



Risk-enhancing behaviors associated with human injuries from bison encounters at Yellowstone National Park, 2000–2015[☆]

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Abstract: Yellowstone National Park is home to the largest bison population on public land in the United States. Although Yellowstone regulations require visitors to remain at least 23 m from bison, since 1980, bison have injured more visitors to Yellowstone than any other animal. We examined a series of bison-related injuries at Yellowstone to evaluate the circumstances of these injuries and to identify common risk-enhancing behaviors that lead to injury. To do this, we analyzed narrative case incident records from law enforcement regarding bison-human encounters in Yellowstone during 2000–2015. Data regarding demographics, pre-encounter activities, number of persons involved, type of injury, and acknowledgement of appropriate viewing distance were extracted from the records. Bison encounters resulted in injury to 25 persons (21 visitors and 4 employees). Age range for injured persons was 7–68 years (median: 49 years), and 13 were female. All injuries occurred in areas of high visitor concentration. Mean visitor distance from bison before injury was 3.4 m (range: 0.3–6.1 m). Twenty persons (80%) actively approached bison before their injuries; 5 (20%) failed to retreat when bison approached. Fifteen persons (60%) were injured when in a group of ≥ 3 persons approaching bison. Twelve persons (48%) sustained injuries while photographing bison. Six persons (24%) acknowledged they were too close to bison. Education alone might not be sufficient to reduce bison-related injuries. Effective injury prevention campaigns for national parks require an understanding of the behaviors and motivations of persons who approach bison. Including behavioral science and behavior change techniques in bison injury prevention campaigns might reduce injuries at Yellowstone.

1. Introduction

American bison (*Bison bison*) are iconic animals of the American West and the largest terrestrial mammals in the Western Hemisphere [1–3]. Bison were hunted to near extinction, and Yellowstone National Park (Yellowstone) became a refuge for them. Over time, bison numbers increased to 4900 by July 2015 [4]. Today, Yellowstone is one of the remaining places where bison roam free and serves as home to the largest U.S. bison population on public land [1,2]. Since 2000, an average of 3.2 million persons have visited Yellowstone each year to see bison and other unique attractions [5].

A portion of visitors approach bison in Yellowstone too closely, and

a limited number will sustain bison-related injuries [6–8]. Yellowstone has developed distance regulations for viewing wildlife; 91 m (100 yards) from bears or wolves and 23 m (25 yards) for any other wildlife [9,10]. These viewing distances are intended to protect persons and preserve the natural habitat of wildlife by minimizing disturbances. The park also has extensive educational outreach campaigns on wildlife viewing [11]. A graphic flyer has been distributed to visitors at park entrances. Signs are displayed throughout campgrounds, developed areas, and along roadsides (Fig. 1). The visitor center has an exhibit that includes videos of bison encounters. Despite these campaigns and regulations, persons continue to sustain injuries from approaching bison too closely [7].

[☆] The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the National Park Service.

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Fig. 1. Informational sign on bison safety at a visitor use trail in Yellowstone National Park.

The sign provides information on how to stay safe around bison by keeping an appropriate distance (> 25 yards) and never approaching bison. This sign is an example of Yellowstone's extensive educational outreach campaigns on wildlife viewing, which includes flyers, signs, website information, exhibits, videos, films, and social media, in addition to in-person contacts.

One Health applies to many determinants of health, but in practice, One Health is often focused on the emergence and transmission of zoonotic diseases [12]. While diseases such as rabies, hantavirus, and tularemia fit well into the One Health framework, infectious diseases are by no means the only way that animals and humans affect each other's health. When humans and wildlife interact in protected areas, such as NPS park units, the risk of injury might be just as concerning as the potential of disease transmission. In addition, public health practices, such as injury prevention, can inform the management of wildlife injuries.

Limited information is available regarding the magnitude and types of injuries from wildlife. One study estimated that wildlife bite 35,000 persons in the United States annually [13]. Injuries from wildlife occurring inside National Park Service (NPS) facilities have not been well studied. Although wildlife-related injuries in national parks are low, compared with the total number of NPS visitors, consequences of interacting with large wildlife species (e.g., bison and bears) are high. A study of large carnivore attacks in upper-middle-income and high-income countries reported that approximately one-half of injured persons were involved in risk-enhancing human behaviors before injury [14], and many human-wildlife interactions in parks are attributable to park visitor behaviors [15]. Reducing risk-enhancing behaviors among park visitors might be one effective means to reduce injuries from human-wildlife interactions.

