



Estimating the Benefits of Reducing
the Risk of Recreational Boating
Accidents: Alternative Sources of
Information on Fatalities, Injuries,
and Property Damages

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TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

EXECUTIVE SUMMARY

CHAPTER 1 INTRODUCTION

- 1.1 Recreational Boating Programs and Policies *1-1*
- 1.2 Current Practices *1-2*
- 1.3 Purpose and Scope of this Project *1-5*

CHAPTER 2 NUMBER AND TYPES OF INJURIES

- 2.1 Current Practices for Estimating Injuries *2-1*
 - 2.1.1 BARD *2-1*
 - 2.1.2 Previous Efforts to Estimate the Degree of Underreporting in BARD *2-4*
- 2.2 Methodology *2-6*
- 2.3 Findings *2-8*
 - 2.3.1 Results of Database Review and Selection *2-8*
 - 2.3.2 National Estimates of Boating-Related Injuries *2-11*
- 2.4 Summary of Findings and Next Steps *2-25*
 - 2.4.1 Summary of Findings *2-25*
 - 2.4.2 Considerations for Next Steps *2-27*

CHAPTER 3 COST OF INJURIES

- 3.1 Conceptual Framework for Valuation *3-1*
 - 3.1.1 Willingness to Pay *3-2*
 - 3.1.2 Averted Costs *3-3*
 - 3.1.3 Monetized Quality-Adjusted Life Years *3-6*
 - 3.1.4 Implications for Coast Guard Analyses *3-11*
- 3.2 Approaches Used in Federal Regulatory Analyses *3-12*
 - 3.2.1 Value of Mortality Risk Reductions *3-12*
 - 3.2.2 Value of Nonfatal Risk Reductions *3-14*
 - 3.2.3 Conclusions *3-20*
- 3.3 Alternative Values for Nonfatal Injuries *3-20*
 - 3.3.1 General Findings *3-21*

3.4 Summary of Findings and Next Steps 3-27

3.4.1 Summary of Findings 3-27

3.4.2 Considerations for Next Steps 3-30

CHAPTER 4 PROPERTY DAMAGES

4.1 Existing Data Collection System 4-1

4.2 History of Property Damage Research 4-3

4.2.1 R-BAR 4-3

4.2.2 NBSAC Workgroup 4-5

4.2.3 Other Efforts 4-5

4.3 Analytic Approach 4-5

4.3.1 Literature and Database Search 4-5

4.3.2 Informational Interviews 4-6

4.4 Findings 4-7

4.5 Conclusions and Recommendations 4-8

4.5.1 Obtain Insurance Industry Statistics from ISO 4-8

4.5.2 Survey the Insurance Industry and/or the Boating Community 4-9

CHAPTER 5 ILLUSTRATIVE CASE STUDIES

5.1 Analytic Approach 5-1

5.1.1 Injury Category Crosswalks 5-2

5.1.2 Injury Valuation 5-6

5.2 Personal Flotation Devices for Children 5-10

5.3 Boat Safety Equipment 5-15

5.4 Ratio of Fatal to Nonfatal Injuries 5-19

5.5 Summary and Conclusions 5-20

CHAPTER 6 CONCLUSIONS

6.1 Summary of Conclusions 6-1

6.2 Considerations for Next Steps 6-4

6.2.1 Priorities for Future Work 6-4

6.2.2 Options for Improving Injury Estimation 6-4

6.2.3 Injury Valuation 6-7

6.2.4 Property Damages 6-8

6.3 Conclusions 6-9

REFERENCES

APPENDIX A ANNOTATED BIBLIOGRAPHY

APPENDIX B DATABASE DESCRIPTIONS

APPENDIX C SUPPLEMENTAL ANALYSIS OF HOSPITALIZATION DATA FOR SELECTED STATES

APPENDIX D ADAPTING NHTSA'S NONFATAL INJURY VALUES FOR APPLICATION IN COAST GUARD ANALYSES

LIST OF ACRONYMS AND ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACSCOT	American College of Surgeons Committee on Trauma
AHRQ	Agency for Health Care Research and Quality
AIS	Abbreviated Injury Scale
BAC	blood alcohol content
BAR	Boating Accident Report
BARD	Boating Accident Report Database
BLAs	Boating Law Administrators
BSS	boating safety scale
BUI	boating under the influence
CDC	Centers for Disease Control and Prevention
CEA	cost-effectiveness analysis
CMS	HHS Centers for Medicare and Medicaid Services
Coast Guard	U.S. Coast Guard
COI	cost of illness
CPSC	U.S. Consumer Product Safety Commission
DHS	U.S. Department of Homeland Security
DOT	U.S. Department of Transportation
ED	emergency department
ELS	equivalent lives saved
EPA	U.S. Environmental Protection Agency
EQ	EuroQol
FDA	U.S. Food and Drug Administration
HALYs	Health-adjusted life years
HC	Household Component
HCUP	Health Care Utilization Project
HCUP-KID	Kids' Inpatient Database
HCUP-NEDS	Nationwide Emergency Department Sample

HCUP-NIS	Nationwide Inpatient Sample
HCUP-SASD	State Ambulatory Surgery Databases
HCUP-SEDD	State Emergency Department Database
HCUP-SID	State Inpatient Database
HHS	U.S. Department of Health and Human Services
HRQL	health-related quality of life
HUI	Health Utilities Index
IC	insurance component
ICD	International Classification of Diseases
ICR	information collection request
IEc	Industrial Economics, Inc.
IOM	Institute of Medicine
IPPS	Medicare Hospital Inpatient Prospective Payment System
ISO	Insurance Services Office, Inc.
MAIS	Maximum AIS
MCOD	Multiple Causes of Death
MEPS	Medical Expenditure Panel Survey
MIB	Marine Index Bureau, Inc.
MIBF	Marine Index Bureau Foundation, Inc.
MISLE	Marine Information for Safety and Law Enforcement
NAMCS	National Ambulatory Medical Care Survey
NASBLA	National Association of State Boating Law Administrators
NAVRULES	Navigation Rules
NBSAC	National Boating Safety Advisory Council
NCHS	National Center for Health Statistics
NCI	National Cancer Institute
NCIS	National Coroner's Information Service
NEISS	National Electronic Injury Surveillance System
NEISS-AIP	All Injury Program
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHDS	National Hospital Discharge Survey
NHIS	National Health Interview Survey
NHTSA	National Highway Traffic Safety Administration
NICB	National Insurance Crime Bureau

NPTR	National Pediatric Trauma Registry
NRBS	National Recreational Boating Survey
NTDB	National Trauma Data Bank
NVSS	National Vital Statistics System
OMB	U.S. Office of Management and Budget
OPPS	Medicare Hospital Outpatient Prospective Payment System
OSHA	Occupational Safety and Health Administration
PDO	property damage only
PFD	personal flotation device
PIRE	Pacific Institute for Research and Evaluation
PWC	personal watercraft-related
QALY	Quality-adjusted life year
QWB	Quality of Well-Being
R-BAR	Recreational Boating Accident Register
RR	relative risk
SASD	State Ambulatory Surgery Databases
SEDD	State Emergency Department Databases
SF	Short Form
SID	State Inpatient Databases
SRG	Strategic Research Group
USPS	U.S. Power Squadrons
VSL	value per statistical life
VSLY	value per statistical life year
VSTR	Victorian State Trauma Registry
WISQARS	Web-based Injury Statistics Query and Reporting System
WONDER	Wide-ranging Online Data for Epidemiologic Research
WTP	willingness to pay

EXECUTIVE SUMMARY

The U.S. Coast Guard (hereafter referred to as “Coast Guard”) requires data on the consequences of recreational boating accidents, so that it can compare the costs of alternative regulations, policies, and programs to their benefits. In particular, information on the number and characteristics of fatal and nonfatal injuries, and on property damages, is needed for accidents that differ in cause, in the type of vessel involved, and in operator and passenger characteristics. In addition, for comparison to costs, benefits must be valued in monetary terms, which requires information on the value of reducing the risks of injuries of different types.

In this report, we review previous research, evaluate alternative data sources, and explore the implications of these alternative data for estimating the benefits of Coast Guard regulations and policies. We focus on (1) the number and types of fatal and nonfatal injuries associated with recreational boating accidents nationally; (2) the per-case monetary value of these injuries; and (3) the economic costs of accident-related property damages nationally. While we are primarily concerned with the use of these data for benefit-cost analysis of potential regulations, our findings may also be useful for prioritizing non-regulatory programs and initiatives. This report also supports Strategy 10.6 of the Strategic Plan of the National Recreational Boating Safety Program, which focuses on gathering existing data and conducting new research to fill gaps in Coast Guard’s Boating Accident Report Database (BARD) and to address under-reporting.

Our research suggests that the information collected by Coast Guard is the most comprehensive source of these data available. Neither academic research studies nor reports from other governmental or nongovernmental organizations provide detailed national data on recreational boating accidents. Thus the question we explore is whether we can use data collected for other purposes to provide some insights into the accuracy and reliability of the BARD data, which are collected by Coast Guard from boat operators involved in reportable accidents.

Our work builds on several other Coast Guard efforts to better understand the limitations of available data and to determine how to best address these limitations. Our findings are reasonably consistent with the results of these previous efforts, but provide information on recent trends as well as additional insights.

For fatal injuries, we find that the Coast Guard’s data on incidence appears reasonably accurate. To value these fatalities, Coast Guard follows a well-established approach. These values are based on estimates of individual willingness to pay (WTP) for small risk

reductions in a defined time period, which is the most appropriate measure for use in benefit-cost analysis.

For nonfatal injuries, our work, as well as previous research, suggests underreporting of incidence increases as severity decreases. Injuries severe enough to result in hospitalization are underreported by less than a factor of two. Less severe injuries may be underreported by much larger amounts. Monetary valuation of these injuries is challenging, because suitable estimates of individual WTP are not available for nonfatal injury risk reductions. Instead, government agencies and researchers often rely on one of two approaches as rough proxies. The first, used by the U.S. Department of Transportation (DOT), combines estimates of averted costs with estimates of quality of life impacts (generally reported as quality-adjusted life years or QALYs). The second relies solely on estimates of averted medical costs and lost productivity. This latter approach results in much lower per-case estimates because it excludes some types of averted costs and does not include monetized QALYs. However, the appropriate construction of the QALY measure and its monetary value has been debated in recent years.

For property damages, we were unable to locate an alternative, comprehensive source of information that is easily accessible. Previous analyses suggest that these damages, as well as the total number of boating accidents overall, may be substantially underreported.

In total, these findings mean that Coast Guard faces a number of challenges when assessing the benefits of its regulations and policies. In general, our analysis suggests that the numbers of nonfatal injuries and the amount of property damages may be significantly understated. In addition, determining the value of nonfatal risk reductions is difficult given the data now available. Fatality estimates are less prone to uncertainty.

Coast Guard has a number of options for addressing these uncertainties. The simplest approach would be to develop standard language to qualitatively discuss the impact of these concerns on the results of its analysis. Approaches requiring a moderate amount of additional effort involve refining currently available data to provide quantitative estimates of incidence and dollar values that can be used as primary estimates or in sensitivity analysis. Coast Guard could also undertake new research, which would require substantially greater effort but would result in estimates better tailored to its analytic needs.

CHAPTER 1 | INTRODUCTION

Coast Guard requires data on the consequences of recreational boating accidents, so that it can compare the costs of alternative regulations, policies, and programs to their benefits. The goal of this project is to support improved estimation of these benefits by reviewing alternative sources of currently available data on: (1) the number and types of injuries associated with recreational boating accidents; (2) the economic value of these injuries; and (3) the economic costs of accident-related property damages.

1.1 RECREATIONAL BOATING PROGRAMS AND POLICIES¹

Under 46 USC 13102, Congress requires that the Coast Guard's Boating Safety Division carry out the National Recreational Boating Safety Program. The Program's mission is to ensure that the public has a safe, secure, and enjoyable recreational boating experience by implementing programs designed to minimize the loss of life, personal injury, and property damage while cooperating with environmental and national security efforts.

To ensure that resources are used effectively, the Program partnered with representatives from industry, the States, the public, and non-profit organizations, and developed The Strategic Plan of the National Recreational Boating Safety Program. The Plan contains the eleven key objectives, quoted verbatim below.

- Increase the number of persons who complete a boating safety course or test that conforms to the National Boating Education Standards as recognized by the USCG.
- Deliver effective boating safety messages through various educational resources and media to reduce deaths and injuries of recreational boaters.
- Increase the number of boaters who have completed advanced and/or on-water, skills-based boating education.
- Increase adult life jacket wear rates nationwide. Targets: 1. Increase the observed adult life jacket wear rate in open motorboats by 3% from the previous year's wear rate. 2. Increase the observed adult life jacket wear rate on non-motorized vessels by 3% from the previous year's wear rate.

¹ Unless otherwise noted, information describing the Coast Guard's Boating Safety Division is taken from its website, <http://www.uscgboating.org>, as viewed on March 27, 2011. Information on the Program's objectives is taken from the March 10, 2011 version of the National Recreational Boating Safety Program's *Strategic Plan 2012-2016* (USCG, 2011), available at the same website.

- Reduce fatalities associated with Navigation Rules (NAVRULES) violations by 2% per year from the previous year.
- Achieve a 5% overall decrease in the number of deaths by CY 2016 (using a five-year moving average) where the use of alcohol or other drugs by a boat's operator and/or occupants was either a direct or indirect cause of the accident. The five-year average for the 2005 to 2009 time period was 156.
- Decrease the recreational boat manufacturer ratio of discrepancies per factory inspection annually by 5% and keep boats with insufficient flotation off the market.
- Increase compliance levels for specific required safety equipment on recreational boats.
- Using the baseline BARD data from 2009, work towards a goal of 100% by 2016, for boat accident report completeness, accuracy and timely submission pursuant to 33 CFR 173 and 174.
- Gather and analyze data relevant to recreational boating accidents and exposures.
- Improve the effectiveness of and increase access to the grant products of the national non-profit organization.

Coast Guard achieves these objectives through information sharing, voluntary programs, and Federal regulation. In addition, it works closely with State Boating Law Administrators (BLAs) to coordinate and enhance State and Federal laws and programs. Coast Guard's work is also guided by the National Boating Safety Advisory Council (NBSAC), which provides technical and strategic planning recommendations. The council consists of 21 members drawn equally from State officials, representatives of the boating industry, and representatives of national recreational boating organizations and the general public.

1.2 CURRENT PRACTICES

Coast Guard requires information regarding current (baseline) risks associated with recreational boating for several purposes. These data assist in the identification of activities or practices resulting in the greatest number of fatal and nonfatal injuries, supporting the prioritization of programs or policies designed to reduce injuries.² Furthermore, accurate annual data allow Coast Guard to evaluate progress made toward its goals.

In addition, and of particular importance to Coast Guard's Office of Standards Evaluation and Development, the agency requires this information to measure the incremental risk reductions resulting from proposed regulations. Specifically, Executive Orders 12866, *Regulatory Planning and Review* (58 FR 51735), and 13563, *Improving Regulation and*

² We use the term "injuries" (rather than "casualties") to encompass both fatal and nonfatal injuries throughout this report.

Regulatory Review (76 FR 3821), direct Federal agencies to estimate the costs and benefits of significant regulatory actions.³ In its guidance to Federal agencies defining “best practices” for the preparation of economic analyses, the U.S. Office of Management and Budget (OMB) directs agencies to measure the benefits and costs of proposed regulations against a baseline. The baseline is defined as “the best assessment of the way the world would look absent the proposed action” (OMB, 2003). In other words, the baseline represents current and projected future risk levels associated with recreational boating in the absence of intervention.

To estimate baseline risk levels, Coast Guard collects data primarily through Boating Accident Report (BAR) forms. Federal and State regulations require boat owners/operators to complete BAR forms and submit them to the State BLA within 48 hours to 10 days of an accident, depending on the circumstances (33CFR173.55). Depending on the accident, and on whether authorities are present at the time of the incident, State BLAs or other State authorities may conduct an investigation and record additional information on the incident. BLAs submit BAR data and other relevant information from any investigations to Coast Guard electronically.⁴ These data are then compiled into Coast Guard’s Boating Accident Report Database (BARD).⁵

The current six-page Federal BAR form requests detailed information on all aspects of an incident. The data requested include the number of fatal and nonfatal injuries (categorized by primary injury type and body part affected), causes of injury, and property damages. Characteristics of the accident, the vessel, and its passengers and other related information are also reported.

Not all accidents involving recreational vessels are reportable to Coast Guard. Under Federal regulations, the operator of any numbered vessel that was not required to be inspected or a vessel that was used for recreational purposes is required to file a BAR

³ A “significant regulatory action” is defined as “a rule that may: (1) Have an annual effect on the economy of \$100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health and safety, or State, local, or tribal governments or communities; (2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or (4) Raise novel legal or policy issues arising out of legal mandates, the President’s priorities, or the principles set forth in the Executive Order” (Executive Order 12866, 1993). Although most of Coast Guard’s regulations are ultimately determined not to be significant actions, it prepares estimates of the benefits and costs of each proposed regulation to confirm this conclusion.

⁴ Approximately half of the incidents recorded in BARD include the source of the accident report. Based on an informal sample of these records, Coast Guard estimates that for approximately 33 percent of incidents, data were recorded on a BAR form. For another 38 percent, data were obtained from a BAR form and an investigation. For the remaining 29 percent of incidents, data were entered into BARD based only on information from an investigation (Personal communication with S. Tomczuk on February 18, 2011). As discussed later in the report, the BAR forms were revised in 2008.

⁵ Data reported to BARD are obtained from two additional sources: (1) reports of Coast Guard investigations of fatal boating accidents that occurred on waters under Federal jurisdiction; and (2) reports received from news media sources where no investigative data were provided by the State (Coast Guard, 2010).

when, as a result of an occurrence that involves the vessel or its equipment (Coast Guard, 2010):⁶

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

Generally, accidents occurring while the vessel is docked or moored, or while it is on a trailer are not reportable. Chapter 2 discusses non-reportable incidents in greater detail.

Interviews with Coast Guard, the National Association of State Boating Law Administrators (NASBLA), and former BLAs reveal that the degree to which owners/operators report accidents varies depending on the priorities of each State and resources used to educate boaters and investigate accidents. Most agree that the reasons for noncompliance are owner/operators' lack of awareness of the requirement to report, followed by fear of incriminating themselves and no knowledge of how to report (NASBLA, 2008a). States vary in how they address these problems.

- Some States are more proactive than others about alerting the public of the need to report and investigating incidents where no BAR is filed. Within States, the ability to pursue these types of activities may change from year to year due to budget cuts and changes in the priorities of new administrations (NASBLA, 2011).⁷
- A recent survey of BLAs reveals that while most States have some combination of civil and/or criminal penalties for failing to report a boating accident, these penalties are largely unenforced (NASBLA, 2008b).

⁶ Individual States may have reporting requirements that are more stringent; however, at a minimum, they must collect the data elements required by Coast Guard, as set out in 33 CFR 174 (Coast Guard, 2010).

⁷ Nevada, for example, passed a statute (488 NRS §550) in 1993 requiring the insurance industry to alert boat owners of their responsibility to submit a BAR when accident claims were made against insurance policies and to alert the BLA of the incident. The BLA worked with insurers to provide materials to encourage compliance with the law, and followed-up with an investigation if no BAR was submitted. Within two years of the law's passage, the number of BARs received annually went up by 60 percent (Messman, 2008). However, this process was labor intensive, and more recently, priorities within the State have shifted (Personal communication with F. Messman, on March 3, 2011). In another example, Ohio's Division of Watercraft currently sends an officer to investigate every accident it learns of through a BAR or other means (e.g., word of mouth through paramedics) (Personal communication with T. Terry, March 23, 2011). NASBLA notes that Ohio provides an example of best, rather than standard, practices among the States.

In addition, certain data elements or requirements are subject to interpretation by BLAs or are not consistently reported.⁸ As a result, differences in estimates of the number of injuries derived from BARD may be influenced as much by changes in State's efforts to enforce compliance with reporting requirements as in actual changes in the number of accidents that occur. Furthermore, given interstate differences, extrapolation of risk rates from one State to another may be difficult.

In the preparation of its regulatory analyses, Coast Guard often begins with estimates of the number of baseline injuries relying on data provided to BARD, supplementing these data with other sources as needed. It uses the descriptions of the incidents to identify injuries that would have been avoided as a result of the proposed rule. Adjustments to BARD data to account for potential underreporting are rare. As noted earlier, the National Recreational Boating Safety Program's Strategic Plan includes improved data gathering and analysis under its tenth objective. More specifically, Strategy 10.6 focuses on filling gaps in BARD and addressing under-reporting, which enhance the data available for these analyses.

Once Coast Guard estimates the expected reduction in the baseline number of fatalities and injuries attributable to a regulation, it then values this reduction in monetary terms for comparison to costs. For fatal risk reductions, Coast Guard applies an approach adopted by the U.S. Department of Homeland Security (DHS) in 2008 (Robinson, 2008 and Robinson *et al.*, 2010). This approach relies on estimates of the public's willingness to pay (WTP) for small changes in risk drawn from studies on the value of occupational risks. To estimate the value of nonfatal injuries, Coast Guard generally relies on a methodology developed by DOT that combines estimates of the medical and administrative costs with estimates of the value of associated lost productivity and reductions in quality of life. To value property damages, it uses the value of such damages reported in BARD.

1.3 PURPOSE AND SCOPE OF THIS PROJECT

For years, Coast Guard has had concerns that BARD does not capture all reportable recreational boating accidents. It has undertaken several efforts to quantify the degree of underreporting, particularly through a grant project funded in the mid-1990s referred to as the Recreational Boating Accident Register (R-BAR) that collected insurance claims data (MIBF, 1995), and more recently through a study completed in 2006 that used publicly-available health databases to estimate the number of boating injuries in 2002 (Lawrence *et al.*, 2006). Coast Guard also funded a survey that asked recreational boaters to report on their boating activity and practices, including whether they had been involved in any

⁸ For example, as discussed in Chapter 2, many States do not report whether nonfatal injuries resulted in hospitalization. In addition, the definition of "first aid," which triggers the need to report, is interpreted differently across States. For example, whether onsite treatment of cases of hypothermia provided by emergency medical technicians or paramedics qualifies as "medical treatment beyond first aid" is subject to debate (Personal communication with T. Terry, March 23, 2011).

accidents during a 12-month period (SRG, 2003). These efforts are described in greater detail in Chapters 2 and 4 of this report.

The purpose of this project is both more narrow and broader in scope than these previous efforts. Also, because this work was contracted by the Office of Standards Evaluation and Development, we prioritize our efforts on data most useful for regulatory analysis conducted as directed by Executive Orders 12866 and 13563.

- In **Chapter 2**, we conduct analysis intended to inform the potential extent to which BARD underreports injuries. While this effort is less extensive than that of Lawrence *et al.* (2006), it provides insights into the extent to which such underreporting may have changed since that report was completed.⁹ We review the research literature and investigate the information provided in four well-established national databases to determine the extent to which underreporting continues to be significant. A detailed discussion of previous efforts, our methodology and results, and considerations for next steps is provided.
- Coast Guard was previously a component of DOT and continues to rely on the approach used by DOT for valuing nonfatal injuries. **Chapter 3** of this report briefly describes conceptual approaches to valuing injuries, identifies and evaluates alternative sources of injury values, and explores their potential use in regulatory analyses. It also discusses Coast Guard's approach for valuing fatalities.
- In **Chapter 4**, we describe the results of our investigation of alternative sources of information regarding the value of property damages resulting from recreational boating accidents. Neither Strategic Research Group (SRG, 2003) nor Lawrence *et al.* (2006) estimate the value of property damages. The R-BAR study represents an extensive, multi-year effort to survey the insurance industry and collect claims data; however, these data are now more than 17 years old. For this effort, we conducted literature searches and limited interviews with Federal and State agencies and members of the insurance industry.¹⁰ We summarize our conclusions and make recommendations for next steps.
- To illustrate how the new information identified through this project could affect the estimation of the benefits of proposed rulemakings, we provide three case studies in **Chapter 5**. These case studies provide simple examples of how the underreporting of injuries and alternative estimates of their value may affect the results of regulatory analyses.

⁹ The Strategic Research Group (SRG) survey results (2003) provide an indication of the magnitude of the potential number of accidents occurring nationally in a 12-month period; however, it does not provide information about the type or severity of these injuries. In addition, the authors do not compare its results to BARD or draw conclusions about the potential understatement of incidents in that database.

¹⁰ The Paperwork Reduction Act requires Coast Guard to obtain permission from OMB prior to requesting information from more than nine non-Federal entities. Therefore, at Coast Guard's direction, we limited the number of interviews to ensure compliance with this law.

- We conclude the report (**Chapter 6**) with a discussion of the advantages and limitations of these data sources and methods and our recommendations for next steps.

References are provided at the end of the report. In addition, detailed information describing the injury databases evaluated is provided in Appendix A. Appendix B includes an annotated bibliography summarizing the published literature and studies reviewed for this effort. Appendix C supplements the analysis in Chapter 2 by discussing our assessment of incidence data for hospitalized injuries from selected States. Appendix D builds on information from Chapters 2 and 5, describing how DOT values for nonfatal injuries can be adjusted for application in Coast Guard analyses.

CHAPTER 2 | NUMBER AND TYPES OF INJURIES

This chapter examines national estimates of the number and types of recreational boating-related injuries in the United States. Specifically, we aim to evaluate the accuracy and reliability of the injury data collected each year by Coast Guard. Over the last decade, Coast Guard has used various methods to substantiate the accuracy of its national estimates. Previous efforts have relied on boater surveys as well as national and State health databases that report statistics on boating-related injuries. Coast Guard has asked IEc to review this question again as several years have passed since the last effort. This chapter addresses the extent to which newly available information exists and evaluates estimates derived from these sources relative to BARD.

