# Barriers to life jacket use among adult recreational boaters

D Alex Quistberg,[1,2] Linda Quan,[1,2,3] Beth E Ebel,[1,2,3,4] Elizabeth E Bennett,[3] Beth A Mueller[1,4,5]

[1]Harborview Injury Prevention & Research Center, University of Washington, Seattle, Washington, USA
[2]Department of Pediatrics, University of Washington, Seattle, Washington, USA
[3]Seattle Children's Hospital, Seattle, Washington, USA
[4]Department of Epidemiology, University of Washington, Seattle, Washington, USA
[5]Fred Hutchison Cancer Research Center, Seattle, Washington, USA

**Correspondence to**
Dr D Alex Quistberg, Harborview Injury Prevention & Research Center, 325 Ninth Ave, Box 359960, Seattle, WA 98104–2499, USA; aquistbe@uw.edu

Received 18 July 2013
Revised 19 December 2013
Accepted 3 March 2014
Published Online First 31 March 2014

## ABSTRACT

**Objective** To identify barriers to life jacket use.

**Design** Cross-sectional survey.

**Setting** Nine public boat ramps in western Washington State, USA, August–November, 2008.

**Participants** 675 adult boaters (>18 years) on motor boats <26 feet long.

**Main outcome** Low or no life jacket use (0–50% of time) versus high life jacket use (51–100% of time).

**Results** Low/no life jacket use (0–50% of time) was associated with longer boat length (per foot, risk ratio [RR] 1.03, 95% CI 1.02 to 1.05), alcohol use (RR 1.11, 95% CI 1.01 to 1.20), perception of life jackets as 'uncomfortable' (RR 1.29, 95% CI 1.09 to 1.52), perceived greater level of swimming ability (RR 1.25, 95% CI 1.03 to 1.53 for 'expert swimmer') and possibly with lack of confidence that a life jacket may save one from drowning (RR 1.13, 95% CI 0.96 to 1.32). Low life jacket use was less likely when an inflatable life jacket was the primary life jacket used by a subject (RR 0.77, 95% CI 0.63 to 0.94), a child was onboard (RR 0.88, 95% CI 0.79 to 0.99) or if the respondent had taken a boating safety class (RR 0.94, 95% CI 0.87 to 1.01).

**Conclusions** Life jacket use may increase with more comfortable devices, such as inflatable life jackets, and with increased awareness of their efficacy in preventing drowning. Boater education classes may be associated with increased life jacket use among adults.

## INTRODUCTION

Drowning remains an important cause of fatal injury. Over the past decade, there has been little change in the annual US drowning rate with an average of 3.56 recreational boating drowning deaths per 100 000 registered boats. In 2012, 459 people drowned in US recreational boating incidents; 85% of these were not wearing a life jacket.[1] In the Puget Sound area of Washington State, 22% of unintentional submersion deaths among adults between 1980–1995 were boating related.[2] Non-fatal submersion rates are also high, thus it is important to identify the opportunities for improving prevention strategies.

Life jackets are United States Coast Guard (USCG)-approved flotation devices, also known as personal flotation devices (PFDs). Life jackets are associated with a 50% reduction in drowning risk.[3] All recreational boats in the USA are required to carry one USCG-approved wearable life jacket that fits for each person aboard.[4] National and state surveys, however, suggest that most boaters do not regularly wear life jackets.[5 6] Efforts to increase life jacket use have targeted all boaters, with the strongest efforts directed towards children. Approaches include legislation mandating life jacket use, strengthened enforcement, life jacket loan programmes and educational efforts to increase awareness. Life jacket use is mandated for children in nearly every state in the USA, although age, boat size and boat movement requirements vary widely.[7] These steps have increased awareness among parents and life jacket use among children; however, non-use remains high.[8–11]

We sought to identify barriers to life jacket use among adult recreational boaters, with a focus on factors that might inform the design of effective interventions or improve public health messages.

## METHODS

### Design

We conducted a cross-sectional survey at nine public boat ramps in King, Pierce and Snohomish counties in Washington State during the 2008 boating season (1 August to 15 November). Study team members approached potential participants (≥18 years) who were launching or retrieving motorboats <26 feet long, a size that permits the boat to be towed on a trailer. This size limit was selected because most recreational boating fatalities occur on boats <26 feet in length.[12] Federal legislation requires life jacket use for certain craft, thus these were excluded: canoes, personal watercraft (eg, Jet Ski), sailboats (including motorised) and kayaks. We used the results of a ramp usage survey commissioned by Washington State in 2003 to proportionally allot survey days (weekend/weekday) and launch ramps to obtain a representative sample. Surveys were conducted in varied weather conditions during daylight hours; one planned site visit was cancelled due to inclement weather. One survey was completed per boat. In order of priority, we first attempted to interview the boat owner, then the pilot (if not the owner) and then any adult passenger if the owner or pilot was unavailable. Although we attempted to interview only one boater per vessel, occasionally two individuals responded jointly, often the pilot and a spouse (n=24). In these instances, the primary respondent was considered to be female, as response patterns were similar to those of female respondents. We attempted to approach every eligible boat, but on busy days we were unable to do so. Boaters who indicated they had previously been interviewed for our study were excluded. We obtained verbal consent from subjects prior to the survey. Surveys lasted approximately 5–8 min. The weather conditions at the time of interview were noted. Institutional Review Board approval was obtained from the University of Washington prior to study conduct.

