

ORIGINAL RESEARCH

Injuries and Fatalities on Sailboats in the United States 2000–2011: An Analysis of US Coast Guard Data

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Background.—Prior sailing injury studies have been small, focused investigations. This large, population-based study examined the mechanisms and factors contributing to sailboat-related injuries and deaths.

Methods.—A retrospective data analysis of the Boating Accident Report Database compiled by the US Coast Guard between 2000 and 2011 was performed. The database was analyzed looking at frequency of events. For each subgroup, proportions were determined and 95% CIs were calculated. These data, used in conjunction with the 2011 US Coast Guard National Recreational Boating Survey, were used to estimate a fatality rate.

Results.—Two hundred seventy-one sailing-related fatalities and 841 injuries were reported. A fatality rate was calculated at 1.19 deaths per million sailing person-days. Weather or hazardous waters were listed as primary contributing factors in 28.0% (95% CI, 22.7–33.4) of deaths; 70.1% (95% CI, 64.7–75.6) of deaths occurred after falling overboard or capsizing. Drowning was the most common cause of death (73.1%; 95% CI, 67.8–78.4), and 81.6% of victims were not wearing a life jacket. Alcohol intoxication contributed to 12.2% (95% CI, 8.3–16.1) of deaths. Operator- or passenger-preventable factors contributed to 52.7% (95% CI, 49.3–56.1) of all injuries; 51.6% (95% CI, 46.1–57.1) of injuries on nonmotorized sailboats were the result of capsizing, and 46.4% (95% CI, 42.1–50.7) of all injuries on motorized sailboats were the result of collisions or grounding.

Conclusions.—The calculated fatality rate is similar to that of alpine skiing. Falls overboard and capsizing were the most common fatal accidents. Operator inattention, inexperience, and alcohol use were common preventable factors contributing to fatal and nonfatal injury.

Key words: drowning, alcohol, sailing, injuries, dinghies, life jacket

Introduction

Sailing has existed as a means of transportation for thousands of years and emerged as a recreational activity in Europe in the 18th century. The sport of yacht racing was first formalized in 1851 when the schooner *America* beat the *Aurora* in a race around the Isle of Wight in what has since become the America's Cup, the oldest major international sporting event in the world.¹

Sailboats vary in size and complexity, from 2.3-m 1-person Optimist dinghies to America's Cup catamarans powered by 40-m-tall rigid sails capable of speeds in excess of 65 km/h. Most sailboats less than 6 m in length use the

crew's weight to maintain stability, are easily capsized, and are not equipped with a motor, whereas most sailboats greater than 6 m in length are equipped with an auxiliary engine, are dependent on a weighted keel for ballast, and are less easily overturned. Federal law requires that all motorized sailboats be registered; however, the registration requirements for nonmotorized sailboats vary among states, and many nonmotorized sailboats are not registered.²

Modern-day sailing encompasses a broad spectrum of activities ranging from day-sailing a small boat on a lake, cruising a sleep-aboard catamaran along the coast, to racing a 21-m keelboat around the world. The US Coast Guard (USCG) estimated that there were 16.9 million sailing person-days in US waters in 2011, and that 3.7% of US households owned a sailboat.^{3,4}

The majority of prior sailing-injury studies have a small sample and focus on a particular sailboat race, a specific

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type of sailboat, or an instructional program. These studies have found that injury rates in sailing are low in relation to those of other sports, and that the most common injuries are minor contusions, abrasions, overuse injuries, and lacerations.⁵⁻⁸ Among novice dinghy sailors, the incidence of injury was found to be 0.29/1000 hours of sailing, with abrasions and contusions accounting for 72.0% of those injuries.⁸ A study of the 2003 America's Cup found an injury rate of 2.2/1000 hours of sailing, which is significantly lower than that of contact team sports,⁹ such as NCAA Division 1 US football (34.8/1000 games).¹⁰ Sailing was found to be among the safest sports in the 2008 Olympics,¹¹ and of the 380 sailors participating in the 2012 Olympics, only 1.0% sustained an injury resulting in the loss of a day or more of training or competition. Comparative injury rates in the London Games were 15.3% for soccer, and 10.0% for the triathlon.¹²

Despite the fact that most sailing injury studies have found relatively low rates of injury, the recent spate of sailing tragedies in the America's Cup, Chicago-Mackinac, Farallon Island, and Newport-Ensenada races, serves as a stark reminder that severe injuries and deaths can and do occur.¹³⁻¹⁵ High winds, slippery, unstable decks, and heavily loaded equipment can create hazardous conditions. Falls overboard, particularly when sailing offshore, carry a high risk of drowning. There are also many well-documented cases of fatal head injuries caused by impact with the boom.¹⁶