First, we review Coast Guard's current reporting methods and previous research on injury estimates. Next, we evaluate the suitability of a number of U.S. health databases to provide national estimates of boating-related injuries. Then, we present methodologies for using four potentially relevant databases to provide national estimates for the number and types of injuries. Next, we present our findings and compare these national estimates to those in BARD and in previous reports. Finally, we summarize our conclusions and discuss considerations for next steps. Examples of methods for applying these data in regulatory analysis are provided in Chapter 5.

2.1 CURRENT PRACTICES FOR ESTIMATING INJURIES

As described in Chapter 1, Coast Guard currently relies largely on data on recreational boating-related accidents compiled in BARD, which forms the basis for its annual reports on accidents nationally and is the primary source used to estimate averted accidents and injuries in Coast Guard regulatory analysis and program evaluation. This section describes the injury data reported in BARD in greater detail. It also summarizes recent efforts to estimate the degree to which BARD reflects underreporting of accidents by boat operators.

2.1.1 BARD

Data reported in BARD are obtained from three sources (Coast Guard, 2010):

- States with an approved casualty reporting system forward BARs to the Coast Guard;
- Coast Guard conducts investigations of fatal boating accidents that occur on waters under Federal jurisdiction. In the absence of investigation data, information is collected from the accident reports filed by boat operators; and

- A minor amount of data is obtained from news media sources for accidents that were not investigated by Coast Guard or reported by the State.

The data reported have evolved over time as Coast Guard has revised the specific data elements collected in its BAR forms as well as the definition of the types of accidents for which reporting is required. Generally, these data include the number of fatal and nonfatal injuries, causes of each injury, and property damages. Injury data include the primary contributing factor, whether alcohol was involved, and the nature of the primary injury type by body part affected. Characteristics of the accident, the vessel, its passengers and other related information are also reported.

More specifically, for injuries, the BARs currently ask boat operators to provide information on “injured people receiving *or in need of* treatment beyond first aid,” listing those injured by name.¹¹ They are further asked whether the “[p]erson received treatment beyond first aid,” and whether the person was admitted to a hospital. The form also requests information on the most serious injury and the body part affected.¹² In a separate section of the report, boat operators are also asked to identify persons from their boat who died or disappeared, indicating whether the death was by drowning or another cause.

Many analyses rely, however, on data collected using earlier versions of this form.¹³ In particular, the prior version of this form, CG-3865 (Rev. 12-06), indicates that boat operators should report information on “injured victims” by name, including whether the injury required treatment beyond first aid, and whether the injured victim was admitted to a hospital. The form also requests information on body region and nature of injury for the primary injury, and for information on the secondary injury.¹⁴ For deaths, the boat operator is asked whether the cause was drowning, trauma, carbon monoxide poisoning, heart attack, hypothermia, electrocution, or other (specify).

Certain types of accidents are not reportable in BARD. For example, currently accidents are not reportable when a person is injured or is missing (Coast Guard, 2010):

- As a result of self-inflicted wounds, alcohol poisoning, gunshot wounds, assault by another person or persons, or ingestion of drugs, controlled substances, or poison while aboard a vessel;

¹¹ This form, CG-3865 (Rev. 07-08), is available at: http://www.uscgboating.org/safety/accident_reporting.aspx.

¹² The form lists the following options: scrape/bruise, cut, sprain/strain, concussion/brain injury, spinal cord injury, broken/fractured bone, dislocation, internal organ injury, amputation, burn, or other (describe).

¹³ The older forms are provided as appendices to the annual Recreational Boating Statistics reports, which are available at: http://www.uscgboating.org/statistics/accident_statistics.aspx.

¹⁴ Listed body regions are head/face, neck, back, chest/abdomen, shoulder/arm, wrist/hand/finger, pelvis/hip, knee/leg, and ankle/foot/toe. Listed injury types are abrasion/contusion (bruise), amputation, carbon monoxide poisoning, concussion/brain injury, dislocation, fracture/broken bone, heart attack, internal organ injury, laceration/cut, spinal cord injury, or sprain/strain.

- As a result of diving, falling, jumping, or swimming from an anchored, moored, or docked vessel or a place of inherent safety, such as the shore or pier;
- As a result of natural causes while aboard a vessel;
- As a result of storms, or unusual tidal or sea conditions; or when a vessel gets underway in those conditions in an attempt to rescue persons or vessels;
- As a result of a fire on shore or a pier that spreads to a vessel or vessels; or as a result of fire or explosions on anchored, docked, or moored boats where the cause of the fire was not attributed to the vessel or vessel equipment;
- While preparing a vessel for launching or retrieving and the vessel is not on the water and ready for its intended use;
- When the only vessel(s) involved are being used solely for governmental, commercial, or criminal activity;
- When the only vessel(s) involved are not numbered and are being used exclusively for racing;
- When the only vessel(s) involved are foreign vessels and thus not subject to U.S. Federal reporting requirements.

Between 2001 and 2009, BARD recorded the following accidents, shown in Exhibit 2-1.

EXHIBIT 2-1: ACCIDENTS AND INJURIES IN BARD, 2001-2009

YEAR	ACCIDENTS	VESSELS INVOLVED	TOTAL FATAL INJURIES	TOTAL NONFATAL INJURIES
2001	6,419	8,974	681	4,274
2002	5,705	7,907	750	4,062
2003	5,438	7,363	703	3,888
2004	4,904	6,725	676	3,363
2005	4,969	6,628	697	3,451
2006	4,967	6,753	710	3,474
2007	5,191	6,932	685	3,673
2008	4,789	6,347	709	3,331
2009	4,730	6,190	736	3,358

Sources: Coast Guard (2003a); Coast Guard (2003b); Coast Guard (2004); Coast Guard (2005); Coast Guard (2006); Coast Guard (2007); Coast Guard (2008); Coast Guard (2009); Coast Guard (2010).

2.1.2 PREVIOUS EFFORTS TO ESTIMATE THE DEGREE OF UNDERREPORTING IN BARD

The Coast Guard has undertaken a number of efforts to supplement BARD with data from other sources as well as to determine the extent to which the data it contains are accurate and reliable. Two recent efforts suggest that BARD does not capture all recreational boating-related injuries. These efforts include a survey of boaters conducted in 2002 by the Strategic Research Group (SRG) (2003) and an analysis of national and State health care databases conducted by the Lawrence *et al.* (2006). Both efforts are summarized below.¹⁵

2.1.2.1 SRG Survey (SRG 2003)

Coast Guard engaged SRG to conduct the National Recreational Boating Survey (NRBS), which was published in 2003. The survey was intended to assist Agencies in developing intervention strategies to reduce boating risk. It included questions about types of boats used and activities associated with boat outings (e.g., swimming, water skiing), frequency of boating activity, safety practices (e.g., life jacket usage, safety training through a boating safety course), the number of accidents experienced by boaters, and the causes and consequences of those accidents.

A total of 25,547 surveys were completed by phone or mail, based on a stratified sampling of boaters who do and do not own boats in 50 States and the District of Columbia. Survey respondents were asked to report boating activity undertaken between September 2001 and September 2002. For accidents, the survey provides information on the characteristics of the individuals involved and the conditions under which the incidents occurred, but not on the type or severity of the injuries.

The survey results suggest approximately two percent of boat operators were involved in an incident that resulted in damage to a boat or property and one percent of boat operators were involved in an incident where one or more people were seriously injured and required medical attention beyond first aid. When weighted to reflect the overall boating population, the survey responses suggest that 550,371 boat operators experienced an incident where one or more boats or property were damaged and 271,470 boat operators experienced incidents resulting in injuries requiring medical attention beyond first aid during the time period covered. Operators who were involved in an accident resulting in damage to boats or property experienced an average of 1.35 such incidents. Operators who were involved in an accident resulting in injuries experienced an average of 1.08 such incidents.

¹⁵ Examples of other studies include the *1998 National Recreational Boating Survey* (JSI Research & Training Institute, Inc., 2000). The survey collected information on boating exposure rates and the level of use of safety equipment and safety-oriented practices. Another example reflects data collected from 2001 through 2005, when the Emergency Nurses Association and the Injury Prevention Institute/EN CARE conducted surveys of patients in emergency departments at 75 hospitals in order to understand the behaviors and causes leading to recreational boating injuries (Emergency Nurses Association *et al.*, no date). Neither study provides estimates of annual, nationwide injuries for comparison to BARD. A third report summarizing the results of the R-BAR program (MIBF, 1995) is discussed in detail in Chapter 4.

The results suggest that BARD under-estimates annual injuries by two orders of magnitude. BARD reported 4,274 nonfatal injuries in 2001 and 4,062 in 2002 (USCG, 2003a and 2003b). While these estimates of boating incidents appear much higher than estimates from BARD, the survey does not provide enough detail on the nature or type of injuries for use in economic analysis. The reasons why this estimate is high in comparison to other sources is also unclear.

2.1.2.2 Lawrence, Miller, and Maxim (2006)

In 2006, Coast Guard published a second study focused specifically on quantifying the magnitude of underreporting in BARD and developing a method for adjusting its baseline injury estimates. The study was prepared by Bruce A. Lawrence and Ted R. Miller of the Pacific Institute for Research and Evaluation (PIRE) and L. Daniel Maxim of the U.S. Coast Guard Auxiliary (hereafter referenced as Lawrence *et al.*, 2006). Advice and oversight was provided by an external review board including economists, statisticians, and physicians from Coast Guard, the National Transportation Safety Board, the National Highway Traffic Safety Administration, the Federal Highway Administration, NASBLA, and the private sector.

Lawrence *et al.* (2006) use existing national and State health databases to estimate the number of boating-related injuries requiring varying types of treatment, which they then compare to BARD. These databases are not specific to boating; rather they are developed for use by public health researchers for a wide variety of purposes, as described in greater detail in the next section. Lawrence *et al.* (2006) use these data sources to estimate recreational boating injuries in the year 2002. While they characterize their work as “exploratory,” it involves detailed analysis of data from several sources. They begin with state-level data, then aggregate to national totals, relying on the following sources:

- For fatalities, they relied on data from the Multiple Causes of Death (MCOB) system maintained by the Centers for Disease Control and Prevention (CDC) National Center for Health Statistics. MCOB, referred to more generally as the National Vital Statistics System (NVSS), is a census of U.S. deaths based on death certificates.
- For nonfatal injuries resulting in hospitalization or emergency department (ED) treatment, they relied on two data sets from the Health Care Utilization Project (HCUP) maintained by the U.S. Department of Health and Human Services (HHS) Agency for Healthcare Quality and Research (AHRQ) – the State Inpatient Database (HCUP-SID) and the State Emergency Department Databases (HCUP-SEDD).
- For nonfatal injuries treated in other locations (such as doctors’ offices or clinics), they rely on previous research estimating the number of such injuries relative to injuries treated in emergency departments based on data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) and the National Ambulatory Medical Care Survey (NAMCS). NHAMCS and NAMCS are conducted by CDC’s National Center for Health Statistics (NCHS).

For fatalities, the authors found that their research supports the BARD-based estimates, which – at the time – the Coast Guard recommended adjusting upwards by 1.0 percent to account for underreporting. These adjusted fatalities totaled 758 in 2002. For nonfatal, hospital-admitted injuries, the authors' estimates were higher than the BARD estimates by about 25 percent; they found 2,181 nonfatal, hospital-admitted injuries compared to 1,752 in BARD in 2002. The difference was much larger for nonfatal, non-admitted injuries: more than 30,000 compared to 2,309 in BARD. However, the authors note that more work is needed to verify these estimates.

2.2 METHODOLOGY

Coast Guard is interested in learning whether new or improved information has become available since the publication of Lawrence *et al.* (2006) that could be used to determine the extent to which the national boating-related injury estimates in BARD are accurate and reliable. To address this issue, we first reviewed the literature, and then conducted a review of available databases, selecting four for in-depth review.

The results of our literature review are provided in an annotated bibliography, included as Appendix A of this report. We did not find additional sources of national data on recreational boating injuries for comparison to BARD, other than those studies identified in Section 2.1. Most other research focuses on a limited geographic location or on certain types of watercraft or injuries, rather than providing the type of comprehensive data needed for Coast Guard policy and regulatory analysis.

However, dozens of health-related databases are compiled in the United States. Data are collected through the efforts of State data organizations, hospital associations, physicians, private data organizations, and the Federal government. Federal and State agencies develop these databases to enable research on a broad range of health policy issues, including: the provision, use, costs, and quality of health care services; reimbursement of health care costs by government and private insurance programs; trends in medical practices; access to health care programs; and the outcomes of treatments. These databases are designed to be used for a wide range of purposes; they are applied in various capacities ranging from medical research to public policy. To identify databases of potential interest, we reviewed citations in recent academic studies as well as industry research and government reports.¹⁶ We also reviewed the websites of government agencies responsible for collecting related data, including various components of the HHS as well as the U.S. Consumer Product Safety Commission (CPSC).

We evaluated those health databases that contain information on the number and types of injuries that require medical treatment in an office, outpatient facility, or hospital setting, to determine which would be useful for this effort. In this section we discuss our review

¹⁶ Lund *et al.* (2009) provides a comprehensive review of more than 80 databases that can be used to estimate health care costs in the United States. While their review is focused on monetary valuation rather than on estimates of the number and types of injuries, it provides useful information for the latter task as well.

of 17 potentially useful datasets, then report our findings in the next section. Appendix C supplements this analysis with data on hospitalized injuries from selected States.

We focus our research on databases that specifically identify boating-related injuries and are suitable for providing national estimates. To select four databases for additional detailed analysis, we considered the following criteria: geographic coverage, the inclusion of codes identifying boating as the cause of injury or death, and the severity of the injuries addressed. Each of these criteria is discussed below.

- **Geographic Coverage:** For policy and regulatory analysis, Coast Guard generally requires national data. Given the scope of this project, we face the choice between exploring national databases, or databases for only a few States. The advantage of relying on national data is that it allows comparison to the national totals in BARD; we are also able to select databases that reflect different injury categories (e.g., fatalities, hospitalizations, emergency department visits, outpatient department visits, doctor's office visits). The disadvantage of relying on national data is that many of these databases rely on samples. Although these samples are large, boating-related injuries are only a small percentage of the national totals and may be under-represented in the database, leading to uncertainty in our comparisons to BARD.

The advantage of relying on instead on State databases would be that they generally provide more comprehensive and detailed data. However, the characteristics of both boating and data reporting practices vary greatly by State, so it is difficult to extrapolate from the results for only a few States to national totals. In addition, collecting state-by-state data and compiling it seems to replicate the work of Lawrence *et al.* (2006) on a smaller scale. While it might be desirable to update and refine their analysis, such an effort is beyond the scope of the current project.

We focus on the national databases, so as to determine the extent to which they report data consistent with what is found in BARD and the previous reports summarized above. Our report explores related uncertainties, including the effects of relying on sample data (where necessary), in our comparisons.

- **Boating-related Injuries:** For its analyses, Coast Guard requires data on accidents related to the types of recreational boating practices that fall under its jurisdiction. Many of the national databases we reviewed rely on coding from the 9th or 10th edition of the International Classification of Diseases (ICD).

ICD-9-CM external cause-of-injury codes (hereinafter referred to as cause-of-injury codes) are used in most of these databases. The subcategories associated with cause-of-injury codes detail characteristics of the injured victim (e.g., occupant of small boat unpowered, crew, water skier, swimmer).

ICD-10-CM codes are currently only used in in the NVSS database. For these, the subcategories reflect the type of vessel (e.g., sailboat, canoe or kayak, water-skis, merchant ship, passenger ship). These vessel categories allow us to separate

commercial from recreational boating to some extent, although the type of vessel is not specified in the majority of cases.

Thus in both cases the estimates of boating-related fatal and/or nonfatal injuries may include commercial as well as recreational boating to some extent. Given that we have been unable to identify a data source (other than BARD) that allows us to clearly separate commercial from recreational boating, we rely on databases that use this ICD coding and discuss the implications when presenting our results.

Severity of Injury: Ideally, Coast Guard would have data on all types of injuries associated with recreational boating accidents. Most of the national databases focus on a particular treatment setting (e.g., hospitalization, emergency departments, outpatient departments, or doctors' offices). Presumably, the treatment settings reflect the severity of the injury as well as other factors, and more severe injuries are more likely to be reported in BARD. Ultimately, our goal is to include data from each formal treatment setting in our analysis, to provide insights into the extent that underreporting varies by injury severity.

After applying these criteria to select databases for detailed review, we compare the estimates of boating-related injuries identified in those databases to: 1) estimates in BARD; and 2) estimates developed by Lawrence *et al.* (2006). We focus on the most recent years for which data are available to capture trends; however, this means that comparisons to Lawrence *et al.* (2006) are somewhat imprecise, as they report results for 2002. Exhibit 2-1 suggests that the absolute number of accidents and fatal and nonfatal injuries decreased in our study period relative to 2002; therefore, we would expect the estimates produced by Lawrence *et al.* (2006) to be higher.

2.3 FINDINGS

In this section, first we summarize the results of our research on available databases and identify the four databases selected for additional analysis. Then, we present estimates of national recreational boating injuries and compare these estimates to: 1) estimates in BARD; and 2) estimates presented in Lawrence *et al.* (2006).

2.3.1 RESULTS OF DATABASE REVIEW AND SELECTION

We identified 17 databases that contain information on the number and types of injuries that require medical treatment in an office, outpatient facility, or hospital setting. Detailed descriptions of these databases are provided in Appendix B. As noted earlier, we also reviewed other research reports on recreational boating injuries, which are summarized in an annotated bibliography provided in Appendix A, and assessed hospitalization data from selected States, as summarized in Appendix C. While these documents and data sources may be useful in assessing the impacts of a particular program or policy, they do not provide the comprehensive national data necessary to determine the extent to which the BARD data are accurate and complete.

Exhibit 2-2 summarizes the results of our review of available data sources, based on the three criteria discussed in Section 2.2. The text is bold in those cells that indicate critical shortcomings of each database, as described below.

EXHIBIT 2-2: SUMMARY OF DATABASE REVIEW

DATABASE	GEOGRAPHIC COVERAGE	BOATING-RELATED CODES	INJURY SEVERITIES
National Databases			
National Vital Statistics System (NVSS); Multiple Causes of Death (MCOB)	National census	ICD-10-CM	Fatalities only
National Ambulatory Medical Care Survey (NAMCS)	National sample	Through 2004 only, ICD-9-CM	Office visits
National Hospital Ambulatory Medical Care Survey (NHAMCS)	National sample	ICD-9-CM	Hospital emergency department and outpatient visits*
National Hospital Discharge Survey (NHDS)	National sample; boating-related cause-of-injury codes provided by about 20 States	ICD-9-CM	Hospitalization
National Health Interview Survey (NHIS)	National sample, but appears too small to support national estimates for boating-related causes	ICD-9-CM	All
Nationwide Inpatient Sample (HCUP-NIS)	Sample includes 42 States; boating-related cause-of-injury codes provided by about 28 States	ICD-9-CM	Hospitalization
Nationwide Emergency Department Sample (HCUP-NEDS)	Sample includes 28 States; boating-related cause-of-injury codes provided by about 20 States	ICD-9-CM	Hospital emergency department visits
Kids' Inpatient Database (HCUP-KID)	Sample includes patients 20 years and younger from 38 States, boating-related cause-of-injury codes provided by about 26 States	ICD-9-CM	Hospitalization
Medical Expenditure Panel Survey (MEPS)	National sample	Drowning only	All

DATABASE	GEOGRAPHIC COVERAGE	BOATING-RELATED CODES	INJURY SEVERITIES
National Electronic Injury Surveillance System (NEISS)	Sample includes about 46 States.	Includes only waterskiing, wake boarding, tubing, and surfing	Hospital emergency department visits
Medicare Hospital Inpatient Prospective Payment System (IPPS)	National sample, Medicare beneficiaries only	ICD-9-CM	Hospitalization
Medicare Hospital Outpatient Prospective Payment System (OPPS)	National sample, Medicare beneficiaries only	ICD-9-CM	Hospital outpatient visits
State Databases			
State Inpatient Database (HCUP-SID)	Varies by State, includes data from about 40 States	ICD-9-CM	Hospitalization
State Emergency Department Database (HCUP-SEDD)	Varies by State, includes data from about 27 States	ICD-9-CM	Hospital emergency department visits that do not result in admission
State Ambulatory Surgery Databases (HCUP-SASD)	Varies by State, includes data from about 27 States	ICD-9-CM	Surgery only
Other Databases			
The National Pediatric Trauma Registry (NPTR)	Voluntary participation by U.S. trauma centers; children and young adults	Personal watercraft and jet skis only	Hospital trauma centers
National Trauma Data Bank (NTDB)	Trauma centers in about 41 States	ICD-9-CM	Hospital trauma centers

* Beginning in 2005, NHAMCS ceased reporting cause-of-injury codes for visits to hospital outpatient departments.

Of the 17 databases, we believe that 11 do not include adequate geographic coverage for our purposes. In some cases, the sample size is too small, or the database includes boating-related cause-of-injury coding for too few States to be useful for comparison to the national totals reported in BARD. In addition, three of the 17 databases do not include adequate coding on boating-related causes. These databases are limited to certain types of accidents (e.g., drowning) or to certain types of watercraft or water sports (e.g., jet skis, waterskiing). This leaves us with four databases that appear suitable for this project, which cover different types of treatment and hence severities of injuries.

We extract information from four of the databases as follows:

- Fatality data from NVSS;

- Hospitalization data from the HCUP Nationwide Inpatient Sample (HCUP-NIS);
- Hospital data on visits to emergency departments and outpatient departments that did not result in admission from NHAMCS; and
- Data on visits to office-based physicians from NAMCS.

However, two of the data sources that meet our other criteria, NAMCS and the outpatient department component of NHAMCS, do not provide cause-of-injury codes beyond 2004, so we cannot easily identify boating-related injuries in more recent years. For this reason, we compare national estimates from these sources to earlier years of BARD data. NVSS is a census of fatal injuries based on death certificates, while the other databases are samples and pose some additional analytic challenges. For example, we must assess the degree of overlap across databases (e.g., because an individual patient may be treated in more than one type of setting), consider the extent to which each sample is likely to provide reliable estimates for boating-related injuries (e.g., because these injuries are a very small proportion of the overall sample), and determine whether it is possible to distinguish cases where an injury appears more than once in the database because of multiple visits or other factors. For each database, we discuss these types of uncertainties, as well as their effects on our comparisons to BARD and Lawrence *et al.* (2006) in the following section.

We select multiple years for comparison, given the likely year-to-year variation in injury rates. For fatalities, hospitalization, and emergency department visits, we extract the most recent available data for up to four years (going back to 2005). For visits to outpatient departments and office-based physicians, we look at the last four years of data with identifiable cause-of-injury codes (2001 to 2004). Detailed tables in the subsequent section of this report show the data extracted from each database and provide comparisons to other sources of data, including BARD and Lawrence *et al.* (2006).

2.3.2 NATIONAL ESTIMATES OF BOATING-RELATED INJURIES

In this section, we present the results of our analysis of four national databases to estimate the annual incidence of fatal and nonfatal injuries by treatment category. First, we discuss our findings on fatal injuries. Then we present the results of our analysis of hospitalizations. Finally, we look at all other nonfatal injuries. We report separately our analysis of emergency department visits from 2005 to 2008 and our analysis of all nonfatal, non-hospitalized injuries from 2001 to 2004 (based on the years for which cause-of-injury codes were reported). In each section, we begin by describing the database(s) in greater detail and our query results. Then, we compare these results to BARD and Lawrence *et al.* (2006).

2.3.2.1 Fatal Injuries

The NVSS registers virtually all deaths nationwide and is the most comprehensive source of mortality data for the U.S. population. NCHS collects information on deaths from the registration offices of each of the 50 States and the District of Columbia, using standard data collection forms and procedures. NCHS developed the Mortality Medical Data System in 1967 to automate the entry, classification, and retrieval of cause-of-death information reported on death certificates (CDC, 2011c). NCHS disseminates the Nation's official vital statistics and publishes numerous reports based on these data, including an annual report on U.S. deaths, death rates, life expectancy, and infant and maternal mortality (CDC, 2011d). Data are available for public use via the Wide-ranging Online Data for Epidemiologic Research (WONDER) system maintained by CDC.¹⁷

Starting with 1999, mortality data are coded using the ICD-10-CM. The relevant boating injury codes are: V90 (Accident to Watercraft Causing Drowning and Submersion); V91 (Accident to Watercraft Causing Other Injury); V92 (Water-Transport-Related Drowning and Submersion without Accident to Watercraft); V93 (Accident on Board Watercraft without Accident to Watercraft, Not Causing Drowning and Submersion); and V94 (Other and Unspecified Water Transport Accidents). Additionally, there is a layer of sub-codes that identify the type of craft. The sub-code categories include: merchant ship; passenger ship; fishing boat; other powered watercraft; sailboat; canoe or kayak; inflatable craft (non-powered); water skis; other unpowered watercraft; and unspecified watercraft.

We report data for 2005 through 2007, the most current year for which final data are available.¹⁸ We present these data alongside BARD estimates of fatal injuries in Exhibit 2-3.

EXHIBIT 2-3: BOATING-RELATED FATAL INJURIES, 2005-2007

YEAR	FATAL INJURIES IN NVSS	FATAL INJURIES IN BARD
2005	523	697
2006	514	710
2007	486	685
Total	1,523	2,092

Generally, BARD estimates are approximately 37 percent higher than NVSS estimates. We expect NVSS estimates to be lower for several reasons. First, research has shown that death certificates alone fail to properly record causes of fatalities. For example, the

¹⁷ We accessed CDC's WONDER system at <http://wonder.cdc.gov> in March 2011.

¹⁸ As of August 2011, preliminary estimates of fatalities are available for 2008 and 2009, but not with sufficient detail to estimate boating-related deaths.

Bureau of Labor Statistics Census of Fatal Occupational Injuries (CFOI), a federal-state cooperative program that has been implemented in all 50 States and the District of Columbia since 1992, reports comprehensive counts of fatal work injuries using multiple data sources (BLS, 2010). A 1997 study of occupational injuries found that death certificates marked “at work” were cited as the initiating source document in less than half of total fatal occupational injury cases that relied on death certificates (Drudi, 1997). For the majority, additional source data were required to verify whether fatalities were work related. CFOI draws information on fatal work injuries from as many as 25 different sources, including: death certificates, State workers’ compensation reports, news media accounts, local police departments, emergency medical services, and Federal agencies. Although this research is focused on job-related deaths, it suggests that the cause of death may be misreported for other types of fatalities as well.