Linked

▶ http://dx.doi.org/10.1136/injuryprev-2013-041022
▶ http://dx.doi.org/10.1136/injuryprev-2013-041005

CrossMark

**To cite:** Quistberg DA, Quan L, Ebel BE, *et al*. *Inj Prev* 2014;**20**:244–250.

We approached 807 individuals and excluded 40 who had previously completed surveys. Among the remaining boaters, 701 (90%) agreed to participate. Most other refusals were due to being in a hurry (N=42) or lack of interest (N=18). For analysis, we excluded 7 surveys missing life jacket use and 19 surveys conducted with participants on boats ≥26 feet, leaving a total of 675 respondents.

### Measures

Life jacket use was measured by asking participants, "What percent of the time do you think you'll wear (or did wear) a life jacket/vest this trip?" We examined the distribution of responses and found that reported life jacket use was non-linear, with only 12% of individuals reporting life jacket use between 1 and 99%. After exploring the distribution of responses and noting the similarities between the larger 'no use' (0%) and smaller 'low use' (1–50%) groups, we ultimately chose to dichotomise life jacket use into low/no use (0–50%) and high use (>50%). We also asked about habitual life jacket use.

We examined the associations of no/low life jacket use with factors related to the day's outing, vessel and situation: respondent characteristics (age, sex, years of boating experience, possession of a State Boater Education Card and self-rated piloting and swimming skills); trip characteristics (salt/fresh water, weather, number of occupants/children onboard and purpose); and boat characteristics (length and types of life jackets onboard). We also queried attitudes (confidence that a life jacket was protective, life jacket comfort) and behaviour (alcohol use while boating).

Daily weather data for each site were obtained from the Climate Data Online database of the National Climatic Data Center[13] and/or weather stations that were part of the Weather Underground Personal Weather Station network.[14] Median income by residence zip code was obtained from the American Community Survey.[15]

We categorised continuous variables as follows: age (18–29, 30–39, 40–49, 50–59, 60+ years), boat length (USCG reporting classifications: <16, 16–20, 21–26 feet), pilot experience (<5, 5–9, 10–19, 20+ years), times boating in the past 12 months (<6, 6 to 10, 11–20, 21–30, 31–40, 41+), swimming frequency (0, 1–12, 12+ times in past 12 months), total number of occupants including self (1, 2, 3–4, 5+) and number of life jackets onboard (<5, 5 to 9, 10+).

### Analysis

Poisson regression with robust variance was used to calculate risk ratios (RR) and 95% CIs[16 17] to estimate associations of respondent, boat and trip characteristics with no/low life jacket use. We evaluated confounding in multivariable models using the change-in-estimate criteria.[18 19] Potential confounding variables were retained if the risk ratio of interest changed by 10% or more in the presence of the potential confounder. We considered the following variables as potential confounders in all models: respondent age, sex, and boating experience, and boat length. In two models (inflatable life jacket use and life jacket comfort), we only examined subjects who had reported any habitual PFD use (N=371). Analyses were conducted using Stata V.11 software (Stata Corp, College Station, Texas).

## RESULTS

Most interviews (86%) occurred on weekends, with an average temperature of 59°F and rain occurring during 31% of surveys (data not shown). Respondents were mostly male (85%) and owned the boat (86%), with a mean age of 46 years (range 18–81) (table 1). A majority (77%) had completed at least some college. Approximately half (53%) were fishing, 25% were on a pleasure

**Table 1** Respondent, boat and trip characteristics of 675 survey participants at public launch ramps in western Washington State, 2008

