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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, preencounter 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 place 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

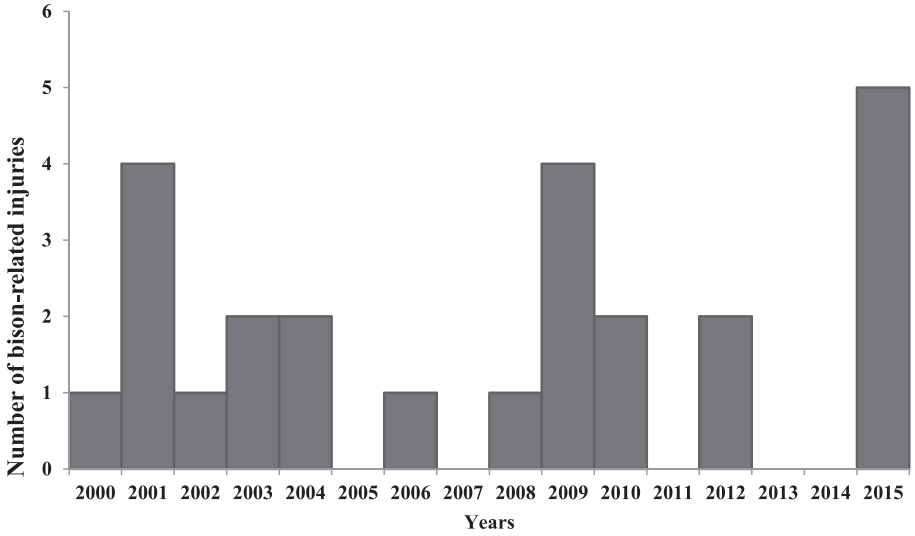

Fig. 2. Number of bison-related injuries by year—Yellowstone National Park, 2000–2015 (N = 25).
During 2000–2015, a total of 25 persons were injured by bison. The number of human injuries from bison encounters varied by year (range: 0–5 persons injured/year) with 2015 having the highest number of injuries (n = 5).

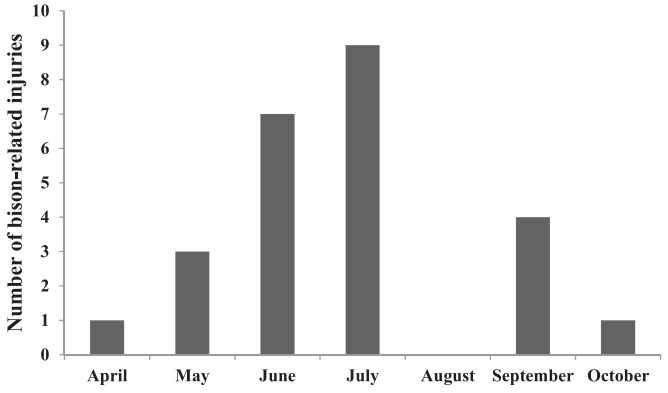

Fig. 3. Bison-related injuries by month of occurrence—Yellowstone National Park, 2000–2015.
All bison-related injuries occurred during April–October, with most injuries occurring in June (n = 7; 28%) and July (n = 9; 36%).

classified as minor injuries. Bison tossed 10 persons into the air, headbutted nine persons to the ground, and gored six persons. Twelve persons (48%) required hospitalization, eight of those were transported by helicopter ambulance; another 10 persons (40%) were treated onsite at a Yellowstone clinic or by paramedics. Injuries ranged from abrasions to puncture wounds and fractured bones (Table 1). No deaths were reported.

Mean distance from human to bison before injury was approximately 3.4 m (range: 0.3–6.1 m). Twenty persons (80%) actively approached bison before their injury; four of these persons were walking at night without a light source and unknowingly approached bison. Five persons (20%) failed to retreat when a bison approached. Fifteen persons (60%) were injured when groups of ≥3 persons approached bison. Twelve persons (48%) sustained injuries while photographing bison (Table 2).