Other factors are potentially counterbalancing, but the impacts appear small. In particular, while the cause is not coded for 0.5 percent of deaths, this is a small proportion of the totals. It may be counterbalanced (to an unknown extent) by inclusion of deaths from commercial boating. The NVSS does not perfectly differentiate between commercial and recreational boating accidents, meaning it may overstate fatalities that are reportable under BARD. Despite the inclusion of sub-codes to identify vessel type in ICD-10-CM, “unspecified watercraft” is coded for approximately 70 percent of boating-related fatalities.¹⁹

In summary, in our own review of NVSS for more recent years, we find that it reports State counts that are approximately 26 percent below BARD counts between 2005 and 2007 (excluding U.S. territories and any accidents that occurred three or more miles offshore). However, each year, as many as nine States show higher estimates in NVSS than BARD (by approximately 3 fatalities each).

Previously, Lawrence *et al.* (2006) compared state-level NVSS data to state-level BARD estimates for 2002 and found that “these counts were highly correlated and generally quite close” (Lawrence *et al.*, 2006, p.13). In their analysis, they take the highest fatality count from either BARD or NVSS for each State to calculate their totals for 2002, and conclude that adjusting the BARD estimates upwards by one percent is appropriate, confirming Coast Guard’s then-standard adjustment factor. If we follow the same procedure (selecting the highest estimate for each State from BARD or NVSS) for the years covered by our analysis, it would increase Coast Guard’s estimate of fatalities by approximately four percent each year.

While our results demonstrate a larger difference between NVSS and BARD data than the earlier Lawrence *et al.* (2006) review, our conclusion is similar. Consideration of the procedures used to collect NVSS and BARD data suggests that the BARD data may be

¹⁹ The extent of over-inclusive reporting of commercial boating-related fatalities may be small. Of the cases that identify the type of vessel, “passenger ship, ferry-boat, or liner” sub-codes account for less than 7 percent and “merchant ship” sub-codes account for less than 1 percent of fatalities.

more reliable. NVSS alone leads to substantially lower estimates, while taking the higher estimate from either BARD or NVSS for each State leads to a slightly higher estimate. Because this latter difference is small and varies from year to year, relying solely on BARD appears appropriate. Extensive efforts have been undertaken by Coast Guard to ensure that all fatalities are captured, and the circumstances surrounding deaths make these types of injuries most likely to be reported (i.e., an investigation by a law enforcement agency likely occurred).

2.3.2.2 Hospital Admissions

We use HCUP-NIS to estimate the number of nonfatal injuries that resulted in admission to a hospital. AHRQ developed this database as part of its mission to support research necessary to improve the quality, safety, efficiency, and effectiveness of the Nation's health care system. HCUP is a well-established federal-state-industry partnership that has built a multi-state health data system. It consists of a family of health care databases containing a core set of clinical and nonclinical information found in a typical discharge abstract, including all-listed diagnoses and procedures; discharge status; patient demographics; and charges for all patients, regardless of payer (e.g., Medicare, Medicaid, private insurance, uninsured). The information is translated into a uniform format to facilitate both multi-state and national-state comparisons and analyses.

Currently, 44 States contribute discharge data to HCUP, encompassing 95 percent of all U.S. community hospital discharges. Some States also include discharges from specialty facilities, such as psychiatric hospitals. The state-specific inpatient databases, known as SIDs, are available for purchase through the HCUP Central Distributor.²⁰

The HCUP-NIS draws a nationally-representative, stratified probability sample from the State data of hospital inpatient stays for the purpose of creating a single, national database. The result is the largest all-payer inpatient care database that is publicly available in the United States, containing data from five to eight million hospital stays each year from about 1,000 hospitals sampled (AHRQ, 2010). Applying weights to calculate national estimates, the data represent 40 million discharges annually.

Each record includes information about the patient's principal and secondary diagnosis reported using ICD-9-CM codes. In addition, some States include ICD-9-CM cause-of-injury codes. However, not all States require medical coding of cause-of-injury data — which may not exist, may be incomplete, or may be underreported by the State health agencies submitting the data.²¹ Currently, 26 States and the District of Columbia mandate the routine collection of cause-of-injury data in their statewide Hospital Discharge Systems.

²⁰ Lawrence *et al.* (2006) rely on HCUP-SIDs in their estimate of hospital admissions.

²¹ Because cause-of-injury codes are not used as a basis for reimbursement, they often receive low priority in the selection process of reported ICD-9-CM codes. When the number of diagnosis codes allowed on a discharge record is limited, cause-of-injury codes may not be included.

The ICD-9-CM boating-related cause-of-injury codes are: E830 (accident to watercraft causing submersion); E831 (accident to watercraft causing other injury); E832 (other accidental submersion or drowning in water transport accident); E833 (fall on stairs or ladders in water transport); E834 (other fall from one level to another in water transport); E835 (other and unspecified fall in water transport); E836 (machinery accident in water transport); E837 (explosion, fire, or burning in watercraft); E838 (other and unspecified water transport accident); and E910.0 (accidental drowning and submersion while water skiing).

Nationally, the number of boating-related hospitalizations likely represents a very small percentage of total hospitalizations from all causes. However, the data from this sample provide a general sense of the proportion of boating injuries relative to all hospitalizations, allowing us to compare BARD to the HCUP-NIS. Specifically, BARD reports approximately 2,000 such admissions annually.²² The analysis by Lawrence *et al.* (2006) suggests that hospitalized injuries are greater than those reported in BARD by a factor of about 1.25, which would increase these estimates to approximately 2,500 (2,000 x 1.25 = 2,500).²³ This represents less than 0.01 percent of total hospital admissions nationally.

We use AHRQ's online query system *HCUPnet*, which provides access to health statistics on hospital inpatient and emergency department utilization based on data from HCUP to calculate national estimates.²⁴ As part of its data use requirements, AHRQ does not report estimates based on 10 or fewer weighted cases or fewer than 2 hospitals to protect the confidentiality of patients (AHRQ, 2010). These statistics are suppressed and designated with an asterisk. It is important to note that the database reports individual "discharges." A single injury may result in more than one discharge from a hospital.

In our initial queries, we search discharge data by individual year and boating-related ICD-9-CM code. Because boating-related injuries are rare in the context of all hospital admissions, many of these initial queries returned results that were suppressed or were considered unreliable for extrapolation to national estimates. Specifically, for approximately three-quarters of the relevant ICD-9-CM codes, there are no records or data are suppressed.

One reason for the lack of boating injury data is that some types of injuries are so rare that they are unlikely to appear in the NIS sample at all or for more than a few cases (e.g., explosion, fire, or burning in watercraft injuring occupant of small powered boat). In addition, hospital staff and medical coders tend to use less specific injury descriptions, frequently referring to "other and unspecified" boating-related cause-of-injury codes. As

²² This estimate is subject to considerable uncertainty, as explained in greater detail later in this section.

²³ Lawrence *et al.* (2006) estimate a total of 2,181 nonfatal hospitalized injuries in 2002, compared to 1,752 in BARD, a 24 percent increase, which they round upwards to 25 percent (p. 16).

²⁴ In addition to NIS, a number of HCUP databases can be queried online, including HCUP-KID, HCUP-NEDS, and HCUP-SID for 35 states.

a result, this query method results in national estimates for the most common types of boating injuries, but likely understates the overall number of injuries.

To address this issue, we instead combine all ICD-9-CM codes into a single query, which conceals the underlying detail to avoid data suppression. However, AHRQ warns, “When you query all-listed diagnoses or procedures for multiple ICD-9-CM codes and request statistics on all codes combined, individual discharges may be counted more than once if multiple ICD-9-CM codes appear on a discharge record.” In other words, an individual injury may be double-counted. We believe double-counting is unlikely for the boating-related cause-of-injury codes relevant to this analysis because the individual codes and sub-codes represent mutually-exclusive categories (e.g., E830 indicates an “accident to watercraft causing submersion”, while E831 indicates an “accident to watercraft causing other injury”).²⁵ The most frequently used ICD-9-CM code is “other and unspecified water transport accident,” which is unlikely to be combined with any more descriptive boating-related category. By combining ICD-9-CM codes E830.0 through E838.9, and E910.0, for the years 2005 through 2008, we are able to obtain a more reliable estimate of hospitalizations.²⁶

Comparing these estimates to BARD presents an additional challenge. In its annual reports summarizing recreational boating accidents, Coast Guard separately reports total fatalities and nonfatal injuries. However, it does not separately identify injuries resulting in hospitalizations from other, less severe injuries. Discussions with representatives of the Boating Safety Division reveal that some, but not all, States identify hospitalizations in their records submitted to Coast Guard.²⁷ Between 2007 and 2008, approximately 84 percent of BARD injury records clearly indicate whether or not the injury resulted in hospital admission. Of those records that include these data, approximately 60 percent are designated as hospital admissions. If we also include the records for which hospitalization data are not reported, about 51 percent of all injuries are classified as hospital admissions. Exhibit 2-4 presents the total number of nonfatal injuries presented in BARD from 2005 to 2008 and the number of those injuries clearly identified as hospital admissions.

²⁵ By comparison, in the NHAMCS database (described in detail in the next section), for which we have greater detail, less than 25 percent of injuries have more than one listed ICD-9-CM code. Between 2002 and 2008, not a single record has more than one boating-related ICD-9-CM code.

²⁶ AHRQ does not consider statistics based on estimates with a relative standard error greater than 0.30 or with a standard error of 0 in the nationwide statistics to be reliable (Personal communication with HCUP User Support, on February 3, 2011). Also, AHRQ does not report estimates based on 10 or fewer observations or fewer than 2 hospitals to protect the confidentiality of patients. No standard errors are calculated for combined cause-of-injury code searches.

²⁷ Personal communication with S. Tomczuk, on February 18, 2011.

EXHIBIT 2-4: ESTIMATED NONFATAL INJURIES IN BARD, 2005-2008

YEAR	ADMITTED TO A HOSPITAL	NOT ADMITTED TO A HOSPITAL	UNKNOWN	TOTAL INJURIES REPORTED	PERCENT OF TOTAL INJURIES KNOWN TO BE ADMITTED TO A HOSPITAL
2005	1,763	1,688*		3,451	51%
2006	1,761	1,713*		3,474	51%
2007	1,799	1,191	683	3,673	49%
2008	1,749	1,128	454	3,331	53%

Source: Personal communication with S. Tomczuk, on February 18, 2011.

* Prior to 2007, injuries where the place of treatment is not specifically noted are categorized as "not admitted to a hospital" by default.

These data suggest that approximately half of the nonfatal injuries reported in BARD resulted in hospitalization. About a third identified as not admitted in 2007 and 2008 were likely treated in emergency departments, outpatient departments, community health centers, or physicians' offices. The place of treatment for the remaining 15 percent of injuries is unknown. Without reviewing the accident and injury description for each individual record, we are unable to assign these remaining injuries to a treatment setting.²⁸

For the purposes of comparison to HCUP-NIS, we assume that none of the unknown injuries resulted in hospital admission. This is a conservative estimate in the sense that it likely understates the number of the most severe, nonfatal injuries. However, it may also lead to an overstatement of the degree to which BARD undercounts these injuries.

Exhibit 2-5 compares the hospitalizations identified in BARD to the total number of boating injuries reported in HCUP-NIS. The results suggest that injuries resulting in hospitalization are 50 to 70 percent higher than reported in BARD. To adjust the number of hospitalizations reported in BARD to equal the number identified in the HCUP-NIS, analysts would multiply the BARD estimate by a factor of 1.5 to 1.7, depending on the year.

²⁸ For example, based on a review of injury descriptions, Louisiana has one of the highest rates of severe injuries (e.g., cracked skulls and collapsed lungs). However, the State does not report to BARD whether injuries resulted in hospitalization (Personal communication with S. Tomczuk, on February 18, 2011).

EXHIBIT 2-5: ESTIMATED HOSPITAL ADMISSIONS RESULTS FROM NONFATAL RECREATIONAL BOATING INJURIES

YEAR	BARD ESTIMATES (INJURIES)	HCUP-NIS ESTIMATES (ADMISSIONS)	HCUP-NIS ESTIMATES RELATIVE TO BARD*
2005	1,763	2,666	1.5
2006	1,761	3,056	1.7
2007	1,799	2,889	1.6
2008	1,749	2,929	1.7
Total	7,072	11,540	1.6

* Assumes each admission represents a separate injury.

Our finding is higher, although of a similar order of magnitude, to Lawrence *et al.*'s (2006, p.16) conclusion that hospital admissions are 25 percent higher than reported in BARD. We suspect that the discrepancy stems in part from the fact that Lawrence *et al.* (2006) build up national totals from state-level estimates, relying on BARD data for States where HCUP-SID data are suppressed or unavailable. As a result, we would expect their approach to identify less of a difference between the two databases.²⁹ In addition, our analysis may reflect changes in hospitalization rates that have occurred since they conducted their analysis in 2002, given changes in the health care system. BARD reporting practices are also likely to change over time.

In Appendix C, we supplement this analysis with assessment of HCUP-SID data from eight State databases. We find that the extent to which the State data are consistent with BARD varies significantly. While HCUP-SID data from four States are relatively similar to BARD (varying by less than a factor of 2.0), data from the remaining four states suggest that the BARD estimates may be significantly understated. This analysis suggests that, for regulations or policies that disproportionately affect certain States, it may be desirable to consider underreporting on a state-by-state basis, rather than using national data.

2.3.2.3 Nonfatal, Non-hospitalized Injuries

To evaluate the reliability of national estimates of nonfatal, non-hospitalized injuries in BARD, we consider additional information from two CDC surveys: NHAMCS (on emergency department visits and outpatient care) and NAMCS (on visits to office-based physicians). We begin by using NHAMCS to estimate the number of emergency visits attributable to boating-related injuries. Next, we combine data from NHAMCS and NAMCS to develop national estimates of all boating-related nonfatal, non-hospitalized

²⁹ Lawrence *et al.* (2006) also note the uncertainty associated with BARD's categorization of injuries resulting in hospital admission.

injuries, including injuries treated in settings other than emergency departments. In both cases, we compare our results to BARD as well as to the findings in Lawrence *et al.* (2006). We introduce the surveys below; more information on each is provided in Appendix B.

NAMCS is a well-established survey designed to collect information on the utilization and provision of ambulatory medical care services in the United States. The survey is conducted annually by NCHS, using probability sampling designed to obtain a nationally-representative sample of visits to office-based physicians. Annually, approximately 30,000 visits are documented by NAMCS and extrapolated to represent more than 900 million visits to office-based physicians. (CDC 2003a; CDC 2004a; CDC 2005a; CDC 2006a). A very small percentage of these visits is attributable to injuries (e.g., in 2004, less than 10 percent of visits were injury-related). Similar to the other databases we reviewed, an even smaller percentage of visits is attributable to boating-related injuries. As noted in Exhibit 2.1, according to BARD such injuries have totaled about 3,500 annually in recent years, which are likely to represent a tiny fraction of the millions of office visits represented in NAMCS even if underreporting is significant.

NHAMCS, a counterpart to the NAMCS, provides similar information for services provided in hospital settings and uses a comparable sampling design to obtain a nationally representative sample (CDC, 2011a). NHAMCS consists of two databases, one for emergency departments and one for outpatient departments.^{30,31} The survey participants include emergency and outpatient departments in non-institutional general and short-stay hospitals, exclusive of Federal, military, and Veterans Administration hospitals, in the 50 States and the District of Columbia.

Annually, approximately 35,000 visits are documented in each NHAMCS database and extrapolated to represent approximately 110 million emergency department visits and approximately 100 million outpatient department visits in the United States (CDC, 2007; CDC, 2008; CDC, 2009; CDC, 2010). It is important to note that both surveys count “injury visits” not “injury episodes” (i.e., an individual injury episode counted in BARD could result in more than one injury visit).

As noted earlier, BARD reports approximately 3,500 total nonfatal injuries annually. Because boating-related injuries account for such a small proportion of the total, they may not be accurately represented in these databases. For example, even if we assume that all of these BARD injuries are seen in emergency departments, and that injuries are

³⁰ CDC warns that estimates pertaining to hospital outpatient departments tend to be less reliable than those for emergency department visits. (Hsiao, 2010)

³¹ Due to a general, nationwide trend away from hospital inpatient to outpatient surgery for many procedures, hospital-based ambulatory surgery centers were added to the NHAMCS in 2009, and freestanding ambulatory surgery centers were added in 2010 (CDC, 2011a). Because our period of analysis incorporates data from 2005 through 2008, we do not include boating injuries that may be treated at these types of facilities. However, we note that such treatment would generally result from a referral by a doctor in another setting. To the extent that injuries that originate with visits to emergency departments or primary care physicians, inclusion of these types of treatment centers would likely double-count boating injuries.

underreported in BARD by an order of magnitude, total recreational boating injuries treated in emergency departments likely represent less than 0.1 percent of all emergency department visits reported in NHAMCS. Thus, it is difficult to identify boating-related injuries in these samples and we face issues of data reliability similar to the issues of data suppression discussed in the previous section on hospitalizations.³² Nonetheless, comparing these estimates to BARD yields information on the possible extent of underreporting and potential adjustment factors for these types of injuries, and helps identify areas where further investigation may be useful.

Prior to 2005, each of these databases included information on the causes of injuries treated. However, the nonresponse rate for cause-of-injury codes was high (e.g., in 2004, the nonresponse rate was 31.9 percent of injury visits to office-based physicians, 35.6 percent of injury visits to outpatient departments, and 16.8 percent of injury visits to emergency departments). For visits to office-based physicians and outpatient departments, NCHS stopped reporting injury cause data in 2005. However, cause-of-injury data continued to be collected for emergency department visits. Therefore, the years included in our analysis vary depending on the treatment categories assessed.

First we present national estimates of emergency department injury visits from 2005 to 2008, consistent with our approach for fatalities and hospitalizations. We use NHAMCS to estimate nonfatal injuries that are treated in an emergency department setting, but do not require admittance to a hospital. Then we present national estimates of all nonfatal, non-hospitalized injury visits from 2001 to 2004 using both databases. To begin our analysis, we conduct a preliminary NHAMCS query for all emergency department records with a boating or water-skiing cause-of-injury code (i.e., ICD-9-CM codes E830.0 through E838.9, and E910.0) each year from 2005 through 2008. No single year provides a sufficient sample size based on this query to calculate reliable national estimates.

To address this problem, we combine the data and run the same NHAMCS query for 2005 through 2008 collectively. In addition, to account for the potential miscoding of boating-related injury codes, we perform an automated keyword search on injury descriptions. We select all records that have one or more of the following words pertaining to the cause-of-injury description: “boat,” “canoe,” “jet ski,” “rafting,” “ship,” or “water ski.” From the resulting records, we review the medical comments on a case-by-case basis to determine whether the injury is a boating accident that meets BARD’s reporting criteria. For example, we exclude irrelevant injuries that contain one of the keywords, such as those involving “model ship building” or “boat trailers.” If an injury does not have a boating-related ICD-9-CM code, but the description of the injury otherwise appears to meet BARD’s reporting criteria, we include the injury. If the injury does have a boating-related ICD-9-CM code, but the description unmistakably indicates it

³² Specifically, NCHS considers an estimate drawn from its sample to be reliable if it has a relative standard error of 30 percent or less. Estimates based on fewer than 30 records are considered unreliable, regardless of the magnitude of the relative standard error (CDC, 2010).

has nothing to do with boating, canoeing, jet skiing, rafting, or waterskiing, we exclude the injury.

To avoid double-counting patients that may have been reported in another database (i.e., injuries that resulted in death or admission to a hospital) or follow-up visits, we exclude all visits:

- Where the visit was not related to an injury;
- Where the patient was admitted to a hospital;
- Where the patient was dead on arrival or died in the emergency department; or
- Where the patient had been seen in the same emergency department within the last 72 hours.

This search identified 63 records over the four-year period that have a boating-related ICD-9-CM injury code or otherwise would be reportable to BARD and are unlikely to have been counted in the previous two sections of this report. Following NHAMCS's protocol for extrapolating to national estimates, we estimate approximately 214,000 boating-related emergency department visits occurred during this period, or an average of slightly more than 53,000 annually, as shown in Exhibit 2-6.³³ Due to considerable uncertainty regarding the precision of these estimates, we round them to two significant digits.

As discussed in the previous section, identifying the number of comparable injuries reported in BARD is challenging. As shown in Exhibit 2-6, we begin by taking the total number of nonfatal injuries reported in BARD and subtracting Coast Guard estimates of injuries resulting in hospitalization. We assume that the remainder includes only injuries that were treated in emergency departments, on an outpatient basis, or in primary care settings. However, as discussed in Section 2.3.2.2, this total may include some hospitalized cases, because not all States report related data. This figure also includes injuries that did not require treatment beyond first aid.³⁴

³³ Each record in the NHAMCS Emergency Department database represents one visit from the sample of approximately 35,000 visits each year. In order to obtain national estimates from the sample, each record is assigned an inflation factor called the "patient visit weight." National estimates are obtained by aggregating the patient visit weights on the sample records (CDC, 2010). Data can be aggregated across years when the same patient record form (i.e., survey instrument) is used to improve the reliability of estimates (CDC, 2011b; Hsiao, 2010). For example, to obtain national estimates for emergency department visits, we aggregate the patient visit weights for records coded as boating injuries in the years 2005 through 2008.

³⁴ As noted earlier, BARD data collection procedures have changed in recent years. The current version of the form indicates that only injuries requiring treatment beyond first aid should be reported. The older form is less clear on whether these relatively minor injuries should be reported.

EXHIBIT 2-6: ESTIMATED BOATING-RELATED EMERGENCY DEPARTMENT VISITS

YEAR	TOTAL NONFATAL INJURIES IN BARD	BARD ESTIMATED INJURIES RESULTING IN HOSPITALIZATION (FROM TABLE 2-5)	REMAINING BARD ESTIMATED NONFATAL INJURIES	NHAMCS ESTIMATED EMERGENCY DEPARTMENT VISITS	PROPORTION OF EMERGENCY DEPARTMENT VISITS RELATIVE TO NONFATAL, NON-HOSPITALIZED BARD INJURIES
2005	3,451	1,763	1,688		
2006	3,474	1,761	1,713		
2007	3,673	1,799	1,874		
2008	3,331	1,749	1,582		
Annual Average	3,482	1,768	1,714	53,000*	31*

* Results rounded to two significant digits to reflect uncertainty; intermediate calculations are based on unrounded data.

Assuming, for simplicity, that all the remaining injuries are treated in emergency departments, the NHAMCS data suggest that in an average year, BARD captures only 3 percent of such injuries (i.e., 1,714 injuries divided by 53,000 emergency department visits). It misses the remaining 97 percent. Put another way, to scale its estimates of all nonfatal, non-hospitalized injuries in BARD to match emergency department visits in NHAMCS, Coast Guard would multiply nonfatal, non-hospitalized injuries by approximately 31. However, this comparison is imprecise, because it compares NHAMCS data on a single treatment setting (emergency departments) to BARD data on all non-hospitalized injuries.

Given that some of the injuries captured in BARD are likely to be treated in doctors' offices or other locations, the degree of underreporting in BARD is even greater. We address this issue below. In addition, if some of these injuries resulted in hospitalization (see previous section for discussion of the "unknown" injuries) rather than solely emergency department treatment, this percentage or scaling factor may be understated. In either case, adjustment would reduce the number of nonfatal, non-hospitalized cases reported in BARD relative to the NHAMCS data.

In their estimation of emergency department visits, Lawrence *et al.* (2006) rely on State databases included as part of the HCUP. In 2002, 11 States compiled data in HCUP-SEDD. Comparing the state-specific estimates of emergency department visits to state-specific estimates of hospitalizations from HCUP-SID, Lawrence *et al.* (2006) found a ratio of 8.49 boating injuries were treated in emergency departments for every boating injury that resulted in hospitalization. Applying this ratio to their BARD-adjusted estimates of hospitalizations (2,181 injuries), Lawrence *et al.* (2006) find that 18,250 boating injuries would be treated annually in emergency departments. The authors note

that they compared this figure with a separate query of NHAMCS, which suggested that the number of boating injuries treated in emergency departments could be as high as 27,000 (Lawrence *et al.*, 2006).³⁵

While similar in terms of the order of magnitude of underreporting found in BARD, our estimate of emergency department visits from NHAMCS is significantly higher than the estimates provide by Lawrence *et al.* (2006). One possible reason for the difference is that we conducted an additional query on the injury descriptions to identify those that appear to be miscoded (i.e., injuries that should have a boating-related cause-of-injury code but did not). Furthermore, the Lawrence *et al.* (2006) primary estimate of 18,250 injuries treated at emergency departments is extrapolated using data from 11 States. It is possible that these States are not representative of the entire United States. Finally, as in the case of hospitalized injuries, the differences between their 2002 estimates and our analysis may reflect changes in the health care system, as well as in the data available in the NHAMCS. Lawrence *et al.* (2006) note that their estimate is likely to be conservative and requires additional research.

Next, we present national estimates for all nonfatal, non-hospitalized injuries. While still uncertain, this estimate is more appropriate for comparison to BARD. These include injury visits to emergency departments, outpatient departments, and office-based physicians. In the above analysis, we assume that all nonfatal injuries in BARD that do not result in hospitalization are treated in emergency departments. Here we allow for the remaining nonfatal, non-hospitalized injuries in BARD to represent those treated in other settings in addition to emergency departments. As above, we assume that injuries for which the treatment setting is not reported in BARD (i.e., the “unknown” category in Exhibit 2.4) are not hospitalized.

