2022 Writing Contest graduate Winner

Decreasing Trend in Upper Extremity Surfing Injuries Presenting to United States Emergency Departments – A 20-Year Analysis

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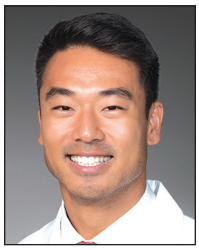

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Abstract

Surfing is a globally popular recreational sport with limited epidemiologic data. Currently, there is a paucity of literature regarding injury profiles and mechanisms of orthopaedic-related injuries. This study analyzed trends, etiologies, and diagnoses of upper extremity orthopaedic-related surfing injuries presenting to United States (US) emergency departments. The National Electronic Injury Surveillance System database was accessed to query upper extremity surfing-related injuries presenting to US emergency departments from January 1, 2002 to December 31, 2021. Data were analyzed for year, body part, mechanism of injury, diagnosis, and disposition. National estimates were calculated based on the assigned statistical sample weight of each hospital. A total of 33 323 surfing-related injuries were included. The most common upper extremity body parts involved 15 169 shoulders (45.5%), 4220 fingers (12.7%), and 3753 hands (11.3%). The most common identifiable mechanisms of injuries were 7474 board-to-body (22.4%), 4188 impact with sand (12.6%), and 2639 impact with water (7.9%). Overuse constituted 7.2% of overall upper extremity injuries but 40% of strains. Only 2.2% of injuries required hospital admission. Between 2002 and 2021, there was a decreasing annual trend in upper extremity surfing-related injuries (P=.01). The decreasing trend in emergency department visits may be due to urgent care utilization and training for surfers and lifeguards to manage these injuries on-site, as the majority were minor given the small proportion requiring hospital admission. Chronic stress on rotator cuff and peri-scapular musculature while paddling in the prone position likely contributed to the large proportion of overuse injury.

Keywords

Surfing, NEISS, emergency department, upper extremity, sports, orthopaedic, trauma, sports medicine, ocean

Abbreviations

AC = acromioclavicular
ED = emergency department
NE = national estimate
NEISS = National Electronic Injury Surveillance System

Introduction

Surfing is a physically demanding sport originating within the Native Hawaiian and Polynesian communities.[1] Recently, it has grown in global popularity, being recognized as an official high school sport in Hawai'i and making a debut appearance as an Olympic event in the Tokyo 2020 Summer Games.[2,3] Given that surfing is primarily a recreational sport, there are limited data regarding global and national participation, though current estimation supposes 30 million surfers worldwide, with most participants in the United States (US), Australia, and Brazil.[4,5] Specifically, the US states with the most surfable locations and most surfers per 1000 individuals are California, Hawai'i, and Florida.[6,7] Unlike other popular surf locations, Hawai'i is the smallest and most isolated archipelago, facilitating easy access to surfing around the entire island year-round. This, combined with the large prevalence of overhead waves and challenging breaks, makes Hawai'i a desirable location for surfers from around the globe.

Unlike non-aquatic sports such as American football, soccer, and lacrosse, aquatic sports involving the ocean entail a larger proportion of uncontrollable environmental hazards, some of

which contribute to orthopaedic-related injuries. These factors include wave size, wave morphology, underlying reef, wind patterns, and ocean floor depth.[1,5,8] The sea floor in Hawai'i is complex and contains various ridges and valleys. These promote shoaling—the compression of wave sets when the first wave speed decreases upon meeting shallow water, and refraction—the convergence of wave energy to the shallowest location.[9] Thus, many locations around Hawai'i have a high frequency of large waves at shallow breaking points and a larger proportion of overhead waves compared to other locations throughout the world.[5,10,11] Subsequently, recent studies found that surfers in Hawai'i are at greater risk of both traumatic and atraumatic injuries.[12–19] Other proposed individual risk factors include surfing in Hawai'i while visiting from one of the 48 contiguous states, surfing >6.5 hours/week, performing aerial maneuvers, and performing at a higher competition level.[4,14,19] Prior reports demonstrate 98% of surfers experience at least 1 injury during their career, with one-third experiencing an acute surfing-related injury each year necessitating medical care, missed work, or missed time surfing.[4] As most individuals surf recreationally, on-site support for acute care is often limited to lifeguards and bystanders.[20] This contrasts professional surfing events, in which athletic trainers and physicians are present.[15] Furthermore, many beaches do not have lifeguards or can be accessed outside of monitored hours.[21]

