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Original Contribution

Zipline-related injuries treated in US EDs, 1997-2012☆

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ABSTRACT

Purpose: To investigate the epidemiology of zipline-related injuries in the United States.
Basic Procedures: The National Electronic Injury Surveillance System database was used to examine non-fatal zipline-related injuries treated in US emergency departments (EDs) from 1997 through 2012. Sample weights were applied to calculate national estimates.
Main Findings: From 1997 through 2012, an estimated 16850 (95% CI, 13188-20512) zipline-related injuries were treated in US EDs. The annual injury rate per 1 million population increased by 52.3% from 7.64 (95% CI, 4.86-10.42) injuries in 2009 (the first year with a stable annual estimate) to 11.64 (95% CI, 7.83-15.45) injuries in 2012. Patients aged 0-9 years accounted for 45.0% of injuries, females made up 53.1% of injuries, and 11.7% of patients required hospitalization. Fractures accounted for the largest proportion of injuries (46.7%), and the upper extremities were the most commonly injured body region (44.1%). Falls were the most common mechanism of injury, accounting for 77.3% of injuries. Among cases where the location of the injury event was known, 30.8% of injuries occurred in a residential setting and 69.2% occurred in a public place.
Principal Conclusions: This study is the first to characterize the epidemiology of zipline-related injuries using a nationally representative database. The rapid increase in zipline-related injuries in recent years suggests the need for additional safety guidelines and regulations. Commercial ziplines and publicly accessible non-commercial ziplines should be subject to uniform safety standards in all states and jurisdictions across the US, and homemade ziplines should not be used.

1. Introduction

First used over a century ago to transport supplies in the Indian Himalayas [1], the zipline has gained popularity as a form of outdoor recreation over the past decade [2]. A zipline, as defined by the United States Consumer Product Safety Commission (CPSC), is a horizontal rope or wire with a device for sliding along by hanging beneath it [3]. Several states have acknowledged the inherent risk of injury associated with ziplines and have established regulations governing commercial ziplines using safety standards developed by ASTM International, the Association for Challenge Course Technology, or the Professional Ropes Course Association [4]. However, the industry is largely self-regulating [5-8]. In recent years, media coverage of isolated serious injuries and deaths associated with ziplines has raised concerns regarding zipline safety [9-13].

Very little research has been conducted on the epidemiology of zipline-related injuries. The only peer-reviewed study related to the topic examined fatalities on challenge courses, finding that nearly one-fourth of all reported deaths were associated with the zipline component of the challenge course. That study did not examine non-fatal injuries and was limited to only 17 deaths. Further, it did not address injuries sustained on stand-alone ziplines or canopy tours, and most deaths were from only one challenge course provider. Therefore, that study was not representative of zipline-related injuries occurring nationally [14]. Several studies have addressed playground zipline-related injuries [15-17], which were excluded from the current study because of fundamental differences between the products involved. Playground ziplines, also termed track rides, are "a form of upper body equipment where the child holds on to a handle or other device that slides along a track above his or her head" [18]. These rides are subject to safety standards developed for playground equipment, unlike the ziplines associated with the injuries in the current study [3].

To our knowledge, this is the first study to examine non-fatal zipline-related injuries, including those occurring on homemade ziplines, commercial operations, challenge courses, and canopy tours, using a nationally representative database. An analysis of the epidemiology of these incidents will allow for a greater understanding of the injury risk associated with zipline use, which will help inform the development of additional safety guidelines and regulations.

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2. Methods

2.1. Data source

Data were obtained from the National Electronic Injury Surveillance System (NEISS), operated by the CPSC, for zipline-related injuries treated in US emergency departments (EDs) from 1997 through 2012. The NEISS is a stratified probability sample consisting of approximately 100 US hospital EDs, representing the more than 5000 24-hour hospital EDs in the United States and its territories with more than six beds [19]. The NEISS database provides information on age, gender, injury diagnosis, body region injured, disposition from the ED, product or activity involved, date of treatment, and locale, as well as a brief narrative describing the injury event. More specific information regarding NEISS data collection is described elsewhere [20].

2.2. Case selection criteria

Cases from the NEISS database were classified as zipline-related if the cases' narratives contained any of the following words: "zipline," "zip line," "zip-line," "zip cord," "zip swing," "zip wire," and "flying fox." The narratives of 830 zipline-related cases were further reviewed and 606 cases met the study criteria. All cases that explicitly stated or implied that they occurred on a playground zipline were excluded, as well as cases that occurred in the school locale and thus were assumed to be playground ziplines. When the type of zipline involved in the injury was not specified, it was presumed a traditional zipline and the case was included, because playground ziplines are customarily termed track rides [16]. Cases that were erroneously classified as zipline-related were excluded as well.

