1)	179	5.7 (4.6–7.1)
Other	7	15.4 (5.7–35.1)	27	11.8 (6.3–21.0)	46	20.8 (15.1–28.1)	181	15.6 (12.7–19.2)	359	12.3 (10.4–14.6)
Location of injury										
Institution/hospital	2	34.9 (5.6–82.7)	1	0.9 (0.1–5.3)	13	22.5 (10.4–42.0)	100	37.4 (30.1–45.4)	951	81.5 (77.8–84.8)
Home	4	49.2 (11.9–87.4)	14	41.7 (19.2–68.2)	22	26.3 (14.0–43.9)	90	28.2 (20.8–37.0)	174	12.5 (9.6–16.1)
Other	4	15.7 (3.6–48.4)	20	57.3 (30.9–80.0)	31	51.1 (36.2–65.8)	87	34.2 (26.4–43.0)	63	5.9 (4.3–8.0)
External cause of injury										
Tips/falls	22	79.1 (49.1–93.6)	107	72.9 (60.6–82.5)	138	65.5 (57.4–72.8)	758	70.8 (66.9–74.4)	2245	80.9 (78.4–83.2)
Transfer mishaps	0†		9	4.0 (1.3–11.7)	33	16.8 (10.9–24.9)	124	12.7 (10.0–16.0)	363	12.2 (10.3–14.3)
Strain	3	11.0 (2.0–42.8)	13	8.8 (4.3–17.3)	16	5.9 (3.2–10.7)	56	5.1 (3.8–6.8)	66	2.1 (1.6–2.8)
Striking of object	1	0.8 (0.1–5.7)	15	11.3 (5.9–20.7)	17	6.8 (3.4–12.9)	83	7.3 (5.7–9.3)	95	3.4 (2.8–4.1)
Other	1	9.0 (1.2–44.0)	6	2.7 (0.7–9.9)	13	4.8 (2.5–8.8)	44	3.9 (2.6–5.6)	34	1.2 (0.8–1.9)
Injury triggering factor										
Wheelchair part	3	62.9 (24.4–89.9)	9	37.0 (15.0–66.2)	12	22.9 (10.9–41.8)	38	20.0 (13.8–27.9)	72	25.2 (18.9–32.7)
Slippery bathroom	0†		0†		6	13.4 (5.2–30.2)	45	25.5 (19.5–32.6)	97	40.4 (32.6–48.7)
Stairs, ramp, curb	6	37.0 (10.0–75.6)	13	45.2 (20.6–72.4)	12	35.7 (20.2–54.9)	43	18.4 (12.9–25.4)	61	22.8 (15.6–32.1)
Other	0†		6	17.6 (4.4–49.6)	14	27.8 (16.2–43.3)	75	36.0 (28.9–43.8)	28	11.5 (7.9–16.4)

*Statistical weights were used in calculations of weighted percentage to account for survey design; thus, weighted % might be different from what would be calculated directly from the number (n) of cases.
†Missing data.

(for example, activities of the wheelchair users, inappropriate prescription of a wheelchair by healthcare professionals, and inadequate maintenance of the wheelchair). Interventions to modify any of these factors may reduce the risk of tips and falls, and therefore reduce the risk of wheelchair related injuries.[15–17] For example, bathroom and home modifications to make home environments more properly suited to wheelchair users' functional limitations have been shown to significantly lower injurious falls.[17]

From an etiology perspective, wheelchair related injuries can be considered to be the result of the interaction among factors in this complex system, which emphasizes the system's accountability rather than solely focusing on the wheelchair user's individual accountability.[9] From a societal perspective, there should be greater movement toward barrier-free, universally accessible physical environments through the use of modifications such as access ramps for disabled people and home, roadway, and public structure designs adapted to meet the needs of wheelchair users.[8 9 11]

Although younger age has been mentioned by some previous studies to be associated with an increased risk of wheelchair related injuries,[15 18] little has been done to describe the patterns of wheelchair related injuries among children. Previously, it was unknown whether the wheelchair related injuries among children have different patterns than those among working age adults or individuals aged 65 years or older. Our results indicate that there are noteworthy differences in wheelchair related injuries between children aged 6–17 years and adults. Unlike wheelchair related injuries among adults, those injuries among children 6–17 years old involve mostly boys. Young wheelchair users (age 6–17 years) are more likely to be injured outside homes or institutions/hospitals, in environments where stairs, ramps, or curbs are associated factors. The different patterns of injury among children may be related to the more frequent participation in outdoor activities, such as sports, in which the risk of injury is high.[15 18] The provision of wheelchairs to young disabled children affords them newfound opportunities to participate in community activities. However these children are at higher risk for injuries normally associated with age appropriate exploratory behavior.[19] This warrants special consideration in prevention of wheelchair related injuries among children, which often requires increased adult supervision and restructuring of their environment (for example, school bus and classroom modifications).

