Recent Research on Recreational Boating Accidents and the Contribution of Boating Under the Influence

Summary of Results

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1. EXECUTIVE SUMMARY

1.1. Introduction

The *United States Coast Guard* (USCG) has the legal responsibility to collect, analyze, and publish recreational boating accident data and statistical information for the fifty states, five U.S. territories, and the District of Columbia. Boating accident statistics are compiled and used for many purposes, such as: identifying trends; characterizing accident causes; assessing the contributions of operator error, mechanical malfunctions, and environmental factors; and evaluating the possible benefits of government initiatives (e.g., boater education, legislation/regulation, and boat construction standards) to reduce the risks associated with recreational boating activity. Complete and accurate accident data are essential for these purposes.

Over the years, USCG and state boating authorities have made many improvements in the quality, accuracy, and relevance of the boating accident and investigation data captured by the *Boating Accident Report Database* (BARD) System. For example:

- USCG and the states have provided training to law enforcement officials who conduct accident investigations and state BARD analysts who process accident reports in an effort to provide greater consistency and accuracy in reporting.
- The accident report forms have been revised to increase clarity and provide more mission-essential data (e.g., occupant use of a personal floatation device at the time of the accident).
- USCG has sponsored research to estimate the utilization of various types of boats to provide exposure measures for the calculation of more meaningful accident rate estimates.

Even though many improvements in the collection of boating accident data and reporting of statistics have been made, opportunities for further improvement remain. For example:

- The evidence suggests that non-fatal boating accidents are significantly under-reported. For various reasons (e.g., lack of knowledge or deliberate choice), some boaters fail to report accidents despite federal regulations requiring them to do so and government efforts to increase reporting. State and federal officials believe that the percentage of non-fatal accidents that goes unreported is appreciable—particularly for less serious injuries or *property damage only* (PDO) accidents. Under-reporting biases the computed accident rates downward and masks the actual magnitude of boating risks. If risks are underestimated, then society may fail to take appropriate actions to control or reduce these risks.
- USCG lacks economic data and methods to estimate the social costs of boating accidents. Such costs serve as an essential input for cost-benefit analysis of intervention strategies and enable inter-modal comparisons of accident costs (e.g., the costs of boating accidents compared to those for aircraft or automobile accidents).
- Boating under the influence of alcohol and/or drugs (as with other forms of transportation) is generally recognized as an important safety issue. Numerous studies have shown that alcohol use increases both the likelihood and severity of boating accidents. Estimates of the contribution of alcohol use to the incidence and costs of boating accidents would be valuable.

USCG sponsored a study by the *Pacific Institute for Research and Evaluation* (PIRE) to address these three issues. The study team was guided by an external review board including economists, statisticians, and physicians from government agencies, the National Association of State Boating Law Administrators, and the private sector.

This document provides a high-level summary of PIRE's key findings and conclusions.[1]

1.2. Under-reporting

The study team investigated the extent of under-reporting of recreational boating accidents by comparing fatal and non-fatal injury data captured by the BARD System in calendar year 2002 with data for the same period from other government sources widely used in the analysis of injuries. Boating injury data were partitioned into three categories: (i) fatal injuries, (ii) non-fatal hospital-admitted injuries, and (iii) non-fatal non-admitted injuries (i.e., those treated in emergency departments, clinics, or doctors' offices). For each category, PIRE developed estimates of total injuries in 2002 and compared these to the corresponding totals captured in the BARD System. For the year 2002:

- This research supports USCG's own BARD-based estimate of 758 boating fatalities in 2002. BARD recorded 750 boating deaths, and USCG's current policy, based on previous analysis, is to adjust the BARD fatality count upwards by 1% to compensate for under-reporting. The research methods employed in this study were different from those used in the earlier USCG studies that quantified the scope of fatal accident under-reporting.
- This study estimated that there were 2,181 non-fatal hospital-admitted boating injuries, while BARD recorded 1,752 for 2002. BARD appears to capture a majority of injuries serious enough to result in a hospital admission but still misses a significant share—approximately 20%. This estimate is based on comparisons between BARD and state hospital data. Additional research (e.g., comparisons for other years) is appropriate to verify this estimate.
- This study estimates that there may have been 30,000 or more non-fatal non-admitted boating injuries in 2002. This contrasts with just 2,309 such injuries captured by the BARD System. BARD appears to under-report injuries that are not serious enough to warrant hospital admission by a substantial margin. As with non-fatal admitted injuries, this estimate is based on a comparison of BARD figures with state hospital data, and additional research is appropriate to verify this estimate.
- The extent of under-reporting varies inversely with the severity of the injury resulting from the accident, being virtually zero for the most serious (fatal) accidents and progressively greater for less serious injuries. This pattern is consistent with USCG expectations. Based on reasonable estimates of the relative social and economic costs of various types of accidents (fatal, non-fatal hospital admitted, and non-fatal non-admitted) the extent of under-reporting (in economic terms) is probably no more than 25%.

Under-reporting of accidents is not unique to domestic boating statistics. A recent study by the *National Highway Traffic Safety Administration* (NHTSA) (Blincoe *et al*., 2002), for example, estimated that 21% of vehicle accidents involving injury, as well as 48% of accidents

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[1] This summary does not address PIRE's work completed on boating accident costs, which is currently under review.

involving property damage only, were not reported.

It is certainly desirable to reduce the extent of non-reporting. Failing this, USCG should consider whether or not to employ statistical adjustments to correct for under-reporting of non-fatal injuries in the BARD data, as is now done for fatalities. A prudent course of action would be to defer this decision until these results have been replicated for other years and/or by other methods. In the long term, such corrections are appropriate and are routinely employed by other agencies (e.g., NHTSA).

1.3. Accidents involving alcohol

Analysis of BARD data for the period 2002 – 2003 suggests that at least 23% of fatalities and 9% of non-fatal injuries resulted from accidents in which alcohol/drugs was a contributing factor. These estimates undoubtedly understate the actual contribution of alcohol/drugs for many reasons (e.g., there are obvious disincentives to identify alcohol use in self-reported accidents).

The extent of alcohol involvement is similar to that reported for automobile accidents (when comparable assumptions are made)—and is greater than reported for other transportation modes (e.g., general or civil aviation, railroads). Thus, there is also a large potential benefit if successful policy initiatives can be devised to lower the incidence of boating while drinking.

Finally, the PIRE study resulted in numerous recommendations (see Section 2.5) that could ultimately improve BARD and suggests additional policy-relevant analyses.

Temporary Insanity II **impaled on day-marker near Bay Bridge Marina on Kent Island (2002). A passenger suffered a broken arm and lacerations in the accident. The skipper claimed to have been "blinded by the lights of a sailboat" and was subsequently charged by Maryland DNR police with negligence, traveling at an unsafe speed, and failure to maintain a proper lookout. Story available from http://www.apg.army.mil/sibo/quotes1.htm#Q15. Photo available from http://safetycenter.navy.mil/photo/archive/archive_1-50/photo43.htm.**

2. DETAILS

2.1. Background

In 1973[2] reported recreational boating fatalities totaled 1,754 nationwide—an annual fatality rate of approximately 27.7 per 100,000 numbered boats.[3] By 2004, even though the number of boats more than doubled in the interim, reported fatalities declined to 676 (a 61% reduction)—equivalent to an annual rate of 5.3 fatalities per 100,000 numbered boats (an 81% reduction compared to 1973). Figure 1 shows the annual number of recreational boating fatalities and the fatality rate per 100,000 numbered boats over the period from 1970 to 2005.