We rely on NAMCS and both the emergency department and outpatient department components of NHAMCS. As discussed above, because NAMCS and the outpatient portion of NHAMCS stopped reporting cause-of-injury codes in 2005, we rely on national estimates based on data from 2001 to 2004. With the exception of combining data from different years and additional sources, our methodology is identical to the steps described above. We conduct a preliminary query for boating-related ICD-9-CM codes, then perform an automated keyword search on injury descriptions to identify any records that may not have been coded properly, and finally review the medical comments pertaining to injury descriptions on a case-by-case basis to determine if the injury is likely to meet BARD’s reporting criteria.

This search identifies 95 records across the three databases over four years that have a boating-related cause-of-injury code or are otherwise reportable to BARD and unlikely to have been counted in other databases as fatalities or hospital admissions. Of these, 62

³⁵ Details of the NHAMCS query performed by Lawrence *et al.* are not provided in their report. However, if this estimate is based on 2002 data only, then because NHAMCS would have returned fewer than 30 observations, the estimate would not be considered to be reliable by CDC.

were emergency department records and 33 were outpatient department or office-based physician records. Following CDC’s protocol for extrapolating to national estimates, we estimate approximately 1,052,000 boating-related injury visits occurred during this period, or an average of 263,000 annually, as shown in Exhibit 2-7. Due to considerable uncertainty regarding precision, we round these estimates to the nearest thousand.

EXHIBIT 2-7: ESTIMATED BOATING-RELATED NONFATAL, NON-HOSPITALIZED INJURY VISITS

YEAR	TOTAL NONFATAL INJURIES IN BARD	BARD ESTIMATED INJURIES RESULTING IN HOSPITALIZATION	REMAINING BARD ESTIMATED NONFATAL INJURIES	ESTIMATED EMERGENCY DEPARTMENT VISITS	ESTIMATED OUTPATIENT AND DOCTORS' OFFICE VISITS	TOTAL ESTIMATED VISITS	PROPORTION OF TOTAL VISITS RELATIVE TO BARD
2001	4,274	1,876	2,396				
2002	4,062	1,752	2,310				
2003	3,888	1,711	2,177				
2004	3,363	1,641	1,722				
Annual Average	3,896	1,745	2,151	48,000*	220,000*	260,000*	120*

Note: Totals may not sum due to rounding.

* Results rounded to two significant digits to reflect uncertainty; intermediate calculations are based on unrounded data.

For comparison, as described above, first we take the total number of nonfatal injuries reported in BARD and subtract Coast Guard estimates of injuries resulting in hospitalization. The remainder (2,151 on average) should include all injuries that were treated in emergency departments, on an outpatient basis, or in primary care settings, as well as some hospitalized injuries for which the place of treatment was not reported. Assuming that all injuries not resulting in hospitalization require some medical treatment beyond first aid, NAMCS and NHAMCS data suggest that BARD captures less than 1 percent of these injuries (2,151 BARD injuries divided by 260,000 NAMCS and NHAMCS visits). It misses the remaining 99 percent. To scale its estimates in BARD to match estimates in all of CDC’s databases, Coast Guard would have to multiply nonfatal, non-hospitalized injuries by approximately 120.

This adjustment factor is subject to considerable uncertainty. Note that we combine three datasets and four years of data to obtain an estimate based on fewer than 100 records. This reflects the tiny proportion of all injuries in the United States that result from boating. Furthermore, since CDC considers any estimate based on fewer than 30 records to be unreliable, we do not provide national estimates at more detailed level of analysis

(i.e., for specific injury types or specific activities). Because boating-related injuries account for such a small proportion of medical care visits in the United States, the sample size from these databases may not be sufficient for producing reliable national estimates through the extrapolation methods recommended by CDC, even when multiple years of data are used. CDC also notes that estimates of outpatient department visits are considered to be less reliable than estimates for other types of medical care visits.

As shown in Exhibit 2-7, we estimate there are approximately 260,000 nonfatal, non-hospitalized boating-related injuries each year. To address this category of injuries, Lawrence *et al.* (2006) rely on work by Finkelstein *et al.* (2006), which estimates that, for every emergency department visit, approximately 0.72 additional injuries are treated in clinics and doctors' offices. Scaling up their count of emergency department visits, they calculate an estimate of $18,250 \times 1.72 = 31,390$. Our estimate is an order of magnitude larger. However, Lawrence *et al.* (2006) also found that a scaling factor based on data in the 1995-2003 NAMCS and NHAMCS was more than twice as large as the factor they used. Based on our queries of boating-related injuries from 2001-2004, we find the ratio of total injuries to emergency department visits is approximately 5.50 compared to Lawrence *et al.*'s ratio of 1.72. Our estimate is also larger because we performed additional database queries to include injuries that were likely boating-related, but did not have cause-of-injury codes. Furthermore, as discussed above, Lawrence *et al.*'s sample from 11 States may not be representative of the entire United States. Lawrence *et al.* note that their estimates are likely to be conservative.

2.4 SUMMARY OF FINDINGS AND NEXT STEPS

The results of our analysis are consistent with earlier findings suggesting BARD is likely to be accurate with regard to identifying fatal injuries, but significantly underreports nonfatal injuries. Furthermore, our analysis confirms earlier conclusions that the degree of underreporting increases as the severity of the injury decreases. Below, we summarize the findings presented throughout this chapter. Then, we provide a general discussion of issues to consider as Coast Guard contemplates its next steps. We demonstrate the application of our findings in case studies presented in Chapter 5 and discuss our conclusions and recommendations in Chapter 6.

2.4.1 SUMMARY OF FINDINGS

In this chapter, we compare estimates of fatal and nonfatal injuries from four national databases to the estimates reported in BARD. The best alternative source of information regarding fatalities is the NVSS, which is based on death certificates. Deaths reported to result from boating accidents are less than those reported in BARD, however researchers have documented the limitations of the NVSS. In particular, this research shows that death certificates alone frequently fail to properly record causes of fatalities.

Given the extensive effort undertaken by Coast Guard to ensure that data on all reportable fatalities are recorded, BARD appears to provide the most reliable estimate of fatalities.

We do not recommend making additional adjustments using the NVSS given its limitations in this context.

Our research confirms the conclusion by Lawrence *et al.* (2006) that BARD underestimates injuries resulting in hospitalization. Depending on the methodology employed, actual hospitalizations could be 25 to 70 percent higher nationally. However, these ratios are subject to considerable uncertainty, and vary significantly by State. Most importantly, it is difficult to determine how to appropriately identify injuries reported in BARD that result in hospitalization so that they can be compared to other sources of injury data.

Our analysis also confirms the conclusion by Lawrence *et al.* (2006) that less severe injuries are significantly undercounted in BARD. However, the degree of uncertainty associated with estimating the actual number of injuries treated in emergency departments and other settings is greater than for hospitalizations. Both our analysis and the analysis in Lawrence *et al.* (2006) suggest that underreporting increases as the severity of the injury decreases.

Exhibit 2-8 summarizes the results of our national analysis. For fatalities, a multiplier of “1” suggests that no adjustment is necessary; the higher multipliers indicate that data in BARD are noticeably under-reported.

EXHIBIT 2-8: COMPARISON OF MULTIPLIERS FOR ADJUSTING BARD DATA

INJURY CATEGORY	LAWRENCE <i>ET AL.</i> (2006) (2002)	IEC (2001 - 2008) ^a
Fatalities	1.01	1
Nonfatal Injuries:		
Hospitalization	1.25 ^b	1.5 - 1.7 ^b
All nonfatal, non-hospitalized (i.e., emergency departments, outpatient departments, and doctors' offices)	13.6 ^c	120 ^d

Notes:

- IEC's analyses of fatalities and hospitalizations are based on data for 2005 - 2008; analysis of all nonfatal, non-hospitalized visits is based on data for 2001 - 2004.
- Based on an estimate of hospitalizations from BARD that counts only confirmed hospitalizations (injuries where the place of treatment is not specified are assumed to be treated in emergency departments or other settings).
- Based on total nonfatal injuries in BARD, minus the estimate of hospitalizations described in note “b”. Lawrence *et al.* note that data from the NHAMCS suggest this ratio should be higher.
- Based on total nonfatal injuries in BARD, minus the estimate of hospitalizations described in note “b”.

Comparison of the factors that should be applied to nonfatal injuries is complicated by the fact that BARD does not indicate whether the individual was hospitalized for many cases, nor does it include the treatment site for non-hospitalized injuries. In addition, if boating accident reporting practices within individual States change (e.g., States begin conducting more investigations or otherwise encouraged reporting), it would be reasonable to see variation in the multipliers. Appendix C provides additional State-level data on hospitalizations.

2.4.2 CONSIDERATIONS FOR NEXT STEPS

As discussed above, given the extensive effort undertaken by Coast Guard to ensure that data on all reportable fatalities are recorded, BARD appears to provide the most reliable estimate of fatalities. No additional adjustments are recommended at this time.

The multipliers for adjusting BARD-reported nonfatal injuries presented in Exhibit 2-8 are preliminary and subject to substantial uncertainty. Coast Guard has several options for improving its estimates of the number of these types of injuries. These options include: (1) conducting an updated analysis of the individual HCUP State databases (e.g., HCUP-SID, HCUP-SEDD) similar to the approach taken by Lawrence *et al.* (2006), building on the analysis in Appendix C; (2) conducting additional analysis of national databases that cover similar or additional treatment locations (e.g., HCUP-NIS and HCUP-NEDs as well as NHAMCS and NAMCS); or (3) undertaking primary research (e.g., a survey of boat owners/operators). The advantages and limitations of each option are summarized in Exhibit 2-9 and discussed in greater detail below. Appendix B provides a detailed discussion of other potentially useful databases.

The first and second options are illustrated in this report and in the previous Lawrence *et al.* (2006) analysis; these efforts could be refined, expanded, and/or updated. This report provides a detailed analysis of four nationwide databases. In contrast, the approach applied in Lawrence *et al.* (2006) includes detailed analyses of state-specific databases available through HCUP. An advantage of this latter approach (illustrated in Appendix C) is that the State databases provide a census of injuries, rather than estimating total injuries based on a probability sample. Thus, concerns related to whether recreational boating accidents are numerous enough to be appropriately captured in national samples are not relevant. However, Lawrence *et al.* (2006) encountered issues of data suppression due to the low number of injuries reported in certain geographic locations. A second advantage is that data would be available to Coast Guard on a state-by-state basis, allowing for analysis of the distributional impacts of proposed interventions (e.g., proposed regulations, policies, or programs may target States with certain types of water bodies or vessels disproportionately).

**EXHIBIT 2-9: COMPARISON OF THE ADVANTAGES AND LIMITATIONS OF
ALTERNATIVES FOR ADDITIONAL RESEARCH**

	ANALYZE STATE DATABASES	ANALYZE NATIONAL DATABASES	CONDUCT PRIMARY RESEARCH
Ease of implementation?	Moderate	High	Low
Requires extrapolation of data to non-participating States?	Yes	No	Potentially
Potential to overstate the number of boating injuries?	Yes	Yes	Uncertain
Feasible to repeat exercise each year?	Yes	Yes	No
Useful for estimating distributional impacts?	Yes	No	Potentially
Includes information about the cause of the accident?	No	No	Yes
Provides information about minor injuries (e.g., those treated in outpatient clinics or doctors' offices or that did not require treatment beyond first aid)	Uncertain ^a	Yes ^b	Yes

Notes:

- a. Our search of databases summarized in Exhibit 2-2 did not identify State databases providing information about treatment in doctors' offices. In addition, we did not perform a detailed analysis of HCUP-SASD, which provides information on surgeries where patients are admitted and released on the same day.
- b. Only for injuries treated in ambulatory medical care settings.

A key consideration is the number of States for which detailed data are available. More States contribute to HCUP now than in 2002, the year of analysis in Lawrence *et al.* (2006). As a result, Coast Guard may be required to extrapolate results to States that do not currently participate or where data are suppressed. As discussed earlier, variation in boating accident investigation and reporting rates across States introduces uncertainty into such exercises. Additional research is required to understand the quality, consistency, and ease of use of the available State databases.

Furthermore, as baseline boating accident reporting practices or boating activity in general change, Coast Guard will require updated comparisons to BARD. An approach based on State databases could be time consuming, particularly if each State has separate databases for each injury setting. Coast Guard should consider whether it has the resources necessary to repeat the analysis on a regular basis.

In contrast, Coast Guard may instead choose to rely on national databases, such as those analyzed in detail in this report. A key advantage of this approach is ease of implementation; only a handful of databases would be analyzed. In addition, this approach avoids issues associated with States for which data are unavailable. However, a

significant limitation of this approach is the concern that recreational boating accidents may not be well-represented in national samples. In addition, both this approach and the state-by-state approach have the potential to overestimate total injuries for the reasons discussed in this chapter and summarized in Appendix C. A further limitation of this approach is the inability to analyze the potential distributional impacts of proposed regulations, policies, or programs.

A third option addresses some of these shortcomings. The Coast Guard might consider conducting primary research, such as a survey of recreational boat owners and operators. Depending on how the survey is constructed and implemented, it could collect data on all types of injuries, including those that are not reportable to BARD but that may be reduced as a result of future Coast Guard regulatory or policy actions.³⁶ In addition, depending on whether the survey is implemented nationally or in particular States, estimation of distributional impacts may be possible and issues associated with transferring results from one location to another may be minimized. Furthermore, Coast Guard could ask questions about the cause of the accidents resulting in particular injuries. Whether or not such an approach is likely to over- or understate injuries is uncertain.

There are several key limitations to conducting primary research. Implementation of a survey requires prior approval by OMB, and the approval process may take six to 12 months. In addition, the time required to design and implement the survey can be significant. As a result, it may be difficult to repeat such an effort at the same frequency that baseline conditions or accident reporting practices change.

Obtaining a representative sample of boat owners/operators also poses challenges. Coast Guard may have access to a list of licensed boaters or registered boats with current, reliable contact information. However, this would exclude certain subpopulations of recreational boaters, such as unlicensed boaters and unregistered boats, who may be more likely to get into boating accidents. The Coast Guard could work with boat and yacht clubs to help fill these gaps, and also use these organizations to help distribute, administer, and encourage respondents to complete the survey. SRG (2003) identified non-owners using random-digit dialing to contact individuals via telephone. More efficient, updated techniques may now be available.

One final issue worth consideration is whether the data in BARD describing less severe injuries (those not requiring hospitalization) are robust enough to support the development of the types of multipliers presented in Exhibit 2-8. While Coast Guard may be able to estimate the total number of such injuries using national or State databases, it also requires information regarding the causes of these injuries. It currently obtains this information from BARD, and such data are generally unlikely to be available in the databases discussed in this report. If these types of injuries are significantly underreported, then information in BARD describing the cause of such injuries may not

³⁶ For example, see Chapter 5 for examples of how injuries only requiring first aid have been incorporated into Coast Guard regulatory analyses.

be representative of all accidents. Primary research might be used as a substitute for BARD for these types of injuries.

CHAPTER 3 | COST OF INJURIES

An important component of the regulatory analyses required under Executive Orders 12866 and 13563 is the comparison of costs and benefits, with benefits valued in monetary terms to the greatest extent possible. Given the complexities of most policies, it is difficult to estimate the value of their impacts as an entirety. Instead, analysts generally disaggregate their effects, value each benefit category separately, then sum the results – taking care to avoid double-counting. Thus instead of estimating the value of “boating safety,” analysts typically value the reduced risks of fatalities, injuries, and property damages (as well as any other beneficial impacts) separately, then sum the results. Coast Guard has a well-established approach for valuing fatality risk reductions, which we briefly summarize below. We then focus on the value of nonfatal injury risk reductions. Averted property value damages are considered in Chapter 4.

We begin by briefly reviewing alternative conceptual approaches to valuing the types of fatal and nonfatal injuries described in the previous chapter, and discuss how the Coast Guard currently values these injuries. We then describe the approach we used to identify and evaluate alternative values that might be useful in this context, and report our results and associated uncertainties. We conclude by proposing how these data can be used in future analyses. In Chapter 5, we demonstrate the application of this approach in three case studies. The key publications referenced in this section are also briefly summarized in the annotated bibliography provided as Appendix A, and Appendix D provides more information on valuing nonfatal injuries using data from motor vehicle accidents.

3.1 CONCEPTUAL FRAMEWORK FOR VALUATION³⁷

The conduct of benefit-cost analysis is based on neoclassical welfare economics. This framework assumes that individuals derive utility, or a sense of satisfaction, from the goods and services that they consume, and that each individual is the best judge of his or her own welfare (generally referred to as “consumer sovereignty”). Within this framework, the value of benefits from policy decisions is most appropriately measured by the change in income that would have the same effect on an individual’s utility as the policy, where income represents one’s ability to purchase other goods and services. In other words, the value of a beneficial outcome is equal to the most an individual would be willing to pay for the outcome; i.e., the point at which he or she would be equally satisfied between having the outcome or having the money to spend on other things.

³⁷ More information on the topics discussed in this section is provided in Robinson (2007a).

When estimates of this WTP are not available, analysts may rely on estimates of averted costs or monetized QALYs as rough proxies, as described below.

3.1.1 WILLINGNESS TO PAY

For risk reductions or other beneficial outcomes, WTP is the maximum amount of money an individual would voluntarily exchange to obtain the improvement, given his or her budget constraints. Willingness to accept compensation is the least amount of money an individual would accept to forego the improvement. While these two measures are not necessarily equal, policy and regulatory analysts typically rely on estimates of WTP due to concerns about the accuracy and reliability of the methods available to estimate willingness to accept compensation.

For outcomes such as risk reductions, which are not traded in markets, economists generally estimate WTP using stated or revealed preference methods. Stated preference methods typically employ survey techniques to ask respondents what they would pay for the outcome of concern. They include contingent valuation surveys, which directly elicit WTP for the scenario(s) that the survey describes. They also include choice experiments (or conjoint analyses) which present respondents with several scenarios involving different amenities (or outcomes with differing attributes) and prices. Estimates of WTP are then derived from the way in which respondents rank, rate, or construct equivalent sets of alternatives. Stated preference methods are attractive because researchers can tailor them to directly value the outcome(s) of concern; i.e., the survey can describe particular types of injuries from recreational boating accidents. However, conducting a study that yields accurate and reliable results can be challenging and expensive, and very few have been completed for nonfatal injuries.

Revealed preference methods estimate the value of non-marketed goods based on observed behaviors or prices and preferences for related marketed goods. For example, wage-risk (or hedonic wage) studies examine the additional compensation associated with jobs that involve higher risks, using statistical methods to separate the effects of fatality risks on compensation from the effects of other job and personal characteristics. Another revealed preference approach involves considering averting behaviors; i.e., defensive measures or consumer products used to protect against perceived risks. Property value studies are an alternative revealed preference method that can be used when an outcome (such as a particular change in environmental quality) is one of the attributes that affects purchase prices.

While stated preference and wage-risk studies are widely used to value health risk reductions, averting behavior and property value studies are applied infrequently in policy analysis (see, for example, reviews by Viscusi and Aldy, 2003 and Blomquist, 2004). Their limitations include difficulties in estimating actual or perceived risks and the need to make assumptions about key factors such as time costs (in some product studies) and whether cancers are likely to be fatal (in some property value studies).

3.1.2 AVERTED COSTS

For nonfatal injuries, few estimates of WTP are available, and regulatory analysts generally rely on other types of measures for benefit valuation. One frequently applied approach involves estimating the averted costs associated with reduced injury incidence, including the costs of medical treatment as well as lost productivity. These cost of illness (COI) studies may include costs paid by patients, their families, and/or third parties (such as insurance companies) as well as employers. They typically include direct medical costs, such as those associated with physician services, medication, and hospital stays. Many studies also include the indirect costs associated with lost productivity. These indirect costs may stem from absence from work or from decreased productivity while at work, and may also include employer costs such as those associated with idle assets or training replacement workers. Some studies consider unpaid work (e.g., volunteer and household services) as well as paid work. Productive time is generally valued using measures of compensation; often referred to as the “human capital” approach. Some studies also include other costs such as those related to litigation or to processing insurance claims.

The logic behind using averted costs to value benefits is that, if a regulation or policy allows society to avoid these costs, then the benefits of the regulation are at minimum equal to these averted expenditures. However, this approach does not yield estimates of WTP, and is not entirely consistent with the benefit-cost analysis framework. We briefly review related issues below, focusing on the costs of medical treatment and lost work time, which are generally the most significant injury-related costs.

First, particularly in the case of health risks, medical costs are partially borne directly by the consumer and partially paid by insurance. The consumer may pay for this insurance directly, and/or indirectly through decreased wages (in the case of employer-paid premiums) or through taxes (in the case of government-funded assistance). An individual’s out-of-pocket costs will understate the costs that are averted by a health risk reduction, but factoring in the costs paid by third parties is difficult given how insurance spreads the costs throughout a large pool of plan participants. The availability of such insurance may lead individuals to seek treatment that they would not have willingly paid for themselves, in which case relying on treatment costs for valuation will overstate their WTP.

Second, medical costs generally reflect treatment rather than prevention, which in turn reflects the technologies available as well as consumer preferences. Treatment may not return an individual to his or her original health state, whereas a policy initiative may prevent an injury from occurring. Even if the individual bears all of the medical costs, his or her WTP to reduce the risk may differ significantly from his or her WTP for treatment. In addition, treatment costs result from the interaction between market factors (the availability of technologies and the willingness of providers to supply the treatment at a particular cost) and the preferences of consumers; they are a market equilibrium (albeit in a heavily regulated market) rather than solely a measure of individual preferences.

Presumably, WTP for avoiding the health effect would exceed WTP for treatment, given that it involves greater avoidance of adverse effects.

Third, averted costs frequently include lost work time, often estimated by multiplying an estimate of hourly compensation by the number of hours or days of productive work lost due to illness, injury, or death. Whether this approach appropriately estimates lost earnings will depend on the employment status of the individual, and on factors such as the availability of disability or life insurance. At times, unpaid work (household or volunteer) is also included, raising issues about how to appropriately value this time.

It is unclear whether earnings appropriately value lost time, however. Earnings may be less or greater than an individual's WTP to avoid time losses due to injury, depending on how he or she values time spent in various work and leisure activities and the constraints that he or she faces in the labor market (see Robinson, 2007b). The human capital approach focuses on productivity and ignores any utility or disutility that individuals gain from different types of time use, aside from what is captured in the wage rate. In addition, reliance on wages for valuation of marginal changes in time use may be problematic; e.g., because the labor market does not allow complete flexibility in the number of hours worked.

Fourth, averted costs do not include the value of avoiding pain and suffering nor other quality of life impacts. This leads many researchers to believe that COI studies may significantly understate WTP. Comparison of COI and WTP estimates from four studies appears to support this hypothesis, suggesting that COI estimates may be significantly lower than WTP for a range of illnesses (EPA, 2000, Appendix B). However, the degree of understatement varies depending on the characteristics of the health effect, the types of costs considered, and the design of the study.³⁸ More work is needed to better understand how the factors discussed above affect this comparison.

Finally, although averted cost methods are often viewed as relatively easy to implement and interpret, comparison across studies suggests that they can lead to differing results depending on the details of the approach (e.g., Bloom *et al.*, 2001; Akobundu *et al.*, 2006). Recognizing the importance of this issue, AHRQ and the National Cancer Institute (NCI) co-sponsored a 2007 workshop on related issues. The resulting papers were ultimately published in a special 2009 issue of *Medical Care* (Yabroff *et al.*, 2009). The researchers summarize the issues as follows:

“...the development of valid, reliable, feasible, and comparable (across studies) measures of health care cost has proved to be challenging, both in the United States and elsewhere. Substantial variation exists across studies in data and methods, even for cost studies with seemingly a similar intent.

³⁸ Comparison of available estimates results in WTP to COI ratios ranging from about a factor of two to a factor of 79; most are between three and six. In other words, the COI estimates are typically one-third to one-sixth of the WTP estimates for the health outcomes considered in these studies. However, it is unclear whether these comparisons reflect limitations of the underlying studies rather than solely the effects of using a COI or WTP estimate.

One major source of difficulty lies with the data. In most health cost analyses, the data for measuring and valuing resource use were created for purposes other than health care costing (primarily reimbursement) and hence are imperfectly designed for the task at hand. The alternative approach, to collect the cost data de novo, is often expensive, and there is not yet consensus on how best to do it. Health care costs are inherently difficult to measure, whatever the choice of data source(s). For multiple reasons, the posted prices of health care goods and services often do not convey accurate or useful information about economic cost. The health care system produces literally thousands of heterogeneous products, whose individual “prices” are often not observed in the complex maze of pricing for bundled services. Moreover, observed prices may reflect differences in market power between buyers and sellers (as reflected, for example, in negotiated price discounts), efforts to cross-subsidize unprofitable services, and other market imperfections and idiosyncrasies.

A second source of difficulties in health care costing is the absence of professional consensus on some data and methods issues. At a general level, there is universal agreement that the cost of any health care activity should be defined in terms of the “economic opportunity costs” of the component resources, with each resource valued in its next best use. In reality, there are substantial variations in how this textbook definition is applied because it provides little specific guidance on a number of practical issues. These include the components (or types) of cost to be included in the analysis, the assignment of opportunity cost values to these components, when and how to combine multiple data sources, key conceptual and study design issues (eg, identifying the cost attributable to a specific disease or activity), statistical challenges (eg, how best to handle heavily right-skewed cost data), and effective approaches for reporting findings.” (Lipscomb et al., 2009, p. S1.)

While these difficulties are far from resolved, researchers have been working to address these issues, often compiling data from several sources to provide a more complete picture of the lifetime costs associated with different health conditions. In the same *Medical Care* issue, Lund et al. (2009) provide a comprehensive inventory of the data sources that can be used to estimate these costs, including 88 such sources. Later in this chapter, we provide examples of how these sources have been used to estimate the costs associated with nonfatal injuries.

Thus averted cost estimates are a well-understood concept, and are a widely-used and relatively easy to implement method for valuing health risk reductions. While not a direct estimate of WTP, they indicate the costs potentially averted by decreased incidence of illness or injury. Because they exclude the value of avoiding quality of life impairments and pain and suffering, averted costs are widely believed to understate WTP. However, factors such as the availability of health insurance complicate this relationship, and more

work is needed to better understand the relationship between averted costs and WTP for particular illnesses and injuries. Because there is not complete agreement on the most appropriate way to measure these costs for application in policy analysis, discussion or quantitative assessment of the effects of uncertainty in the estimates is generally desirable.