| Characteristics | N* | % |
|---|---|---|
| Respondent | | |
| Age (years), mean (SD) | *46* | *(12)* |
| <30 | 68 | 10 |
| 30–39 | 116 | 17 |
| 40–49 | 218 | 33 |
| 50–59 | 179 | 27 |
| 60+ | 89 | 13 |
| Male | 517 | 85 |
| Education level | | |
| <12 years | 26 | 4 |
| High school | 128 | 19 |
| Some college/technical school | 201 | 30 |
| College | 237 | 36 |
| Postgraduate | 73 | 11 |
| Mean income level (US$), mean (SD)† | *76 368* | *(22 741)* |
| Boat owner | 581 | 86 |
| Years of boating experience, mean (SD) | *25* | *(15)* |
| <5 | 73 | 11 |
| 5–9 | 51 | 8 |
| 10–19 | 110 | 16 |
| 20–29 | 143 | 21 |
| 30–39 | 140 | 21 |
| 40+ | 155 | 23 |
| Times boating last 12 months | | |
| <6 | 99 | 15 |
| 6–10 | 126 | 19 |
| 11–20 | 192 | 29 |
| 21–30 | 111 | 17 |
| 31–40 | 35 | 5 |
| 41+ | 100 | 15 |
| Taken piloting or boat safety class | 225 | 38 |
| Has WA State Boater Education Card | 64 | 11 |
| Self-rated boating skills | | |
| Expert | 268 | 45 |
| Intermediate | 299 | 50 |
| Beginner | 33 | 6 |
| Boat and trip | | |
| Boat length (feet), mean (SD) | *19.4* | *2.6* |
| <16 | 47 | 7 |
| 16–20 | 424 | 63 |
| 21–26 | 204 | 30 |
| Activity | | |
| Fishing, hunting, crabbing | 357 | 53 |
| Pleasure or cruising | 169 | 25 |
| Waterskiing, tubing, swimming, diving | 96 | 14 |
| Transport, maintenance, work, other | 52 | 8 |
| Total no. of occupants, mean (SD) | *3* | *(2)* |
| 1 | 93 | 14 |
| 2 | 199 | 30 |
| 3–4 | 294 | 44 |
| 5–10 | 87 | 13 |
| Children (<10 years) onboard | 84 | 13 |
| Preteens/teens (10–18 years) onboard | 95 | 14 |
| Life jacket use on day of survey (%) | | |
| 0 | 488 | 72 |
| 1–50 | 81 | 12 |
| 51–99 | 15 | 2 |
| 100 | 91 | 14 |

*Numbers may not add to total due to missing data.
†Median income level (US$) based on residential zip code in US Census 2010, mean (SD).
The italicised values are means and standard errors rather than statistically significant findings.

**Table 2** Respondent, boat and trip characteristics associated with reported low/no life jacket use

| | Life jacket use | | |
|---|---|---|---|
| | High (51–100%) (n=106) % | Low (0–50%) (n=569) % | RR (95% CI)* |
| Respondent characteristics | | | |
| Female† | 9 | 17 | 1.09 (1.01 to 1.17) |
| Age (years) | | | |
| <30 | 8 | 11 | Ref |
| 30–39 | 14 | 18 | 0.99 (0.88 to 1.10) |
| 40–49 | 30 | 33 | 0.97 (0.88 to 1.08) |
| 50–59 | 36 | 25 | 0.89 (0.80 to 1.00) |
| 60+ | 12 | 14 | 0.97 (0.86 to 1.09) |
| Mean, SD | 48 (12) | 46 (12) | *0.98 (0.95 to 1.01)*‡ |
| Some college | 79 | 77 | 0.98 (0.91 to 1.06) |
| Household median income, mean (SD)§ | 76 657 (21 534) | 76 315 (22 975) | *1.00 (0.99 to 1.01)*¶ |
| Piloted today | 81 | 79 | 0.99 (0.87 to 1.11)** |
| Boat owner | 84 | 87 | 1.05 (0.92 to 1.20)†† |
| Years of boating experience | | | |
| <5 | 10 | 11 | Ref‡‡ |
| 5–9 | 10 | 7 | 0.92 (0.78 to 1.10) |
| 10–19 | 15 | 17 | 1.02 (0.90 to 1.15) |
| 20–29 | 18 | 22 | 1.04 (0.93 to 1.17) |
| 30–39 | 25 | 20 | 0.98 (0.86 to 1.12) |
| 40+ | 22 | 23 | 1.06 (0.93 to 1.21) |
| Mean, SD | 25 (15) | 25 (15) | 1.01 (0.99 to 1.04)‡,‡‡ |
| Ever taken piloting or boat safety class§§ | 46 | 36 | 0.94 (0.87 to 1.01)¶ |
| Have WA State Boater Education Card§§ | 17 | 10 | 0.90 (0.78 to 1.03)*** |
| Times boating in last 12 months | | | |
| <6 | 23 | 14 | Ref††† |
| 6–10 | 20 | 19 | 1.09 (0.95 to 1.24) |
| 11–20 | 21 | 31 | 1.14 (1.00 to 1.29) |
| 21–30 | 14 | 17 | 1.14 (1.00 to 1.30) |
| 31–40 | 7 | 5 | 1.04 (0.86 to 1.27) |
| 41+ | 17 | 15 | 1.09 (0.95 to 1.26) |
| Self-rated piloting skills | | | |
| Expert | 49 | 44 | Ref‡‡‡ |
| Intermediate | 48 | 50 | 1.01 (0.95 to 1.09) |
| Beginner | 3 | 6 | 1.09 (0.95 to 1.25) |
| Boat characteristics | | | |
| Boat length (feet) | | | |
| <16 | 20 | 4 | Ref |
| 16–20 | 62 | 61 | 1.59 (1.21 to 2.08) |
| 21–25.5 | 18 | 34 | 1.71 (1.30 to 2.24) |
| Mean, SD | *17.8 (3.5)* | *19.6 (2.8)* | *1.03 (1.02 to 1.05)* |
| Trip characteristics | | | |
| Salt water | 64 | 55 | 0.94 (0.88 to 1.00) |
| Daily high temperature (Fahrenheit), mean (SD) | *66.7 (11.6)* | *69.9 (11.5)* | *1.04 (1.01 to 1.07)*§§§ |
| Activity | | | |
| Waterskiing, tubing, swimming or diving | 8 | 15 | Ref¶¶¶ |
| Fishing, hunting or crabbing | 58 | 52 | 0.98 (0.85 to 1.13) |