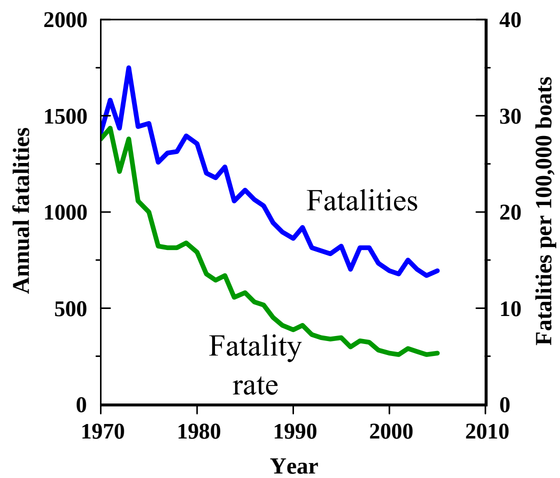

Figure 1. *Recreational boating fatalities and fatality rate per 100,000 numbered boats, 1970 – 2005.*

Source: USCG

Despite this notable progress in reducing accident, injury, and fatality rates, the number of recreational boating casualties remains high—particularly as most are preventable and even if not, simple measures, such as wearing of *personal floatation devices* (PFDs) would dramatically reduce the resulting number of fatalities. For example, the Coast Guard estimates (*Boating Statistics*, 2002) that 70% of all fatal boating accident victims drowned and, among those who drowned, nearly 85% were not wearing a PFD.

In recent years, recreational boating accidents (after automobile accidents) accounted for the second largest number of transportation fatalities annually—more than those reported for general aviation, rail and bus transportation, commercial marine transportation, commercial aviation

[2] This was the peak year for recreational boating fatalities.
[3] The numbered boat population is based on the annual Report of Certificates of Number Issued to Boats that each state and jurisdiction sends to the Coast Guard.

(including air taxi), and pipelines.[4] For this reason, it is important to study the frequency, causes, and possible means for reducing the number/severity of recreational boating accidents.

2.1.1. Boating accident reporting

Boating accident statistics are derived from boating accident reports collected by the states. Current Federal regulations (33 *Code of Federal Regulations* [CFR] 173.55) require the operator of any recreational vessel to file a *Boating Accident Report* (BAR) when; as a result of an occurrence that involves the vessel or its equipment:

1. A person dies; or
2. A person is injured and requires medical treatment beyond first aid; or
3. Damage to the vessel and other property totals $2,000 or more or there is complete loss of the vessel; or
4. A person disappears from the vessel under circumstances that indicate death or injury.[5]

Obviously a serious accident. Boat on trailer is only thing keeping truck from falling down embankment, while driver struggles to get out of cab. Nonetheless, this is not a reportable recreational boating accident. The photograph is available from http://safetycenter.navy.mil/photo/images/images-0-50/photo43_1.jpg.

[4] See e.g., Department of Transportation, Bureau of Transportation Statistics, Fatalities by Transportation Mode 1970-2002, available electronically at http://www.bts.gov/publications/pocket_guide_to_transportation/2004/html/table_02.html.

[5] These are federal requirements for accident notification. Individual states may have more stringent reporting requirements, such as a lower value of the reporting threshold for property damage. Property damage thresholds have changed over the years.

A standard form (CG-3865, *Office of Management and Budget* [OMB] control number 1625-0003) is used for accident reporting. The BAR is filled out by either an investigating officer or the operator(s) of the vessel(s) involved. BARs are gathered on a state-by-state basis and sent to the *United States Coast Guard* (USCG) for collation and analysis. USCG[6] compiles the accident information into the *Boating Accident Report Database* (BARD).

Reportable recreational boating accident or not? Photograph available from http://safetycenter.navy.mil/photo/images/images-0-50/photo43_2.jpg.

2.1.2. Utility of BARD

Boating accident data are used for many purposes. For example:

- USCG uses accident data and statistical information to establish National *Recreational Boating Safety* (RBS) Program goals, objectives, strategies, and performance measures.

- Both cross-sectional and longitudinal analyses are used (among other purposes) to identify relevant trends, to characterize accident causes, to identify possible manufacturer defects in boats or equipment, to develop boat manufacturing standards, to develop safe boating education and accident prevention programs, to study the role of environmental variables, and to assess the possible benefits of various intervention strategies (e.g., education, regulation, and vessel design).

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[6] Title 46 *United States Code* (USC) 6102(a) requires a uniform marine casualty reporting system, with regulations prescribing casualties to be reported and the manner of reporting. The statue requires a State to compile and submit to the Secretary (delegated to the Coast Guard) reports, information, and statistics on casualties reported to the State.

➢ USCG (Inspections & Compliance Directorate) publishes data summaries in an annual report, *Boating Statistics*.

➢ At a more detailed level, many states use these data for accident investigations.

One fatality and eight others injured when speedboat rammed cabin-cruiser in Missouri in 1967. The analysis in this report indicates that nearly all fatalities are captured in BARD. Photo and story available from http://www.safetycenter.navy.mil/photo/archive/archive_1-50/photo10.htm.

Because of the importance and utility of these data, USCG and the states[7] have worked diligently over the years to assess and effect continuous improvement[8] in data quality and to increase the relevance and quality of the information derived from these data. This said, there are many opportunities for improvement. For example:

[7] Acting individually or through the *National Association of State Boating Law Administrators* (NASBLA). Helpful comments and suggested improvements have also been provided by many others in the RBS community.

[8] Periodically (see e.g., 71 *Federal Register* 47, pp 12378 *et seq*.), under terms of the Paperwork Reduction Act of 1995, USCG requests public comments on the form. These comments have proven useful over the years. However, USCG continually seeks to identify improvements to the data collection forms, system for collation, and methods of analysis.

- BARD does not include every accident involving a recreational vessel. Boaters are not required to report certain accidents (e.g., because there were no reportable injuries and the property damage did not exceed the applicable regulatory threshold). Of more concern, some accidents are not reported because boaters are unaware of their obligation to report accidents or otherwise choose not to comply with these regulations.[9] USCG believes that nearly all fatal accidents are included in BARD, but reporting may be far from complete for other accidents, even those involving injuries.[10,11] Because accident data are typically reported as rates and accidents (or fatalities, injuries, or vessels involved in accidents) are generally in the numerator of the rate expression, this is informally termed the *numerator problem*.
- BARD does not include estimates of the social and economic costs of fatalities and injuries (e.g., medical expenses, lost wages) associated with boating accidents. For cost-benefit and other analyses, such as intermodal comparisons (e.g., Miller *et al.,* 1999; Blincoe *et al*., 2002), it would be valuable to estimate these costs. This is another dimension of the numerator problem.
- BARD contains data on *accidents*, not *utilization* or *exposure*. Historically, accident rates were computed based on "numbered vessels," for example, as fatalities per hundred thousand numbered vessels. But, not all vessels are required to be registered and, moreover, not all vessels have the same intensity (frequency or duration) of use. What is needed is an improved measure of exposure (e.g., operating hours per year, boat-days per year, or miles per year[12]). Because the utilization or exposure variable appears in the denominator of a rate expression, this is informally termed the *denominator problem*.

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[9] Most states publicize the requirement to file BARs via pamphlets and Internet postings, (e.g., www.dgif.state.va.us/boating/boat_accident.html), citing the applicable law requiring completion of these reports. Most states include provisions to keep information in BARs confidential – e.g.,
Pennsylvania (www.pacode.com/secure/data/058/chapter101/chap101toc.html),
Texas (www.tpwd.state.tx.us/fishboat/boat/responsible/accident_reports/),
Utah (http://www.stateparks.utah.gov/New%20bu%20Folder/parks/boating/study%20guide.pdf), and
Washington (www.boatwashington.org/boat_accident.htm). In these states the report cannot be used in any trial resulting from an accident. In states where a BAR may not be used in any action or proceeding against a person, USCG may not use it either (46 USC 6102 (b)). Although it might be argued that either the federal government or the states are not doing enough to encourage required reporting, such measures are being taken.