Six persons (24%) voluntarily acknowledged that they were too close to bison. Eleven case incident narratives (44%) highlighted the importance of social context and the influence of others on a person's behavior. One man, who was gored by a bison, reported to Yellowstone rangers that his family wanted a picture taken close to a bison, although he thought to himself that it was not a good idea. However, he said that he felt more comfortable about it because others were close; therefore, he took a picture of his family in front and to the side of the bison. In a different incident, an injured woman recounted to park rangers that her family read warnings in park literature and signage about not approaching wildlife, but when they saw other people close to bison, they thought they would be safe. A witness to another incident stated the injured person started creeping toward the bison to get better pictures and eventually was at an unsafe distance from the animal. Other photographers saw his example and started moving closer to bison as well.

4. Discussion

Systematic examination of case incident records identified a number of patterns. The majority of persons (80%) were injured when they approached bison, and photography was the most common activity that was involved in persons approaching bison. In addition, the majority (60%) of injuries occurred when a person was among ≥3 other persons. Therefore, the key behaviors that might be further explored for messaging and injury prevention campaigns are the importance of maintaining an appropriate distance from bison, especially for photography, and not crowding bison.

All persons who approached bison were reported to be much closer than the minimum 23 m, as Yellowstone regulations specify. During 2000–2015, injured persons were a mean of 3.4 m from the bison before the encounter. Previous analysis of 79 Yellowstone bison-related injuries during 1980–1999 reported the average distance from the bison was 8.9 m [6], indicating that persons are moving closer to bison than they did in the past.

A common reason for approaching bison was to take or pose for a photo with a bison. Approximately half (48%) of the injuries from 2000 to 2015 involved photography, whereas, during 1980–1999, only 10 of 34 injury cases (29%) with information available on preencounter activity included photography [6], indicating that injuries from photography also might be increasing. The last bison encounter of 2015 garnered media attention because the injured woman was taking a selfie (cell phone self-portrait) at the time of the injury [7,24]. Selfies are a particularly dangerous type of photography to attempt with wildlife, because a selfie requires a person to move close to the animal and turn their back to ensure the person and the animal are in the photograph. Media have reported numerous other examples of wildlife selfie incidents (e.g. selfies with rattlesnakes, bears, elk, and raccoons), indicating this phenomenon is not restricted to bison or NPS settings [24–28]. The popularity of sharing selfies on social media might explain