Recent studies have investigated common surfing injuries and associated etiologies, although most are from the United Kingdom (UK) or Australia. A retrospective epidemiologic study from Australia analyzed mechanisms and types of injuries, however data were limited to 1 year and did not report anatomic fracture location.[4] Recent studies analyzing surfing injuries found the shoulder constituted 7-16% of acute injuries.[4,22,23] Importantly, previous studies have found most acute surfing injuries do not require emergency department (ED) or hospital management.[8,10,24] Given the variability in wave and ocean characteristics, injury profiles and associated fracture patterns may differ between surfers in the US and the UK or Australia.

Prior studies have utilized the National Electronic Injury Surveillance System (NEISS) to analyze trends in sports-related orthopaedic injuries presenting to US EDs.[25–32] Klick et al utilized the NEISS database to analyze surfing injuries and found the most common diagnoses were lacerations (40.7%), sprains/strains (14.4%), contusions (12.9%), and fractures (11.9%).[24] However, the study did not specify the body part injured, nor did it calculate national estimates (NE) to present representative patient demographics or outcomes. Given the known risk of traumatic injury, including orthopaedic fractures, and the paucity of epidemiologic studies on upper extremity surfing injuries, the purpose of this study was to analyze trends, etiologies, and diagnoses of upper extremity orthopaedic-related surfing injuries presenting to US EDs. The authors hypothesized that (1) there would be an increasing trend of upper extremity surfing injuries over time due to growing participation in the sport, and (2) these injuries would primarily involve the shoulder.

Materials and Methods

Data Collection

The Consumer Product Safety Commission's NEISS database was used to analyze sports-related injuries. The NEISS is a national public database containing ED visits from 100 hospitals with a minimum of 6 beds and 24-hour services. Each hospital is assigned a statistical sample weight to generate NE, which are reliable, representative epidemiological data for the 5000 US hospital EDs. Trained coders enter data and assign weights to each hospital, which are used to calculate NE.

The dataset was built by querying different product codes associated with activity, diagnosis, body part, disposition, sex, and age. This included surfing-related injuries (product code 1261: surfing [activity, apparel or equipment]) involving the shoulder (product code 30), elbow (product code 32), lower arm (product code 33), wrist (product code 34), upper arm (product code 80), hand (product code 82), and finger (product code 92). All available diagnoses and dispositions were included in the query. Treatment dates ranged from January 1, 2002 to December 31, 2021. Age was collected in years and all ages were included. Sex was not specified to ensure all data were included.

The dataset contained information regarding date of ED presentation, age, sex, race, body part, injury diagnosis, disposition, and a brief narrative detailing the injury written by the healthcare provider. The narratives were individually reviewed by the first author to confirm the injury took place while surfing without use of additional equipment (ie, paddles or foils) and to identify mechanism of injury including board-to-body, board-to-head, collision with another surfer, impact with reef, impact with sand, impact with water, leash-associated injury, overuse, other, or not specified. The narrative was used to differentiate between strains and sprains as they are categorized under the same code (product code 64). Narratives were also used to differentiate acromioclavicular (AC), scapular, and clavicular injuries categorized under the code for shoulder. Overuse injuries were identified as shoulder injuries associated with multiple instances of surfing.

Exclusion Criteria

The narratives were also used to identify injuries sustained during non-surfing activities, which may have been inadvertently coded as surfing-related in the NEISS. Exclusion criteria included surfboard injuries that did not take place in the ocean (eg, surfing in the snow); injuries involving a surfboard but were unrelated to surfing (eg, tripped and fell while holding surfboard); non-surfing related aquatic activities (eg, paddleboarding, foiling, wake boarding, skim boarding, tubing, water skiing, etc); and injuries that did not specify surfing within the narrative.