3.1.3 MONETIZED QUALITY-ADJUSTED LIFE YEARS

Another approach for valuing health risks in policy and regulatory analysis involves applying monetized QALYs. QALYs are a non-monetary measure of the effects of injury or illness on the quality of life over time. They allow analysts to combine the impacts of various conditions into a single measure, that can encompass fatalities as well as nonfatal conditions. Originally developed for use in ranking or prioritizing public health problems and in analyzing the cost-effectiveness of health policy and medical treatment decisions, QALYs are at times combined with dollar values and used for valuation in regulatory benefit-cost analyses. However, the methods used are not entirely consistent with the underlying economic theory, and the results are not equivalent to estimates of individual WTP. In addition, many available QALY estimates do not meet current “best practice” recommendations for use in regulatory analysis.

Conceptually, QALYs focus on an individual’s willingness to trade-off different health states and longevity. These trade-offs are usually represented by placing the health-related quality of life (HRQL) impacts of each state on a scale anchored by death (a value of “0”) and by perfect or optimal health (a value of 1.0). For example, a very minor injury could lead to an HRQL value close to 1.0 (assuming the individual’s health is not otherwise impaired), while a very severe injury could lead to an HRQL level close to zero. The types of quality of life impacts considered depend on the approach used, but may include physical effects (e.g., mobility limitations) as well as psychological effects (e.g., pain and anxiety). These HRQL impacts are then multiplied by the duration of the health state to estimate the associated QALYs. Using QALY estimates in benefit-cost analysis requires then determining their monetary value. Typically, this value is a constant, often based on estimates of the value per statistical life year (VSLY).

These calculations are illustrated in simple terms in Exhibit 3-1. In reality, each of these steps involves a number of complex considerations, as briefly summarized below.

EXHIBIT 3-1:

SIMPLIFIED ILLUSTRATION OF THE CALCULATION OF MONETIZED QALY GAINS

1. If “with condition” HRQL is 0.8, and “without condition” HRQL is 0.9, then the HRQL decrement attributable to the condition is 0.1.
2. If this condition persists for 5 years, then the QALY gain associated with preventing the condition is 0.5 (HRQL decrement averted = 0.1 * 5 year duration).
3. If a QALY is valued at \$200,000, then the value of this gain would be \$100,000 (0.5 QALYs * \$200,000 per QALY).

The initial step, determining the effects of the health state on HRQL, is usually completed by experts or by patients familiar with the condition. Patient data are generally preferable, although often more expensive and time-consuming to collect. This description addresses the different ways in which the condition affects the quality of life, potentially including physical limitations, social or cognitive effects, and emotional impacts. A condition could be described, for example, as significantly limiting mobility, preventing involvement in one’s usual activities, leading to moderate pain or discomfort, and creating mild anxiety or depression.

These HRQL impacts are weighted and placed on a scale anchored “0” (representing a state equivalent to death) and 1.0 (representing perfect or optimal health), assigning intermediate values to other health states, with lower values for more severe conditions. (Values below zero are possible for health states ranked as worse than death.) The placement of health states on this scale is determined by asking individuals to rank or compare the condition to other health states, indicating their relative preferences for each condition.³⁹

The third step, multiplying the HRQL impacts by duration, is relatively straightforward. The weighted HRQL results (i.e., the values on the zero-to-one scale) are simply multiplied by the estimated length of time each health state is likely to be experienced, taking into account the remaining life expectancy of the affected individuals.

This process can be implemented using new primary research; e.g., by surveying the affected population to ascertain their HRQL estimates for the health conditions of concern. However, analysts often rely on other approaches that require less time and funding to implement. One frequently used option is to apply one of several generic HRQL indices, which employ standardized classification systems with several

³⁹ Researchers generally apply one of three stated preference methods to determine the relative weights (or preferences) for each State. These methods include: standard gamble (trade-offs between different health risks); time trade-off (trade-offs between time spent in different health states); or category weighting (locating each condition on a visual analog or similar scale). Another approach is the person trade-off method (trade-offs between health improvements affecting different groups of people).

dimensions.⁴⁰ For example, one frequently-used index, the EuroQol (EQ)-5D includes the dimensions of mobility, self-care, usual activities, pain, and anxiety and depression. A particular health state is rated within each dimension; for example, as causing no, some, or extreme problems. Each attribute of the health state (such as having “some” problems with mobility) is then weighted based on a survey developed especially for that index. These indices have the advantage of standardizing the approach for describing each health state and including pre-established weights for each attribute.

The process ends here when QALYs are used in cost-effectiveness analysis, or for ranking or prioritizing public health problems, but another step is needed for benefit-cost analysis: the QALY estimates must be assigned a dollar value. Analysts often assume that the value of a QALY is a constant, derived from estimates of the value per statistical life (VSL). As discussed in more detail below, the VSL is simply a conventional way of expressing individual WTP for fatality risks: it is equal to WTP for a small risk change (e.g., 1/10,000) within a defined time period, divided by the risk change. It is not the value of saving an individual’s life.

This VSL is then typically converted into a constant VSLY by dividing it by the expected number of life-years remaining for an individual of mean age in the underlying study. (In these calculations, life-years are typically discounted to reflect time preferences.) In other words, if a study yields a mean VSL of \$6.0 million, the mean individual in that study is age 40, and mean (population) life expectancy for an individual who reaches age 40 is an additional 35 years, the estimated VSLY would be \$279,000 using a three percent discount rate. This VSLY is then applied to the QALY gains associated with a policy or regulation.

While the use of QALYs for cost-effectiveness analysis and for prioritizing health policy interventions is well-established, their monetization and use in benefit-cost analysis has been subject to criticism. This criticism relates both to improving current practices for estimating QALYs and to questioning the assumption that their value is a constant.

First, QALYs are not entirely consistent with the framework for benefit-cost analysis. As discussed in Hammitt (2002), the construction of QALYs assumes that how individuals value health states is independent of the duration of the state, the age of those affected, and their remaining life expectancy. These assumptions that are not necessarily supported by economic theory nor by WTP research (see, for example, Haninger and Hammitt 2011). In addition, QALYs reflect only how individuals trade-off different health states and longevity; they do not reflect the trade-off between spending on health improvements and spending on other goods or services. Thus they do not reflect the trade-offs implicit in government policies or regulations, which generally require deciding whether to spend money on reducing the risks of concern or allowing those affected to use the money for other purposes.

⁴⁰ In addition to the EuroQol (EQ)-5D, commonly used indices include, the Health Utilities Index (HUI), the Quality of Well-Being (QWB) scale, and the Short Form (SF)-6D.

A second set of issues relates to improving the methods used to estimate QALYs. In 2006, an expert panel convened by the Institute of Medicine (IOM), and funded by a consortium of Federal agencies, published a report on the use of QALYs in regulatory cost-effectiveness analysis (IOM, 2006). That report includes several recommendations for improving QALY measurement, which have not yet been integrated into the official OMB guidance nor fully implemented across all regulatory agencies. The recommendations related to the construction of QALY estimates are provided in Exhibit 3-2; the report also includes recommendations on how the results of cost-effectiveness analyses are reported and used, as well as recommendations for further research.

EXHIBIT 3-2: RECOMMENDATIONS FOR DEVELOPING QALY ESTIMATES FOR USE IN REGULATORY ANALYSIS (IOM, 2006)
<p>“Recommendation 1: Regulatory CEAs [cost-effectiveness analyses] that integrate morbidity and mortality impacts in a single effectiveness measure should use the QALY to represent net health effects.</p> <ul style="list-style-type: none"> • QALY estimates should be based, to the greatest possible extent, on research that considers the risk characteristics addressed and the population affected by the regulatory intervention. • The index values estimated for health conditions or health states of interest should be based on information from the population affected by the costs, benefits, or other impacts of the regulatory intervention, which for most economically significant regulations will be best represented by the general U.S. population. • In the absence of direct preference elicitation for health conditions of interest from the affected population, QALY estimates should be based on well-developed, generally accepted, and widely used generic HRQL indexes, whose valuation is based on general population samples. • The characterization of the health states or conditions of interest using generic HRQL indexes should be based on information obtained from people who are familiar with the conditions, such as patients.” <p>“Recommendation 3: The life-year and QALY estimates used in regulatory analyses should reflect actual population health as closely as possible, comparing the predicted HRQL and life expectancy of the affected population in the absence of the intervention (i.e., the regulatory baseline) to the predicted postintervention HRQL and health-adjusted life expectancy.”</p>

Source: Extracts from IOM (2006), pp. 11-12.

These recommendations address three limitations of many previously developed QALY estimates. First, descriptions of the effects of a health condition on HRQL are often developed based on the opinions of medical experts or others, which may differ from the views of patients who have experienced the effect. Second, the weights placed on

different health states (i.e., their placement on the zero-to-one scale) are often derived from small subpopulations, not from the populations likely to be affected by the costs, benefits, or other impacts of Federal interventions. Particularly in the case of major Federal regulations, the affected population may be more similar to the general U.S. population than to the small samples used in many QALY studies.⁴¹ Third, many studies compare health status with the condition to perfect or optimal health (HRQL of 1.0), whereas the population affected may not be in perfect health even in the absence of the condition of concern. For example, health status generally declines with age; in the absence of a boating-related injury, we would not necessarily expect a middle-aged or elderly individual to be in perfect health.

The third set of issues relates to assigning monetary values to a QALY. There is substantial evidence that the VSLY, and the value of a QALY, may not be constant. Much of this research focuses on the extent to which an individual's WTP for risk reductions varies depending on their age. As discussed in Hammitt (2007), there is little theoretical basis for assuming that the VSL or VSLY increases, decreases, or remains the same at different ages. Some argue that the relationship between VSL and age should follow the pattern of consumption over the lifecycle, which is typically an inverse-U: increasing with age in early adulthood, peaking in middle age, and then declining.⁴² Studies focused on individuals older than working-age find less consistent results.⁴³ As a result, two U.S. expert panels have recommended against the use of a constant VSLY in policy analysis (Cropper *et al.*, 2007; National Academies, 2008). This research and related recommendations indicate that the practice of assuming that the monetary value of a QALY is constant regardless of the age of those affected leads to results that will not reflect the preferences of those affected.

Recent research that explicitly considers WTP per QALY also finds that this value is not a constant for reasons other than the age of those affected. For example, Haninger and Hammitt (2011) find that the value also depends on the magnitude of the expected QALY gain and the duration of the effect. More studies are needed to explore this relationship; however, this type of research eventually may be useful in creating a (non-constant) valuation function for QALYs that can be directly applied in regulatory analysis.

The concerns discussed above led the IOM (2006) expert committee to recommend that QALYs (or health-adjusted life years (HALYs) more generally) should not be assigned monetary values, as indicated below.

⁴¹ Over the past five years, researchers have completed a number of new studies that provide U.S. weights for the generic indices referenced earlier. Researchers are now beginning to incorporate these weights when developing new QALY estimates, but most of the QALY literature relies on older weighting schemes based on smaller subpopulations.

⁴² The relationship between wages and job-related risks generally follows this pattern, although Aldy and Viscusi (2007) find that the rate of increase and decrease and the age at which VSL or VSLY peaks varies across studies.

⁴³ Krupnick (2007) finds that some stated preference studies of older individuals do not find statistically significant relationships between age and the VSL, while others find that the VSL decreases among older individuals in varying patterns and amounts.

“Recommendation 7: Regulatory analyses should not assign monetary values to estimates of HALYs as a method for valuing health states.”

“...Although the Committee recognizes that in the short term, regulatory agencies might continue this practice of using monetized QALY values in BCAs [benefit-cost analyses] due to the lack of willingness-to-pay estimates for morbidity effects, we disapprove of and discourage this practice...willingness-to-pay and HRQL valuation and measurement have developed out of distinct disciplinary and methodological traditions. Given their different theoretical underpinnings and the different types of trade-offs they consider, it is misleading to combine them.” (IOM, 2006, p. 181)

Thus the practice of including monetized QALYs in benefit-cost analysis arose out of the need to find proxies for individual WTP for health risk reductions, particularly for nonfatal illnesses or injuries given that few WTP estimates are available for these effects. While QALYs are useful for cost-effectiveness analysis and for prioritizing interventions, their appropriateness for application in benefit-cost analysis is more questionable. Whether monetized QALYs accurately represent WTP for reductions in nonfatal risks is uncertain, given issues related to their consistency with individual preferences for trading-off income and risk reductions, to how QALYs are estimated, and to their monetary value.

3.1.4 IMPLICATIONS FOR COAST GUARD ANALYSES

The discussion above suggests that ideally both fatal and nonfatal injury risks would be valued in benefit-cost analyses using estimates of WTP. WTP is the measure most consistent with theory, captures the full suite of attributes associated with risk reductions, and mimics the types of trade-offs implicit in policy or regulatory decisions. More specifically, WTP reflects the trade-off between income (or the ability to purchase other goods and services) and risk reductions, not simply averted costs nor the trade-offs between different health states implicit in QALY measurement. WTP also incorporates preferences for different population and risk characteristics (e.g., the age of those affected, the extent to which the risk is voluntarily incurred) in addition to impacts on quality of life and longevity, and allows for values that vary with duration, rather than assuming they are constant.

As discussed below, Coast Guard and other Federal agencies currently have well-established approaches for valuing fatality risks based on WTP estimates, but often rely on other measures for valuing nonfatal injury risks. We next introduce the approaches used by Federal agencies, then describe how we researched and developed alternative approaches for valuing nonfatal injuries for potential use in Coast Guard analyses.

3.2 APPROACHES USED IN FEDERAL REGULATORY ANALYSES

The approach used to value risk reductions in Federal regulatory analyses is determined, at least in part, by guidance issued by OMB to implement Executive Order 12866, as supplemented by Executive Order 13563 (58 FR 51735; 76 FR 3821). This guidance is contained in OMB's Circular A-4, *Regulatory Analysis* (2003), and clarified in OMB (2010a) and Sunstein (2011). The guidance discusses how to value health risk reductions in both benefit-cost and cost-effectiveness analysis.

For benefit-cost analysis, Circular A-4 notes that estimates of WTP based on the preferences of the affected population are the most appropriate measure of benefits, consistent with the discussion in the prior section. The Circular indicates that estimates from well-conducted revealed preference studies may be preferable to those based on stated preference studies, but that professional judgment is needed to determine which approach is best. The Circular provides criteria for evaluating the quality and applicability of each type of study.

Circular A-4 also indicates that WTP estimates are preferred over COI measures. However, individual WTP may only include the private gains or losses that accrue directly to the individual who would receive the risk reduction. In such cases, Circular A-4 suggests that it may be desirable to add the medical costs financed by third parties, and/or productivity costs not experienced by the affected individuals, to the estimates of WTP. Circular A-4 also supports the use of monetized QALYs for valuation when WTP estimates are not available. However, as discussed above, an IOM committee commissioned by OMB and other Federal agencies subsequently (in 2006) recommended against the use of monetized QALY measures.

The Circular provides Federal agencies with some flexibility in determining the valuation approaches that they use in their regulatory analyses. The approach ultimately applied results from negotiation between OMB and the agency when OMB reviews a rule and the accompanying analysis prior to promulgation. Although increased standardization across agencies is one of the stated goals of Circular A-4, agencies currently vary in how they value fatal and nonfatal risk reductions.

As discussed in more detail in Robinson and Hammitt (2011), for mortality risks Federal agencies rely largely on revealed preference studies that consider the additional compensation received by workers for more risky jobs. However, the studies each agency uses, and the resulting estimates, vary to some extent. For nonfatal risks, some agencies rely on WTP estimates, using averted cost estimates as rough proxies when necessary. Others combine averted cost estimates and monetized QALYs. Below, we discuss the range of approaches, including the approaches now used by DHS generally and Coast Guard in particular.

3.2.1 VALUE OF MORTALITY RISK REDUCTIONS

For mortality risks, all Federal agencies now rely on estimates of WTP, conventionally converted into VSL estimates as introduced earlier. The starting point is an estimate of individual WTP for a small risk reduction in a particular time period; e.g., for a one-in-

ten-thousand change in the chance of dying in the current year. This WTP is then divided by the risk change to estimate the individual's VSL. Alternatively, this WTP can be multiplied by a population risk change to determine the value of a community-wide risk reduction.

For example, if an individual is willing to pay \$600 for a 1 in 10,000 reduction in his or her risk of dying in the current year, then his or her VSL is calculated as:

$$\begin{aligned} & \$600 \text{ individual WTP} \div 1/10,000 \text{ annual risk change} \\ & = \$6.0 \text{ million VSL} \end{aligned}$$

Alternatively, if \$600 is the average WTP for this risk reduction across all affected individuals, and the number of affected individuals is 10,000, then aggregating these values leads to the same VSL:

$$\begin{aligned} & \$600 \text{ average individual WTP} \times 10,000 \text{ affected individuals annually} \\ & = \$6.0 \text{ million VSL} \end{aligned}$$

VSL is not the value of an individual's life; it is simply the conventional way to express the value of small risk reductions.

OMB Circular A-4 (2003) notes that the then-available research suggested that VSL is generally between roughly \$1 million and \$10 million (no dollar year reported). OMB allows agencies some discretion in determining which VSL estimate best fits their regulations, and most now use central values somewhat above the middle of this range. Of these agencies, the U.S. Environmental Protection Agency (EPA) historically has been responsible for the majority of the regulations that include quantified mortality risk reductions and has devoted considerable attention to the valuation of these risks. The DOT, U.S. Food and Drug Administration (FDA), and DHS have also promulgated a number of economically significant regulations that address fatality risks in recent years (OMB, 2010b). We summarize the current approaches of these agencies below; other agencies generally rely on similar approaches.

The EPA now relies on a default central VSL of \$7.9 million (in 2008 dollars) based on a literature review conducted in the early 1990s (EPA, 2010a). Most of the underlying studies (21 out of 26) consider the trade-off between job-related risks and wages; the remaining (5 out of 26) are stated preference studies that focus on other types of risks. EPA is currently considering revising these values: its Science Advisory Board (Kling *et al.*, 2011) recently reviewed a White Paper (EPA 2010b) on changes to its approach; however, these changes have not yet been implemented.

FDA applies EPA's central estimate in its recent analyses (e.g., FDA's cigarette warning rule at 75 FR 69524). As of 2009, DOT's central value was somewhat lower, \$6.0 million (2008 dollars), based on review of three meta-analyses and one wage-risk study (DOT, 2009). Most of the studies included in the meta-analyses also consider the trade-off between wages and job-related risks.

DHS generally relies on a VSL of \$6.3 million (2007 dollars), based on a review conducted in 2008 (Robinson, 2008; Robinson *et al.*, 2010).⁴⁴ After considering the quality and applicability of the available research, that review determined that substantially more research would be needed to develop a VSL tailored specifically to particular DHS programs or policies. Instead, it recommends that the VSL be transferred from a recent "best practices" wage-risk study, Viscusi (2004), updating the results for both inflation and real income growth. This approach is very similar to the approaches used by other agencies, in that it relies on a study of job-related risks, and results in a similar estimate. However, it recognizes that the data and methods used in these studies have improved in recent years.⁴⁵ The \$6.3 million VSL continues to be used by DHS in general, and by Coast Guard in particular, in their regulatory analyses.

3.2.2 VALUE OF NONFATAL RISK REDUCTIONS

The approaches used by Federal agencies to value nonfatal risk reductions are more diverse than the approaches used to value fatality risks. While OMB recommends that agencies apply estimates of individual WTP, such estimates are lacking for many of the nonfatal risks of concern in Federal policy and regulatory analysis, and agencies differ in the approaches they use as proxies. We first provide examples of the estimates used by other agencies, then discuss the approaches currently used by the Coast Guard when assessing recreational boating safety regulations.

The diversity of approaches is illustrated by the practices of the major regulatory agencies. Generally, EPA applies WTP estimates to the extent possible and relies on averted cost estimates only when necessary (see, for example, EPA, 2011). In contrast, both FDA and DOT routinely use monetized QALYs in their analyses. FDA first estimates the QALY gains associated with each regulatory option, then monetizes them using a constant value per QALY, testing the effects of a range of estimates to reflect associated uncertainties (see, for example, 75 FR 69524). DOT follows a somewhat different approach. It first categorizes injuries by severity, then calculates both the economic costs and monetized QALY losses associated with injuries in each category (e.g., Blincoe *et al.*, 2002). While FDA's values are not necessarily standardized across

⁴⁴ In addition, that review suggests that a range of \$4.9 million to \$7.9 million be used in sensitivity or probabilistic uncertainty analysis.

⁴⁵ The older studies used to develop the EPA estimates, as well as the studies included in the meta-analyses used to develop the DOT estimates, use less reliable sources of fatality risk data and less sophisticated econometric models, as discussed in detail in Cropper, Hammitt, and Robinson (2011).

analyses, the DOT applies the same values in all its analyses once they are established for each transportation mode (e.g., trucks, automobiles).

Because the Coast Guard is interested in injury risks, and EPA and FDA are interested largely in risks of illness, below we focus on the approach for valuing injuries now used by DOT. Of the DOT agencies, the National Highway Traffic Safety Administration (NHTSA) promulgates the largest number of economically significant rules (OMB, 2010b). Thus we illustrate the DOT approach by describing how NHTSA values nonfatal injuries in recent regulatory analysis.⁴⁶ We also briefly summarize the approach used by the Occupational Safety and Health Administration (OSHA), which also addresses injury risks but less frequently promulgates economically significant regulations, and uses a substantially different approach.

In its recent regulatory analyses (e.g., NHTSA, 2009), NHTSA updates an approach described in Blincoc *et al.* (2002) to reflect 2007 price levels. It converts injuries to “equivalent lives saved” (ELS) based on their relative dollar values, including both economic costs and monetized quality of life impacts. In other words, ELS is a fractional value that indicates the relationship of nonfatal injuries to fatalities. For example, if an injury has an ELS ratio of five percent, this means that its dollar value is five percent of the value of a life saved, and averting 20 such injuries would have the same value as averting one fatality.

While NHTSA first developed this approach to support its cost-effectiveness analyses, it now also uses it for its benefit-cost analyses. The agency calculates ELS ratios for a given year for different injury categories (based on data from motor vehicle crashes that occurred in that year), then uses the ratios for each injury category in its subsequent rulemakings.

NHTSA’s approach includes the following steps (Blincoc *et al.*, 2002; Robinson, 2004).

1. NHTSA collects data on a sample of crash-related injuries and categorizes them using the Abbreviated Injury Scale (AIS), which is a simple numerical system for ranking and comparing the severity of crash-related injuries in terms of their threat to life. A score of “0” indicates that there were no injuries, whereas a score of “6” indicates that the injury was likely to be immediately fatal; intermediate scores of 1 through 5 indicate injuries of increasing severity. When an individual experiences multiple injuries, the case is scored according to most life-threatening injury; i.e., the Maximum AIS or MAIS.
2. NHTSA then estimates the per person economic costs of crashes for the injuries in each MAIS category. Injury-related costs include those related to medical treatment, emergency services, lost workplace and household productivity,

⁴⁶ As discussed in Robinson (2007a), the Federal Motor Carrier Safety Administration and the Consumer Product Safety Commission also use approaches that combine estimates of averted costs and monetized QALYs, but focus on different causes and categories of injuries.

employer replacement of disabled workers, litigation, and administration of insurance claims.⁴⁷

3. NHTSA next estimates the HRQL impacts of the injury, focusing on changes in functional status over time, based on an approach described in Miller *et al.* (1991) and Miller *et al.* (1995).⁴⁸ If a case involves more than one injury, it is characterized by the injury associated with the largest quality of life decrement. The HRQL estimates that result from this index are then combined with information on duration and life expectancy to estimate the QALYs associated with each case.
4. NHTSA then multiplies the estimates of QALY losses by the VSLY, after first subtracting the value of after-tax wages and household production from its VSL estimate to address concerns about double-counting.⁴⁹ The resulting value is added to the economic costs (from step 2) to determine the total (or “comprehensive”) average cost per case for injuries in each MAIS category.
5. Finally, NHTSA divides the comprehensive dollar value for each nonfatal MAIS category by the value of a fatality to estimate the ELS ratio for injuries in each category.

For cost-effectiveness analyses, NHTSA then sums the ELS estimates across MAIS categories (including both fatal and nonfatal injuries), and divides the costs of the rule by the number of equivalent lives saved. For benefit-cost analyses, NHTSA multiplies the ELS estimates by the value per fatality to determine the total monetary value of related benefits, then subtracts the costs of the rule to estimate net benefits.

The values NHTSA has used recently, as reported in NHTSA (2009), are provided in Exhibit 3-3 below. These estimates are based on DOT’s 2007 VSL of \$5.8 million, rather than the 2008 estimate of \$6.0 million noted earlier. NHTSA adjusts the VSL for productivity changes (adding updated estimates of after-tax wages and household production, replacing the estimates subtracted under step 4 above), resulting in a value per fatality of \$6,104,611. As illustrated by the exhibit, NHTSA estimates that the total value (economic and quality of life combined) of an injury in the least severe category is \$16,798. Because \$16,798 is 0.28 percent of the per fatality value (i.e., of \$6,140,611), NHTSA assumes that each injury in this category is equivalent to 0.28 percent of a life saved.

⁴⁷ NHTSA’s approach also includes “non-injury” values (i.e., travel delays and property damage associated with motor vehicle crashes) as well as the injury-related values discussed in this section.

⁴⁸ NHTSA is now revising the QALY estimates used to develop these values, but the results are not yet available. (Personal communication with P. Belenky, on March 18, 2011.)

⁴⁹ Lost productivity is included in the economic costs discussed under step 2.