Although in-depth retrospective analyses of individual sailing disasters have been undertaken, no large population-based studies have systematically reviewed sailing casualties over time. The aim of this study is to examine the mechanisms and contributing factors leading to fatal and nonfatal sailboat-related injuries occurring in US waters between 2000 and 2011 using the Boating Accident Report Database (BARD) compiled by the USCG. Furthermore, we sought to calculate a fatality rate based on annual sailor exposure data from the USCG 2011 National Recreational Boating Survey (NRBS).³ Analysis of these data will help identify recurrent patterns of injury that may be useful when developing evidence-based injury prevention strategies.

Methods

This is a retrospective analysis of boating incident data collected by the USCG. Under federal regulation, the operator of any recreational vessel is required to file a Boating Accident Report (BAR) "when as a result of an occurrence that involves a vessel or its equipment" a person on board dies, disappears from the vessel (under circumstances indicating death), or has an injury requiring more than first aid, or when there is more than \$2000

of damage to the vessel.⁴ These reports are collected by state agencies and forwarded to USCG headquarters in Washington, DC, where they are manually entered into the BARD. In an attempt to make sure all boating fatalities are included in the BARD, the USCG continuously monitors news media sources for stories relating to boating fatalities and notifies state boating management officials of any fatal accidents occurring in their jurisdiction for which a report has not been received. All boating fatalities are investigated by state boating authorities or the USCG, and that information is entered into the BARD. During the years 2007 to 2011 for which data are available, an average of 0.7% of fatalities and 2% of all injuries (among all boat types) were discovered by the USCG via media scrutiny.^{2,4,17-19}

Boating accident reports are not required if a person died of natural causes while on board or died or was injured while swimming from a vessel that was docked or moored, or if the vessel was being used as a platform for other activities, such as scuba diving, in which the vessel did not directly contribute to injury or death. It should be noted that not all boating accidents resulted in injury or death.

The BAR form is divided into 13 sections that contain check box responses to most queries. A copy of the form can be found at http://www.uscg.mil/forms/cg/CG_3865.pdf.

The BARD is managed by personnel at the Boating Safety Division of the USCG in Washington, DC, who provided the study investigators with customized, de-identified tables containing aggregate data regarding all reported accidents, injuries, and fatalities occurring on sailing vessels from 2000 to 2011. The USCG categorizes sailing vessels into 2 types: auxiliary sail, meaning they are equipped with a motor (motorized), or sail only, indicating they have no motor (nonmotorized).

Composite data were provided to investigators for the following fields:

- Accident mechanism: capsizing, falls overboard, collisions, grounding, sinking, and fires. The BAR allows up to 3 types of accidents to be listed in order of occurrence. For example, if a collision caused a vessel to capsize, collision would be listed as the primary accident mechanism. Unless otherwise specified, investigators were given access to data regarding primary accident mechanism.
- Contributing factors such as operator inexperience, weather (defined as stormy or windy conditions usually connoting rough or high seas and dangerous operating conditions), hazardous waters (defined as rapid tidal flow or currents resulting in hazardous

conditions), alcohol, equipment failure, or other factors contributing to the accident. As with mechanism of accident, the BAR allows for multiple entries. Unless otherwise specified, investigators were given access to data regarding the primary contributing factor. The USCG provided us with further detail regarding type of equipment failure that resulted in injury or death (eg, steering failure, dismasting). Some contributing factors such as operator inattention, alcohol, and overloading are deemed by the USCG to be operator- or passenger-preventable factors.

- Type and location of injury. Beginning in 2009, the USCG began collecting information regarding type of injury and anatomic location of injury.
- Cause of death (eg, drowning, trauma, hypothermia) and life jacket use by deceased victim.
- Annual number of sailboats registered in the United States by boat length and vessel type.

The BARD lists 26 different types of contributing factors, 23 different accident mechanisms, and 10 anatomic locations of injury. Some of these categories are similar in nature (eg, collision with commercial vessel, collision with recreational vessel, and collision with vessel). In an effort to consolidate data, some categories of accident mechanism, contributing factors, and anatomic location of injury were merged using the following protocol. Two authors independently reviewed the following original data: primary accident mechanism resulting in injury, primary accident mechanism resulting in fatality, primary contributing factor resulting in injury, primary contributing factor resulting in death, and anatomic location of injury.