Statistical Analysis

Statistical analyses were performed using STATA/MP Software 13.0 (StataCorp LLC, College Station, TX). Linear regression was performed to analyze the relationship between the year and total annual incidence of surfing injuries. Statistical significance was set at $P < .05$. NEs were calculated by multiplying each raw data point with the respective statistical weight (corresponding to the hospital) and rounded to the nearest 10 place.

Results

From January 1, 2002 to December 31, 2021 there were 1462 (NE = 82330 ED-diagnosed surfing-related upper extremity injuries. After reviewing the narratives using inclusion and exclusion criteria, 542 (NE = 33320) patients with surfing-related injuries were included for analyses and 920 (NE = 49010) injuries were excluded (**Figure 1**). Of the included patients, 449 (NE = 28180; 84.6%) were male and 93 (NE = 510; 15.4%) were female. Mean age at presentation was 30.3 years (NE = 30.8 years; range = 5 to 82 years). There were 353 White patients (NE = 22210; 66.6%), 133 that did not specify race (NE = 7610; 22.8%), 36 other race (NE = 2230; 6.7%), 12 Asian patients (NE = 920; 2.8%), and 8 Black patients (NE = 360; 1.1%).

The most common upper extremity body parts injured involved 241 shoulders (NE = 15 170; 45.5%), 74 fingers (NE = 4220; 12.7%), 61 hands (NE = 3750; 11.3%), and 50 lower arms (NE = 3060; 9.2%) (**Table 1**). The most common diagnoses presenting to the ED were 131 dislocations (NE = 8970; 26.9%), 122 fractures (NE = 6840; 20.5%), 77 lacerations (NE = 5400; 16.2%), and 77 strains (NE = 4680; 14.0%) (**Table 2**). There were 124 shoulder dislocations (NE = 84300; 94.7%), 4 finger dislocations (NE = 320; 3.6%), 1 elbow dislocation (NE = 80; 0.9%), and 2 AC joint dislocations (NE = 70; 0.8%). The most common sites of fractures were 25 fingers (NE = 1380; 21.3%), 20 clavicles (NE = 1250; 19.2%), and 19 lower arms (NE = 1030; 16.0%) (**Table 3**). The most common sites of strains were 57 shoulders (NE = 3580; 76.6%), 10 wrists (NE = 590; 12.7%), and 4 hands (NE = 220; 4.7%). The most common sites of sprains were 18 shoulders (NE = 870; 35.7%), 9 AC joints (NE = 680; 27.7%), and 10 fingers (NE = 424; 17.4%).

Narratives were reviewed to identify the mechanism of injury: 189 not specified (NE = 12 450; 37.4%), 124 board-to-body (NE = 7470; 22.4%), 71 impact with sand (NE = 4190; 12.6%), 45 impact with water (NE = 2640; 7.9%), 38 overuse (NE = 2390; 7.2%), 42 other (NE = 2340; 7.0%), 14 leash-associated injuries (NE = 850; 2.6%), 14 impact with reef (NE = 710; 2.1%), 2 collisions with another surfer (NE = 160; 0.5%), and 3 board-to-head (NE = 110; 0.3%). The 3 most common mechanisms of injury for the shoulder were 95 not specified (NE = 6570, 43.3%), 40 impact with sand (NE = 2170, 14.3%), and 36 impact with water (NE = 2170, 14.3%). The 3 most common mechanisms of injury for the finger were 26 board-to-body (NE = 1610, 38.1%), 22 not specified (NE = 1250, 29.5%), and 9 leash-associated injuries (NE = 610, 14.4%). The 3 most common mechanisms of injury for the hand were 29 board-to-body (NE = 1680, 44.8%), 16 not specified (NE = 1250, 33.2%), and 9 impact with reef (NE = 420, 11.2%).