Continued

trip, 14% were participating in a watersport activity such as towing a waterskier or inner tube and 8% reported other activities (eg, boat maintenance or preparing the boat for storage). Most (72%) reported no life jacket use on the day of the survey. Consistent life jacket use was uncommon, with 14% of respondents stating they had worn a life jacket for the entire boating trip. One out of ten boaters reported that they always wear a life jacket when boating.

### Respondent, boat and trip characteristics

No/low life jacket use on the day of the survey was not associated with respondent age, education, income, status as a boat owner or pilot, or the day's activity. It was more commonly reported by females (RR 1.09, 95% CI 1.01 to 1.17) and by respondents on larger boats (RR 1.71, 95% CI 1.30 to 2.24 for boats >21 feet, table 2). No/low life jacket use was also significantly associated with warmer temperatures.

**Table 2** Continued

| | Life jacket use | | |
|---|---|---|---|
| | High (51–100%) (n=106) % | Low (0–50%) (n=569) % | RR (95% CI)* |
| Pleasure or cruising | 23 | 26 | 0.95 (0.86 to 1.06) |
| Transportation, maintenance, storage, other | 11 | 7 | 0.95 (0.79 to 1.14) |
| Any children (<10 years) onboard | 15 | 12 | 0.88 (0.79 to 0.99)**** |
| Any preteens/teens (10–18 years) onboard | 15 | 14 | 0.91 (0.82 to 1.01)†††† |

*Risk ratio and 95% CI.
The italicised values are means and standard errors rather than statistically significant findings.
†Male category is male respondent(s) only, Female category includes only female respondent or female and male respondents.
‡RR and 95% CI are per 10 years.
§US Census household median income within participant's zip code.
¶RR and 95% CI are per $10 000.
**Adjusted for gender, age, education, temperature, any rain and owner.
††Adjusted for gender, age, education, temperature, any rain and piloted.
‡‡Adjusted for gender, age and education.
§§Question was only asked of pilots, users (n=94); non-users (n=516).
¶¶Adjusted for age, ownership, education, usual water type and boat length.
***Adjusted for gender, education, ownership and usual water type.
†††Adjusted for gender, experience and boat length.
‡‡‡Adjusted for age, gender, education, experience, boat length, taken boating class and usual water type.
§§§RR and 95% CI are per 10°F.
¶¶¶Adjusted for age, gender, education, high temperature, any rain, time of day, boat length, boating frequency, taken boating class and usual water type.
****Adjusted for age, gender, education, boating frequency, high temperature, boat length and usual water type.
††††Adjusted for age, gender, education, experience, boating frequency, high temperature, any rain, boat length, activity and usual water type.

Significantly fewer respondents reported no/low life jacket use when children <10 years old were onboard (RR 0.88, 95% CI 0.79 to 0.99), with similar, but non-statistically significant, results for those with preteens/teens onboard. This latter estimate, after excluding respondents with children <10 years old onboard in order to focus on the association with preteens/teens only, was only modestly altered (RR 0.94, 95% CI 0.84 to 1.05, data not shown). Although not statistically significant, no/low life jacket use was less often reported by those who had ever taken a boater education class or those with a Washington State Boater Education Card (BEC).

### Life jacket use characteristics, perceptions and behaviours

Discomfort was associated with no/low life jacket use, as measured by the question, "How comfortable is your life jacket?" (RR 1.29, 95% CI 1.09 to 1.52, for 'uncomfortable', table 3). No/low life jacket use was also significantly associated with having swum in 'open water' at least 12 times in the last year (RR 1.15, 95% CI 1.05 to 1.26), and self-perceived 'intermediate' or 'expert' swimming ability (RR 1.25, 95% CI 1.03 to 1.53 for the latter). Any reported level of alcohol use while boating was also significantly associated with no/low life jacket use (RRs ranging from 1.09 to 1.13). Our data also suggest that no/low use may be associated with having 'no confidence' that a life jacket may save one from drowning, although this finding was not statistically significant.

No/low life jacket use was significantly less likely for those who reported use of inflatable-type life jackets (RR 0.77, 95% CI 0.63 to 0.94) and those who had inflatable life jackets onboard (RR 0.79, 95% CI 0.68 to 0.88). Boaters who reported using inflatable jackets more frequently rated them as being comfortable (80%) compared with those who used other types of jackets (45%). No/low life jacket use was significantly less frequently reported (RR ranging from 0.84 to 0.98) for several proposed situations (when fishing, if area is crowded, after drinking alcohol, when Coast Guard is near), although being in 'choppy waters' was positively associated with no/low use (RR 1.16, 95% CI 1.06 to 1.27).