Categories of accident mechanism, contributing factors, and anatomic location of injury were merged when both authors independently agreed that categories were similar in nature; however, original category names were preserved. For example, when categorizing primary accident mechanism leading to injury, the category operator inattention was combined with the category improper lookout to create a single category, operator inattention or improper lookout. If there was lack of agreement between authors, categories were not combined. Some double categories in the BARD such as fire/explosion, or careless/reckless operation were part of the original database and not created by the investigators. Once appropriate categories were combined, the categories were arranged by decreasing frequency of occurrence. In following the protocol above, we were left with 21 categories for contributing factors, 13 for accident mechanism, and 6 for anatomic location of injury.

This study was approved by the Institutional Review Board at Rhode Island Hospital.

DATA ANALYSIS

Data for the years 2000 to 2011 were entered into a spreadsheet for subsequent analysis. Frequencies of events leading to deaths or injuries were recorded for motorized sailboats, nonmotorized sailboats, and sail unknown, then tallied under the categories of primary accident mechanism, contributing factors, primary contributing factors to falls overboard, cause of death, and body part injured. Similar categories were combined as agreed on by the investigators, and frequencies were calculated. For each subgroup analysis, proportions were determined, and 95% CIs were calculated. Data were analyzed using SAS 9.3 (SAS Institute, Cary, NC). Pearson χ^2 analysis was applied to compare proportions between motorized and nonmotorized sailboats. Statistical significance was set at $P < 0.05$.

Sailing exposure data from the 2011 NRBS were used to calculate a fatality rate. The 2011 NRBS is a large-scale, population-based, weighted (based on 2010 US census counts) national survey that reports accurate state-level estimates of boaters' annual boating exposure hours, exposure days, types of boats used, and demographics, with the aim of helping to evaluate the effectiveness of safety programs. Boating exposure data for the NRBS was calculated by using a mail survey and population-based random-digit dialing (RDD) telephone survey of boat owners. The mail survey was derived from state boating registration lists, and only involved registered boats. The RDD telephone survey was population-based and included owners of registered and unregistered boats. Owners were asked the number of days their boat was taken out on the water, average number of hours the boat was used per day, and the average number of people aboard when the boat was used. Sailboat owners completed 2182 mail surveys (49% response rate), and 1026 telephone surveys.

The full methodology and results are available via the USCG at the following website: http://www.uscgboating.org/assets/1/workflow_staging/AssetManager/671.pdf.

Results

During the study period 2000 to 2011, 4180 sailboat-related BARs were filed with the USCG. Included among the 4180 BARs were 271 fatalities (annual average, 22.6 ± 6.6) and 841 injuries. The sum total of annual sailboat registrations during the study period was 3.38 million (annual average, $282,000 \pm 22,200$).

FATALITY RATE

The 2011 NRBS found that there were 70.9 million sailor person-hours and 16.9 million sailor person-days in aggregate that year, including motorized, nonmotorized, registered, and unregistered sailboats. Using these exposure data and the assumption that the annual number of sailor person-days is directly proportional to the annual number of registered sailboats, a fatality rate was calculated as follows. In 2011, there were 249,800 registered vessels, yielding 67.6 sailor person-days/registered sailboat. Given the fact that there were a sum total of 3.38 million annual boat registrations from 2000 to 2011, it was estimated that there were 229 million sailor person-days for the study period. Dividing the known number of fatalities (271) by sailor person-days results in a fatality rate of 1.19 deaths per million sailor person-days (0.283 per million sailor person-hours).

PRIMARY ACCIDENT MECHANISMS

Among motorized sailboats, collisions were the leading accident mechanism resulting in injury, accounting for 46.4% (95% CI, 42.1–50.7) of injuries. These included collisions with other vessels (22.2%; 95% CI, 18.6–25.8), the seafloor (11.0%; 95% CI, 8.3–13.7), fixed objects such as piers (8.7%; 95% CI, 6.3–11.1), submerged objects (3.9%; 95% CI, 2.2–5.6), and floating objects (0.8%; 95% CI, 0.04–1.6). Capsizes and falls onboard the vessel caused 12.3% (95% CI, 9.5–15.1) and 11.0% (95% CI, 8.3–13.7) of injuries, respectively, as noted in Table 1. In contrast, more than half of all injuries (51.6%; 95% CI, 46.1–57.1) on nonmotorized

sailboats were associated with capsizing, and 22.8% (95% CI, 18.2–27.4), with collisions.