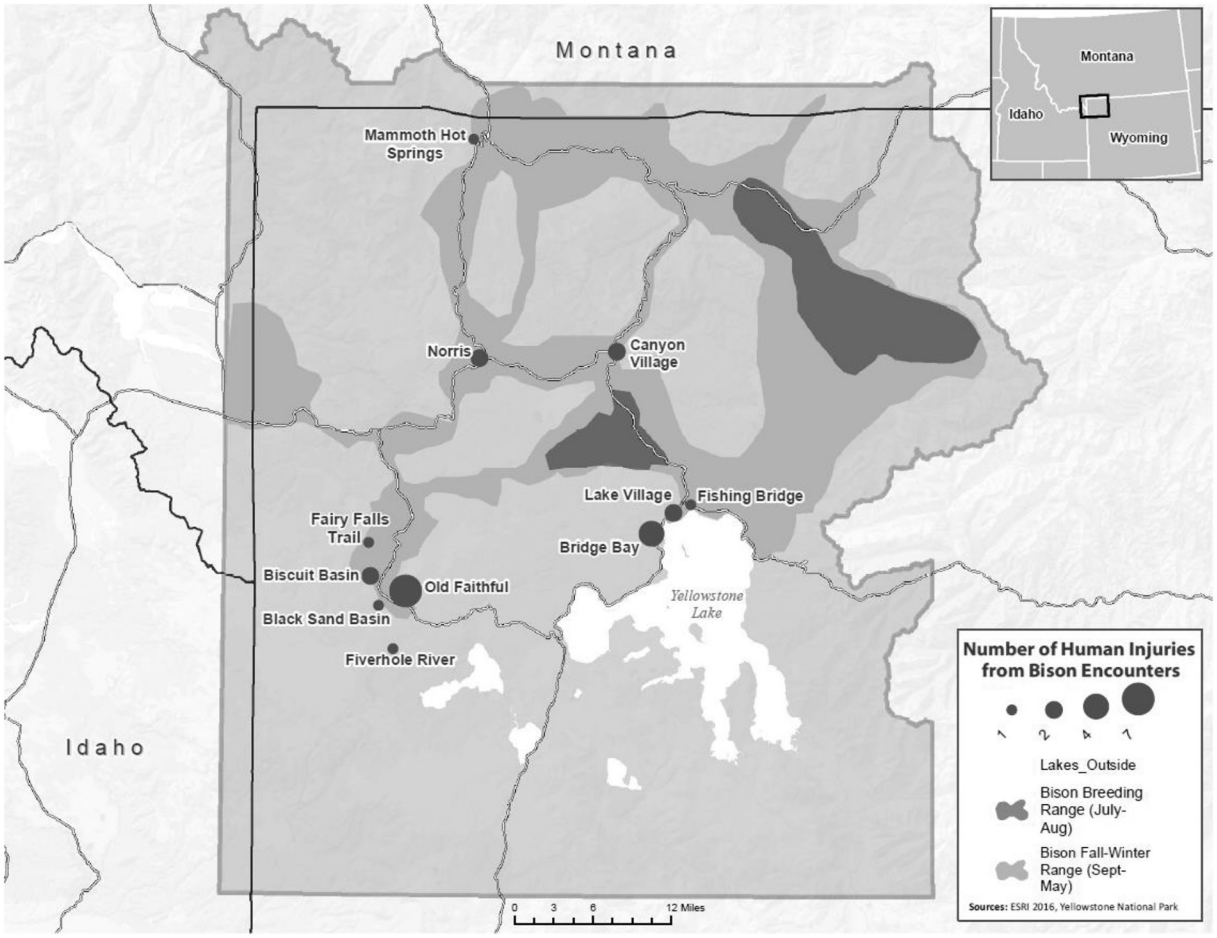

Fig. 4. Locations of bison-related injuries—Yellowstone National Park, 2000–2015 (N = 25).
Circles represent general locations of human injuries from bison encounters at Yellowstone. The larger the circle, the more injuries that occurred in that area of the park. One injury report did not include a location and is not shown on this map. Dark and light gray shaded areas represent locations of bison herds in summer (dark gray), fall/winter (light gray). All human injuries from bison encounters occurred in developed areas, such as hiking trails, geyser basins, or near campgrounds. The Old Faithful geyser area had the highest number of bison encounters with seven injuries reported. Developed areas have the highest concentration of visitors but not the highest concentration of bison. The majority of human injuries occurred in summer when the majority of the bison herd is in breeding areas (depicted in dark gray), and a limited number of bison are in developed areas.

Table 1
Description of bison-related injuries to humans—Yellowstone National Park, 2000–2015 (N = 25).

Type of injury[a]	No.	%
Unspecified injury	8	32
Laceration	7	28
Abrasion	7	28
Bruising	6	24
Puncture wound	6	24
Fractured bone(s)	1	4

[a] Some persons had multiple injuries; categories total > 100%.

Table 2
Injured person's activity immediately before bison encounter—Yellowstone National Park, 2000–2015 (N = 25).

Activity	No.	%
Posing with or photographing bison	12	48
Walking past bison	6	24
Observing bison close up	4	16
Other	3	12

why wildlife are approached more closely than when traditional camera technology was used [7].