The 3 most common board-to-body injuries were 52 lacerations (NE = 3540; 65.5% of all lacerations), 27 fractures (NE = 1380; 21.3% of all fractures), and 23 contusions/abrasions (NE = 1370; 37.9% of all contusions/abrasions). The 3 most common impact with sand injuries were 21 fractures (NE = 1160; 17.9%), 15 dislocations (NE = 990; 11.1%), and 10 sprains (NE = 690; 28.4%). The 3 most common impact with water injuries were 21 dislocations (NE = 1,330; 15.0%), 8 strains (NE = 520; 11.0%), and 6 fractures (NE = 390; 6.0%). The 3 most common overuse injuries were 29 strains (NE = 1870; 40.0%), 4 other (NE = 240; 20.8%), and 3 dislocations (NE = 180; 19.8%).

There were 529 patients (NE = 32 570; 97.8%) who did not require admission, 12 patients (NE = 730; 2.2%) who did require admission, 1 patient (NE = 20; 0.0%) that did not specify the disposition, and 0 fatalities. For patients not requiring admission, 521 (NE = 32 240; 96.7%) were treated and released or examined without treatment and 8 (NE = 340; 1.0%) left without being seen. For patients requiring admission, 10 (NE = 570; 1.7%) were treated and admitted and 2 (NE = 170; 0.5%) were treated and transferred to another facility.

Looking at overall annual upper extremity injury trends, simple linear regression demonstrated a decreasing trend of 47 upper extremity orthopaedic-related surfing injuries per year over the 20-year study period ($P = .01$) (coefficient = -46.6; 95% CI: [-81.7 to -11.6]) (**Figure 2**).