The vast majority of the 271 sailing-related deaths (motorized and nonmotorized) occurred when boaters entered the water unintentionally as a result of falls overboard or ejection from vessel (41.3%; 95% CI, 35.4–47.2), capsizing (28.8%; 95% CI, 23.4–34.2), flooding (7.0%; 95% CI, 4.0–10.0), or sinking (0.37%; 95% CI, –0.4–1.2), as noted in Table 2. The proportion of fatalities attributed to capsizing was significantly greater for nonmotorized sailboats (39.5%; 95% CI, 30.9–48.1) as compared with motorized sailboats (20.1%; 95% CI, 13.6–26.6; $\chi^2(2) = 140.0$; $P < 00001$). Purposeful departure from vessel (eg, getting into a dinghy or going overboard to free a line) was the next most common fatal type of accident (7.8%; 95% CI, 4.6–11.0). When reviewing secondary and tertiary accident mechanisms, 9 fatalities on nonmotorized sailboats and 2 on motorized sailboats were attributed to falls overboard.

Traumatic mechanisms as a group caused only 7.4% (95% CI, 4.3–10.5) of all fatalities.

FACTORS CONTRIBUTING TO NONFATAL AND FATAL INJURIES

As seen in Table 3, operator- or passenger-preventable factors contributed to more than half (52.7%; 95% CI, 49.3–56.1) of all nonfatal injuries. The leading contributing factors resulting in injury during the study period were improper lookout or operator inattention, weather, and operator inexperience, which resulted in 21.6% (95% CI, 18.8–24.4), 19.6% (95% CI, 16.9–22.3), and 11.4% (95% CI, 9.3–13.6) of injuries, respectively. Operator inexperience was more frequently noted to be

Table 1. Number of nonfatal injuries by primary accident mechanism and vessel type, 2000–2011

Primary accident type	Motorized sailboats	Nonmotorized only	Sail (unknown)	Total
Collision with vessel or fixed, submerged, or floating object	184 (35.5%)	72 (22.8%)	1 (16.7%)	257 (30.6%)
Capsizing	64 (12.3%)	163 (51.6%)	0 (0.0%)	227 (27.0%)
Fall in vessel	57 (11.0%)	17 (5.4%)	0 (0.0%)	74 (8.8%)
Other	41 (7.9%)	21 (6.7%)	0 (0.0%)	62 (7.4%)
Grounding	57 (11.0%)	4 (1.3%)	0 (0.0%)	61 (7.3%)
Falls overboard or ejected from vessel	35 (6.7%)	20 (6.3%)	1 (16.7%)	56 (6.7%)
Fire/explosion	33 (6.4%)	4 (1.3%)	1 (16.7%)	38 (4.5%)
Struck by boat or propeller	19 (3.7%)	9 (2.9%)	0 (0.0%)	28 (3.3%)
Flooding/swamping or sinking	17 (3.3%)	4 (1.3%)	3 (50.0%)	24 (2.9%)
Unknown	7 (1.4%)	2 (0.6%)	0 (0.0%)	9 (1.1%)
Carbon monoxide exposure	3 (0.6%)	0 (0.0%)	0 (0.0%)	3 (0.4%)
Departure from vessel	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
Skier mishap	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
Total	519	316	6	841

Table 2. Number of deaths by primary accident mechanism and vessel type, 2000–2011

<i>Primary accident type</i>	<i>Motorized sailboats</i>	<i>Nonmotorized sailboats</i>	<i>Sail (unknown)</i>	<i>Total</i>
Falls overboard or ejected from vessel	64 (44.4%)	47 (37.9%)	1 (33.3%)	112 (41.3%)
Capsizing	29 (20.1%)	49 (39.5%)	0 (0.0%)	78 (28.8%)
Departure from vessel	17 (11.8%)	4 (3.2%)	0 (0.0%)	21 (7.8%)
Flooding/swamping or sinking	8 (5.6%)	10 (8.1%)	1 (33.3%)	19 (7.0%)
Collision with vessel or fixed or submerged object	9 (6.3%)	4 (3.2%)	0 (0.0%)	13 (4.8%)
Unknown	3 (2.1%)	6 (4.8%)	0 (0.0%)	9 (3.3%)
Other	2 (1.4%)	4 (3.2%)	0 (0.0%)	6 (2.2%)
Fire/explosion	3 (2.1%)	0 (0.0%)	1 (33.3%)	4 (1.5%)
Carbon monoxide exposure	3 (2.1%)	0 (0.0%)	0 (0.0%)	3 (1.1%)
Grounding	3 (2.1%)	0 (0.0%)	0 (0.0%)	3 (1.1%)
Electrocution	1 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.4%)
Fall in vessel	1 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.4%)
Struck by propeller	1 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.4%)
Total	144	124	3	271

a factor contributing to injuries in nonmotorized vessels (17.7%; 95% CI, 13.5–21.9) than in motorized vessels (7.7%; 95% CI, 5.4–10.0; χ^2 (2) = 19.3; $P < .001$). Equipment or machinery failure was the fourth leading

cause of injury. Dismasting caused 17 nonfatal and 3 fatal injuries during the study period, and engine, exhaust, or fuel-system issues caused 17 injuries and 1 carbon monoxide poisoning death in motorized sailboats.