[10] *Boating Statistics* 2002, for example, notes "We believe that only a small fraction of all non-fatal boating accidents in the United States are reported to the Coast Guard, State, or local law enforcement agencies. However, we believe that nearly all fatal recreational boating accidents are included in this report. Overall, the more serious the accident, the more frequent the reporting."

[11] Accident underreporting is not limited to boating accidents, this also occurs with other transportation modes including motor vehicles (see e.g., Wilde, 2001; Blincoe *et al*., 2002) and even aircraft (Bowermaster, 2006). Under reporting of accidents also occurs in non-recreational contexts. The Marine Accident Investigation Branch of the UK's Department for Transport (MAIB, 2002) report on fishing vessel accident data observed: "The actual number [of fishing vessel accidents] is *likely to be much larger owing to the known under-reporting of accidents* by fishing vessel owners and skippers." [Emphasis added.] And, according to one source (Aeron-Thomas, 2000), under-reporting of certain types of road accidents in third-world countries is as high as 97%.

[12] These and other measures have been suggested. The choice among possible bases for normalization of rates is complex, determined in part by the purposes of analysis (see e.g., Wilde, 2001) and data availability. Even in well regulated and studied modes of transportation, such as aviation, denominator issues exist (see e.g., NTSB, 2002).

Over the years USCG and the states have worked to improve both numerator and denominator. Addressing the denominator, for example, USCG has sponsored studies (e.g., Mangione *et al*., 2000; Strategic Research Group, 2003) on vessel utilization in order to compute improved exposure/activity indices. This research continues.

2.2. The PIRE Study

As part of its ongoing efforts to improve the quality of recreational boating accident statistics USCG sponsored a study by the *Pacific Institute for Research and Evaluation*[13] (PIRE) to address some of the numerator issues. An external review board including economists, statisticians, and physicians from government agencies, the *National Association of State Boating Law Administrators* (NASBLA), and the private sector provided advice and oversight to the PIRE study team.

This document provides a high-level overview of the key findings and recommendations of the PIRE study.

In brief:

- PIRE used data from other sources that are widely employed in injury research and generally accepted as reliable to estimate the possible degree of under-reporting of accidents/injuries and to develop improved estimates of the number of recreational boating injuries. These results are summarized below.
- PIRE used methods consistent with those used for costing accidents in other transportation modes (e.g., automobiles) to investigate the suitability of the BARD data for calculating the social costs of boating accidents[14] and to provide perspective on the significance of possible under-reporting of accidents. Selected remarks on these findings are provided below.
- Because alcohol use is believed to be a factor in a substantial proportion of boating accidents, increasing both their likelihood and severity (see, e.g., Smith *et al*., 2001), the PIRE study examined the role of alcohol.[15] These results are discussed below.

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[13] BUI study for USCG recreational boating safety outreach program, task order HSCG23-04-F-D01003 by PCI Communications, Inc.

[14] These results are preliminary and not reviewed in this document. However, this research identified possible enhancements to BAR, which are included.

[15] In simple terms, alcohol impairs human performance; it has detrimental effects on cognitive functions such as information processing, memory, verbal skills, and psychomotor abilities (Newman, 2004).

Although this speedboat is now on land, this accident is reportable as it started out in the water! Photo available from http://freshcrash.com/boatcrash.htm.

2.2.1. Exploratory data analysis

The PIRE study is properly characterized as *exploratory data analysis* (EDA).[16] The intent of EDA is to identify issues, problems, opportunities, and hypotheses for subsequent, more detailed analysis. This might be loosely translated as the use of "sophisticated back-of-envelope" methods to identify issues and suggest possible solutions. Subsequent *confirmatory* or *adjudicatory data analysis* must be used to refine these preliminary estimates and make the analysis more rigorous.

2.2.2. Accident focus

Accidents involving death or injury are an appropriate focus of study because these accidents (compared to *property damage only* [PDO] accidents) are the most serious and are likely to have the greatest social/economic costs.[17]

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[16] A term coined by the late statistician John W. Tukey to be distinguished from "confirmatory" or "adjudicatory" data analysis.

[17] This is not to imply that other accidents or incidents are unimportant. Serious accidents are typically infrequent and (because of limited sample sizes) present greater challenges for statistical analysis. According to one widely quoted rule of thumb (see e.g., Schmidt, 1998, 2004; Naval Safety Center, undated), the Heinrich ratio, for every fatal accident, there are 10 non-fatal accidents, 30 "reportable incidents," and 600 "unsafe acts." (The numbers quoted are meant to be illustrative, not taken literally.) Ranter (2002) claims that the Heinrich pyramid or iceberg shows that for every major accident, there will be 3 –5 significant accidents, and 7 – 10 incidents, but at least several hundred (unreported) occurrences. Potentially valuable information can be gained from the study of "near misses" and other unsafe acts. And, indeed, these are being studied in the aviation community.

Injuries are typically subdivided into three classes; those resulting in (1) fatalities, (2) injuries requiring hospital admission ("non-fatal, admitted"), and (3) injuries treated in emergency departments, clinics, and doctors' offices ("non-fatal, non-admitted"). This partition is necessary because, among other reasons, (1) the social costs of accidents in each category differ and (2) different surrogate data sources (see below) are available.

2.2.3. Search for other data sets

The first objective of the study team was to investigate the possible degree of under-reporting of recreational boating fatalities or injuries. It is known that accidents are under-reported for other transportation modes (e.g., motor vehicles) and reasonable to believe that boating accidents would likewise be under-reported.

One approach to estimate possible BARD under-reporting is to find other (ideally more complete) data sources to serve as benchmark or reference data sets for comparison with BARD. This is the approach followed in the US (Blincoe *et al*., 2002 and contained references) and the UK (UK Department for Transport, 2006) to estimate under-reporting of automobile casualties. Accordingly, the study team identified several data sets managed by federal government agencies that are widely employed in injury research and have proven suitable for this purpose in the analysis of motor vehicle accidents. These data sets included:

- **Fatalities:** The study team selected recreational boating fatalities from the 2002 *Multiple Cause of Death* (MCOD) data.[18] MCOD data are compiled by the *National Center for Health Statistics* (NCHS), which is part of the U.S. *Department of Health and Human Services* (HHS), *Centers for Disease Control and Prevention* (CDC). The MCOD records every death that occurs in the United States, based on official death certificates filed in each state and territory. It includes medical diagnoses and external causes of injury coded according to the *International Classification of Diseases, 10th Revision* (ICD-10). The MCOD provides a complete census of fatalities.[19] Although the MCOD fatality count is believed to be accurate and complete, ICD-10 cause coding cannot precisely identify fatalities resulting from recreational boating accidents.[20]

- **Non-fatal injuries:** The study team employed two data sets from the *Healthcare Cost and Utilization Project* (HCUP),[21] both available from the *Agency for Healthcare Research and Quality* (AHRQ), also part of HHS. The 2002 *State Inpatient Database* (HCUP-SID)[22] contains hospital discharge data from 36 states[23] and the *State Emergency Department*

[18] For more detail on MCOD data, see www.cdc.gov/nchs/products/elec_prods/subject/mortmcd.htm.

[19] MCOD does not include deaths of U.S. citizens and members of the Armed Services that occur outside the U.S. are not included.

[20] In particular, ICD-10 does not differentiate cleanly between commercial marine and recreational boating accidents. Because the annual fatalities from commercial marine accidents are reported to be substantially lower than fatalities associated with recreational boating accidents, this bias may be small.