## DISCUSSION

Our results are consistent with findings of some qualitative studies[20–22] and anecdotal information about life jacket use and behaviours: no/low life jacket use was associated with being on a larger boat, perception of life jackets as uncomfortable and self-perceived ability as a capable swimmer. No/low life jacket use was associated with warmer weather. Higher life jacket use was positively associated with higher prevalence of inflatable life jacket use and the presence of children onboard.

The decreased life jacket use on longer boats may result from an increased sense of security among boaters on larger vessels. However, all the boats in the study were small, 'trailer-able' vessels, in the size range relevant to the majority of drowning-related boating deaths, indicating a need for efforts to increase life jacket use among these boaters specifically.

At least one previous study suggested that boaters dislike bulky life jackets that are uncomfortable and limit motion.[22] Among life jacket ever-users in our study, inflatable life jackets were considered more comfortable than other models, although they are not suitable for all boaters. Inflatables are not appropriate for smaller children and can be costly. The cheapest inflatables currently cost about $70–$80, whereas traditional life vests may be <$20. Inflatables require periodic maintenance at additional expense; for example, a replacement cartridge costs approximately $20. Efforts to increase comfort of life jackets by engineering less bulky devices may promote more consistent use, especially in warmer conditions.

No/low life jacket use was associated with any level of alcohol use. Alcohol use is one of the most important risk factors for drowning, with estimates suggesting that alcohol contributes 10–30% of the attributable risk for all drowning deaths.[23] Even low levels of blood alcohol (10 mg/dL) appear to increase the risk for death among recreational boaters.[24] Alcohol-related drowning deaths in western Washington decreased by 81% between 1975 and 1995, potentially due to increased life jacket use and decreased alcohol use.[25] Since that time, Washington and many states have passed legislation prohibiting persons with a 0.08% or higher blood alcohol content (BAC) from boat

**Table 3** Respondent life jacket use characteristics, perceptions and behaviours associated with no/low life jacket use

| | Life jacket use | | |
|---|---|---|---|
| | High (51–100%) (n=106) | Low (0–50%) (n=569) | |
| Characteristic | % | % | RR (95% CI)* |
| Usually wear inflatable life jacket† | 33 | 11 | 0.77 (0.63 to 0.94)‡ |
| Inflatable life jacket onboard | 37 | 15 | 0.78 (0.68 to 0.88)‡ |
| Confidence that life jacket may save from drowning | | | |
| Very confident | 88 | 84 | Ref§ |
| Confident | 11 | 14 | 1.03 (0.94 to 1.14) |
| No confidence | 1 | 3 | 1.13 (0.96 to 1.32) |
| How comfortable is your life jacket† | | | |
| Very comfortable | 75 | 46 | Ref¶ |
| Somewhat comfortable | 21 | 34 | 1.19 (1.04 to 1.35) |
| Uncomfortable | 4 | 20 | 1.29 (1.09 to 1.52) |
| Do you usually wear a life jacket in these situations** | | | |
| In choppy waters | 65 | 77 | 1.16 (1.06 to 1.27)†† |
| When fishing | 37 | 16 | 0.84 (0.74 to 0.94)†† |
| When crowded | 44 | 26 | 0.90 (0.82 to 0.98)†† |
| When Coast Guard is nearby | 29 | 13 | 0.86 (0.76 to 0.98)‡‡ |
| After drinking | 26 | 16 | 0.89 (0.80 to 0.99)§§ |
| Times swam in pool last 12 months | | | |
| 0 | 40 | 41 | Ref¶¶ |
| 1–12 | 46 | 38 | 0.91 (0.85 to 0.99) |
| 13+ | 14 | 21 | 0.96 (0.88 to 1.04) |
| Times swam in open water last 12 months | | | |
| 0 | 47 | 30 | Ref*** |
| 1–12 | 41 | 42 | 1.08 (0.99 to 1.18) |
| 13+ | 13 | 29 | 1.15 (1.05 to 1.26) |
| Perceived swimming ability | | | |
| Beginner/non-swimmer | 17 | 6 | Ref††† |
| Intermediate | 50 | 52 | 1.24 (1.02 to 1.52) |
| Expert | 33 | 42 | 1.25 (1.03 to 1.53) |
| Drink alcohol while boating | | | |
| Never | 69 | 48 | Ref‡‡‡ |
| Rarely | 12 | 19 | 1.11 (1.02 to 1.20) |
| Occasionally | 15 | 25 | 1.09 (1.02 to 1.18) |
| Often | 4 | 8 | 1.13 (1.03 to 1.25) |