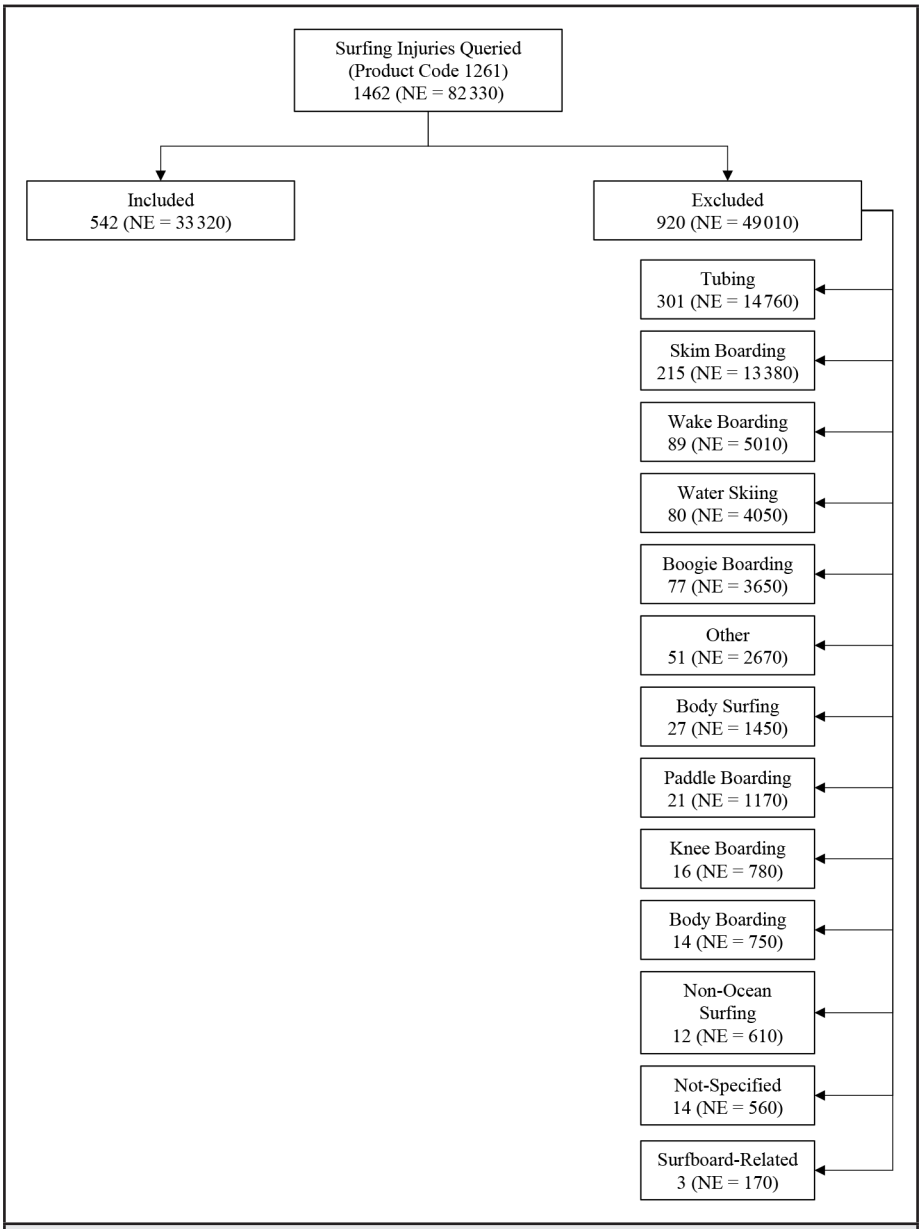

Figure 1. Flow Chart of Included and Excluded NEISS Surfing Injuries by Sport Identified Within the Narrative

NEISS = National Electronic Injury Surveillance System, NE = weighted national estimate
The total NE may not add up perfectly due to rounding after calculations.

Table 1. Distribution of Upper Extremity Surfing Injuries by Body Part, National Electronic Injury Surveillance System, 2002 to 2021

Body Part	Count	National Est[a]	Weighted %
Shoulder	241	15 170	45.5
Finger	74	4220	12.7
Hand	61	3750	11.3
Lower Arm	50	3060	9.2
Wrist	35	2110	6.3
Elbow	25	1500	4.5
Clavicle	20	1250	3.7
Upper Arm	18	960	2.9
AC Joint	11	750	2.2
Scapula	7	550	1.6
Totals	542	33 320	100.0

Abbreviations: AC= acromioclavicular

[a] Weighted national estimates and weighted percentages may not add up perfectly due to rounding.

Table 2. Distribution of Upper Extremity Surfing Injury Diagnoses, National Electronic Injury Surveillance System, 2002 to 2021

Diagnosis	Count	National Est[a]	Weighted %
Dislocation	131	8870	26.6
Fracture	122	6840	20.5
Laceration	77	5400	16.2
Strain	77	4680	14.0
Contusion or Abrasion	61	3620	10.9
Sprain	47	2440	7.3
Other	22	1140	3.4
Hematoma	4	250	0.7
Amputation	1	90	0.3
Totals	542	33 320	100.0

[a] Weighted national estimates and weighted percentages may not add up perfectly due to rounding.

Table 3. Distribution of Upper Extremity Surfing Fractures, National Electronic Injury Surveillance System, 2002 to 2021

Fracture Location	Count	National Est[a]	Weighted %
Finger	25	1380	21.3
Clavicle	20	1250	19.2
Lower Arm	19	1030	16.0
Wrist	13	680	10.5
Hand	11	630	9.8
Scapula	7	550	8.5
Shoulder	12	540	8.4
Elbow	8	390	6.0
Upper Arm	2	20	0.3
Totals	117	6470	100.0

[a] Weighted national estimates and weighted percentages may not add up perfectly due to rounding.