[21] For details on HCUP, see www.ahrq.gov/data/hcup/.

[22] For details on HCUP-SID, see www.hcup-us.ahrq.gov/sidoverview.jsp.

[23] States from which AHRQ did not obtain hospital inpatient data for the 2002 HCUP-SID were Alaska, Alabama, Arkansas, Delaware, Idaho, Indiana, Louisiana, Mississippi, Montana, North Dakota, New Hampshire, New Mexico, Oklahoma, and Wyoming. The HCUP-SID also lacked data from the District of Columbia and U.S.

Database (HCUP-SEDD)[24] contains *emergency department* (ED) discharge data from 11 states. These data record all hospitalizations and ED treatments in the respective states. AHRQ selected non-fatal cases with external-cause-of-injury codes that enabled boating accidents to be identified

- **ED/clinic/office split:** In order to estimate how many of the non-admitted cases were treated in an ED and how many were treated in other locations, such as doctors' offices or clinics, the study team used 1999-2000 data from the *National Hospital Ambulatory Medical Care Survey* (NHAMCS), the *National Ambulatory Medical Care Survey* (NAMCS), and the 1999 *Medical Expenditure Panel Survey* (MEPS).[25] NHAMCS and NAMCS are national surveys that collect information about the provision and use of ambulatory medical care services in the United States.[26] NHAMCS covers outpatient treatment in hospitals, while NAMCS covers visits to office-based (or free-standing clinic-based) physicians and osteopaths. Both data sets include ICD-9-CM diagnosis and external-cause-of-injury codes for each case. To avoid double counting cases where the patient was admitted to an ED or hospital or returned to a referring physician[27] were excluded.

2.3. Estimating the incidence of recreational boating fatalities and injuries

Incidence estimates were developed separately for the three types of accidents in the injury taxonomy—fatal, non-fatal hospital admitted, and non-fatal non-admitted. This is customary in injury analysis for three reasons. First, as noted above, data for injuries of different levels in the taxonomy come from different sources, and analysis methods must be tailored to the information that is available from each data source. Second, different costs apply to injuries of different levels.[28] Third, it is plausible that the extent of under-reporting of boating accidents might vary with the severity of the resulting injuries.

The incidence estimates presented in this study were computed at the state level then aggregated to a nationwide total. This is appropriate because institutional, environmental, and demographic factors vary from state to state,[29] and because BARD provides state-level data. Readers should exercise caution, however, in placing reliance on the state-level estimates, particularly for interstate comparisons. Non-fatal data from HCUP were not available for all

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territories and possessions.

[24] For details on HCUP-SEDD see www.hcup-us.ahrq.gov/db/state/sedd/Intro_to_SEDD_042905.pdf.

[25] MEPS is published by AHRQ. Details on this survey can be found electronically at http://www.meps.ahrq.gov/.

[26] For details on these surveys, see www.cdc.gov/nchs/about/major/ahcd/ahcd1.htm.

[27] The NAMCS/NHAMCS data cannot be used to estimate incidence directly because they count injury visits, as opposed to injury episodes. (An episode may entail multiple visits.) They do indicate whether a patient was treated previously by another physician or was admitted to a hospital following the visit, but they do not distinguish other acute-care follow-up visits from initial visits and do not always indicate whether patients were treated in other settings. To arrive at a unique injury incidence count for cases treated only in doctors' offices, the NAMCS and NHAMCS totals were adjusted to match the corresponding count of injuries (not visits) treated only in doctors' offices and only in outpatient departments from the 1999 MEPS.

[28] For example, coroner costs apply only to fatalities and hospital inpatient costs apply only to admissions.

[29] For example, environmental factors include length of boating season, nature of waters, and climate; demographic factors include the number and mix of boats and the age distribution of boaters; and institutional factors include mandatory education laws, law enforcement presence, and hospital admission policies.

states, which required extrapolation across states. In addition, data quality might vary from state to state, as well as from year to year for a given state. Finally, substantial year-to-year variability in injury incidence can obscure underlying patterns of interstate variation in accident frequency or severity. Interstate comparisons are certainly of interest, but ideally should be based on data spanning a period of several years. Therefore, any conclusions regarding state-to-state comparisons must be viewed as tentative. In the language of exploratory data analysis, these are hypotheses to be tested in subsequent confirmatory data analysis.

2.3.1. Deaths

The study team compared counts of non-commercial boating deaths by state in 2002 from both BARD and the MCOD. As expected these counts were highly correlated ($R^2 = 0.92$[30]) and generally quite close.[31] Results of this study are consistent with USCG's own estimate that the total fatality count in BARD should be scaled up by a factor of 1% to adjust for under-reporting.[32] For example, BARD recorded 750 fatalities in 2002. This estimate was scaled -up by USCG to 758 fatalities for the year.

It is interesting to note in passing that there are significant differences in the ratios of recreational boating fatalities to registered boats among the states. Overall, the 2002 boating fatality rate was approximately 5.9 fatalities per 100,000 registered boats. However, rates among states varied from a low of 0 for New Mexico and Hawaii to a high of 35 in Alaska. Figure 2 presents a bar chart showing fatality rates by state in descending order. Many states (those clustered in the middle) have similar rates that are not significantly different.

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[30] R^2 measures the percentage of the variation of the dependent variable (here BARD fatality estimates) associated with changes in the independent variable (here MCOD fatality estimates). High values of R^2 indicate the variables are highly correlated. Several regression models were used to explore the relationship between BARD and MCOD state by state fatality estimates. For a simple linear model the adjusted R^2 was 0.92, for a log-log model (states with 0 fatalities omitted) the adjusted R^2 was 0.86. Using non-linear least squares, the 95% confidence interval on β_1 for the model BARD = β_0 (MCOD)$^{\beta 1}$ was [0.81 0.99] and the resulting R^2 was 0.91. But these are details. The key findings are that BARD counts are highly correlated with, but slightly higher than, MCOD estimates and that the total of the larger of the BARD or MCOD counts for all states and other jurisdictions are close to the BARD fatality estimates.

[31] Assuming conservatively that there are only *errors of omission* in either data set suggests that an improved estimate for each state would be the maximum of either the BARD or the MCOD value. The total of these estimates for 2002 was only 1.7% higher than the total of the BARD values for each state. In fact, it is possible that some of the MCOD values were misclassified in terms of cause, which would mean that some of these fatalities were non-reportable as recreational boating accidents.

[32] USCG (*Boating Statistics*, 2002) estimated that fatal accidents were under-reported by 1% in BARD: "To ensure all fatal boating accidents are captured by the casualty reporting system and required data are input into the BARD system, the Coast Guard successfully implemented a process to notify and provide information to State Boating Law Administrators of fatal accidents that occurred in their jurisdiction. After evaluating the effectiveness of this process improvement in 2002, we estimate a fatal accident under-reporting factor of one percent. As a result the Coast Guard is required to report an additional one percent … on top of the 750 fatalities captured by the Boating Accident Report Database in calendar year 2002."