*Risk ratio and 95% CI.
The italicised values are means and standard errors rather than statistically significant findings.
†Only among those who reported any habitual life jacket use overall (high use, N=106; low use, N=265).
‡Adjusted for boating frequency.
§Adjusted for age, gender, education, income, experience, boating frequency, activity, boat length, inflatable onboard, how often drink and swimming ability.
¶Adjusted for boating frequency and use inflatable life jacket.
**Reference category is 'no'.
††Adjusted for life jacket comfort and usual water type.
‡‡Adjusted for life jacket comfort, usual water type and boat length.
§§Adjusted for life jacket comfort and how often drink.
¶¶Adjusted for age, swimming ability, ocean swimming and usual water type.
***Adjusted for swimming ability and usual water type.
†††Age, boat length, boating frequency, activity, boat length, pool swimming and open water swimming.
‡‡‡Boat length and swimming ability.

operation. The USCG enforces the federal BAC level of 0.1% in waters it patrols.[26 27] Enforcement of laws prohibiting operation of a boat while intoxicated is important, but it is unclear what role this might have in increasing levels of life jacket use. It is possible that people who choose to drink while boating, even if they do not drink to intoxication, may also be those who choose not to wear life jackets. Given, however, that drinking increases the risk of capsizing, a collision or falling overboard,[28] increased life jacket use among drinking boaters and all passengers onboard with a drinking or sober pilot is likely to reduce fatalities.[29] In the absence of life jacket laws for all adult boaters, linking enforcement of 'boating while intoxicated' laws to encouragement of life jacket use and inspections regarding presence of life jackets onboard may improve life jacket use.

Mandatory life jacket use among children and awareness efforts targeting parents appear effective at increasing life jacket use among children and adolescents.[5 8 9] Our results suggest that life jacket legislation and increased use among children (and possibly among preteens/adolescents) may increase use among adults on the same boat. Parents can role-model safety behaviours by wearing life jackets when boating with children, a practice also associated with improved life jacket use.[5] Strengthening the legislative and enforcement climates are promising strategies for future efforts to prevent boating-related drowning.

In addition to legislation and enforcement efforts around life jacket use, some have suggested implementing measures similar to those effective at reducing impaired driving. These include encouraging a designated boat operator, sobriety checkpoints and increasing public awareness of laws and enforcement campaigns.[30 31] Additional strategies may be needed to reduce drowning risk for impaired passengers.[29] Aggressive enforcement of life jacket laws has the added potential benefit of identifying other risky boating behaviours (eg, alcohol use) and may increase compliance among higher-risk boaters, who face greater risk of drowning. As noted with primary enforcement seat belt campaigns,[32] in a more aggressive enforcement climate, impaired boaters may be more willing to wear life jackets out of concern that a Coast Guard official may identify other illegal activity.

Perceived swimming expertise may contribute to the decision to not wear a life jacket. Previous research suggests many US adults overestimate their swimming ability, although this may vary by age, race/ethnicity and gender.[33] Perceived swimming ability also likely depends on exposure to aquatic activities.[34] Our data also suggest a possible incongruity between one's perceived swimming ability and self-reported swimming frequency. Public health campaigns to increase life jacket use may be more effective if they emphasise awareness of factors unrelated to swimming ability that contribute to boating fatalities, such as hypothermia and trauma from a capsize or collision, rather than swimming ability.

Our results suggest that individuals who had taken a piloting or boating safety class, or had obtained a BEC, were more likely to report life jacket use, although this finding was not statistically significant. If there is an association, it may be with the safety course (which emphasises life vest use) or with the characteristics of individuals taking a safety course, but either way, the promotion of boater education courses that teach safety benefits and comfort options for life jackets may be beneficial. Previous studies examining the association of piloting/boat safety classes with life jacket use levels have had mixed results. One observed little difference in life jacket use levels between those with and without formal boat safety training.[35] An early case–control study in Ohio compared boat operator characteristics of those involved in fatal boating incidents with characteristics of registered boaters without boating incidents in the previous 4 years. They observed that operators without formal boat safety training were slightly but not statistically significantly more likely to be involved in fatal incidents (RR 1.27, 95% CI 0.63 to 2.57).[36] In Washington State, a BEC is required of boat operators with motorboats with ≥15 horsepower. At the time of our survey, only those who were ≤20 years were required to have the BEC. Two of eight participants in this age group reportedly owned a BEC. By 2014, a BEC will be required for all boaters born in 1955 or later. As more boaters obtain safety training, there are increased opportunities to provide education about the risks, benefits and legal requirements, as well as to emphasise that boating laws will be enforced.

There are limitations common to surveys such as ours. As with any observational study, the possibility of residual confounding exists. Although a majority of respondents reported no/low life jacket use, it is likely that some gave socially desirable answers, which may have underestimated the true level of no/low life jacket use. In our study, 27% of respondents reported some life jacket use on the day of the survey, 14% reported wearing one for the entire trip (100% use) and 10% reported that they always wear a life jacket when boating. Observational studies of adult boaters in the USA have slightly lower estimates of life jacket use (<10%), although these reflect one brief point of time onboard.[6 37] Our reported life jacket use level was similar to observational studies in our region that have generally observed higher life jacket usage proportions (13–17%) compared with rates of use in contemporaneous national studies.[5 9 38] These higher rates in Washington State may be due to sustained local and statewide educational and legislative efforts to increase life jacket use over the past 20 years.[8 39] It is also important to note that some of the associations we observed, although statistically significant, were modest. Our ability to examine some associations may have been hampered by small numbers for some variables. It is possible that there are other factors we did not explore that may better explain barriers to life jacket use.