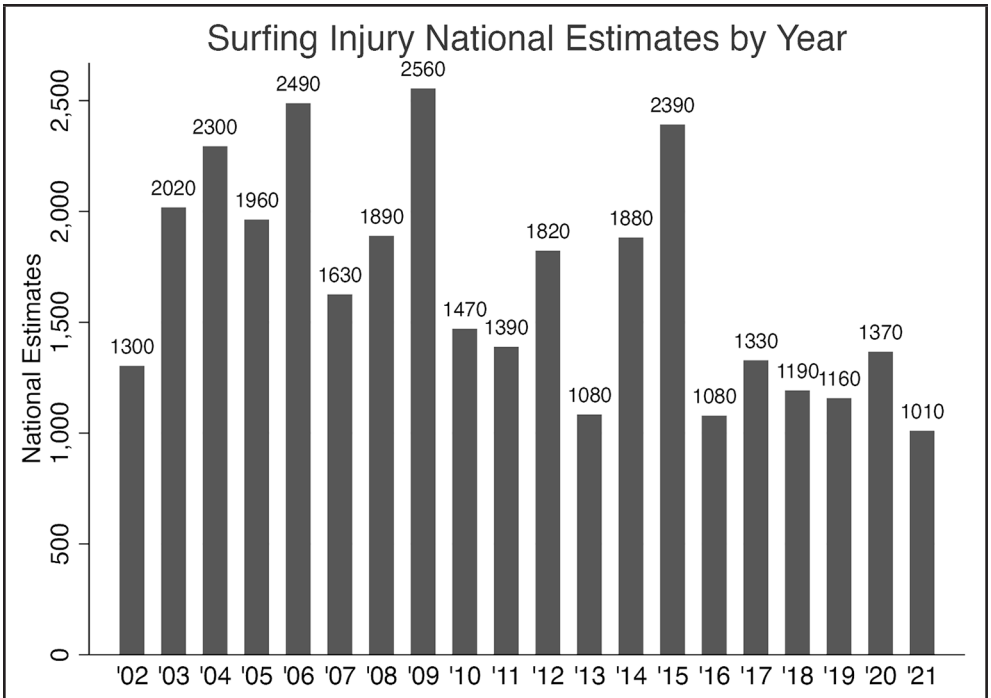

Figure 2. Upper Extremity Surfing Injury National Estimates by Year From 2002 to 2021

Discussion

The current study found a significant decline of 47 upper extremity orthopaedic-related surfing injuries presenting to US EDs for every 1-year increase from 2002 to 2021. Most (96.7%) upper extremity surfing injuries presenting to the ED were presumed to be not life-threatening as they were treated without further admission, similar to the 95.7% reported in prior studies.[24] High-energy trauma, fractures and internal injury to craniofacial structures, and neurological injury have been associated with hospital admission, although epidemiological studies on severity of surfing injuries necessitating hospitalization are limited.[15,33–36] Importantly, surfing injuries warranting hospital admission constitute a small minority of overall injuries and the downtrend of ED presentations may be attributed to increased access to care for lower-acuity upper extremity injuries outside of the hospital setting.[24] This access may include the burgeoning presence of urgent care clinics and improved lifeguard training to manage common and minor injuries (eg, strains, sprains), obviating the need for an ED visit. Importantly, previous studies highlight the higher prevalence of surfing-related injuries in rural areas of Hawai‘i.[14,19] These findings emphasize the importance of accessible urgent care clinics in rural areas where there is a high prevalence of surfing-related injuries and limited hospital access.[14] As surfing continues to gain popularity worldwide, this will increase the number of individuals who may be on-site and can aid when other surfers are injured. It has been estimated that greater than 80% of surfers have assisted with 1 or more surf rescues and 23% assisted with more than 5.[37] Likewise, the implementation of surfing training and education programs on surf rescue has demonstrated promise, as surfers with enhanced training have performed more water rescues.[23,37] Additionally, recent advancement in surfboard designs and technology have aimed to improve gross motor coordination and surfboard mechanics, which may also contribute to the down-trending upper extremity injuries seen at US EDs over the study period.[38–40] The increased use of “soft top” surfboards, which have the board’s deck covered in a softer foam material, lessen the board-to-body impact.

The most common identifiable mechanism of injury was the surfboard impacting the upper extremity (board-to-body), which is consistent with prior studies.[5,8,23] In this study, board-to-body impact most commonly resulted in lacerations, fractures, and contusions/abrasions. Lacerations presenting as the most common surfing injury supports prior literature, which can be attributed to contact with the board or sharp reef.[5,23] Board-to-body impact was the most common mechanism of injury for the hand (44.8%) and finger (38.1%), which were the second and third most injured body parts, respectively. Interestingly, previous literature attributed 83.8% of surfing-related finger injuries to the leash.[41,42] In the current study, leash-associated injuries constituted only 14.4% of finger injuries and 2.6% of overall injuries.