Table 3. Number of nonfatal injuries by primary contributing factor and vessel type, 2000–2011

<i>Contributing factor for injuries</i>	<i>Motorized sailboats</i>	<i>Nonmotorized sailboats</i>	<i>Sail (unknown)</i>	<i>Total</i>
Operator-/passenger-preventable factors				
Improper lookout or operator inattention	131 (25.2%)	51 (16.1%)	0 (0.0%)	182 (21.6%)
Operator inexperience	40 (7.7%)	56 (17.7%)	0 (0.0%)	96 (11.4%)
Careless/reckless operation or excessive speed or sharp turn	28 (5.4%)	27 (8.5%)	0 (0.0%)	55 (6.5%)
Passenger behavior	28 (5.4%)	12 (3.8%)	0 (0.0%)	40 (4.8%)
Alcohol use	22 (4.2%)	5 (1.6%)	0 (0.0%)	27 (3.2%)
Rules of the road infraction	18 (3.5%)	4 (1.3%)	0 (0.0%)	22 (2.6%)
Improper loading or overloading	7 (1.6%)	4 (1.3%)	0 (0.0%)	11 (1.3%)
Lack of or improper lights	4 (0.8%)	3 (1.0%)	0 (0.0%)	7 (0.8%)
Standing/sitting on gunwales, bow, transom	2 (0.4%)	0 (0.0%)	0 (0.0%)	2 (0.2%)
Improper anchoring	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
Other factors				
Weather ^a	62 (12.0%)	100 (31.7%)	3 (50.0%)	165 (19.6%)
Equipment or machinery failure	57 (11.0%)	7 (2.2%)	0 (0.0%)	64 (7.6%)
Unknown	30 (5.8%)	20 (6.3%)	3 (50.0%)	53 (6.3%)
Other	28 (5.4%)	10 (3.2%)	0 (0.0%)	38 (4.5%)
Hazardous waters ^b	28 (5.4%)	6 (1.9%)	0 (0.0%)	34 (4.0%)
Restricted vision	8 (1.5%)	3 (1.0%)	0 (0.0%)	11 (1.3%)
Hull failure	7 (1.4%)	3 (1.0%)	0 (0.0%)	10 (1.2%)
Force of wave/wake	6 (1.2%)	3 (1.0%)	0 (0.0%)	9 (1.1%)
Congested waters	3 (0.6%)	2 (0.6%)	0 (0.0%)	5 (0.6%)
Ignition of spilled fuel or vapor	5 (1.0%)	0 (0.0%)	0 (0.0%)	5 (0.6%)
Failure to vent	4 (0.8%)	0 (0.0%)	0 (0.0%)	4 (0.5%)
Total	519	316	6	841

^a Stormy or windy conditions usually connoting rough or high seas and dangerous operating conditions.

^b Rapid tidal flow or currents resulting in hazardous conditions.

When analyzing sailing-related fatalities, weather or hazardous waters were listed as primary contributing factors in 76 (28.0%; 95% CI, 22.7–33.4) of the 271 deaths (Table 4). Weather contributed to a significantly higher proportion of fatalities on nonmotorized sailboats (26.6%; 95% CI, 18.8–34.4) than on motorized sailboats (11.8%; 95% CI, 6.5–17.1; $\chi^2(2) = 14.5$; $P < .001$). Alcohol use was listed as a primary contributor in 12.2% (95% CI, 8.3–16.1) of all deaths, and when including secondary and tertiary contributing factors, alcohol was implicated in 15% of all deaths. In aggregate, operator-preventable primary contributing factors were associated with 36.9% (95% CI, 31.2–42.7) of all fatalities.

FALLS OVERBOARD OR EJECTED FROM VESSEL

Falls overboard and ejections resulted in a significant percentage of deaths (41.3%; 95% CI, 35.4–47.2), and injuries (6.7%; 95% CI, 5.0 to 8.4; Table 5). Alcohol use (14.6%; 95% CI, 9.2–20.0) and stormy or windy weather conditions (12.2%; 95% CI, 7.2–17.2) were most commonly cited. Operator- or passenger-preventable factors accounted for 42.1% (95% CI, 34.5–49.7) of all falls overboard.