In contrast to other safety behaviours such as helmet or seat belt use, fewer women reported always wearing a life jacket. This was unexpected and needs confirmation in future studies, given the observed higher levels of injury occurrence and risk-taking behaviours among males. It may also reflect uncontrolled confounding by boat size or passenger role (eg, women may be less likely to waterski or fish).[5] One could speculate that women were more likely to report life jacket use levels accurately than males, but it is also possible that women were more likely to consider life jackets as uncomfortable or that they were less likely to have taken boater safety training classes, both of which were associated with life jacket use in our study.

Wearing a life jacket is a personal choice and is not currently mandated for most adult recreational boaters and boating activities. Despite evidence that life jackets reduce the risk of drowning deaths,[3] in the absence of a legal requirement, it is likely that many recreational boaters will choose not to wear them. Our results suggest this may be for many reasons, including personal comfort, lack of confidence in a life jacket's life-saving ability, a possible perceived low risk onboard 'larger' (16–25 foot) small recreational boats and a perceived low risk of drowning due to a belief in one's own swimming prowess. Based on this information, suggested strategies to increase life jacket use include engineering modifications to improve their comfort, and educational and marketing steps to increase accessibility to and awareness of inflatable life jackets. Efforts to alter risk perception are more complex. Although having had a boat safety class was not significantly associated with life jacket use, boating education classes present opportunities to increase awareness of life jacket effectiveness and to review state alcohol laws and penalties applicable to boaters.

### What is already known on the subject

- US recreational boating drowning rates have varied little in the past decade; 85% of recreational boating drowning victims do not wear a life jacket.
- Life jackets may reduce drowning risk by 50%; however, <10% of adult recreational boaters generally wear them.

### What this study adds

- Adult boaters accompanied by children <10 years old were more likely to report high life jacket use.
- Using or having an inflatable life jacket was associated with higher life jacket use.
- Recreational boaters who consider themselves good swimmers are less likely to wear a personal flotation device.
- No/low life jacket use was greater among those who drink alcohol while boating.

**Acknowledgements** We would like to thank Tony Gomez, R.S., of the Injury Prevention Program, Public Health—Seattle & King County, WA, for assistance in developing the survey and identifying launch ramps. We are grateful to the King County Parks and Recreation Division for allowing access to public boat launches to interview boaters. We would like to thank the research assistants who helped recruit and interview the study participants.

**Contributors** LQ, EEB and BAM conceived of and designed the study. BAM supervised all aspects of this study. LQ and BEE offered administrative, technical and material support. LQ and BAM obtained funding for this study. DAQ and BAM acquired the data. DAQ conducted the statistical analysis.DAQ, BEE and BAM drafted the manuscript. All authors contributed to the analysis and interpretation of the data, reviewed and critically revised the manuscript, and provided final approval of this manuscript for publication.

**Funding** This project was funded by Centers for Disease Control and Prevention, grant #3R49CE00197. DAQ received support from The Eunice Kennedy Shriver National Institute of Child Health and Human Development of the National Institutes of Health under award number 5T32HD057822. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The funding organisations had no input or influence on the analysis or reporting of the results.

