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Stair-related injuries treated in United States emergency departments

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ABSTRACT

Objective: To investigate the characteristics of stair-related injuries among individuals of all ages and estimate national injury frequencies and rates using a representative sample of patients treated in United States emergency departments.

Methods: Data from the National Electronic Injury Surveillance System were analyzed for patients treated for stair-related injuries in United States emergency departments from 1990 through 2012.

Results: An estimated 24,760,843 patients were treated in emergency departments for a stair-related injury during the 23-year study period, averaging 1,076,558 patients annually, or 37.8 injuries per 10,000 United States residents. The annual rate of stair-related injuries decreased by 12.6% ($p < 0.001$) during 1990–1996, followed by an increase of 24.0% ($p < 0.001$) during 1996–2012. Although the highest injury rates occurred among younger children and older adults, the majority (67.2%) of emergency department visits for stair-related injuries was by individuals 11–60 years old. Most patients were female (62.4%), who also had a higher injury rate (46.5 vs. 29.1 per 10,000) than males. Sprains and strains (32.3%), soft tissue injuries (23.8%), and fractures (19.3%) were the most common types of injury. The body regions most frequently injured were the lower extremities (42.1%) and head/neck (21.6%). Patients ≤ 10 years old experienced more head/neck injuries. Older adult patients more frequently sustained fractures than younger age groups.

Conclusions: Stairs are a common source of injury among individuals of all ages and the frequency and rate of stair-related injuries are increasing. This underscores the need for increased prevention efforts, particularly those related to stair design and construction.

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1. Introduction

Stairs are present inside an estimated 49% of homes in the United States (US), not including single-story dwellings that may require stairs for access [1]. Although frequent exposure to these structures may lead many people to underestimate their potential to be associated with injury, such injuries are well-documented in the research literature [2–14]. Most stair-related injuries do not result in serious medical outcomes [2–6,11]; however, it is important to note that fatalities do

occur [2,8,10,15,16]. Overall, falls are the leading cause of non-fatal injury in the US, and are associated with significant morbidity and mortality among older adults [16,17]. Because stairs are so prevalent in society and are a common location for falls to occur, it is important to study stair-related injuries across all age groups.

Previous studies have documented the frequency and characteristics of stair-related injuries among children [3–6,11–13,18]. There is also existing research describing high rates of stair-related injuries among older adults, as well as the associated morbidity and mortality [2,8,10,14,19,20]. Numerous studies have examined gait characteristics of different age groups and their relationship to relative injury rates [21–31]. In addition to describing injuries, studies have also investigated the costs associated with stair-related injuries [32–35]. It is estimated that non-fatal injury-related direct medical and indirect costs are \$92 billion annually in the US [35].

The objective of the current study is to investigate the epidemiological characteristics of stair-related injuries among all ages using a nationally representative sample over a multi-year period. Our study

Abbreviations: CHI, Closed head injury; CI, Confidence interval; CPSC, United States Consumer Product Safety Commission; ED, Emergency department; NEISS, National Electronic Injury Surveillance System; RR, Relative risk; US, United States.

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also expands upon prior research on this topic to investigate the mechanisms of stair-related injuries and examine trends.

2. Methods

2.1. Data source

Data for patients treated in US emergency departments (EDs) for stair-related injuries from January 1, 1990 through December 31, 2012 were obtained through the National Electronic Injury Surveillance System (NEISS). The NEISS, developed in 1972 and maintained by the US Consumer Product Safety Commission (CPSC), provides consumer product-related and sports and recreational activity-related injury data from a stratified probability sample of approximately 100 US hospital EDs that provide 24-h care and have at least six beds [36]. Professional NEISS coders review ED medical charts at each participating hospital and transcribe data into the NEISS database. Data are weighted to provide national estimates of injury.

2.2. Case selection criteria

All NEISS cases from 1990 through 2012 that involved stairs or steps (NEISS product code 1842, which excludes pull-down and folding stairs) were obtained. Fatalities were excluded ($n = 192$), because the NEISS does not capture fatal cases well. Cases involving escalators, ladders, or step stools (NEISS codes 0618, 0619, 0620, 0688, 1890, 3262, 4032, 4033, 4077, and 4078) were not included in this study. After applying case selection criteria, there were 650,255 unweighted stair-related injuries included in this study.