2.3. Variables

NEISS variables for diagnosis, body region injured, patient age, disposition from the ED, and locale were recategorized for analysis. Diagnoses were categorized into (1) lacerations (including lacerations and punctures), (2) concussions/closed head injuries (including internal injuries to the head region), (3) soft tissue injuries (including contusions and abrasions), (4) fractures, (5) strains and sprains, and (6) other (including dislocations, burns, dental injuries, and internal injuries not to the head). Body region injured was classified as (1) head and neck (including the categories of head, face, mouth, eyeball, and neck), (2) trunk (including upper and lower trunk and pubic region), (3) upper extremity (including finger, hand, wrist, lower arm, elbow, upper arm, and shoulder), (4) lower extremity (including upper and lower leg, knee, foot, ankle, and toe), and (5) other. Patient age was grouped into <10, 10-19, and ≥20 in order to compare injuries incurred by young children with those among older children and adults. Disposition from the ED was grouped into (1) treated and released and (2) hospitalized (including treated and transferred to another hospital, treated and admitted, and kept for <24 hours for observation). One fatality was excluded from this study, in which an eight-year-old girl suffered a skull fracture and epidural hemorrhage after falling ten feet from a homemade zipline.

The primary mechanism of injury was determined from the case narratives and categorized as (1) fell from the zipline or zipline platform, (2) collision with a static object or another person, or (3) other (hand caught in zipline, zipline broke or malfunctioned, hit by zipline handle, anxiety or stress, and difficulty landing). The height of the fall also was determined from case narratives and categorized as (1) ≤10 feet or (2) >10 feet. Locale was classified as (1) residential (including homes and farms), or (2) public place (including sport/recreation areas and other public places).

2.4. Data analyses

Statistical analyses were conducted using IBM SPSS version 20.0 (IBM Corp, Armonk, NY), and SAS 9.3 (SAS Institute Inc, Cary, NC) statistical software. Sample weights provided by the CPSC were used to calculate the national injury estimates. The Taylor series linearization method, which accounted for the NEISS sampling design, was used to calculate the variance of the estimates. All reported results are stable national estimates unless stated otherwise. An estimate is potentially unstable if it is based on <20 actual cases, the estimate is <1200, or the coefficient of variation is >30%. National injury rates were calculated using US Census Bureau July 1 intercensal and postcensal residential population estimates for 1997 through 2012 [21-23] as denominators. Due to potentially unstable annual estimates from 1997 to 2008, trend analysis was not conducted for the entire study period and was restricted to years with stable annual estimates (2009-2012). The Rao-Scott χ^2 test was used to test for association, and relative risks (RRs) with 95% confidence intervals (CIs) were also calculated. Statistical tests were considered significant at $\alpha = .05$. The institutional review board at the authors' institution approved this study.

3. Results

3.1. General characteristics

From 1997 through 2012, an estimated 16850 (95% CI, 13188-20512) zipline-related injuries were treated in US EDs, resulting in an injury rate of 3.58 (95% CI, 2.80-4.36) per 1 million US residents. The majority (67.7%) of the injuries occurred from 2009 through 2012. The annual injury rate per 1 million US residents increased by 52.3% from 7.64 (95% CI, 4.86-10.42) injuries in 2009 (the first year with a stable annual estimate) to 11.64 (95% CI, 7.83-15.45) injuries in 2012 (Fig. 1). This corresponded to a 55.8% increase in the annual number of injuries, from 2345 (95% CI, 1492-3198) injuries in 2009 to 3653 (95% CI, 2457-4849) injuries in 2012. The mean patient age was 16.0 years (SD, 1.5) and the median patient age was 9.6 years (range, 2-82; interquartile range, 6.4-17.1). Patients aged <10 years accounted for 45.0% of injuries, followed by patients aged 10-19 years (33.0%) (Table). Among the 79.5% of cases where locale was known, 30.8% occurred in a residential area, either at the patient's home or at the home of a relative, friend, or neighbor. Females accounted for 53.1% of all zipline-related injuries, and 11.7% of patients were admitted to the hospital. Most (91.2%) of the injuries occurred from early spring (April) through late fall (October) with the number of injuries peaking in July (Fig. 2).

3.2. Injury diagnosis and body region injured

Fractures accounted for 46.2% of all zipline-related injuries, followed by soft tissue injuries (15.2%) and strains/sprains (15.1%) (Table). Concussions and closed head injuries constituted 7.7% of all injuries. Patients aged <10 years were more likely to suffer a fracture compared with older patients (RR, 1.68; 95% CI, 1.32-2.14). The most commonly injured body region was the upper extremities (44.1%), followed by the lower extremities (24.3%), head and neck (18.6%), and trunk (13.0%) (Table). Injuries to the upper extremities were more likely to result in a fracture than injuries to other body regions (RR, 3.38; 95% CI, 2.37-4.82). Patients <10 years of age were more likely to incur an injury to the upper extremities (RR, 1.84; 95% CI, 1.41-2.41) than older patients. Patients aged ≥20 years were more likely to sustain an injury to the lower extremities than younger patients (RR, 2.81; 95% CI, 1.86-4.25).

3.3. Mechanism of injury

Among all zipline-related injuries where mechanism of injury was stated, falls accounted for 77.3% and collisions accounted for 13.4% (Table). Fall-related injuries were commonly diagnosed as fractures (56.3%) and frequently occurred to the upper extremities (51.8%) or the head and neck region (17.6%). Among those hospitalized, 77.9% were admitted for a fall-related fracture. Falls accounted for 90.4% of the injuries among children aged <10 years and 77.7% of all injuries