Limitations of the study

Several limitations of the NEISS data and this study should be considered when interpreting study findings. First, injury rates could not be calculated because accurate national estimates of the number of wheelchair users were not available. Therefore, the increased number of wheelchair related injuries observed in this study may reflect the increase in the number of individuals relying on wheelchairs in the US in recent years. Second, study researchers coded, where possible, the circumstances of the injury event and the characteristics of wheelchair related injuries. In some instances, narrative information was unavailable for the study variables, and it was not possible to obtain the original medical records or contact the patients or patients' families to get the missing information. Finally, because the NEISS only captures injuries treated in emergency departments, this study's findings may not be representative of injuries treated in other medical facilities or injuries for which no medical care was sought.[12]

Key points

- Wheelchair related injuries treated in emergency departments in US may have increased during the past decade.
- The leading cause of injuries across all age groups was tips and falls.
- Wheelchair related injuries among children aged 6–17 years had different injury patterns from those of adults.

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REFERENCES

1 **McNeil JM**. *Americans with disabilities 1994–1995*. Washington, DC: US Department of Commerce, Economics and Statistics Administration, Census Bureau, 1997.
2 **National Institute on Disability and Rehabilitation Research**. Trends in disability prevalence and their causes: proceedings of the Fourth National Disability Statistics and Policy Forum. Paper presented at: National Disability Statistics and Policy Forum, 1997; Washington, DC.
3 **Kaye S**, Kang T, LaPlante M. Wheelchair use in the United States. *Disability Statistics Abstract* 2002;**23**:1–4.
4 **Xiang H**, Leff M, Stallones L. Non-fatal injuries among adults with activity limitations and participation restrictions. *Inj Prev* 2005;**11**:157–62.
5 **Petridou E**, Kedikoglou S, Andrie E, *et al*. Injuries among disabled children: a study from Greece. *Inj Prev* 2003;**9**:226–30.
6 **Asada T**, Kariya T, Kinoshita T, *et al*. Predictors of fall-related injuries among community-dwelling elderly people with dementia. *Age Aging* 1996;**25**:22–8.
7 **Leland NL**, Garrand J, Smith DK. Comparison of injuries to children with and without disabilities in a day-care center. *J Dev Behav Pediatr* 1994;**15**:402–8.
8 **Ummat S**, Kirby RL. Nonfatal wheelchair-related accidents reported to the National Electronic Injury Surveillance System. *Am J Phys Med Rehabil* 1994;**73**:163–7.
9 **Gavin-Dreschnack D**, Nelson A, Fitzgerald S, *et al*. Wheelchair-related falls: current evidence and directions for improved quality care. *J Nurs Care Qual* 2005;**20**:119–27.
10 **Calder CJ**, Kirby RL. Fatal wheelchair-related accidents in the United States. *Am J Phys Med Rehabil* 1990;**69**:184–90.
11 **Kirby RL**, Ackroyd-Stolarz SA. Wheelchair safety—adverse reports to the United States Food and Drug Administration. *Am J Phys Med Rehabil* 1995;**74**:308–12.
12 **Quinlan K**, Thompson M, Annest J, *et al*. Expanding the National Electronic Injury Surveillance System to monitor all nonfatal injuries treated in US hospital emergency departments. *Ann Emerg Med* 1999;**34**:637–45.
13 **Statistical Analysis Software (SAS)**. Version 8.02. Cary, NC: SAS Institute, 2003.
14 **Shah BV**, Barnwell BG, Bieler GS. *SUDAAN User's Manual, release 7.5*. Research Triangle Park, NC: Research Triangle Institute, 1997.
15 **Hays RM**, Jaffe KM, Ingman E. Accidental death associated with motorized wheelchair use: a case report. *Arch Phys Med Rehabil* 1985;**66**:709–10.
16 **Gaal RP**, Rebholtz N, Hotchkiss RD, *et al*. Wheelchair rider injuries: causes and consequences for wheelchair design and selection. *J Rehabil Res Dev* 1997;**34**:58–71.
17 **Berg K**, Hines M, Allen S. Wheelchair users at home: few home modifications and many injury falls. *Am J Public Health* 2002;**92**:48.
18 **Kirby RL**, Ackroyd-Stolarz SA, Brown MG, *et al*. Wheelchair-related accidents caused by tips and falls among noninstitutionalized users of manually propelled wheelchairs in Nova Scotia. *Am J Phys Med Rehabil* 1994;**73**:319–30.
19 **Scheidt P**, Harel Y, Trumble A, *et al*. The epidemiology of nonfatal injuries among US children and youth. *Am J Public Health* 1995;**85**:932–8.