EXHIBIT 3-3: NHTSA VALUES FOR INJURIES AND FATALITIES (COSTS PER CASE, 2007 DOLLARS)

SEVERITY CATEGORY (EXAMPLES)	INJURY RELATED COSTS ¹ (A)	QUALITY OF LIFE IMPACTS ² (B)	COMPREHENSIVE COSTS (C = A + B)	RELATIVE FATALITY RATIO ³ (D = C/\$6,104,611)
MAIS 1: Minor Injury (whiplash, bruise, broken tooth)	\$7,680	\$9,118	\$16,798	0.0028
MAIS 2: Moderate Injury (closed leg fracture, finger crush)	\$79,412	\$186,525	\$265,937	0.0436
MAIS 3: Serious Injury (open leg fracture, amputated arm, major nerve laceration)	\$228,468	\$262,189	\$490,657	0.0804
MAIS 4: Severe Injury (partial spinal cord severance, concussion with neurological signs - unconscious less than 24 hours)	\$434,999	\$784,778	\$1,219,777	0.1998
MAIS 5: Critical Injury (complete spinal cord severance, concussion with neurological signs - unconscious more than 24 hours)	\$1,388,460	\$2,674,628	\$4,063,088	0.6656
MAIS 6: Immediately Fatal	\$1,214,812	\$4,889,799	\$6,104,611	1.0000

Sources:

MAIS examples are from Miller *et al.* (1991), p. 10.

Dollar values are from NHTSA (2009) Table C-2, p. 207, and exclude travel delays and property damage.

Notes:

1. Includes medical treatment, emergency services, lost workplace and household productivity, replacement costs for workers with disabilities, legal and court fees from litigation, and administration of insurance claims.
2. Reflects monetized QALY losses.
3. Relative values are calculated by dividing the comprehensive costs for the MAIS category by the dollar value of a fatality. This later value is based on a VSL of \$5.8 million adjusted for productivity changes. These fractions are then used in the calculation of equivalent lives saved.

The values discussed above have not yet been incorporated into the DOT-wide guidance, which reflects factors based on much older research (Miller *et al.*, 1988) and suggests that they be applied to current VSL estimates (DOT, 2009, p. 8).⁵⁰ Exhibit 3-4 compares the older and newer factors by MAIS level. This comparison suggests that the use of newer data noticeably affects the results, increasing the ratios in all nonfatal injury categories other than MAIS 5. The ratio for MAIS 6 remains the same by definition, because fatalities are always represented by an ELS of 1.0.

EXHIBIT 3-4: COMPARISON OF NHTSA AND DOT RELATIVE FATALITY RATIOS

SEVERITY CATEGORY	“OLD” RELATIVE FATALITY RATIOS ^A	“NEW” RELATIVE FATALITY RATIOS ^B
MAIS 1: Minor	0.0020	0.0028
MAIS 2: Moderate	0.0155	0.0436
MAIS 3: Serious	0.0575	0.0804
MAIS 4: Severe	0.1875	0.1998
MAIS 5: Critical	0.7625	0.6656
MAIS 6: Fatal	1.0000	1.0000

Sources:

- a. DOT (1993), DOT (2008), DOT (2009); based Miller, Brinkman and Luchter (1988) analysis of motor vehicle crashes.
- b. NHTSA (2009), p. 118-119; based on Blinco *et al.* (2002) analysis of motor vehicle crashes in the year 2000, updated for inflation and for changes in the VSL.

Note:

Values include averted costs and monetized QALYs. DOT and NHTSA are currently considering updates to these ratios.

As noted earlier, OSHA promulgates relatively few economically significant rules, but includes nonfatal injury values in assessing a recent regulation addressing the safety of construction cranes (75 FR 47906). In that analysis, it applies a value per statistical case of \$50,000 per serious injury in 2000 dollars, inflated to \$62,500 in 2010 dollars. The source of the estimate appears to be WTP estimates from the same Viscusi and Aldy (2003) meta-analysis that OSHA uses as the basis for its VSL, although detailed information on the derivation of the estimate is not provided.⁵¹

⁵⁰ This means that the DOT (2009) factors reflect older averted cost estimates as well as QALYs monetized using DOT’s previous VSL (\$3 million). In contrast, the NHTSA (2009) estimates inflate averted cost estimates from the year 2000 and monetize QALYs using a more recent DOT VSL (\$5.8 million).

⁵¹ Different agencies use differing values from the Viscusi and Aldy meta-analysis. While it is one of the four studies that underlie the DOT VSL, OSHA uses a higher VSL (\$8.7 million in 2010 dollars) in its crane and derrick safety rule (75 FR 47906).

In the Viscusi and Aldy (2003) analysis, the authors review VSL estimates from revealed preference research conducted around the world, and also identify 40 studies that consider the relationship between nonfatal risks and wages. Of these latter studies, 31 were conducted in the United States and the remaining nine were conducted in other countries. While the publication dates for the U.S. studies range from 1974 through 2001, the underlying data are older; the earliest were collected in 1960 and the most recent in 1994.⁵² Because of labor market participation patterns and decisions made by the researchers, the data are primarily for working-aged males.

In these studies, the risk variable is defined as either the overall injury rate, the rate for only injuries severe enough to result in a lost workday, or the rate of total lost workdays. When converted from WTP estimates to the value per statistical case, Viscusi and Aldy report that most of the estimates are in the range of \$20,000 to \$70,000 per injury (2000 dollars), with several larger values.⁵³ Thus while they find that value of a nonfatal injury is uncertain, the range they identify encompasses the value reported in OSHA's crane and derrick safety rule (75 FR 47906).

Thus NHTSA and OSHA use very different methodologies for valuing nonfatal injuries, reflecting the flexibility provided by the OMB guidance as well as differences in the types of injuries each addresses. NHTSA combines estimates of averted costs and monetized QALYs for different injury categories for motor vehicle accidents, while OSHA uses a single estimate, based on estimates of individual WTP for serious job-related injuries. Applying either approach to recreational boating would involve transferring estimates across contexts; i.e., from motor vehicle accidents or job-related risks to boating accidents. While OSHA's reliance on WTP estimates is more consistent with the benefit-cost analysis framework discussed earlier, the NHTSA approach better discriminates between the values of injuries that differ in severity. Both approaches are based on relatively outdated data and methods, and it is unclear how the use of more recent studies that follow current "best practices" would affect these values.

The approach used by the Coast Guard in its recreational boating safety regulatory analyses is very similar to the approach used by NHTSA, which is not surprising given that Coast Guard was part of DOT from 1967 until it moved to DHS in 2003. Two examples are provided in the case studies in Chapter 5, which describe the approach and the results of the analysis in more detail. Both case studies rely on the "old" DOT factors (currently reflected in the DOT guidance), as listed in the second column of Exhibit 3-4. As noted above, that DOT guidance has not yet been updated to reflect the more recent factors now applied by NHTSA. We discuss the process for updating the newer NHTSA estimates to reflect changes in the VSL in more detail in Appendix D.

⁵² As discussed in Cropper, Hammitt, and Robinson (2011), the older data and methods used in these analyses leads to significant uncertainty in the VSL, and will also affect the validity and reliability of the values for nonfatal risks. Newer studies rely on improved data and methods.

⁵³ Of the 31 U.S. studies, values were not available from six. For the remaining 25 studies, eight report values that are outside of this range – many of which are well over \$100,000 per statistical injury.

3.2.3 CONCLUSIONS

The Coast Guard has a well-established approach for valuing fatal injuries that applies a VSL derived from WTP estimates from recent research. While Federal agencies vary in the VSLs they use, the Coast Guard estimate is based on similar research and is within the range applied by other Federal agencies. However, the Coast Guard approach for valuing nonfatal injuries is based on relatively old data that addresses injuries from motor vehicle accidents rather than from boating. That approach combines monetized QALYs with estimates of averted costs, consistent with the approach that DOT has used for many years.

The use of monetized QALYs has been questioned recently, as discussed in detail in Section 3.1.3. Because of these concerns, we focus on the use of averted cost estimates as an alternative rough proxy for WTP in the discussion that follows, after confirming that suitable WTP estimates are not available.

NHTSA's approach for estimating QALYs was developed before new best practice guidance became available in IOM (2006), and NHTSA is now in the process of updating its QALY estimates to reflect methodological improvements. In addition, advances in medical technology and treatment will influence the effect of nonfatal injuries on the quality of life, as well as the duration of the recovery period, and hence will result in changes in the QALY gains associated with risk reductions. Thus, if Coast Guard is interested in supplementing averted cost estimates with monetized QALYs, either as sensitivity analysis or for comparison with past analysis, it may wish to rely on NHTSA's newer estimates when they become available, as discussed in the final section of this chapter.

3.3 ALTERNATIVE VALUES FOR NONFATAL INJURIES

Identifying approaches for valuing the nonfatal injury risks averted by recreational boating safety policies and regulations requires considering both the quality of the available studies and the suitability of the estimates for this particular context. For quality, the initial question is the extent to which the method used for valuation is consistent with the benefit-cost analysis framework; i.e., whether the approach is based on WTP, averted costs, or monetized QALYs, as discussed in Section 3.1. Within each of these approaches, quality considerations include whether the study adheres to generally-accepted best practices and was peer-reviewed, as well as the accuracy of the underlying data, the appropriateness of the statistical analysis, and the evidence that the results are valid and reliable.

Suitability includes whether the study addresses injuries similar to the types of injuries associated with recreational boating accidents, as discussed in Chapter 2. Because these injuries are diverse, we focus on approaches that use a consistent method to estimate the value of injuries that vary in type and severity. Ideally, such studies would report results disaggregated by type of injury, so that the values for each injury category can be weighted to reflect the distribution of injuries likely to be averted by a particular policy or

regulation. In addition, values for the U.S. population are preferable, given that such values are likely to vary across countries due to cultural differences, characteristics of their health care systems, and other factors.

The starting point for our review is a report on valuing nonfatal injuries previously prepared for DHS (Robinson, 2007a). That report was not intended as a comprehensive literature review, but discussed alternative approaches to valuation and provided examples of each approach. For this project, we then conducted key word searches of bibliographic databases including EconLit, PubMed, and Google Scholar, to identify additional research. We also contacted selected researchers to determine whether they were aware of any potentially useful studies, including those that have not yet been published. In general, we focused on studies published in the year 2000 and later, because such studies rely on more recent data and often reflect methodological improvements. Below, we first briefly summarize the results of this search, then discuss selected studies in more detail.

3.3.1 GENERAL FINDINGS

Ideally, we would rely on WTP estimates for valuation in regulatory analyses. However, neither the search conducted for our 2007 report nor the search conducted for this report identified studies that provide estimates for the range of injury categories addressed by recreational boating policies and regulations. The studies we identified generally provided a single value for a wide range of injuries, such as the Viscusi and Aldy (2003) study discussed in Section 3.2.2, and/or were conducted outside of the United States.⁵⁴ We identified only one study that provides WTP estimates for different injury categories. Henscher *et al.* (2009) estimate WTP for permanent, major, or minor injuries per person per car trip in Australia, then combine the estimates with information on traffic flows to estimate the value per statistical injury of each type. Because this study was not conducted in the United States, focuses on motor vehicle accidents rather than those associated with recreational boating, and does not directly provide values per statistical case, we do not rely on it in this report.⁵⁵ We did not identify any studies that provide WTP estimates for boating-related injuries.

Robinson (2007a) also considers studies that assess the QALY gains associated with averting different types of injuries, and Robinson *et al.* (2005) demonstrate the results of applying alternative QALY measures to motor vehicle-related injuries to children. While the options for QALY measurement are diverse, few studies provide estimates for the range of injury categories of interest for this report. For example, the small number of injury studies included in the comprehensive Cost-Effectiveness Registry maintained by Tufts Medical Center (<https://research.tufts-nemc.org/cear4/Home.aspx>) consider specific types of injuries (e.g., spinal cord injuries or tibia fractures), rather than providing

⁵⁴ For example, Hammitt and Ibarra (2006) estimate a single value for nonfatal job-related risks in Mexico City.

⁵⁵ Because the estimates are derived per person per trip, assumptions about traffic patterns are needed to convert them into estimates of the value per case averted.

consistently estimated values for a broad range of injury categories.⁵⁶ In addition, many studies that estimate QALY gains do not meet the best practice recommendations for regulatory analysis included in IOM (2006). We did not search for additional QALY studies for this report, because the problems with determining the monetary value of a QALY (as discussed in Section 3.1.3) limit their usefulness for benefit-cost analysis.⁵⁷

Our review of estimates of averted costs was more promising. While many studies focus on annual rather than lifetime costs, or are limited to particular types of injuries, two sources provide the sorts of comprehensive, disaggregate estimates that may be useful for analysis of boating safety policies and regulations.⁵⁸ The first is a book developed by CDC (Finkelstein *et al.*, 2006); the second is a CDC online calculator that became operational in February 2011, building on that book and allowing for different types of aggregation. We discuss both of these resources below.

Finkelstein *et al.* (2006) develop COI estimates for all types of injuries using a systematic approach. They present incidence-based estimates of lifetime costs per case for all injuries that occurred in the United States in 2000. These costs are reported by cause (mechanism or source of injury), including: motor vehicles and other road users; falls; struck by or against; cut or pierced; fire or burned; poisoning; drowning or submersion; and firearms or gunshot. In addition, costs are generally reported by gender, age, body region, severity, and nature of the injury as well as by whether the individual was hospitalized. The estimates are often provided both as national totals and as averages per injury episode.

For medical costs, this analysis includes on-the-scene treatment, emergency transport, hospitalization, nursing home care, rehabilitation services, and outpatient treatment. For lost productivity, it includes the value of wages and fringe benefits as well as household services. Lost productivity is assessed for first six months after injury, for after six months, and for fatalities. Short-term productivity losses reflect estimates of lost work days, whereas long-term losses reflect estimates of permanent or partial disability. In addition, the analysis considers the effects of injury on survival probabilities and includes lost productivity due to premature mortality. To categorize injuries by severity, the book uses the AIS; the same scale that underlies the NHTSA values discussed in Section 3.2.2 above. As described earlier, this is a simple numerical system for ranking injuries in terms of their threat to life.

⁵⁶ One significant exception is the NHTSA approach discussed in Section 3.2.2, which is now being updated, although it focuses on injuries related to motor vehicle accidents.

⁵⁷ However, emerging research, such as Haninger and Hammitt (2011), may eventually support the development of a function for valuing QALYs that varies depending on factors such as severity and duration, and is useful for policy and regulatory analysis.

⁵⁸ Some of the databases discussed in Chapter 2 also provide data on costs; a more complete inventory of these data sources is provided in Lund *et al.* (2009). However, these estimates would need to be aggregated across episodes or visits and across types of treatment to estimate the average lifetime costs for each injury category. Because this type of aggregation is available in the resources discussed in this section, we did not use the databases to develop independent cost estimates for this report.

Exhibit 3-5 provides an example of the data from this book, reporting incidence and direct and indirect costs by AIS category. Because the researchers do not provide estimates specific to boating, we focus on national totals for injuries from all causes. There were over 50 million cases of injury in the United States in 2000, with total lifetime costs of \$406 billion. As the exhibit illustrates, 66 percent of the cases are very minor (AIS = 1) but account for only 27 percent of the total costs, reflecting the increase in cost per injury episode as severity increases. For minor and moderate (AIS = 1 or 2) as well as fatal injuries (AIS = 6), the costs associated with lost productivity exceed medical costs – by a substantial amount in the case of fatalities. The two types of costs are more balanced for serious through critical injuries (AIS = 3 through 5).

EXHIBIT 3-5: INCIDENCE AND ECONOMIC BURDEN OF U.S. INJURIES BY SEVERITY CATEGORY (FINKELSTEIN *ET AL.*, 2006; 2000 DOLLARS; 3 PERCENT DISCOUNT RATE)

MAXIMUM AIS CATEGORY	INJURY INCIDENCE	LIFETIME MEDICAL COSTS	LIFETIME PRODUCTIVITY LOSSES	TOTAL LIFETIME COSTS
AIS 1: Minor Injury	33 million cases (66 percent)	\$31 billion (39 percent)	\$79 billion (24 percent)	\$110 billion (27 percent)
AIS 2: Moderate Injury	9 million cases (18 percent)	\$19 billion (24 percent)	\$68 billion (21 percent)	\$89 billion (22 percent)
AIS 3: Serious Injury	0.8 million cases (2 percent)	\$12 billion (15 percent)	\$12 billion (4 percent)	\$24 billion (6 percent)
AIS 4: Severe Injury	0.1 million cases (0.3 percent)	\$6 billion (7 percent)	\$5 billion (2 percent)	\$12 billion (3 percent)
AIS 5: Critical Injury	0.03 million cases (0.1 percent)	\$2 billion (3 percent)	\$3 billion (1 percent)	\$4 billion (1 percent)
AIS 6: Immediately Fatal	0.1 million cases (0.3 percent)	\$0.8 billion (1 percent)	\$142 billion (44 percent)	\$142 billion (35 percent)
AIS Unknown	7 million cases (14 percent)	\$9 billion (11 percent)	\$17 billion (5 percent)	\$24 billion (6 percent)
All Categories	50 million cases (100 percent)	\$80 billion (100 percent)	\$326 billion (100 percent)	\$406 billion (100 percent)

Source: Calculated from data presented in Finkelstein *et al.* (2006), Figures 1.5, 2.11, 4.10; Tables 1.1, 1.4, 2.4, 3.5, 3.6, 4.1.

Note:

Estimates vary somewhat depending on which tables and figures are used in the calculations, presumably due to rounding in the source document.

Detail may not add to total due to rounding.

Exhibit 3-6 provides a different break-out of the injury and cost estimates, based on whether the injury resulted in fatality, hospitalization, or no hospitalization. The estimates illustrate the interaction between the number of injuries and the unit costs per case. Fatalities are small in number but lead to large productivity losses. Non-hospitalized cases are very large in number but small in costs per case. Hospitalized cases are relatively few in number, but more costly. Overall, productivity losses are almost four times greater than medical costs, due largely to the effects of premature mortality. In total, lifetime costs for each category total between 23 and 42 percent of the total costs.

EXHIBIT 3-6: INCIDENCE AND ECONOMIC BURDEN OF U.S. INJURIES BY TREATMENT (FINKELSTEIN *ET AL.*, 2006; 2000 DOLLARS; 3 PERCENT DISCOUNT RATE)

CATEGORY	INJURY INCIDENCE	LIFETIME MEDICAL COSTS	LIFETIME PRODUCTIVITY LOSSES	TOTAL LIFETIME COSTS
Non-hospitalized	48 million cases (96 percent)	\$45 billion (56 percent)	\$125 billion (38 percent)	\$171 billion (42 percent)
Hospitalized	1.9 million cases (4 percent)	\$34 billion (43 percent)	\$59 billion (18 percent)	\$92 billion (23 percent)
Fatal	0.1 million cases (0.3 percent)	\$1 billion (1 percent)	\$142 billion (44 percent)	\$143 billion (35 percent)
All Categories	50 million cases (100 percent)	\$80 billion (100 percent)	\$326 billion (100 percent)	\$406 billion (100 percent)

Source: Calculated from data presented in Finkelstein *et al.* (2006), Tables 1.2, 2.1, 3.1, and 4.1.

Note:

Estimates vary somewhat depending on which tables and figures are used in the calculations, presumably due to rounding in the source document.

Detail may not add to total due to rounding.

The estimates in Exhibits 3-5 and 3-6 reflect all types of injuries nationally. Of the total number of injuries, the injury mechanism is identified as “other” for 33 percent, “falls” for 23 percent, “struck by or against” for 21 percent, and “motor vehicles or other road users” as 10 percent, with the remainder distributed across several other categories (Finkelstein *et al.*, 2006, Table 1.2). Separate estimates for boating-related injuries are not provided, and it is unclear whether boating would lead to the same distribution of costs across severity categories or types of treatment. In addition, costs for each category reflect the distribution of all national injuries within each severity or treatment category, and again this distribution may differ from the distribution if only boating injuries were included.

In February 2011, CDC posted a new injury cost calculator on its Web-based Injury Statistics Query and Reporting System (WISQARS) website (<http://www.cdc.gov/injury/>)

wisqars/index.html), which allows users to calculate 2005 costs for fatal or nonfatal injuries, categorized by the intent or mechanism of injury or by the body region and nature of the injury. The data include only fatal and nonfatal injuries treated in emergency departments or hospitals; injuries treated elsewhere are not included. Thus the estimates are likely to reflect relatively severe cases. Although data are available for a number of injury subcategories (including drowning), boating-related injuries are not reported separately.

Users can specify the geographic coverage for fatal injuries (United States, region, or State); for nonfatal injuries all data are available only for the entire United States. In addition, the data can be broken-out by age and gender. Both medical costs and lost work time are reported, both as totals and per case.

The methods used to develop these estimates build on the Finkelstein *et al.* (2006) report described above, and are documented in Lawrence *et al.* (2009). The starting point is fatality data from the NVSS, and data on nonfatal injuries from the NEISS-AIP, described in the prior chapter.⁵⁹ Because the data sources used to estimate costs are often categorized using ICD codes, but the injury counts are based on the NEISS, the authors develop a crosswalk for matching the NEISS and ICD codes.

For deaths, costs are estimated separately depending on whether the death occurred on-scene or at home, on arrival at a hospital, in a hospital emergency department, in a hospital after inpatient admission, or in a nursing home. For hospitalized injuries, the calculations include facilities and non-facilities charges, rehabilitation costs, nursing home costs, follow-up costs, and transportation costs. The researchers also consider the probability of hospital readmission. For most injuries, these costs are estimated for up to seven years post-injury; longer term costs are estimated for spinal cord and traumatic brain injuries. For injuries treated in emergency departments, costs include the emergency department visit, follow-up visits and medication, and transport.

While some of the cost data are taken from the 2005 HCUP-NIS and HCUP-SEDDs, a variety of other information sources are used. These include individual research studies as well as State, commercial, and other national databases. In many cases, the estimates rely on analysis original conducted by Finkelstein *et al.* (2006).

Productivity losses are calculated based on estimates of earnings by age and sex, including both paid work and household services, from Haddix *et al.* (2003). For fatalities, the estimates reflect remaining lifetime earnings. For nonfatal injuries, both short- and long-term losses are considered. For short-term disabilities, estimates of the likelihood that an injury would lead to lost work time are taken from the 1987-1996 National Health Interview Survey (NHIS), then combined with estimates of the number of work days lost from BLS' 1993 Annual Survey of Occupational Injury and Illness. For

⁵⁹ The NEISS-AIP includes all injuries treated in emergency departments nationally. However, as discussed in Chapter 2, it does not include codes that allow us to identify recreational boating injuries.

longer term losses, a variety of different data sources are used to estimate the likelihood of permanent total or partial disability.

In Exhibit 3-7, we summarize the total costs.

EXHIBIT 3-7: INCIDENCE AND ECONOMIC BURDEN OF U.S. INJURIES BY TREATMENT (CDC/WISQARS, 2005 DOLLARS, 3 PERCENT DISCOUNT RATE)

CATEGORY ^A	INCIDENCE	MEDICAL COSTS	PRODUCTIVITY LOSSES	TOTAL LIFETIME COSTS
Emergency Department Visits	27 million visits (92 percent)	\$35 billion (45 percent)	\$70 billion (25 percent)	\$105 billion (30 percent)
Hospitalized	2 million cases (7 percent)	\$40 billion (52 percent)	\$74 billion (27 percent)	\$114 billion (32 percent)
Fatal	0.2 million cases (0.6 percent)	\$2 billion (2 percent)	\$134 billion (48 percent)	\$136 billion (38 percent)
All Categories	29 million cases ^b (100 percent)	\$77 billion (100 percent)	\$278 billion (100 percent)	\$355 billion (100 percent)

Source: Based on CDC/WISQARS queries (<http://www.cdc.gov/injury/wisqars/index.html>) for all injuries, conducted in March 2011.

Notes:

- a. Excludes nonfatal injuries not treated in hospitals or emergency departments.
- b. Assumes each emergency department visit is one case; i.e., a single injury does not result in more than one visit.

Exhibit 3-7 illustrates some similar patterns to Exhibit 3-6. Fatalities are relatively few but lead to large productivity losses. Injuries that result only in emergency department visits are many but have lower costs per case. Hospitalized cases are relatively few, but more expensive. Overall, productivity losses are about three times greater than medical costs, and dominated by the effects of premature mortality. In total, lifetime costs for each category total between 30 and 38 percent of the total costs for all injuries included in the database.

The authors note that these estimates have several limitations, illustrating some of the difficulties inherent in developing averted cost estimates, as discussed in Section 3.1.2. In particular, while they attempt to rely on the best available data, the data sources used vary in quality and coverage, as well as in the year in which the data were collected. (Some data are well over 10 years old, and do not reflect recent changes in treatment options, the effects on recovery periods, or costs.) Under this approach, it is difficult to develop quantitative measures of uncertainty; and it is not possible to generate the estimates of standard errors that can be developed when working with a single sample.

While these estimates are more up-to-date than the averted cost estimates included in the NHTSA (2009) analysis discussed earlier, and are based on work by many of the same

researchers, they are not directly comparable. The estimates in Exhibits 3-6 and 3-7 include injuries from all causes rather than only those associated with motor vehicle accidents and include only medical costs and lost productivity (while the NHTSA estimates include other averted administrative costs and monetized QALYs). However, given the data that underlie the CDC/WISQARS estimates, it may be possible to use these data to develop estimates that cover all injuries based on severity (rather than treatment) to support future work.

3.4 SUMMARY OF FINDINGS AND NEXT STEPS

Determining the value of fatal and nonfatal injuries averted by recreational boating policies and regulations is a complex and difficult process. Issues include the consistency of different measures with the framework used for benefit-cost analysis, the lack of consensus on “best practices” in some areas, and limitations in the data available. Below, we first summarize our findings, then discuss possible next steps. We demonstrate the application of our findings in case studies presented in Chapter 5 and summarize our conclusions and recommendations in Chapter 6.

3.4.1 SUMMARY OF FINDINGS

As discussed in this chapter, estimates of WTP are most appropriate for use in benefit-cost analysis, but are not available for the range of injuries associated with recreational boating safety regulations. Thus while for fatal injury risk reductions, Coast Guard can rely on WTP estimates (transformed into a VSL of \$6.3 million (2007 dollars)), it must rely on other approaches to value reductions in the risks of nonfatal injuries.