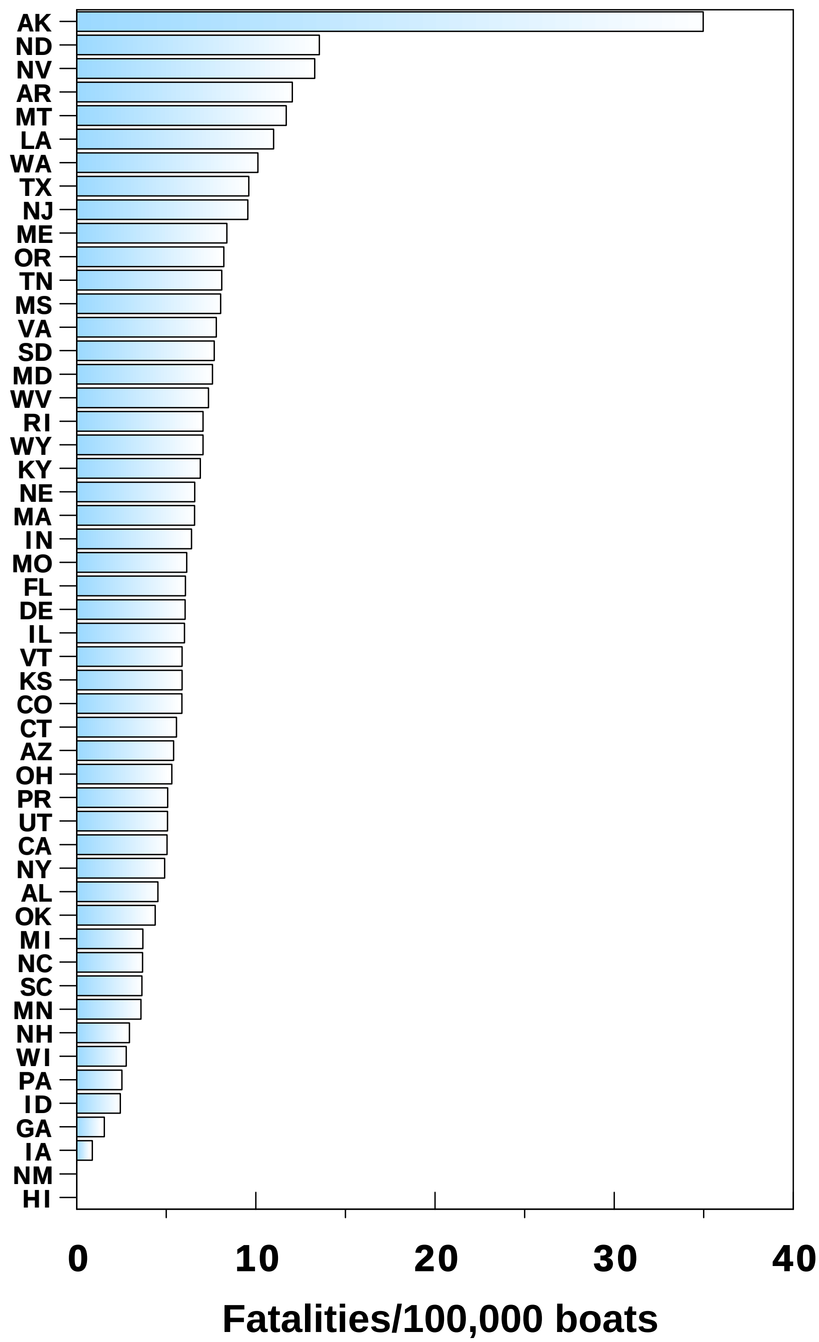

Figure 2. *Fatalities per 100,000 registered boats by state, 2002.*

Care must be taken in interpreting these results[33], but some differences are substantial and worthy of further exploration in search of assignable causes. It is not surprising that there would be state-to-state differences; differences are also found in motor vehicle crashes and fatalities (see, e.g., Blincoe *et al*., 2002).

2.3.2. Hospital-admitted non-fatal injuries

The next category in the injury taxonomy includes hospital-admitted non-fatal injuries. Because of limitations on data availability it was necessary to develop the estimate in a number of steps. The estimate of the number of these injuries in 2002 was derived from BARD and benchmark data sets by plausible, but arguably *ad hoc*, steps as follows:

- For some states, counts were available from both BARD and HCUP-SID. If errors of omission predominate, a reasonable estimate for each state is to select the larger of the BARD or the HCUP-SID counts.[34]

- For a few states, AHRQ did not provide exact HCUP-SID counts because of a policy against reporting small cell sizes. For these cases the BARD estimates were used, if available.

- For yet other states HCUP estimates were available, but BARD did not give a breakdown of admitted vs. non-admitted cases. HCUP estimates were selected for states in this category.

- Finally, there were a few states, for which BARD counts were available but not HCUP-SID counts. For these states, estimates were derived by scaling up the BARD counts.

The nationwide total was calculated by adding the subtotals for each group of states.

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[33] Excluding American Samoa, the District of Columbia, Guam, the Northern Mariana Islands, and the Virgin Islands, each of which has fewer than 10,000 registered boats. Caution is indicated because the rates are based on only one year's data and are based on registered boats, not exposure hours. Additionally, many other factors, such as the mix of types and sizes of boats, climate, utilization rates, and presence of hazards to navigation are potentially relevant variables that vary by state. Readers should also bear in mind that states also have different numbering requirements – some number all watercraft and some only motorboats, while others have more complex rules (see *Boating Statistics, 2002*, for details).

[34] We believe that any errors in either data set are of the sort likely to result in undercounts, rather than overcounts. BARD is known to miss some boating accidents. And, while the HCUP-SID captures every hospital admission in each state, the cause of the injury is often coded imprecisely, e.g., "unspecified accident." It is interesting to note that the BARD fatality counts were usually higher—presumably more complete—than the HCUP-SID counts of recreational boating injuries. There are two ways in which our HCUP-based estimate could, hypothetically, overcount recreational boating injuries in a given state. First, HCUP's cause coding is less precise than that of BARD, so our case selection could include a few commercial boating cases. Second, a victim who is injured in one state and hospitalized in another state would be attributed to the first state in BARD and the second in HCUP.

The resulting estimate of total hospital-admitted injuries in 2002 was 2,181—approximately 25% higher than the raw BARD count of 1,752.[35] Put another way, the raw BARD count (1,752) under-reported the estimated value (2,181) by 429 injuries, 19.7% of the total. Thus, according to this estimate, BARD misses approximately 20% of the total hospital-admitted injuries.

As expected, the extent of under-reporting was greater for non-fatal injuries than for deaths. The estimated extent of under-reporting is consistent with data from motor-vehicle accidents: the *National Highway Traffic Safety Administration* (NHTSA) estimates that 21.4% of non-fatal crash injuries are missed in police crash reports.[36] ***However, BARD does appear to capture a majority of the injuries serious enough to result in hospital admission.***

There are several possible ways to estimate the total hospital-admitted injuries in addition to that noted above. For example, the ratio of the maximum of BARD and HCUP-SID counts to the BARD count (for those states and jurisdictions where both counts are available) might be used to scale-up the BARD counts for other states. The development of an "optimal" scale-up factor for hospital-admitted injuries is an appropriate task for future work.

2.3.3. Non-admitted, non-fatal injuries

The final accident category includes those accidents that resulted in non-fatal injuries that did not require hospital admission. Both *a priori* and based on data for other transportation modes, it is likely that the incidence of under-reporting is greater than that for either fatalities or non-fatal hospital-admitted cases. It is also likely that scale-up estimates are likely to be less precise for this category. Both conjectures are supported by the data.

For 11 states, counts of ED-treated boating injuries were available from the HCUP-SEDD. A preliminary comparison of the HCUP counts with the non-admitted BARD injury counts from these same 11 states revealed that the BARD counts were, on average, 78% smaller than the HCUP counts. Moreover, the apparent BARD undercounts varied widely between states, from 61% in Utah to 100% in Vermont. This suggests that BARD captures only a small—and highly variable proportion—of injuries.

To explore this further another procedure was used. The number of non-admitted injuries can be estimated from the number of hospital admissions in each state. Consider first the boating injury cases from the 11 states for which both HCUP-SID and HCUP-SEDD data were available for 2002. The ratio of ED visits to hospital admissions for non-fatal boating-related injuries in these states averaged 8.49. Based on this ratio and the estimated total number of hospital admissions (2,181, see above) there would be approximately 18,250 ED-treated boating injuries nationwide. This estimate is probably conservative; NHAMCS suggests there are as many as 27,000 ED-treated boating injuries annually.