**Competing interests** None.

**Ethics approval** University of Washington Institutional Review Board.

**Provenance and peer review** Not commissioned; externally peer reviewed.

## REFERENCES

1 USCG. *Recreational Boating Statistics—2012*. Washington, DC: United States Coast Guard, US Department of Homeland Security, 2013.
2 Quan L, Cummings P. Characteristics of drowning by different age groups. *Inj Prev* 2003;9:163–8.
3 Cummings P, Mueller BA, Quan L. Association between wearing a personal floatation device and death by drowning among recreational boaters: a matched cohort analysis of United States Coast Guard data. *Inj Prev* 2011;17:156–9.
4 USCG. *Federal Requirements and Safety Tips for Recreational Boats*. Washington, DC: United States Coast Guard, US Department of Homeland Security, 2005.
5 Chung C, Quan L, Bennett E, *et al*. Informing Policy on Open Water Drowning Prevention: Observational Survey of Life Jacket Use among Adult, Adolescent and Child Boaters. *Inj Prev* 2014;20:238–43.
6 Mangione TW, Chow W, Nguyen J. Trends in life jacket wear among recreational boaters: A dozen years (1999–2010) of US observational data. *J Public Health Policy* 2012;33:59–74.
7 United States Coast Guard. *Reference Guide to State Boating Laws—Life Jackets (Table 4.9)*. Washington: US Department of Homeland Security. 2007.
8 Bennett E, Cummings P, Quan L, *et al*. Evaluation of a drowning prevention campaign in King County, Washington. *Inj Prev* 1999;5:109–13.
9 Treser CD, Trusty MN, Yang PP. Personal Floatation Device Usage: Do Educational Efforts Have an Impact? *J Public Health Policy* 1997;18:346–56.
10 Quan L, Crispin B, Bennett E, *et al*. Beliefs and practices to prevent drowning among Vietnamese-American adolescents and parents. *Inj Prev* 2006;12: 427–29.
11 Wang W. The effects of state regulations on boating accidents and fatalities. *Appl Econ Letters* 2000;7:373–8.
12 United States Coast Guard. *Boating Statistics—1997–2007*. Washington, DC: US Department of Transportation, 2009.
13 National Climatic Data Center. *Climate Data Online: National Atmospheric & Oceanic Administration*. Department of Commerce, US Government, 2013.
14 Weather Underground. *Weather Forecast & Reports*. Atlanta, GA: The Weather Channel Companies, 2013.
15 US Census Bureau. *American Community Survey 2007–2011 5-Year Estimates. January 29, 2013 ed: US Census Bureau*. US Department of Commerce, 2013.
16 Barros A, Hirakata V. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 2003;3:21.
17 Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004;159:702–6.
18 Greenland S. Modeling and variable selection in epidemiologic analysis. *Am J Public Health* 1989;79:340–9.
19 Greenland S, Rothman KJ, Lash TL. *Modern epidemiology*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2008.
20 Responsive Management. Hunters' and Anglers' Attitudes Toward Boating Safety, the Use of Personal Flotation Devices, and various Messages that Communicate the Benefits of wearing Personal Flotation Devices: Focus Groups results: BoatUS, 2001.
21 Baker AC, Giles AR, Strachan S, *et al*. 'Don't be scared, you don't have to wear your lifejacket': using the theory of planned behaviour to understand lifejacket usage in Tuktoyaktuk, Northwest Territories, Canada. *Polar Record* 2009;46:328–35.
22 Quistberg DA, Bennett E, Quan L, *et al*. Low life jacket use among adult recreational boaters: A qualitative study of risk perception and behavior factors. *Accid Anal Prev* 2014;62:276–84.
23 Driscoll TR, Harrison JA, Steenkamp M. Review of the role of alcohol in drowning associated with recreational aquatic activity. *Inj Prev* 2004;10:107–13.
24 Smith G, Keyl P, Hadley J, *et al*. Drinking and Recreational Boating Fatalities: A Population-Based Case-Control Study. *JAMA* 2001;286:2974–80.
25 Cummings P, Quan L. Trends in Unintentional Drowning: The Role of Alcohol and Medical Care. *JAMA* 1999;281:2198–202.
26 The National Association of State Boating Law Administrators. Reference Guide to State Boating Laws, 2007.
27 United States Coast Guard. *Boating Under the Influence Initiatives*. Washington, DC: Department of Homeland Security, 2009.
28 Stempski S, Schiff M, Bennett E, *et al*. Boating-related injuries and fatalities in Washington State. *Inj Prev* 2014;20:232–7.
29 Howland J, Smith GS, Mangione T, *et al*. Missing the boat on drinking and boating. *JAMA* 1993;270:91–2.
30 DeJong W, Hingson R. Strategies to reduce driving under the influence of alcohol. *Annu Rev Public Health* 1998;19:359–78.
31 Shults RA, Elder RW, Sleet DA, *et al*. Reviews of evidence regarding interventions to reduce alcohol-impaired driving. *Am J Prev Med* 2001;21:66–88.
32 Voas RB, Fell JC, Tippetts AS, *et al*. Impact of primary safety belt laws on alcohol-related front-seat occupant fatalities: five case studies. *Traffic Inj Prev* 2007;8:232–43.
33 Gilchrist J, Sacks JJ, Branche CM. Self-reported swimming ability in US adults, 1994 [letter]. *Public Health Rep* 2000;115:110.
34 Howland J, Hingson R, Mangione TW, *et al*. Why are most drowning victims men? Sex differences in aquatic skills and behaviors. *Am J Public Health* 1996;86:93–6.
35 Bell NS, Howland J, Mangione TW, *et al*. Boater training, drinking and boating, and other unsafe boating practices. *J Drug Educ* 2000;30:467–82.
36 Molberg PJ, Hopkins RS, Paulson J, *et al*. Fatal Incident Risk Factors in Recreational Boating in Ohio. *Public Health Rep* 1993;108:340–6.
37 United States Coast Guard, JSI Research & Training Institute Inc. *2007 National Life Jacket Wear Rate Observation Study Final Report*. Boston, MA: US Department of Homeland Security, 2008.
38 Quan L, Bennett E, Cummings P, *et al*. Are life vests worn? A multiregional observational study of personal flotation device use in small boats. *Inj Prev* 1998;4:203–5.
39 Quan L, Bennett E, Cummings P, *et al*. Do parents value drowning prevention information at discharge from the emergency department? *Ann Emerg Med* 2001;37:382–5.