In addition to photography, social interactions might play an important role in bison-related injuries. Some injured persons provided statements that indicated they were initially engaging in activities with wildlife that they were not comfortable with, but others encouraged them, either directly or indirectly, through example. Indeed, we tend to look at what others do to make decisions about our own appropriate behaviors [29]. Individual persons use their perceptions of social norms as a standard to compare personal behavior and direct action [29]. We often look to social norms to understand how to respond in times of uncertainty [30]. The majority (60%) of injuries occurred when groups of ≥3 persons approached a bison. Three or more persons near a bison likely encourages others to participate in this dangerous behavior.

The number of persons near bison not only influences human behavior, it likely causes bison to feel threatened, and bison react with physical force. Research has shown that animals perceive human disturbances as analogous to predation risks. A disturbed animal will track short-term changes of the disturbance (e.g. ≥3 persons approaching) and determine a response. The stronger the perceived risk, the greater chance the animal will respond [31]. As humans approach too closely or surround a bison, the likelihood increases for the bison's reaction to cause injury to the humans. Bison reactions to being approached too closely by humans in Yellowstone is an expected behavior from a wild

animal.

Through evaluation of case incident records, we identified common preencounter behaviors, such as photography and social interactions. However, information on the motivation or reason for a person to approach a bison at all was not collected. Drivers of behavior are complex and can be expressed at individual, group, and institutional levels [32]. We recognize that to develop effective injury prevention campaigns, we must understand target audience perceptions of risk, motivations, perceived benefits, and barriers to performing the desired behaviors [20]. We know that speculation does not yield desired results in developing behavior change programs [20]; however, lessons learned from analysis of case incident records can be used to design a standardized component for future case incident reporting, as well as observational studies, surveys, or focus groups that will further elucidate the motivations and other drivers of park visitor behaviors.

Noncompliant visitor behaviors are a significant problem in national parks [32,33], and traditionally, the NPS has relied on educational methods to inform park visitors about safety concerns at parks. Most park managers who deal with noncompliant behaviors prefer to use techniques that do not impede the human experience of visiting the park [32,34], and education has become the favored way to address undesirable behaviors [32,35,36]. Educational campaigns rely on the assumption that increasing awareness about risk-enhancing behaviors will change those behaviors [37]. Despite Yellowstone's extensive educational materials, the results show a recent increase in human injuries from bison encounters, indicating that education alone is not sufficient to reduce bison-related injuries. Injury reduction is rarely possible without some amount of behavior change [38]. An increasing recognition is observed regarding the importance of using behavioral science approaches for injury prevention and control [16]. Applying behavior change techniques like those used by public health practitioners should be considered to reduce bison related injuries.

This analysis has several limitations. We do not know how many people approach bison without adverse effects; therefore, we cannot determine the actual incidence of bison-related injuries at Yellowstone. We also do not know the incidence of injuries that are minor and unreported. Because law enforcement case incident records are narratives, data were not collected systematically, and information concerning the motivation for a person to approach a bison was not explored. In addition, the narrative data are comprised of self-reports from the injured party, witness statements, or on-scene investigation from responding rangers. Memories are subject to a host of cognitive biases, such as recall bias, selective perception, or other memory distortions [39,40]. A standardized approach to recording incidents might help reduce these biases. This analysis is also restricted to one species of wildlife in one national park; therefore, these results are not generalizable to other wildlife or other locations.

Our examination of injuries from bison-human encounters at Yellowstone illustrates the opportunity to expand the One Health framework into topics beyond disease and incorporate behavior change models into wildlife injury prevention campaigns. As we learn more about the public's motivations to approach wildlife, we might be able to affect risk-enhancing behaviors and potentially limit wildlife injuries at Yellowstone and other parks. Injuries are largely preventable [37], and behaviors that lead to injury are responsive to preventive interventions [16]. Increasing responsible human behaviors regarding safe wildlife viewing will better protect the health and welfare of humans, as well as the wildlife we watch.

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