2.3. Variables

NEISS variables included in study analyses were patient age and gender, body region injured, injury diagnosis, disposition from the ED, locale of injury, as well as the brief case narrative describing the incident. Cases were categorized into nine single-decade age groups for investigation of age-related trends. In order to examine injury frequencies and rates among younger children and older adults separately, we divided cases into three broader age categories: (1) younger children (≤ 10 years), (2) older children and adults (11–60 years), and (3) older adults (≥ 61 years). Body region injured was collapsed into 5 body regions: (1) head/neck, (2) upper extremity (including shoulder), (3) trunk, (4) lower extremity, and (5) other/not specified. Diagnosis was categorized as: (1) strains/sprains, (2) soft tissue injury (including contusions, abrasions, and hematomas), (3) fractures, (4) lacerations (including lacerations, amputations, and punctures), (5) concussion/closed head injury (CHI; i.e., internal organ injury to the head region), and (6) other/not specified. Disposition from the ED was regrouped into four categories: (1) examined/treated and released from the ED, (2) hospitalized (including treated and admitted, transferred for hospitalization or to another hospital, and held for observation), (3) left against medical advice, and (4) not specified. The location of injury was recoded as (1) home (including home, apartment, condo, and mobile home), (2) outside of the home (including school, farm/ranch, street/highway, industrial place, other public property, sports or recreation place), or (3) not specified.

Assisted by a computerized keyword search, information included in the case narratives was used to categorize mechanism of injury into the following groups: (1) fell on stairs via unspecified mechanism (including tumbles); (2) slid or slipped on stairs; (3) tripped on the stairs or over an object on the stairs; (4) missed a step or had a misstep (including stumbles); (5) running or playing (including intentional risky behaviors, such as riding down the stairs on a toy or sliding down the banister); (6) fell while carrying an object, child, or person, or while being carried; and (7) other. For case narratives describing multiple mechanisms of injury, the first mechanism in a temporal sequence of

mechanisms was chosen. For example, if a person was carrying a basket of clothes down the stairs and then tripped, the case was coded as carrying an object.

2.4. Statistical analysis and ethical statement

Data were analyzed using IBM SPSS 24.0 (Armonk, NY) statistical software. Statistical analyses included piecewise linear regression to evaluate the statistical significance of secular trends, chi-square analysis, and relative risk (RR) with a 95% confidence interval (CI). The estimated slope from the regression model (m) was reported with the associated p -value. The level of significance was set at $\alpha \leq 0.05$ for all statistical tests. Injury rates per 10,000 US residents were calculated using data from the US Census Bureau [37–39]. US census data combine all individuals 85 years of age and older into one age group; therefore, injury rates in this study were calculated accordingly. National estimates were calculated using NEISS weights provided by the CPSC, and all numbers reported in this study are national estimates unless otherwise identified as unweighted cases. The institutional review board at the authors' institution determined that this study was exempt.

3. Theory

This study provides a comprehensive epidemiological analysis of nationally representative emergency department data covering a 23-year period regarding an important source of injury morbidity in the US. In addition, within the context of study findings, this article describes relevant injury prevention strategies.

4. Results

4.1. Overall injury characteristics and trends

An estimated 24,760,843 (95% CI: 20,833,284–28,688,402) individuals were treated in US EDs for stair-related injuries from 1990 through 2012, averaging 1,076,558 stair-related injuries per year or an annual rate of 37.8 per 10,000 US residents (Table 1, Fig. 1). The number of injuries decreased (-5.8% , $m = -8391.1$, $p = 0.065$) from 951,550 cases in 1990 to 896,769 cases in 1996, before increasing to 1,296,148 cases in 2012 (44.5%, $m = 24,925.0$, $p < 0.001$; Fig. 1). This corresponded to a 12.6% ($m = -0.765$, $p < 0.001$) decrease in the rate of stair-related injuries from 1990 (38.1 per 10,000 population) to 1996 (33.3 per 10,000 population), followed by a 24.0% ($m = 0.494$, $p < 0.001$) increase from 1996 to 2012 (41.3 per 10,000 population).

Patients ranged in age from < 1 to 115 years old, with a mean age of 36.7 years (standard error of the mean: 0.53; median: 33.6, interquartile range: 18.4–52.0). Female patients accounted for 62.4% of all stair-related injuries, and the majority of injuries (61.2%) occurred at home (Table 1). The body regions most commonly injured were the lower extremities (42.1%), head/neck (21.6%), and trunk (18.1%), and the most common diagnoses were strain/sprain (32.3%), soft tissue injury (23.8%), and fracture (19.3%) (Table 1). Lower extremity injuries were most commonly strains/sprains (54.1%) and fractures (21.4%), upper extremity injuries were primarily fractures (37.0%) and soft tissue injuries (26.1%), and most trunk injuries were soft tissue injuries (38.9%) and strain/sprains (27.0%). Among head/neck injuries, 34.1% were lacerations, 26.6% were concussions/CHIs, and 25.6% were soft tissue injuries.

The majority (93.8%) of patients were examined/treated and released from the ED and 5.7% of injuries resulted in hospitalization (Table 1). The rate of hospitalization per 10,000 population decreased by 26.7% ($m = 0.11$, $p < 0.001$) from 2.1 in 1990 to 1.6 in 1997, and then increased by 99.8% ($m = 0.10$, $p < 0.001$) from 1997 to 3.1 in 2012. More than one-half of the injuries requiring hospitalization were fractures (59.4%), and an additional 14.2% were concussions/CHIs. Overall, 59.4% of injured patients fell down the stairs without a

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