The shoulder is also under significant stress from chronic use. Overuse injuries constituted 7.2% of overall upper extremity injuries in this study but were the highest proportion associ-

ated with strains (40% of upper extremity strains). Overhead paddling in the prone position induces chronic strain on rotator cuff and peri-scapular musculature. Paddling constitutes 54% of the surfer's time in the water and is the most common cause of chronic injury.[43–45] Furthermore, surfers push down with both hands to "duck dive" under an oncoming wave or "pop up" on the board to get to standing position, putting additional strain on the shoulder. Previous studies have reported the shoulder being the second most common location for chronic injuries in surfers, with 76% experiencing unilateral or bilateral complaints and 63% experiencing impingement symptoms.[45,46] Interestingly, recreational surfers are more likely to have chronic injuries than competitive surfers, which may reflect the necessary conditioning required for surfing.[45] A prior study found 42-55% of surfers presenting to orthopaedic clinics have rotator cuff tears and 35-40% to have labral tears.[43,47] With year-long access to surf in Hawai'i, total hours spent surfing may be greater than in other geographic regions, predisposing to chronic upper extremity injury. Thus, providers should be cognizant that there may be a larger proportion of chronic upper extremity injuries secondary to surfing presenting to EDs in Hawai'i compared to that of the continental US.

The most common locations of fractures were the finger, clavicle, and lower arm. Importantly, this is the first study to report the incidence of clavicle fractures in surfers presenting to EDs. Although the available data in this study could not delineate location (eg, proximal, middle, or distal one-third) or characteristics of the clavicle fractures (eg, z-deformity, vertical displacement, distraction, shortening), these injuries require time off from surfing, with or without surgery, given the increased risk of subsequent nonunion and potential for reduced shoulder strength and endurance. For surfers requiring clavicle surgery, estimates of return to surfing may be extrapolated from other studies indicating a return-to-sport time of 65-83 days for athletes competing in high-impact sports.[48–50]

There are multiple limitations to this study, largely stemming from utilization of a national database. First, classification of mechanisms was limited to information in the narrative. A large proportion of mechanisms were not specified (37.4%), which may have influenced the overall findings had more details been provided. However, outcomes of the current study reflect that of prior literature and additional information may have contributed positively to the distribution of mechanisms. These data were included to provide better representations of the overall trends in ED visits. Second, the data were unable to delineate whether lifeguards, surfers, or other personnel were present to assist at the time of injury. Thus, the authors are unable to determine the effectiveness of on-site management of injuries and the proportion necessitating ED visits. Lastly, the true incidence of national surfing injuries is unknown given the stratification of the NEISS across 100 different hospitals. However, it is not feasible to determine the true epidemiologic data on surfing injuries in the US given it is predominantly a recreational sport. Thus, this is the most reliable sample available regarding surfers and surfing injuries.

Going forward, Hawai'i-specific data are needed to investigate state-level trends in surfing injuries presenting to EDs. Importantly, these studies could stratify data based on hospital location (eg, island and county-specific) and analyze trends based on presence of nearby urgent care centers. Urgent care-specific data may also demonstrate if there is a corresponding increase in surfing injuries. Lastly, studies quantitatively and qualitatively evaluating rotator cuff tears in surfers, as well as outcomes following treatments, are needed to guide both physician and patient expectations.

The current study found a statistically significant decreasing trend in annual upper extremity surfing injuries presenting to US EDs. This may be due to increased urgent care utilization, implementation of surfer and lifeguard training, and improvements in surfboard technology to improve board control and decrease the force of board-to-body impact. Overuse injuries constituted the greatest proportion of strains in the study, highlighting the chronic stress on rotator cuff muscles in recreational surfers.

Conflict of Interest

None of the authors identify a conflict of interest.

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