BODY AREAS INJURED AND INJURY TYPE

The USCG began collecting data regarding type of injury and body region injured in 2009. Lacerations and contusions to the head and extremities were most common, as noted in Table 6. The trunk or body was the most frequently injured region of the body followed by the head. There were 13 hand (including 3 finger amputations) and 8 foot injuries.

CAUSE OF DEATH

There were 271 fatalities on sailing vessels during the period 2000 to 2011. Drowning was the most common cause of death for sailboats of all types, accounting for 73.1% (95% CI, 67.8–78.4) of fatalities overall (Table 7). Eighty-one percent (81.6%; 95% CI, 77.0–86.2) of drowning victims included in the study were not wearing a life vest. Trauma, the second leading cause of death, resulted in approximately 10.4% (95% CI, 5.4–15.4) of fatalities on motorized sailing vessels and 4.0% (95% CI, 0.6–7.5) on nonmotorized sailboats. Other causes of death included hypothermia, cardiac arrest, and carbon monoxide poisoning.

Table 4. Number of deaths by primary contributing factor and vessel type, 2000–2011

Contributing factor for death	Motorized sailboats	Nonmotorized sailboats	Sail (unknown)	Total
Operator-/passenger-preventable factors				
Alcohol use	21 (14.6%)	12 (9.7%)	0 (0.0%)	33 (12.2%)
Operator inexperience	11 (7.6%)	10 (8.1%)	0 (0.0%)	21 (7.8%)
Improper lookout or operator inattention	14 (9.7%)	6 (4.8%)	0 (0.0%)	20 (7.4%)
Passenger behavior	5 (3.5%)	2 (1.6%)	0 (0.0%)	7 (2.6%)
Careless/reckless operation, excessive speed or sharp turn	2 (1.4%)	4 (3.2%)	0 (0.0%)	6 (2.2%)
Improper loading or overloading	2 (1.4%)	4 (3.2%)	0 (0.0%)	6 (2.2%)
Improper anchoring	2 (1.4%)	0 (0.0%)	0 (0.0%)	2 (0.7%)
Lack of or improper lights	2 (1.4%)	0 (0.0%)	0 (0.0%)	2 (0.7%)
Standing or sitting on gunwales, bow, transom	2 (1.4%)	0 (0.0%)	0 (0.0%)	2 (0.7%)
Rules of the road infraction	0 (0.0%)	1 (0.8%)	0 (0.0%)	1 (0.4%)
Other factors				
Unknown	33 (22.9%)	22 (17.7%)	2 (66.7%)	57 (21.0%)
Weather ^a	17 (11.8%)	33 (26.6%)	1 (33.3%)	51 (18.8%)
Hazardous waters ^b	13 (9.0%)	12 (9.7%)	0 (0.0%)	25 (9.2%)
Other	13 (9.0%)	5 (4.0%)	0 (0.0%)	18 (6.6%)
Equipment or machinery failure	5 (3.5%)	7 (5.7%)	0 (0.0%)	12 (4.4%)
Sudden medical condition	0 (0.0%)	3 (2.4%)	0 (0.0%)	3 (1.1%)
Restricted vision	0 (0.0%)	2 (1.6%)	0 (0.0%)	2 (0.7%)
Dam/lock	0 (0.0%)	1 (0.8%)	0 (0.0%)	1 (0.4%)
Failure to vent	1 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.4%)
Hull failure	1 (0.7%)	0 (0.0%)	0 (0.0%)	1 (0.4%)
Total	144	124	3	271

^a Stormy or windy conditions usually connoting rough or high seas and dangerous operating conditions.

^b Rapid tidal flow or currents resulting in hazardous conditions.