Next the number of ED cases was scaled up by a factor of 1.72 to account for injuries treated in settings other than EDs, such as clinics and doctors' offices. This factor, from Finkelstein,

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[35] Only 1,603 BARD cases are actually identifiable as hospital-admitted. Another 149 cases from Michigan and Vermont were coded as admitted, but it is not clear whether these states actually identify a victim's admission status.

[36] Blincoe *et al*., (2002), p9.

Corso, *et al*. (2006), is based on weighted incidence of all injuries[37] from the 1999-2000 NAMCS and NHAMCS data, adjusted to prevent double counting by eliminating follow-up visits from NAMCS. The resulting estimate 18,250 x 1.72 = 31,390[38] is much larger than the 2,309 cases[39] recorded in BARD. This calculation suggests that non-fatal non-admitted injuries are significantly under-reported.

This estimate of non-fatal, non-admitted boating injuries is more speculative than those for fatal and hospital-admitted injuries. The estimate of nearly 32,000 non-fatal, non-admitted injuries cannot be regarded as statistically rigorous or of known accuracy—and should be checked (confirmatory data analysis) in follow-up efforts. ***This said, the exploratory data analysis suggests that the probable extent of under-reporting is quite high for non-fatal, non-admitted injuries.***

To recapitulate briefly, this study found:

- BARD counts of fatalities are probably quite accurate. The data examined as part of this effort are consistent with USCG conclusions and the small (1%) official scale-up factor used to correct for bias. For 2002, the BARD count was 750 fatalities, adjusted to 758 fatalities.

- Non-fatal, hospital-admitted injuries are significantly under-reported. In 2002, BARD reported 1,752 injuries of this type, compared to an estimate derived from BARD and other sources of nearly 2,200. The degree of under-reporting (19.7%) is comparable to that estimated for motor vehicle accidents.

- The degree of under-reporting for non-fatal, non-admitted injuries is potentially very much larger than that for non-fatal, hospital-admitted injuries, perhaps as great as 93%—although this estimate is speculative and needs to be investigated further.

2.3.4 Social and economic costs

Taken at face value, these results are reassuring for fatalities, but potentially of concern for non-fatal injuries, particularly for non-fatal, non-admitted injuries. However, this potential under-reporting should be placed in perspective. To do so, consider the possible economic/social costs of these accidents. Fatalities are obviously more serious than non-fatal injuries. And most estimates of the social/economic cost of fatalities greatly exceed those for other types of injuries.[40] Therefore, even though some injuries are under-reported in BARD, the injuries that are captured in BARD will account for most of the social cost of boating injuries.

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[37] It should be noted that this factor is based on all injuries, not just boating injuries. A similar estimate based just on boating injuries in the 1995-2003 NAMCS and NHAMCS produced a factor more than twice as high, but it was based on only 33 NAMCS cases for the nine years combined. Moreover, two-thirds of these cases had a cause code with a fifth character of 9, which indicates the victim was an "unspecified person;" one whose role cannot be definitively classified as recreational. Still, it indicates that 1.72 is a very conservative estimate.

[38] This many significant figures are included only to allow the reader to follow the arithmetic. In view of the likely precision of the estimates, this should be interpreted as "approximately 30,000."

[39] Only 1,662 cases in BARD were actually identifiable as non-admitted. Another 647 cases from Florida, Michigan, Minnesota, and Virginia were coded as non-admitted, but this coding was meaningless, as these states do not report whether a victim was admitted or not.

[40] To be sure, it is possible that certain debilitating injuries that require expensive long-term care could be even more

To see this, take the economic costs (at least unit costs) of motor vehicle accidents as a rough surrogate for boating accident costs. For motor vehicle accidents several estimates have been published:

- The *National Safety Council* (NSC)[41] estimated the average economic cost of a motor vehicle crash in 2004 resulting in a death was $1,130,000, compared to a nonfatal disabling injury of $49,700, or a property damage crash (including non-disabling injuries) of $7,400. Put another way, for every $100 of economic cost of a fatal injury, a non-fatal disabling injury cost $4.40, and a non-disabling injury cost $0.65.

- NSC estimated that the average comprehensive cost (including lost quality of life) of a motor vehicle crash in 2004 resulting in a death was $3,760,000, compared to a non-fatal incapacitating injury of $188,000, and a non-incapacitating injury of $48,200. Based on these estimates, for every $100 of comprehensive cost of a motor vehicle fatality, a nonfatal incapacitating injury is valued at $5.00, and a non-incapacitating injury $1.28.

- The Alberta Motor Association[42] estimated the average economic cost of a motor vehicle fatality in 1999 as $2.9 million, which compares with costs of $100,000 per injury, and $7,000 - $8,000 per property damage due to collision. Normalizing to $100 per fatality, this works out to $3.45 per injury and $0.26 per PDO crash.

- The Bureau of Transport and Regional Economics[43] (Australia) has estimated that the average cost of a motor-vehicle fatality in 2000 was $1.5 million, a serious injury $325,000, and a minor injury $12,000. In relative terms for every $100 for a fatal injury, $21.67 for a serious injury, and $0.80 for a minor injury.

- The U.S. Dept. of Transportation, Federal Highway Administration[44] estimated motor vehicle costs in 1994 as $2.8 million for a fatal injury, $180,000 for an incapacitating injury, and $36,000 for an "evident" injury. In this same relative scale, $100; $6.42; $1.29.

- NHTSA periodically estimates the economic impacts of motor vehicle crashes (see e.g., Blincoe *et al*., 2002). For the year 2000, comprehensive costs per fatality were estimated at $3.36 million, with progressively smaller amounts for various accident injury categories. According to an analysis of the NHTSA cost estimates by the Victoria (BC) Transport Policy Institute,[45] the comprehensive costs of "moderate" injuries was $157,958, and minor injuries $15,017. In a similar relative scale, these are $100; $4.70; $0.45.

These cost estimates are developed using different assumptions and different data. And, of course, they are for motor vehicle, not boating, injuries. However, the relative costs of fatal injuries compared to non-fatal injuries are probably similar and can be used to place possible under-reporting of injuries in economic perspective. For illustrative purposes, assume that the

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"expensive" than fatal injuries. However, this is not the case for most non-fatal injuries.

[41] Available electronically at http://www.nsc.org/lrs/statinfo/estcost.htm.

[42] Available electronically at http://www.pembina.org/pdf/publications/12_auto_crashes_and_injuries.pdf.

[43] Bureau of Transport and Regional Economics (2000). *Road Crash Costs in Australia*, Report, 102.

[44] Available electronically at http://www.fhwa.dot.gov/legsregs/directives/techadvs/t75702.htm.

[45] Available electronically at http://www.vtpi.org/tca/.

relative costs of a fatal boating injury, non-fatal hospital-admitted injury, and non-fatal, non-admitted injury are $100, $5.00, and $1.00, respectively. These "round" numbers are reasonably representative of the relative costs summarized above. Given these social/economic costs for injuries in the various classes and the reporting errors, what is the error in the estimated total annual social cost using unadjusted BARD non-fatal hospital-admitted and non-fatal non-admitted counts? The answer is approximately 27%,[46] a very much smaller discrepancy than that based on counts alone (86%).

Put another way, even if the degree of under-reporting of non-fatal hospital-admitted, and non-fatal non-admitted injuries is as great as estimated here, because fatal injuries are so much more costly, BARD captures cases accounting for the majority of total social costs. This "back-of-envelope" calculation is made to lend perspective to the significance of the reporting errors, not to suggest that efforts to improve reporting and/or develop statistical methods for correcting for underreporting are unimportant.