These other approaches include monetized QALYs and averted costs. The approaches used to estimate QALY gains are diverse; best practice recommendations are now available to guide the use of QALYs in regulatory analysis (IOM, 2006) but have not yet been fully implemented. QALYs were originally developed for use as nonmonetary measures in cost-effectiveness analysis. For benefit-cost analysis, they must be converted to dollar values; however, the monetary value of a QALY is highly uncertain. Current estimates of monetized QALYs (as well as averted costs) are provided in Exhibit 3-3 for injuries resulting from motor vehicle accidents.

For averted costs, two recent data sources provide estimates for a range of injuries. Finkelstein *et al.* (2006) provide estimates for all injuries nationally, and the CDC/WISQARS program provides a query-based system for estimating the costs of injuries treated in emergency departments and hospitals. In Exhibits 3-8 and 3-9, we provide per case estimates from both sources. These estimates are substantially lower than the estimates reported in Exhibit 3-3, because they exclude monetized QALYs as well as averted administrative expenditures. However, they rely on newer estimates of medical costs and lost productivity.

Exhibit 3-8 provides per case estimates by MAIS category based on the data reported in Exhibit 3-5 from Finkelstein *et al.* (2006); we cannot compare these estimates to

WISQARS because it does not provide estimates by MAIS category. We include the costs of fatalities in this exhibit for completeness; however, we do not recommend these values for use in policy and regulatory analysis because of the availability of more suitable WTP estimates. As is evident from the exhibit, the costs of fatalities are dominated by lost productivity. However, overall WTP for averting the types of small mortality risks associated with boating and many other activities (expressed as VSL), is much larger than the productivity loss.

EXHIBIT 3-8: COST PER INJURY BY SEVERITY CATEGORY (FINKELSTEIN *ET AL.* 2006, 2000 DOLLARS, 3 PERCENT DISCOUNT RATE)

MAXIMUM AIS CATEGORY	LIFETIME MEDICAL COSTS	LIFETIME PRODUCTIVITY LOSSES	TOTAL LIFETIME COSTS
AIS 1: Minor Injury	\$945	\$2,391	\$3,336
AIS 2: Moderate Injury	\$2,146	\$7,606	\$9,752
AIS 3: Serious Injury	\$15,008	\$14,814	\$29,822
AIS 4: Severe Injury	\$37,354	\$32,531	\$69,885
AIS 5: Critical Injury	\$48,027	\$51,948	\$99,975
AIS 6: Immediately Fatal	\$5,336	\$944,546	\$949,882
AIS Unknown	\$1,267	\$2,460	\$3,727
All Categories	\$1,601	\$6,504	\$8,105

Source: See Exhibit 3-5.

Note:

Detail may not add to total due to rounding.

For the other severity categories, both medical costs and productivity losses increase as severity increases. For minor injuries (MAIS 1 and 2), productivity losses outweigh medical costs; however, these losses are more balanced with medical costs for injuries of greater severity (MAIS 3, 4, and 5). These estimates reflect all injuries nationally, and it is unclear whether boating accidents within each of these categories would lead to the same average costs per case.

In Exhibit 3-9, we compare per injury costs by treatment category from both data sources. Where estimates for the same category are reported in both sources, the values are relatively similar, which is not surprising given that they both result from similar methods and data sources. As expected, the WISQARS estimates are somewhat larger than the Finkelstein *et al.* (2006) estimates, because they are expressed as 2005 rather than 2000

values. The inflators used in these studies vary depending on the cost component, but overall the consumer price index increased about 13 percent between these two years.⁶⁰

EXHIBIT 3-9: COST PER INJURY CASE OR EPISODE BY TREATMENT CATEGORY

CATEGORY		LIFETIME MEDICAL COSTS		LIFETIME PRODUCTIVITY LOSSES		TOTAL LIFETIME COSTS	
		FINKELSTEIN <i>ET AL.</i> (2000 DOLLARS)	WISQARS (2005 DOLLARS)	FINKELSTEIN <i>ET AL.</i> ^B (2000 DOLLARS)	WISQARS (2005 DOLLARS)	FINKELSTEIN <i>ET AL.</i> (2000 DOLLARS)	WISQARS (2005 DOLLARS)
Non-hospitalized	Doctor's office	\$667 ^a	N/A	\$2,604	N/A	\$3,468	N/A
	Outpatient	\$891 ^a	N/A		N/A	\$3,520	N/A
	Emergency department	\$1,139 ^a	\$1,307		\$2,614	\$3,548	\$3,921
Hospitalized		\$18,042	\$20,162	\$31,402	\$36,807	\$49,444	\$56,969
Fatal		\$7,463	\$9,323	\$952,820	\$771,830	\$960,283	\$781,153

Sources:

Finkelstein *et al.* (2006), Table Appendix 2.1, Appendix 3.3, Appendix 4.1.

WISQARS queries (<http://www.cdc.gov/injury/wisqars/index.html>) for all injuries, conducted in March 2011.

Notes:

Detail may not add to total due to rounding.

a. When averaged across all non-hospitalized cases, medical costs average \$944 per case according to Finkelstein *et al.* (2006).

b. Finkelstein *et al.* (2006) do not provide a breakdown of productivity losses across injuries treated in doctors' offices, outpatient departments, and emergency departments.

For averted costs, which data source is more useful depends on the types of breakouts needed. Data from the CDC/WISQARS query system reflect some recent refinements, but are missing values for injuries not treated in hospitals or emergency departments, and do not provide estimates by MAIS category. However, the system provides estimates broken out by age and gender. The Finkelstein *et al.* (2006) book provides a wealth of data in its many tables and charts, which provide more detailed breakouts. In our case

⁶⁰ See: http://www.bls.gov/data/inflation_calculator.htm.

studies in Chapter 5, we illustrate the effects of relying on the NHTSA (2009) estimates of monetized QALYs and averted costs, and compare the results to those that result when we apply the Finkelstein *et al.* (2006) estimates, adjusting for inflation and for the VSL used by DHS in its regulatory analyses.

3.4.2 CONSIDERATIONS FOR NEXT STEPS

The above discussion indicates that the Coast Guard approach for valuing fatal injuries is well-established and consistent with the overall benefit-cost analysis framework. While VSL estimates used by Federal agencies will continue to evolve as new research becomes available, DHS' current estimate is within the range applied by other agencies and is based on similar research. In contrast, the options for valuing nonfatal injuries have significant shortcomings.

As illustrated in Chapter 5, one option is for the Coast Guard to continue to rely on currently available data for valuing nonfatal injuries, perhaps reporting a range of estimates. In Appendix D, we discuss how Coast Guard could adapt NHTSA's approach for use in its future analyses.

If Coast Guard is interested in refining these estimates to better reflect the types of nonfatal injury risks averted by boating safety policies and regulations, three options may be worth exploring: (1) contact the researchers responsible for the data that underlie the DOT/NHTSA, Finkelstein *et al.* (2006) and CDC/WISQARS estimates, to determine whether these data can be used to develop estimates tailored to nonfatal injuries from recreational boating accidents; (2) conduct new research on averted costs, relying on more recent data, improved methods, and data on boating-related rather than other types of injuries; and/or (3) conduct new research to derive WTP estimates for boating-related injuries.

The first option would be relatively easy to implement with moderate expenditure of time and effort. The various studies now used to value nonfatal injuries were conducted by many of the same authors and rely on similar data sources and methods. The underlying data sets contain more information than provided in the publicly-available reports, and the researchers may be able to provide data that are better tailored to the types of injuries associated with recreational boating. In addition, Coast Guard also may wish to contact DOT to learn more about its ongoing work to update its approach.

Developing new estimates of averted costs under the second option would require a higher level of effort, but would allow Coast Guard to update and refine the approaches used in previous analyses. As discussed in Chapter 2, many of the national databases include boating-related codes, and several also include cost estimates; sources of cost data are also summarized in Lund *et al.* (2006). The starting point for this analysis could be the approach used in Finkelstein *et al.* (2006) as well as in Lawrence *et al.* (2009) for the CDC/WISQARS cost calculator. However, the approach could be refined to reflect emerging work on best practices for developing these estimates (e.g., as discussed in Yabroff *et al.*, 2009) as well as more recent data. This approach would provide Coast

Guard with updated estimates directly applicable to its boating safety polices and potentially to other programs.

Conducting new WTP research would also require a relatively high level of effort and potentially the longest timeframe. This research would provide estimates that are more appropriate for use in benefit-cost analysis and that fully reflect the value of risk reductions associated with boating safety regulations. Such estimates could be useful for many other DHS components as well as other government agencies, and for nongovernmental organizations and scholars. However, as discussed in Chapter 2, new primary research requires OMB approval for information collection, which can significantly extend the amount of time that elapses before the data are collected.

In sum, Coast Guard has a variety of options for valuing the risk reductions associated with recreational boating regulations and policies. It could address the limitations of the available valuation approaches qualitatively, conduct simple sensitivity analysis, or collect new data through accessing existing data sources or conducting new studies.

CHAPTER 4 | PROPERTY DAMAGES

To evaluate the potential benefits of future regulatory actions and other policy options, as well as to prioritize its programs and policies, Coast Guard requires estimates of the monetary value of property damages resulting from recreational boating accidents. However, as discussed in Chapter 1, non-compliance with reporting requirements leads to substantial underreporting of these data in BARD (Maxim and Kilby, 2009). This chapter first summarizes the existing system for collecting data on property damages. Next, we briefly summarize Coast Guard's previous efforts to identify alternative sources of data. We follow with a brief description of our analytic approach for further exploring other existing sources of property damage data. The chapter concludes with our findings. Recommendations for next steps are discussed in Chapter 6.

4.1 EXISTING DATA COLLECTION SYSTEM

Coast Guard obtains property damage data primarily through BAR forms submitted by boat owners/operators to the State BLAs. Property damage data are now reported in two fields and include an estimation of the value and a description of the damages to the owner/operator's boat and to the owner/operator's other property. Coast Guard assumes that each boat owner/operator involved in an accident will complete a separate BAR form.⁶¹ States may develop their own accident report forms, but must at a minimum include all data on the Federal form.

Coast Guard collects property damage data in BARD only from what it considers "reportable" accidents. Since July 2001, under Federal regulation, the operator of a vessel must file a BAR when: (1) a person dies; (2) a person disappears from the vessel under circumstances that indicate death or injury; (3) a person is injured and requires medical treatment beyond first aid; (4) damage to vessels and other property totals \$2,000 or more; or (5) there is a complete loss of any vessel. Property damages are *not* reportable if a boat is undergoing certain activities at the time damages were incurred, such as if it is docked or moored, or if damages are from theft or vandalism.^{62,63}

⁶¹ Prior to 2009, form CG-3865 (Rev. 12-06) requested information about damage to the owner/operator's vessel and to other property; however, it did not clarify that the person submitting the form should not report losses incurred by other parties (Coast Guard, 2009).

⁶² A full list of reportable damages is available on pp. 10-11 of Coast Guard (2010).

⁶³ In some States, the minimum damage threshold for a reportable accident is lower. For example, Ohio requires reports for accidents resulting in property damages in excess of \$500. Some States include these incidents when they transfer their

Owners/operators should include information about property damages in the designated fields of the BAR regardless of the conditions triggering the need for the report. Coast Guard expects that damages of any value will be reported in incidents resulting in fatal or other injuries requiring treatment beyond first aid. However, owners/operators may not be aware of the need to estimate property damages for accidents also resulting in injuries.⁶⁴

Exhibit 4-1 summarizes the annual value of property damages reported to BARD between 2005 and 2009. Approximately 4,700 to 5,200 accidents are reported annually involving between 6,000 and 7,000 vessels. Of those accidents, approximately 16 to 39 percent resulted only in property damage; no injuries occurred. The total annual value of reported damages for all accidents ranged from \$36 million to \$55 million.⁶⁵

EXHIBIT 4-1: ANNUAL PROPERTY DAMAGES REPORTED IN BARD (2009 DOLLARS)

YEAR	REGISTERED RECREATIONAL VESSELS ¹	ACCIDENTS	VESSELS INVOLVED	TOTAL PROPERTY DAMAGES ²
2005	12,942,414	4,969	6,628	\$42,530,000
2006	12,746,126	4,967	6,753	\$46,460,000
2007	12,873,091	5,191	6,932	\$54,950,000
2008	12,692,892	4,789	6,347	\$54,080,000
2009	12,721,541	4,730	6,190	\$35,900,000

Source: Coast Guard (2006); Coast Guard (2007); Coast Guard (2008); Coast Guard (2009); Coast Guard (2010).

Notes:

1. Coast Guard notes that regulations regarding the types of vessels requiring registration vary by State. Thus these figures do not represent the total universe of recreational vessels subject to the Federal accident reporting regulations.
2. Damages adjusted to 2009 dollars using the Consumer Price Index - All Urban Consumers (CPI-U) (U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index: All Urban Consumers (CPI-U), <ftp://ftp.bls.gov/pub/special.requests/cpi/cpi.ai.txt>).
3. Coast Guard revised the BAR form at the end of 2008 to clarify that owner/operators should only report their own property damage losses. Prior to 2009, it is possible that the same damages were reported by multiple parties involved in a single accident, resulting in double-counting.

accident reports to BARD (Personal communication with T. Terry, on March 23, 2011). Prior to July 1, 2001, the Federal threshold for reporting property damages was \$500 (Coast Guard, 2003a).

⁶⁴ Representatives of NASBLA note that the current BAR form does not come with instructions. They believe that the need to include an estimate of property damages for all reportable accidents may not be clear, and collection of this information may depend on whether the State conducts an investigation of the incident (Personal communication with D. Gona and T. Terry, on March 23, 2011).

⁶⁵ Property damage losses in years prior to 2009 may be overstated if the same damages for a single accident were reported by multiple boat owner/operators involved in the accident.

Coast Guard believes that property damages are significantly underreported. A study conducted in 1995, as well as more recent interviews with experts, suggest that BARD may record as little as 5 to 6 percent of property damages for accidents where no injuries occurred.⁶⁶ The extent of underreporting for all reportable property damages, including for incidents that also resulted in injury, is unknown. Underreporting is thought to be caused, in large part, by a lack of awareness of the need to report, as well as various other reasons such as not knowing how to report the incident, and the perceived self-incriminating nature of the BAR forms (NASBLA, 2008). Furthermore, where damages are reported, their value may be inaccurately estimated at the time of the incident by owners, operators, or in the case of an investigation, law enforcement officials.

4.2 HISTORY OF PROPERTY DAMAGE RESEARCH

At various points over the last two decades, Coast Guard has undertaken efforts to measure the magnitude of property damage losses that go unreported. The most significant was the multi-year R-BAR program conducted in the early 1990s. Below we briefly describe these efforts.

4.2.1 R-BAR

The R-BAR program was an effort to provide the insurance industry and the Coast Guard with more complete information on accidents involving recreational boats.⁶⁷

Recreational boat owners obtain insurance through two types of providers (Maxim and Kilby, 2009). Generally, smaller boats, which are either defined by length (e.g., <15'), horsepower (e.g., <25 HP), or value (e.g., covered for up to \$1,000), are insured under a boat owner's homeowner's insurance policy. Larger, more expensive boats are more likely to be directly insured under specialized marine insurance policies. Separate boat insurance policies may also be required by law in some States, required by a yacht club or marina, or required if a boat is financed by a bank loan. However, boat insurance is not required by Federal law, so a number of recreational boats are not covered by insurance. In total, hundreds of insurance companies provide coverage for recreational boats.

Funded by a Coast Guard grant, R-BAR was formed in 1990 by a task force of insurance industry representatives, marine surveyors, attorneys, Coast Guard personnel, and boating writers. The R-BAR program established the MIBF, a non-profit, non-governmental organization, for the primary purpose of developing recreational boating accident statistics using data from insurance claims.

The R-BAR program collected and analyzed data from the insurance industry for two years, from October 1993 through September 1995. In September 1995, Coast Guard's financial support of the R-BAR program ended. According to MIBF, it intended to

⁶⁶ Personal communication with L. D. Maxim, on 2 March 2011; MIBF, 1995.

⁶⁷ General background information describing R-BAR was obtained from Marine Index Bureau Foundation, Inc. (1995).

continue data collection, seeking funding from its parent company, the Marine Index Bureau, Inc. (MIB) (MIBF, 1995, p. 59).

MIBF identified 292 companies that insured 3,413,131 recreational boats in 1994, including companies that specialized in boating insurance as well as companies that also provide other lines of coverage (e.g., homeowners insurance) (MIBF, 1995, pp. 3,8).⁶⁸ It developed a stratified sampling plan based on the number of boats insured by those companies, geographic location, and willingness to participate. In 1994, the final full year of the project, 19 companies providing coverage to 62.4 percent of the total boating insured population provided claims data (MIBF, 1995, p. viii).

The types of information collected included timing and location of the accident; characteristics of the boat; operator characteristics; description of the accident and cause of loss, and loss amount paid (MIBF, 1995, p. 13). Claims meeting Coast Guard's definition of "reportable" were tracked independently (MIBF, 1995, p. ix).⁶⁹ If the insurance company providing data for a particular incident did not provide a dollar loss figure, MIBF assumed the accident was not reportable to Coast Guard.

In 1994, R-BAR estimates 92,248 claims were made nationally for property damage and bodily injuries resulting from reportable accidents.⁷⁰ MIBF notes that of the additional 46,341 non-reportable property damage and bodily injury claims captured in R-BAR, many would have counted as "reportable" if the insurers had reported the dollar loss figure. In the same year, States reported 6,906 accidents resulting in 784 fatalities and 4,084 injuries to Coast Guard (Coast Guard, 1995, p. 8).

Dollar losses associated with the reportable claims totaled \$409,300,000 (property damage and bodily injury claims) (MIBF, 1995, p.xi). MIBF do not separately report the loss amount associated solely with property damages. However, the authors note that the average dollar loss for a property claim was \$2,517 (other's property) and \$2,857 (own property) (MIBF, 1995, p. xii). Boats between 13 and 20 feet in length accounted for 56 percent of reportable claims, while boats between 20 and 29 feet accounted for another 36 percent (MIBF, 1995, p. xii). Open motorboats were the most frequently cited type of vessel experiencing a loss, representing 77 percent of the value of claimed losses (MIBF, 1995, p. xii).

⁶⁸ Coast Guard identified 11,429,585 numbered boats nationally in 1994 (Coast Guard, 1995, p. 7). "Numbered boats" are boats that are registered in accordance with State regulations (e.g., boats that are powered or that exceed a certain length). Not all recreational boats require registration.

⁶⁹ Note that at the time of data collection, Coast Guard applied a property damage threshold of \$500 for reportable accidents.

⁷⁰ Of these claims, 4,896 only sought compensation for injuries. Of the remaining 87,352, MIBF does not provide information regarding the number that only claimed property damages (MIBF, 1995, pp. x-xi). Detailed information regarding the injury claims is not provided. R-BAR focuses on estimating the number of reportable accidents that occurred, rather than the number of injuries. We do not have information regarding when, as a result of an injury, claims are made against a boating policy as opposed to other types of insurance, such as medical coverage provided by an employer.

4.2.2 NBSAC WORKGROUP

In February 2009, a NBSAC workgroup convened with the task of making recommendations to the Coast Guard on how to address underreporting of recreational boating accidents (Maxim and Kilby, 2009). The workgroup concluded that the insurance industry was the most likely source of additional accident data. Boat owners/operators likely have greater incentives to file claims with insurers than to complete BAR forms. In particular, the group hypothesized that claims data could be a valuable source of data for “property damage only” (PDO) accidents.

The workgroup identifies three options for obtaining claims data, including urging or requiring insurance companies to:

- Require claimants to submit BARs;
- Report claims data directly to State agencies; or
- Report claims data to a third party, such as the National Insurance Crime Bureau (NICB) or the MIB, who would provide the data to State agencies.

Representatives of the insurance industry suggest that requiring claimants to submit BARs is likely to be subject to legal challenge.

4.2.3 OTHER EFFORTS

Efforts such as NASBLA committees, an NBSAC Accident Reporting Task Force, and Coast Guard accident mitigation meetings have included participation by boat insurers and resulted in discussions of the possibility of using insurance information to improve the quality and completeness of boat accident data. However, these discussions have not led to any significant efforts to compile or collect such data.⁷¹

4.3 ANALYTIC APPROACH

To identify potential sources of information or data on property damages resulting from recreational boating accidents, we researched several sources of information. First, we searched for relevant literature published in academic journals and reports or databases published by government and non-governmental organizations. In addition, we conducted informational interviews with government and industry experts. The details of these efforts are described in greater detail below.

4.3.1 LITERATURE AND DATABASE SEARCH

First, we conducted a comprehensive literature search to identify publicly-available, published reports or papers providing information on property damages resulting from boating accidents. Using engines including Google, Google Scholar, and EconLit, we searched on combinations of terms including recreational boating, pleasure boating, property damage, accident damage, insurance data, insurance claims, cost, and value.

⁷¹ Personal communication with Susan Tomczuk, on March 2, 2011; ABYC, 2011.

Next, we reviewed the websites and/or contacted staff at governmental and non-governmental organizations that might collect and store boating accident data. The organizations we researched included the following:

- **Recreational boating associations**, including the American Boating Association and US Sailing;
- **Boating law and safety associations**, including NASBLA, U.S. Power Squadrons (USPS), NBSAC, and the National Safe Boating Council;
- **Transportation and safety statistics agencies**, including the National Transportation Safety Board, the Bureau of Transportation Statistics, the National Safety Council, and the U.S. Census;
- **Boat and marine insurers**, including BoatUS; and
- **Data firms supporting the insurance industry**, including Insurance Services Office, Inc. (ISO), which purchased MIB in 2001.

4.3.2 INFORMATIONAL INTERVIEWS

In order to establish a more complete understanding of previous property damage research, how data reporting and collection are conducted, and how boating law administration and boat insurance operate, we conducted interviews with experts in the fields of boating law and safety, transportation statistics, and the insurance industry. We identified these experts through the literature and data searches described in the previous section, conversations with Coast Guard, and interviews with other experts. Specifically, we spoke with the following individuals:⁷²

- **John Giknis**, ISO;
- **Dr. Deborah Gona**, PhD, Engineering, Reporting & Analysis Committee Staff, NASBLA Research Consultant and Project Director;
- **Bill Gossard**, National Transportation Safety Bureau;
- **Karlton Kilby**, BoatUS;
- **Dr. Daniel Maxim**, PhD, U.S. Coast Guard Auxiliary;
- **Fred Messmann**, BLA of Nevada 1989-2009, Deputy Chair of the National Safe Boating Council;
- **Tamara Terry**, Chairperson of NASBLA's Engineering, Reporting & Analysis Committee and the Recreational Boating Accident Program Manager for Ohio's Division of Watercraft; and
- **Susan Tomczuk**, U.S. Coast Guard Boating Safety Division.

⁷² The Paperwork Reduction Act (44 U.S.C. Chapter 35) requires Coast Guard to obtain permission from OMB prior to requesting information from more than nine non-Federal entities. Therefore, at Coast Guard's direction, we limited the number of interviews to ensure compliance with this law.

4.4 FINDINGS

Our research did not identify any new sources of comprehensive recreational boating accident statistics. The literature searches did not identify reports with original data or information, and we found no indication of data-driven projects underway to further our knowledge regarding the magnitude of recreational boating property damages. Other Federal agencies that report boating accident statistics (e.g., DOT's Bureau of Transportation Statistics) obtain their information from Coast Guard. Similarly, non-governmental organizations such as NASBLA or the USPS also report statistics based on data available in BARD. Importantly, such organizations, particularly NASBLA, are actively engaged in researching and developing tools to promote accident reporting in the hope of improving future data collection.

Our research confirms the conclusions of earlier work that the most likely source of property damage data is the insurance industry. However, the potential use of these data is subject to several limitations. First, data on claim values are not currently collected and stored in a centralized database. Rather, the data are proprietary in nature and held by hundreds of private insurers. Second, available data suggest that a large proportion of recreational boat owners may not carry insurance specifically covering their boats; therefore, claims may not be submitted for accidents.⁷³

We identified one potential source of preliminary data that could be used to inform estimates of the potential magnitude of underreporting with regard to the number of accidents resulting in property damage. ISO is likely the most comprehensive and centralized source of property damage insurance claims data. ISO works with a membership of insurance providers who submit preliminary claims information to an ISO database. ISO then uses these data to provide information to underwriters upon request to assist in the claim adjudication process. Approximately 93 percent of all property insurers are members, making ISO the largest and oldest provider of this service (ISO, 2011). ISO's database includes boating claims filed under both homeowners' insurance and separate boat insurance policies, and would therefore capture claims information for a large portion of insured boats.⁷⁴

ISO does not own the claims data in its database; therefore, the company cannot share information about specific claims with Coast Guard. As a result, information about the characteristics of specific incidents, such as the type of boat involved and the reason for

⁷³ MIBF identified 292 companies that insured 3,413,131 recreational boats in 1994 (MIBF, 1995, p. 3). By comparison, Coast Guard identified 11,429,585 numbered boats in the same year (Coast Guard, 1995, p.7). It is unclear from MIBF's report whether its survey was focused solely on boat-specific policies provided by insurers, or whether it also collected claims data submitted under homeowners' insurance policies. It appears that MIBF focused on boat-specific policies (MIBF, 1995, p. 3). Thus, a large portion of the numbered boats identified by Coast Guard may have insurance through their homeowners' policy, and therefore may not have been included in MIBF's survey. However, it is also possible that a large number of lower-value boats are not insured.

⁷⁴ Personal communication with John Giknis, on March 8, 2011.

the accident, is not available. However, ISO indicated it may be able to provide Coast Guard with summary statistics, such as the total number of claims related to recreational boating filed annually. Additionally, information regarding the value of property damages is unlikely to be available because ISO receives information from insurers early in the claims process, prior to a final determination of total loss value.