Table 5. Number of fatal and nonfatal injuries by primary contributing factor for falls overboard, 2000–2011

<i>Contributing factor for falls overboard</i>	<i>Motorized sailboats</i>	<i>Nonmotorized sailboats</i>	<i>Sail (unknown)</i>	<i>All</i>
Operator-/passenger-preventable factors				
Alcohol use	15 (15.5%)	9 (13.9%)	0 (0.0%)	24 (14.6%)
Operator inattention or improper lookout	10 (10.3%)	3 (4.6%)	0 (0.0%)	13 (7.9%)
Passenger behavior	11 (11.3%)	2 (3.1%)	0 (0.0%)	13 (7.9%)
Operator inexperience	0 (0.0%)	8 (12.3%)	0 (0.0%)	8 (4.9%)
Standing or sitting on gunwales, bow, transom	4 (4.1%)	0 (0.0%)	0 (0.0%)	4 (2.4%)
Careless or reckless operation or sharp turn	1 (1.0%)	3 (4.6%)	0 (0.0%)	4 (2.4%)
Improper loading	0 (0.00%)	2 (3.1%)	0 (0.0%)	2 (1.2%)
Improper anchoring	1 (1.0%)	0 (0.0%)	0 (0.0%)	1 (0.6%)
Other factors				
Unknown	24 (24.7%)	10 (15.4%)	2 (100.0%)	36 (22.0%)
Weather ^a	9 (9.3%)	11 (16.9%)	0 (0.0%)	20 (12.2%)
Hazardous waters ^b	9 (9.3%)	4 (6.2%)	0 (0.0%)	13 (7.9%)
Other	8 (8.3%)	5 (7.7%)	0 (0.0%)	13 (7.9%)
Equipment or machinery failure	4 (4.1%)	5 (7.7%)	0 (0.0%)	9 (5.5%)
Force of wave or wake	1 (1.0%)	1 (1.5%)	0 (0.0%)	2 (1.2%)
Sudden medical condition	0 (0.0%)	2 (3.1%)	0 (0.0%)	2 (1.2%)
Total	97	65	2	164

^a Stormy or windy conditions usually connoting rough or high seas and dangerous operating conditions.

^b Rapid tidal flow or currents resulting in hazardous conditions.

Discussion

To our knowledge, this is the first population-based study to examine contributing factors and causes of sailing-related fatalities, and the first to establish a fatality rate for the sport of sailing. Although other studies have shown that injury rates in sailing are relatively low compared with other sports, our calculated fatality rate of 1.19 per million sailor person-days is

similar to published fatality rates for alpine skiing and snowboarding (1.06 per million skier or snowboarder person-days).²⁰ It is worth noting that during the study period, there were more deaths in the United States related to sailing (271) than to American football (197).²¹

Many prior studies have found an association between high winds and sailing-related injuries.^{5–8} We found stormy conditions to be the leading contributing factor for both injury and death in nonmotorized (smaller)

Table 6. Nonfatal injuries on motorized and nonmotorized sailboats by injury type and body region when treatment was beyond first aid, 2009–2011

	<i>Upper ext</i>	<i>Trunk</i>	<i>Lower ext</i>	<i>Head</i>	<i>Neck</i>	<i>Other</i>	<i>Unknown</i>	<i>Total</i>
Amputation	3 (14.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3
Broken bone	3 (14.3%)	2 (2.4%)	7 (31.8%)	3 (7.9%)	0 (0.0%)	0 (0.0%)	4 (17.4%)	19
Burns	2 (9.5%)	1 (1.2%)	2 (9.1%)	1 (2.6%)	0 (0.0%)	0 (0.0%)	1 (4.3%)	7
Carbon monoxide poisoning	0 (0.0%)	2 (2.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2
Contusion	3 (14.3%)	3 (3.5%)	3 (13.6%)	7 (18.4%)	0 (0.0%)	1 (100.0%)	4 (17.4%)	21
Cut	6 (28.6%)	1 (1.2%)	7 (31.8%)	12 (31.6%)	0 (0.0%)	0 (0.0%)	6 (26.1%)	32
Dislocation	3 (14.3%)	1 (1.2%)	1 (4.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5
Head injury	0 (0.0%)	0 (0.0%)	0 (0.0%)	11 (28.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	11
Hypothermia	0 (0.0%)	53 (62.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	53
Internal organ injury	0 (0.0%)	8 (9.4%)	0 (0.0%)	2 (5.3%)	1 (25.0%)	0 (0.0%)	0 (0.0%)	11
Spinal injury	0 (0.0%)	1 (1.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1
Sprain/strain	1 (4.8%)	10 (11.8%)	2 (9.1%)	0 (0.0%)	3 (75.0%)	0 (0.0%)	1 (4.3%)	17
Unknown	0 (0.0%)	3 (3.5%)	0 (0.0%)	2 (5.3%)	0 (0.0%)	0 (0.0%)	7 (30.4%)	12
Total	21	85	22	38	4	1	23	194