2.4. Alcohol and drug involvement in recreational boating injuries

Another objective of this project was to determine the impact of *boating under the influence of alcohol and drugs* (BUI) on the incidence of recreational boating injuries. Numerous studies have concluded that alcohol and drug usage increases both the likelihood and severity of automobile and boating accidents.[47] By some prior estimates, as many as 60% of boating fatalities (including persons who fell overboard) were alcohol related.[48] *A priori*, therefore, it is reasonable to expect that alcohol and drug involvement would be positively correlated with fatal and non-fatal injuries.

Two measures of alcohol and drug involvement were used in this analysis:

- Alcohol/drugs as a *contributing factor* comprises cases where alcohol or drug use was listed as a cause of the accident, the operator was arrested for *operating while intoxicated* (OWI), or the victim's *blood alcohol content* (BAC) level was .04 grams per deciliter or higher.
- Alcohol/drugs *mentioned* was a less stringent criterion, which included any of the above conditions plus any positive BAC or a "yes" value in the variable, *alcohol-involved*. An alcohol-involved incident is one in which alcohol was found to be present. In some incidents coded as alcohol-involved, alcohol might not have played a role in causing either the accident or the injury.

BARD data from 2002 and 2003 were used for this analysis. Using two years of data provides a larger sample, which can be expected to produce a more stable estimate. The OWI criterion could be used only for the 2003 cases, because this data field was frequently miscoded in 2002.

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[46] This percentage depends upon the relative proportion of each type of injury and on the relative social costs. It is particularly sensitive to the relative costs for non-fatal, non-admitted costs. For example, if this were $0.50, rather than $1.00 as assumed in the original calculation, undercounting would result on only a 16.5% understatement of total annual social costs, rather than 27%.

[47] With respect to automobile accidents, see Borkenstein *et al.* (1974); Farris *et al*. (1977); Perneger and Smith (1991); Perrine *et al*. (1971); and Zador (1991). With respect to boating accidents, see Smith *et al*. (2001); Glover *et al.* (1995); Howland *et al*. (1993); Smith *et al*. (1999); Talley (1994), and others shown in the references.

[48] See, e.g., Howland *et al*. (1993). Also www.niaaa.nih.gov/publications/aa25.htm.

(While only 3% of cases involved an OWI arrest in most years, 29% of cases were coded as resulting in an OWI arrest in 2001-2002—a discrepancy that cannot be explained.)

2.4.1. Fatalities in BARD

Of 1,453 BARD fatalities in 2002-2003, 328 (22.6%) had alcohol/drugs as a contributing factor, and 520 (35.8%) had a mention of alcohol/drugs somewhere on the record.[49] These measures were constructed from a hierarchical combination of conditions:

283	Alcohol or drug[50] use listed as a cause of the accident
17	OWI arrest[51] (used as a criterion only in 2003)
14	BAC ≥ .08
14	BAC ≥ .04
7	BAC positive
140	Alcohol involved (from Deceased Table)
45	Alcohol involved (from Primary Table)[52]

This breakout allows for examination of the impact of the BAC level chosen to define alcohol as a contributing factor (as opposed to mere mention). In cases that did not meet the first two criteria, but where BAC was measured, a BAC of .04 was chosen as the threshold for alcohol/drug use as a contributing factor. Therefore, the number of cases meeting the criterion was 283+17+14+14 = 328. Raising the threshold to .08 would reduce the count of contributing-factor cases from 328 to 314. Thus, these estimates are not sensitive to the BAC level chosen. (This finding is consistent with results from highway accidents.)

Alcohol/drug involvement appeared lower in 2003 than in 2002. In 2002 there were 292 cases (38.9%) with an alcohol/drug mention out of 750 reported fatalities. In 2003, there were 228 cases (32.4%) with an alcohol/drug mention out of 703 reported fatalities. It would be premature, however, to conclude that alcohol-involved deaths are decreasing.

The estimated association of boating fatalities and alcohol is broadly consistent with the literature. For example, Smith *et al*. (2001) cite 1980-85 data from four states with high testing rates, noting that 51% of people who died in boating accidents had a BAC of at least 0.04 and 30% had a BAC higher than 0.10.

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[49] *Boating Statistics 2002* notes that alcohol was *involved* in 39% of all boating fatalities in 2002. Involvement more nearly matches "mention of alcohol/drugs" as used herein.

[50] For this purpose, BARD defines *drug use* as "When non-prescription and/or prescription drugs are consumed in the boat and the investigating official has determined that the operator was impaired or affected while operating the boat."

[51] Some OWI arrests may not result in convictions.

[52] This criterion means only that alcohol was somehow present in the incident. It is possible that in some cases alcohol was consumed neither by the victim nor by any of the operators, but by a third party.

The above estimate of alcohol/drug involvement in boating fatalities is significantly greater than for deaths in air travel. For example, Taneja and Wiegman (2002) conducted a comprehensive review of 2,696 fatal general aviation accidents from 1990-1998 using database records maintained by the *National Transportation Safety Board* (NTSB) and *Federal Aviation Administration* (FAA). They found 216 accidents (8.01%) that had some form of impairment/incapacitation or physiological causes mentioned in the accident report. Impairment due to drugs (n = 88, 3.3%) and alcohol (n = 68, 2.5%) were the most common causes. Canfield *et al*. (2000) reported that alcohol above the legal limit of 0.04% was found in the bodies of 124 of 1,683 pilots (7.35%) in fatal crashes over the period 1994-1998. The incidence of alcohol consumption in commercial airline and military operations is much lower than in general aviation (Newman, 2004).

Moody *et al*. (1991) reported that approximately 40% of fatal train accidents once had at least one employee who tested positive for alcohol. Other sources (e.g., National Institute on Alcohol Abuse and Alcoholism, 1994; Kolstad, 1992; Spicer and Miller, 2005) indicate that the percentage of alcohol-involved rail accidents declined dramatically following federal intervention and mandatory random drug and alcohol testing.[53]

Blincoe *et al.* (2002) reported that alcohol-involved motor vehicle crashes accounted for 22% of all crash costs. They concluded that alcohol involvement increases with injury severity. Alcohol-involved crashes accounted for 10% of PDO crash costs, 21% of non-fatal injury crash costs, but 46% of fatal injury crash costs.

NHTSA statistics summarized in the *Sourcebook of Criminal Justice Statistics* (Pastore and Maguire, 2003) showed alcohol-related motor vehicle fatalities accounted for a declining proportion of total motor vehicle fatalities—down from 60% in 1982 to 41% in 2002.[54] Beirness *et al*.[55] reported that alcohol was involved in approximately 44% of motor vehicle fatalities in Ontario, a figure comparable to U.S. statistics. As in aviation, alcohol use is less of an issue with commercial drivers than with the general public. For example, only 4% of all drivers of large trucks who were killed in crashes during 1995 had BACs of 0.10 or more, compared with 35% of fatally injured passenger vehicle drivers.[56]

Based on this work and prior Coast Guard estimates, recreational boating accidents are statistically more like automobile accidents than other modes of transportation with regard to alcohol involvement.

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[53] For details, see Kolstad (1992). Kolstad provides NTSB data claiming that 23 of 156 (14.7%) rail accidents involved alcohol or other drugs. Later, in mandatory tests conducted on rail workers after accidents, 3.2% tested positive for alcohol. See also www.niaaa.nih.gov/publications/aa25.htm.

[54] See www.albany.edu/sourcebook/pdf/t3103.pdf.