Public health practitioners are increasingly using behavioral science approaches that target risk-enhancing behaviors to reduce public health risks [16]. Some well-known behavior change campaigns include promotion of condom use, breastfeeding, improved nutrition, increased physical activity, and reduction in misuse of alcohol, tobacco, and illicit drugs [17–19]. Behavior change campaigns fundamentally differ from educational and informational campaigns because they attempt to address audience motivations and perceived benefits and barriers related to the target behavior, not just increase knowledge or awareness of risks [20,21]. Indeed, there is a growing recognition that public health campaigns developed based on general information alone rarely achieve desired behavior changes [20–23]. Instead, various behavioral science methods and frameworks (e.g. ecological model, theory of reasoned action, health belief model, and social marketing) are used to encourage practices that promote health behaviors or prevent injuries

for a specific target audience [15,18]. Identifying the specific behaviors that need to be addressed is at the core of these campaigns. Therefore, identifying the specific risk enhancing behaviors that lead to human-wildlife injuries is the first step in creating effective injury prevention campaigns that ensure the safety of both park visitors and wildlife.

Because of the limited data regarding wildlife-related injuries, we sought to learn more about the circumstances associated with wildlife-related injuries in an NPS setting. We selected Yellowstone and focused on bison-related injuries for two reasons. Since 1980, bison have injured more park visitors to Yellowstone than any other animal [6,7], and Yellowstone maintains robust records of these injuries. By examining all known bison-related injuries at Yellowstone from 2000 to 2015 and evaluating the circumstances of these injuries, we sought to identify behaviors that might be targeted in human-wildlife injury prevention campaigns.

2. Methods

We analyzed Yellowstone's law enforcement case incident records, completed by rangers for each report of a bison-human encounter, collected during 2000–2015. Records contain the incident nature, location, date, and demographics of the persons involved. Law enforcement records detail the incident in narrative form through self-reporting by the injured party, witness statements, or on-scene investigation from responding rangers. Records can also contain photographic evidence of the encounter. Individual records vary in the amount of information collected on the incident.

We abstracted data from case incident records, focusing on variables such as park affiliation (visitor or employee), preencounter activities, preencounter distance from bison, encounter type, number of persons involved, injury description and outcome, treatment, and appropriate viewing distance acknowledgement. We entered data into a standardized database and analyzed it by using Epi Info™ 7.1.4.0 (Epi Info, Atlanta, Georgia). Categorical variables were described as counts and proportions; continuous variables were described using median and range. Responses were not provided for all fields, and missing data were not reported.

We defined an injury to a human from a bison encounter as an injury sustained from physical contact between a bison and human. Injuries that occurred while avoiding a physical encounter with a bison (e.g. fell down while avoiding a bison, but had no contact with bison) or from a vehicle crash with a bison were not included in this analysis. We classified the type of bison encounters as gored, tossed, or butted. These injuries were categorized based on the most severe encounter type, with goring as the most severe. Gored was defined as the injured person receiving a penetrating wound from the horn of a bison. Tossed was defined as a bison lifting a person into the air. Butted was defined as a person being knocked to the ground when pushed by the bison's head. CDC reviewed this study for human subjects protection and deemed it to be nonresearch.

3. Results

During 2000–2015, bison encounters at Yellowstone resulted in injury to 25 persons (21 visitors and 4 employees) (Fig. 2). The median number of injuries was 1/year (range: 0–5/year). The highest number of encounters occurred in 2015 when five persons were injured by bison. All bison-related injuries occurred during April–October, with the majority of injuries occurring in June ($n = 7$; 28%) and July ($n = 9$; 36%) (Fig. 3). All incidents occurred in developed areas, such as hiking trails or geyser basins (Fig. 4). These are also the areas with the highest concentration of visitors but not the highest concentration of bison. The Old Faithful geyser area had the highest number of bison encounters with seven injuries reported.

Age range for injured persons was 7–68 years (median: 49 years); 13 (52%) were female. The majority of injuries ($n = 16$; 64%) were

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