Table 7. Number of deceased victims by cause of death and vessel type, 2000–2011

<i>Cause of death</i>	<i>Motorized sailboats</i>	<i>Nonmotorized sailboats</i>	<i>Sail (unknown)</i>	<i>Total</i>
Drowning	106 (73.6%)	91 (73.4%)	1 (33.3%)	198 (73.1%)
Unknown	14 (9.7%)	16 (12.9%)	0 (0.0%)	30 (11.1%)
Trauma	15 (10.4%)	5 (4.0%)	1 (33.3%)	21 (7.8%)
Hypothermia	3 (2.1%)	7 (5.7%)	1 (33.3%)	11 (4.1%)
Cardiac arrest	2 (1.4%)	4 (3.2%)	0 (0.0%)	6 (2.2%)
Carbon monoxide poisoning	4 (2.8%)	0 (0.0%)	0 (0.0%)	4 (1.5%)
Other	0 (0.0%)	1 (0.8%)	0 (0.0%)	1 (0.4%)
Total	144	124	3	271

vessels, most commonly linked to capsizing. Although high winds were also associated with casualties in motorized sailboats, the leading factors contributing to injury and death in these larger vessels were lapses in attention by operator or lookout, and alcohol use, respectively. On motorized sailboats, collisions were the most common mechanism of injury, and falls overboard the most common fatal accident mechanism.

Alcohol use, although likely underreported for fear of legal repercussions, was found to be the leading preventable contributing factor for sailing-related deaths (15.0%) and falls overboard (14.6%). These data strengthen the argument that legislation prohibiting boat operators from being intoxicated should be broadened to include passengers because, as noted by Howland et al,²² “a drunken passenger is at increased risk from falling overboard and drowning, regardless of the sobriety of the operator.”

Not unexpectedly, 76.4% of victims died after suddenly finding themselves in the water from falls overboard, capsizing, flooding, or sinking, with 73.1% of deaths caused by drowning. Of those who drowned, only 18.0% were wearing a life jacket. A USCG observational study conducted during the period of our study noted that 17% to 28% of adults and 62% to 75% of children onboard sailboats were wearing life jackets.²³ There is compelling evidence from other studies that many of these drowning deaths could have been prevented by wearing a life jacket. A before-and-after study in Australia showed a significant decrease ($U=26$; $P=.04$) in drowning deaths among sailors once the use of life jackets was mandated by law.²⁴ Stempski et al²⁵ found that victims of fatal boating accidents in the state of Washington were 2.6 times less likely to be wearing a life jacket than their counterparts who survived.

LIMITATIONS

The USCG believes that many sailing injuries go unreported because many boaters are not aware of accident reporting regulations or fail to comply with

those regulations. Furthermore, injuries only requiring first aid at the scene need not be reported. As a result we did not attempt to calculate an injury rate with these data. However, the USCG believes that nearly all fatal boating accidents are included in the BARD, and that the more severe the accident, the more likely it is to be reported.²⁶ Although accidents involving fatalities are investigated by state authorities or the USCG, the USCG does not verify cause of death from coroner’s reports. Similarly, injuries are reported by the boat operator and not by a physician, and thus may not accurately reflect the true nature of an injury.

In calculating a sailing fatality rate, we made the assumption that the number of annual sailboat registrations is correlated with the number of sailing person-hours, using the 2011 NRBS and USCG registration data as a baseline. However, there may be fluctuations in how much time is spent aboard each registered sailboat annually. The 2011 NRBS states that “while the overall proportion of boats used varies from year to year (due to economy, weather, or water levels), previous national studies indicate that the overall proportion of boats used has remained relatively constant over the last 20 years.”³ Another possible confounding variable is the proportion of sailboats that are unregistered. The NRBS included time spent on unregistered vessels in its exposure data, and the BARD includes injuries and fatalities on unregistered sailboats. We made the assumption that the ratio of registered to unregistered sailboats in 2011 is constant throughout the study period, but it is possible that the ratio may have changed with time.

Conclusions

Based on USCG data, the fatality rate for recreational sailing was estimated to be 1.19 per million sailing-person days, which is comparable to that of in-bounds alpine skiing and snowboarding. Drowning was the most common cause of death, and 82.0% of victims were not wearing a life vest. Seventy percent of deaths occurred as

a result of the vessel capsizing or the victim falling overboard.

Operator- or passenger-preventable factors, including operator inattention and improper lookout, alcohol intoxication, and operator inexperience, contributed to 52.7% of all injuries and 36.9% of all deaths. Severe weather and hazardous waters were also common contributing factors. It is likely that many deaths and injuries could be avoided if sailors routinely wore life jackets, abstained from alcohol while boating, and participated in boating safety courses.

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