[55] Beirness, D.J., Mayhew, D.R., Simpson, H.M., and Lefebvre, J.L., "Alcohol-Involved Motor Vehicle Fatalities in Ontario," www.druglibrary.org/schaffer/Misc/driving/s27p1.htm.

[56] See www.usroads.com/journals/aruj/9705/ru970503.htm.

2.4.2. Non-fatal injuries in BARD

Of 7,950 cases, 694 (8.7%) had alcohol/drugs as a contributing factor, and 1,033 (13.0%) had a mention of alcohol/drugs somewhere on the record. These measures were constructed from a hierarchical combination of conditions:

621	Alcohol or drug use listed as a cause of the accident
51	OWI arrest (used as a criterion only in 2003)
17	BAC $\geq$ .08
5	BAC $\geq$ .04
12	BAC positive
327	Alcohol involved (from Primary file)

Raising the BAC threshold to .08 would reduce the count of contributing-factor cases from 694 to 689.

Alcohol/drug involvement in non-fatal injuries appeared higher in 2003 than in 2002 (the reverse of the pattern in fatal injuries). In 2002, there were 470 cases (11.6%) with an alcohol/drug mention out of 4,062. In 2003, there were 563 cases (14.5%) with an alcohol/drug mention out of 3,888. As with fatal injuries, there are insufficient data to claim that a trend exists.

The finding that the incidence of alcohol involvement is lower for non-fatal than for fatal injuries for recreational boating accidents has also been observed with automobile accidents (Blincoe *et al*., 2002).

2.4.3. Source of report

As noted above, some BAR forms are filled out by investigating officials (typically for more serious accidents) and others by the operators of the vessels involved. In cases where the operators fill out the questionnaire, there are obvious incentives to understate alcohol involvement.

It is interesting and instructive to examine the incidence of alcohol/drug mentions by the source of the report—that is, according to whether the report was filed by an investigating law-enforcement officer ("Investigation") or by an operator involved in the incident ("Operator report"). When officials prepared the report (44.1% of cases), 17.3% of cases had an alcohol/drug mention. However, when filed by an operator (8.9% of cases), only 8.5% of cases had an alcohol/drug mention. And when the source of causes was missing (44.7% of cases), 9.6% of cases had an alcohol/drug mention.[57]

In cases where the operator (rather than a law enforcement officer) fills out the accident report, there is a clear disincentive to report alcohol use. What is surprising is that operators filling out the form would report alcohol use at all! This finding has a straightforward explanation: operators were attributing alcohol/drug use to *other boaters* involved in the

[57] Most of the cases with a missing source came from a few states, including Florida and California, which do not report this information.

accident. In single-vessel accident reports filed by operators, only 3.7% list alcohol/drugs as a cause. In two-vessel accidents, by contrast, 15.2% of operators list alcohol/drugs as a cause.

2.5. Findings and recommendations

There are several potentially important findings and conclusions of this work with implications for policy decisions and further research:

- This analysis demonstrates that BARD provides an accurate count of boating accident fatalities. USCG reached the same conclusion. But, because this analysis used a wholly different methodology than used by USCG, this finding provides a valuable crosscheck.

- This analysis indicates that there is material under-reporting (19.7%) of non-fatal hospital-admitted injuries resulting from recreational boating accidents. This degree of under-reporting is comparable to that estimated for motor-vehicle accidents, but is potentially of concern nonetheless. Although non-fatal injuries entail less social cost than fatal injuries, those requiring hospital admission are worthy of attention. The methods used in this analysis need to be refined and made more rigorous, but the overall approach is sound. Additional confirmatory analysis is recommended and USCG should establish closer ties with agencies producing relevant data.

- The apparent degree of under-reporting of non-fatal non-admitted injuries is very much greater than for non-fatal hospital admitted injuries. The methods used in this analysis are admittedly crude and the estimate of possible under-reporting speculative, but this conclusion is qualitatively correct. Additional work to refine the methods used in this report is indicated. Alternatively (in view of the relatively low unit costs of these accidents), USCG might consider whether or not to continue to require reporting of these accidents.

- Despite under-reporting of non-fatal hospital-admitted and non-fatal non-admitted injuries from recreational boating accidents, it is likely that BARD captures injuries that result in a large fraction (75%) of the aggregate social costs of recreational boating accidents. Non-fatal hospital admitted and non-fatal non-admitted injuries are much more numerous than fatalities, but the unit social costs of these injuries (especially the non-admitted injuries) are probably very small in comparison to those for fatal accidents.

- Continued improvement in BARD is highly desirable. Undoubtedly, part of the solution lies in establishing reporting standards and training those who prepare accident reports to follow them. However, finding ways to decrease under-reporting is even more important. The degree of under-reporting varies widely from state to state, suggesting that efforts at improvement might be most fruitfully directed towards selected states. NASBLA might provide a suitable forum for states to share "best practices" and ideas for improvement.

- USCG has a policy choice to make regarding the incorporation of adjustments to its published non-fatal injury incidence estimates. Options include (i) incorporating scaled-up estimates directly, (ii) deferring this decision until the estimates for 2002 have been replicated for other years, and (iii) brief mention (perhaps as a footnote) in *Boating Statistics*. The methods developed for adjustment of hospital-admitted and non-admitted non-fatal injury incidence are plausible, and resulting estimates are likely to be superior compared to the simple expedient of disregarding reporting bias. Nonetheless, the methods used, however worthwhile, are *ad hoc* and are conditioned in part on the availability of exogenous data. Further work will be required if these methods are to be institutionalized and made a routine part of USCG reporting.

- Analysis of BARD data for two years indicates that at least 22.6% of fatalities resulted from accidents in which alcohol/drugs were noted as a contributing factor. The percentage is lower (8.7%) for accidents resulting in non-fatal injuries. Both estimates—particularly that for accidents with non-fatal injuries—are likely to understate alcohol involvement. (For example, there are clear disincentives for accurate reporting in cases where the operator who completed the accident report form was intoxicated.) Clearly, more work needs to be done, but even if the above estimates were accurate, there is a substantial potential benefit if ways can be found to reduce alcohol-related accidents.

- Alcohol involvement in boating accidents is statistically similar to that for motor vehicle accidents and proportionately greater than that for general aviation, commercial aviation, commercial trucking, and rail transportation. There are, of course, substantial differences in regulations and enforcement activities among these modes (among other things) that might explain differences in alcohol involvement in accidents. Nonetheless, these precedents suggest that present rates of alcohol involvement are not inevitable.

- This is a fairly high-level summary of the results of the PIRE investigations. On a more detailed level the investigators have provided recommendations regarding improvements to the reporting form and identified data fields that appear to have higher error rates. For example, PIRE investigators have recommended that the injury codes listed on the accident reporting form be changed so as to mesh more closely with codes used by other reporting agencies. This change will facilitate the estimation of the economic and social costs of accidents at a later date.

- As noted, these findings are preliminary and the result of exploratory data analysis. Additional confirmatory data analysis should be undertaken as part of continuing efforts to improve the quality of recreational boating accident data and data analyses.

2.6. Acknowledgements

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Chris Preovolos / Indianapolis Star

While on a boating trip on Indianapolis, Indiana's White River, two couples and an infant hit an obstruction that damaged the propeller of their boat so extensively that it could not develop sufficient thrust to keep out of the strong current leading to the spillway. The boat went over the spillway and lodged as depicted in the photograph. Over the next several hours, multiple attempts to rescue the occupants by boat, rope pulley, and fire truck ladder proved unsuccessful. Two officers from the Indiana State Police arrived in the department's helicopter and rescued all five people on the craft in less than 15 minutes. Officers were subsequently decorated. Story available from http://www.fbi.gov/publications/leb/2002/july2002/july02leb.htm.

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