A representative from the boat insurance industry estimated that ISO may only see 10 percent of boat-related claims.⁷⁵ Because boat-related claims are low in value relative to other types of property damage claims, commonly totaling less than \$500, insurance providers are unlikely to use ISO's services to investigate the potential for a fraudulent claim, and therefore will not submit claim information for these incidents to the database. However, the absence of these smaller claims from ISO's database may not pose a significant issue for Coast Guard, as these claims are unlikely to be greater than the \$2,000 threshold for a reportable PDO incident.^{76,77}

4.5 CONCLUSIONS AND RECOMMENDATIONS

A primary focus of the National Recreational Boating Safety Program is to improve boating safety by reducing fatal and nonfatal injuries. While Coast Guard also aims to minimize losses related to property damages, such benefits are likely to be ancillary to regulations and programs conceived to reduce injury risks. Therefore, in order for data on the value of property damages to be most useful in assessing public policy, these data would ideally be linked to information about incident characteristics (e.g., the reason for the accident) as well as the types of injuries that might result. With this consideration in mind, below we describe the strengths and weaknesses of several options available to Coast Guard for collecting data on property damages.

4.5.1 OBTAIN INSURANCE INDUSTRY STATISTICS FROM ISO

As discussed previously, ISO may be able to provide summary information to the Coast Guard on the number and characteristics of boating claims. ISO's proprietary database represents the most comprehensive source of recreational boating accident property damage data currently available. Information from ISO may include statistics such as the number of reportable accidents and the types of events resulting in the most costly damages. If available, these statistics could provide Coast Guard with a point of comparison for BARD, potentially informing the estimation of annual rates of incident

⁷⁵ Personal communication with Karlton Kilby, on March 8, 2011.

⁷⁶ Property damages totaling less than \$2,000 would be included in BARD when they occur as part of an incident that is reportable for another reason, such as when a person is seriously injured or dies. Therefore, the absence of these smaller incidents from the ISO database could bias comparisons to BARD data. The potential degree of bias is unknown.

⁷⁷ Some boat insurance policies include property and indemnity coverage (P&I) covering medical expenses from injuries incurred during an incident on an insurance holder's boat. The value of such claims may double-count the value of injuries estimated in Chapter 3 and therefore is likely to be of lower research value to Coast Guard.

underreporting. These data might also offer additional information to supplement current knowledge of PDO events.

It will be difficult, however, to link this property damage claims information to incidents that also result in injuries. Although some boat insurers include liability for bodily injury, information about injuries is unlikely to be captured in the majority of boat insurance claims. However, to the extent that both property damage and injury information are included in the same claim, these data may provide useful information on relationships between the two types of outcomes.

4.5.2 SURVEY THE INSURANCE INDUSTRY AND/OR THE BOATING COMMUNITY

Coast Guard may consider obtaining the information it needs for regulatory and other analyses by undertaking a substantial survey-based data collection effort. The two populations that could provide relevant data are the insurance industry and boat owners or operators.

Data collection by survey requires careful design and implementation and would likely involve consultation with someone with expertise in the field in order to assure that the survey will result in useful and meaningful data. The limitations of this approach include that it is a time- and labor-intensive process, and must comply with government timelines and detailed procedures (44 U.S.C. §3507). In order to conduct a survey of this scope, the Coast Guard would first be required to obtain OMB approval of an information collection request (ICR). As part of the ICR, the Coast Guard would need to develop a survey plan designed to collect a statistically-representative sample from all categories of insurers providing coverage for boats or boat owners/operators (OMB 2006a, OMB 2006b).⁷⁸ Below we discuss the benefits and limitations of conducting a survey of each of these populations.

4.5.2.1 A Survey of the Insurance Industry

Whereas ISO cannot provide individual claims data to Coast Guard, insurance providers themselves might be able to provide such data in a format similar to the R-BAR data collection effort. The primary benefit of this approach is that it is likely to result in the most accurate data on the value of property damages. In addition, any summary statistics from ISO would provide an internal check of the completeness and accuracy of survey data collected.

There are a few likely challenges involved in conducting an industry survey of this size:

- The ability to identify the population of all insurance providers. As described above, the insurance industry includes a population of hundreds of entities, spanning the homeowners' and specialized marine insurance sectors;

⁷⁸ Full documentation of government guidance on surveys, as well as the Federal standards for survey design and implementation can be accessed at http://www.usa.gov/webcontent/reqs_bestpractices/laws_regs/paperwork_reduction.shtml in the section titled "Resources".

- The ability to reliably contact an individual at each company who is both able and authorized to answer the survey request; and,
- The likelihood of receiving responses, particularly if there is little or no compensation or incentive for the participants.

Identifying the population of insurers may be possible using an existing industry database such as Dunn & Bradstreet. Contact information for individual entities may also be available through the same source, although the contact provided may not be the person who is best qualified to respond to the survey. The ability to work in collaboration with an entity such as an industry association may assist in addressing some of these challenges.

As with the ISO data, the availability of information that would link property damage incidents to injury incidents would depend on how frequently medical claims are filed under a boat insurance policy. In addition, as discussed above, this approach is unlikely to capture all accidents resulting in property damages because either (1) boats are not insured; or (2) the value of the damage is too small to be worth the effort required to submit a claim. The latter limitation may be of less importance to Coast Guard as these smaller claims may not be reportable.

4.5.2.2 A Survey of Recreational Boaters

A survey of recreational boaters would allow Coast Guard to design a survey instrument that collects information about all the consequences of a single incident, including both injuries and property damages. A well-constructed and carefully conducted representative survey is the most reliable way to link property damage data to information on types of incidents. Such a survey could be tailored to provide data that are ultimately useful for assessing the reduction in property damages associated with regulations that influence the occurrence of certain types of recreational boating injuries. Furthermore, this approach is more likely to provide estimates of the total number and characteristics of reportable incidents.

Identifying and contacting the population of recreational boaters, and obtaining a statistically representative sample, is likely to present significant challenges. Coast Guard may have access to a list of licensed boaters or registered boats with current, reliable contact information. However, this would exclude certain subpopulations of recreational boaters, such as unlicensed boaters and unregistered boats, who may be more likely to get into boating accidents. The Coast Guard could work with boat and yacht clubs to help fill these gaps, and also use these organizations to help distribute, administer, and encourage respondents to complete the survey. As discussed in Chapter 2, SRG (2003) conducted a national survey of boat owners/operators. It identified non-owners using random-digit dialing to contact individuals via telephone. More efficient, updated techniques may be available.

CHAPTER 5 | ILLUSTRATIVE CASE STUDIES

In the previous chapters, we reviewed data on fatal and nonfatal recreational boating injuries, the value of averting these injuries, and the value of related property damages. In this chapter, we illustrate the potential effects of our findings by considering three case studies. Although the Coast Guard relies on boating accident data for a variety of purposes, in this chapter we focus on its use in regulatory analysis. Our case studies include one based on a 2002 interim regulation requiring the use of personal floatation devices by children; a second based on a regulation requiring boating safety equipment; and a third that examines the implications of differing ratios of fatal to nonfatal injuries. We use these examples to explore the impact of assuming different degrees of underreporting of the injury data (as discussed in Chapter 2) and of using different approaches for valuation (as discussed in Chapter 3). We do not consider the effects of alternative estimates of the value of property damages (as discussed in Chapter 4), which are less frequently addressed in Coast Guard regulatory analyses. Chapter 6 then discusses the implications of these case studies, including the extent to which the alternative approaches illustrated in this chapter might be useful for sensitivity analysis of the impacts of regulatory options.

We begin by describing our analytic approach, which includes categorizing injuries both by severity and type of treatment and selecting monetary values for use in the case studies. We then apply the injury underreporting factors and monetary values to each of our three cases studies, and conclude by discussing the implications of this exercise.

In this chapter, our goal is to illustrate how the estimates of the benefits of recreational boating safety regulations might change given the likely underreporting of nonfatal injuries and the use of alternative approaches for monetary valuation. Our case studies are simplified versions of the analyses conducted for Coast Guard rulemakings, and lack the detailed exploration of these impacts and the assessment of uncertainty that are integral parts of such analyses. Our intent is to illustrate the potential effects of the findings in the previous chapters, not to provide examples of the sort of thorough and rigorous analysis required in the case of actual rule development.

5.1 ANALYTIC APPROACH

The starting point for each of our case studies is estimates of the fatal and nonfatal injuries averted by each rule. We follow the Coast Guard's current approach for categorizing these injuries, then apply the underreporting factors and selected monetary values from the previous chapters.

5.1.1. INJURY CATEGORY CROSSWALKS

To conduct the case studies, we first need estimates of the number of fatal and nonfatal injuries averted by a rule, categorized in a way that allows us to apply the underreporting factors and the monetary values discussed in previous chapters. For underreporting, estimates are available only for treatment categories, as discussed in Chapter 2. The monetary values in Chapter 3 are classified either by injury severity, using the AIS, or by the type of treatment, i.e., whether the individual was hospitalized, treated in an emergency department, and so forth.

To apply these two categorization schemes in our case studies, our starting point is the Coast Guard's current approach for classifying injuries. Coast Guard relies on data from its BARD system (discussed earlier in this report) as well as other sources to estimate the injuries averted by its regulations. For our illustrative case studies, we rely on a crosswalk of the BARD categories developed by Coast Guard staff for use in recent regulatory analyses.⁷⁹ Exhibit 5-1 provides this crosswalk, which matches the injuries reported in BARD to the AIS categories. As an intermediate step, Coast Guard staff rely on categories used in the Marine Information for Safety and Law Enforcement (MISLE) system, which provide the necessary bridge between boating injuries and the AIS scale. In the exhibit, the first two columns provide the AIS categories and descriptors, the third and fourth columns provide information from MISLE, and the fifth column provides the BARD injuries placed by Coast Guard staff in each category.

⁷⁹ Provided by Paul Large, Office of Standards Evaluation and Development, U.S. Coast Guard, via email on January 26, 2011 and February 17, 2011, and discussed in a February 18, 2011 meeting.

EXHIBIT 5-1: CROSSWALK OF NONFATAL INJURY CATEGORIES BY SEVERITY

AIS LEVEL	CATEGORY/ DESCRIPTION	MISLE DESCRIPTION	MISLE EXAMPLES	BARD INJURY CATEGORIES
1	Minor	The injury is minor or superficial. No professional medical treatment was required.	Minor/superficial scrapes (abrasions); minor bruises; minor cuts; digit sprain; first degree burns; minor head trauma with headache or dizziness; minor sprain/strain.	Abrasion Contusion Laceration Sprain/Strain
2	Moderate	The injury exceeds the minor level, but did not result in broken bones (other than fingers, toes or nose), loss of limbs, severe hemorrhaging, muscle, nerve, tendon or internal organ damage. Professional medical treatment may have been required. If so, the person was not hospitalized for more than 48 hours within 5 days of injury.	Broken fingers, toes or nose; amputated fingers or toes; degloving of fingers or toes; dislocated joint; severe sprain/strain; second or third degree burns covering 10% or less of body; herniated disc.	Burns Back Injury Carbon Monoxide Dislocation Hypothermia
3	Serious	The injury exceeds the moderate level and requires significant medical/surgical management. The person was not hospitalized for more than 48 hours within 5 days of the injury.	Broken bones other than fingers, toes or nose; partial loss of limb; degloving of entire hand/arm or foot/leg; second or third degree burns covering 20-30% of body; bruised organs.	Broken Bones Head Injury Neck Injury Teeth and Jaw
4	Severe	The injury exceeds the moderate level and requires significant medical/surgical management. The person was hospitalized for more than 48 hours of the injury and, if was in intensive care, was in for less than 48 hours.	Internal hemorrhage; punctured organs, severed blood vessels; second/third degree burns covering 30-40% of body; loss of entire limb.	Internal injuries Shock Amputation
5	Critical	The injury exceeds the moderate level and requires significant medical/surgical management. The person was hospitalized and in intensive care for more than 48 hours within 5 days of injury.	Spinal cord injury; extensive second or third degree burns; concussion with several neurological signs; severe crushing injury; second/third degree burns covering over 40% or more of body; severe/multiple organ damage.	Spinal Injury

Source: Provided by Office of Standards Evaluation and Development, U.S. Coast Guard, February 17, 2011.

While the AIS categories are used for valuation in several of the sources described in Chapter 3, the databases used to explore underreporting in Chapter 2 (see Exhibit 2-8) do not provide information for these categories. Instead, they are based on treatment categories (i.e., whether the injury resulted in hospitalization or only treatment in emergency departments or office settings). In our case studies, we use the treatment

descriptions from MISLE (column 3 in Exhibit 5-1) to determine possible treatment facilities. We use a range of underreporting factors for categories where we are particularly unsure about how to best crosswalk the injury data and the underreporting factors. In addition, as discussed in Chapter 2, we are unable to identify the extent to which BARD nonfatal non-hospitalized injuries were treated in particular settings (emergency departments, outpatient or doctors' offices). For minor injuries (AIS = 1), we use the highest underreporting factor from Chapter 2, which reflects all nonfatal, non-hospitalized injuries regardless of treatment location (emergency department, outpatient department, or office-based physician). For moderate injuries (AIS = 2), because treatment may range from no professional treatment to hospitalization, we use the full range of factors for non-hospitalized and hospitalized cases. For serious injuries (AIS = 3), we assume the individual was hospitalized.

The results are provided in Exhibit 5-2. This categorization is highly uncertain and provided solely for illustrative purposes. More work is needed to determine whether this approach leads to conclusions that are reliable and valid.

As indicated by the exhibit and discussed in Chapter 2, underreporting increases dramatically as injury severity decreases. However, there is significant uncertainty regarding the extent of underreporting for those injuries requiring less extensive treatment, as well as regarding the crosswalk between the treatment and AIS severity categories above.

EXHIBIT 5-2: CROSSWALK OF NONFATAL INJURY CATEGORIES BY SEVERITY (FOR ILLUSTRATION ONLY)

AIS LEVEL	CATEGORY/ DESCRIPTION	TREATMENT FROM MISLE DESCRIPTION	ASSUMED CATEGORY FOR CASE STUDIES ^a	UNDERREPORTING MULTIPLIERS	
				LAWRENCE <i>ET AL.</i> (2006)	THIS REPORT (SEE CHAPTER 2)
1	Minor ^{b,c}	No professional medical treatment was required.	Not assessed; assume same as all non-hospitalized injuries	13.6	120
2	Moderate ^c	Professional medical treatment may have been required. If so, the person was not hospitalized for more than 48 hours within 5 days of injury.	All non-hospitalized or hospitalized injuries	1.25-13.6	1.5-120
3	Serious	The injury requires significant medical/surgical management. The person was not hospitalized for more than 48 hours within 5 days of the injury.	Hospitalized injuries	1.25	1.5-1.7
4	Severe	The injury requires significant medical/surgical management. The person was hospitalized for more than 48 hours of the injury and, if was in intensive care, was in for less than 48 hours.	Hospitalized injuries	1.25	1.5-1.7
5	Critical	The injury requires significant medical/surgical management. The person was hospitalized and in intensive care for more than 48 hours within 5 days of injury.	Hospitalized injuries	1.25	1.5-1.7
6	Fatal	N/A	N/A	1.01	1.0

Source: MISLE Descriptions from Exhibit 5-1; injury multipliers from Exhibit 2-8.

Notes:

- Categories in this column are highly uncertain and used for illustrative purposes only.
- The extent to which minor injuries are reported in BARD may decrease over time. As discussed in Chapter 2, the 2008 revision to the Recreational Boating Accident Report form requires reporting of only those injuries that require treatment beyond first aid, which would exclude those injuries now in AIS category 1.
- The MISLE categories suggest that minor injuries do not require any professional treatment, and that moderate injuries may be not be treated or treated only in a physician's office rather than in an emergency department or hospital. However, because we lack independent underreporting factors for these treatment categories, we apply the factors for all nonfatal, non-hospitalized injuries in the first case, and both this factor and the hospitalization factor in the second case, reflecting related uncertainties.

5.1.2 INJURY VALUATION

In Chapter 3, we note that WTP estimates are the preferred measure for valuing fatal and nonfatal risk reductions in regulatory analysis. For fatal risks, the Coast Guard has well-established values based on WTP for small changes in these risks. These values are conventionally converted to VSL estimates, by dividing individual WTP by the risk change; the VSL is not the value of saving an individual's life. The VSL currently applied by DHS is \$6.3 million in 2007 dollars.

For nonfatal injuries, as also discussed in Chapter 3, consistently-derived WTP estimates that distinguish among the injury categories of concern are not available; the few WTP estimates available are either averages for a wide-range of injuries or only address injuries of a particular type. As a result, other measures must be used as proxies.

As described in detail in that chapter, there are two dominant alternatives in the injury valuation literature. One involves adding estimates of averted medical and administrative costs to monetized QALY estimates, assuming a constant value per QALY. This approach is currently followed by NHTSA as well as other DOT agencies. The second relies on estimates of averted medical costs and productivity losses only, as illustrated by Finkelstein *et al.* (2006) and the online injury cost calculator provided as part of the CDC's 2011 WISQARS (documented in Lawrence *et al.*, 2009).

Choosing among these approaches involves significant trade-offs related to whether the data are up-to-date, whether the data differentiate between the costs associated with injuries that vary in severity, whether the approach includes data on injuries from varying causes, and whether the approach is consistent with the benefit-cost analysis framework. We summarize the three primary sources of values from Chapter 3 according to these criteria in Exhibit 5-3 below.

There is some commonality across all of these data sources, given that many of the same people were involved in developing all three of them (i.e., Ted Miller and his colleagues at the Pacific Institute for Research and Evaluation). Some of the methods and data sources used to estimate averted costs for the NHTSA report are also used in Finkelstein *et al.* (2006), which in turn was the basis for the development of the estimates in CDC/WISQARS. The differences include the extent to which the estimates have been updated, the types of breakouts each source provides, and the types of values included. Because medical innovations lead to changes in treatment costs and recovery time, in turn affecting the quality of life and productivity losses, the use of older data can lead to significant uncertainty. In addition, evolution of health care practices and reimbursement policies can significantly affect the types of treatment received and related costs. However, the three sources identified above appear to provide the most recently constructed, comprehensive estimates available for the range of injuries that may be of interest in Coast Guard regulatory analyses.

EXHIBIT 5-3: COMPARISON OF VALUATION APPROACHES

APPROACH	UP-TO-DATE?	AVAILABLE BY SEVERITY CATEGORY?	DIFFERENTIATE BY INJURY CAUSE?	CONSISTENT WITH BENEFIT-COST ANALYSIS FRAMEWORK?
DOT/NHTSA (2009)	Last detailed update published in 2002; adjusted for inflation and revised VSL in 2009. Estimates are for the year 2007. Date of underlying data sources varies.	Reported by AIS category.	Motor vehicle accidents only.	Includes averted medical and administrative costs and monetized QALY gains. QALY estimates do not fully comply with recent best practice recommendations; use of constant value per QALY not supported by recent research.
Finkelstein <i>et al.</i> (2006)	Published in 2006; estimates are for the year 2000. Date of underlying data sources varies.	Reported by AIS category and by type of treatment.	Reported for all causes and several subcategories; estimates are not available specifically for recreational boating injuries. ^a	Includes averted medical costs and lost productivity only.
CDC/WISQARS (2011)/ Lawrence <i>et al.</i> (2009)	Methodology published in 2009; estimates are for the year 2005. Date of underlying data sources varies.	Reported by type of treatment, covers injuries treated in emergency departments and through hospitalization only.	Reported for all causes and several subcategories; estimates are not available specifically for recreational boating injuries. ^b	Includes averted medical costs and lost productivity only.

Note: See Chapter 3 for more discussion of these data sources.

a. Subcategories in Finkelstein *et al.* (2006) include: motor vehicle/other road user, falls, struck by/against, cut/pierce, fire/burn, poisoning, drowning/submersion, firearm/gunshot, and other.

b. Subcategories in CDC/WISQARS (2011) include: cut/pierce, drowning/ submersion, fall, fire/burn (subcategorized as fire/flame, residential, and hot object/substance), firearm, machinery, natural/environmental, overexertion, poisoning, struck by/against, suffocation, transportation (subcategorized as: motor vehicle, traffic (involving motorcyclist, occupant, pedal cyclist, pedestrian, other person, unspecified person); pedal cyclist and pedestrian (involving other pedal cyclist, other pedestrian), other land transport, other transport, other specified and classifiable other specified/not elsewhere classified, and unspecified.

In our case studies, we apply the approaches from both NHTSA (2009) and Finkelstein *et al.* (2006). Each has advantages and limitations in terms of the types of injures and types of values included. As indicated below, these two approaches lead to values that differ by

orders of magnitude for some severity categories, due largely to the inclusion of a wider range of costs and monetized QALYs in the NHTSA estimates. However, it is unclear whether the NHTSA approach under- or overstates these values, both because the data are somewhat outdated and because the underlying research does not entirely adhere to more recent best practice recommendations.⁸⁰ NHTSA also addresses motor vehicle accidents rather than boating-related injuries. The Finkelstein *et al.* (2006) values are more recent and address the injuries from all causes, but only include medical costs and lost productivity. We do not apply the values from the CDC/WISQARS system in our case studies, because it lacks estimates broken out by AIS severity category and does not include estimates for less severe injuries (i.e., those not treated in emergency departments or hospitalized). Below, we first address our application of the NHTSA estimates in more detail, and then discuss our application of the estimates from Finkelstein *et al.*

The NHTSA (2009) values are an update of the values currently used by the Coast Guard. Because Coast Guard was previously part of DOT, it now uses DOT's "old" relative fatality ratios (see Exhibit 3-4) for valuing nonfatal injuries, applying them to the DHS VSL of \$6.3 million. This approach is consistent with the current DOT (2009) guidance. As discussed in Chapter 3, DOT adds estimates of averted costs to the value of monetized QALYs, and then calculates the value of injuries in each AIS category as a percentage of the value of a fatality. The DOT guidance suggests that these factors then can be applied to a revised VSL as the VSL changes over time.

However, this strategy introduces some internal inconsistency into the estimates. The current VSL (to which the factors are applied) differs from the original VSL used to monetize QALYs when building the relative fatality ratios. In addition, this approach assumes that the averted cost components scale upwards or downwards with VSL changes. The factors driving changes in costs (e.g., inflation, changes in practices and technologies) differ from the factors driving changes in the VSL, which primarily result from new research findings, although the VSL is also affected by inflation and real income growth.

The updated factors from NHTSA (2009) at least partially address these problems. NHTSA starts from revised cost and QALY estimates for the year 2000, reported in Blincoe, *et al.* (2002), rather than the older estimates reflected in the DOT guidance. It then inflates the cost estimates to 2007 dollars, and also monetizes the QALY estimates using DOT's then-official VSL of \$5.8 million (in 2007 dollars).

For comparison to the current Coast Guard approach, we apply the NHTSA (2009) ratios to the DHS VSL of \$6.3 million (2007 dollars). For costs, we use the NHTSA (2009) values directly, which are based on data collected for the year 2000 and inflated to 2007 dollars. For QALYs, we apply the injury-to-fatality ratios from NHTSA (2009) to the DHS VSL rather than to the DOT VSL. This process is described in more detail in Appendix D; the results are provided in Exhibit 5-4. The dollar estimates are higher than

⁸⁰ As noted in Chapter 3, NHTSA is now in the process of updating its estimates.

the NHTSA (2009) values, and the relative fatality ratios are somewhat lower (see Exhibit 3-4), because of the use of a higher VSL to monetize QALYs.

**EXHIBIT 5-4: APPLICATION OF NHTSA RELATIVE FATALITY APPROACH TO DHS VSL
(VSL = \$6.3 MILLION IN 2007 DOLLARS)**

AIS LEVEL (A)	CATEGORY/ DESCRIPTION (B)	AVERTED COSTS ^a (C)	QALY INJURY- TO- FATALITY RATIO (D)	MONETIZED QALYS (E)=(D)* (\$6.3 MILLION VSL) ^{b,c}	TOTAL (F)=(C)+(E)	RELATIVE FATALITY RATIO (G)=(F)/ (\$7,514,812)
1	Minor	\$7,680	0.0019	\$11,970	\$19,650	0.0026
2	Moderate	\$79,412	0.0381	\$240,030	\$319,442	0.0425
3	Serious	\$228,468	0.0536	\$337,680	\$566,148	0.0753
4	Severe	\$434,999	0.1605	\$1,011,150	\$1,446,149	0.1924
5	Critical	\$1,388,460	0.5470	\$3,446,100	\$4,834,560	0.6433
6	Fatal	\$1,214,812	1.0000	\$6,300,000	\$7,514,812	1.0000

Source: Costs and QALY ratios from NHTSA (2009), Table C-2.

Notes:

Detail may not add to total due to rounding.

a. Includes injury-related costs only; excludes motor vehicle-related property damage and travel delay.

b. Applies NHTSA QALY ratios to DHS VSL of \$6.3 million, rather than to the DOT VSL.

c. NHTSA adjusts the DOT VSL for changes in productivity. We do not make this adjustment here, both because the rationale for this adjustment is unclear and because NHTSA does not report the details of its calculations.

As an alternative to the estimates in Exhibit 5-4, we rely on the Finkelstein *et al.* (2006) estimates of averted medical costs and productivity losses. These estimates are not reported separately for recreational boating accidents, which may fall into several of the injury subcategories addressed in that study (listed in the footnotes in Exhibit 5-3). For example, one can imagine cases where a nonfatal boating-related injury could be classified either as a “fall” or as a “drowning/submersion,” and the drowning/submersion category may reflect swimming pool and other water-related accidents that differ from boating accidents in their consequences.

In Exhibit 5-5, we inflate the estimates for injuries from all causes (from Exhibit 3-8) to 2007 dollars, and add the VSL estimate for fatalities. These estimates are substantially lower than the estimates in Exhibit 5-4, in part because they do not include monetized

QALYs or costs other than medical treatment and lost productivity.⁸¹ In addition, they reflect all injuries nationally (rather than only from motor vehicle accidents) and more recent information on costs.

EXHIBIT 5-5: COST PER INJURY BY SEVERITY CATEGORY (FINKELSTEIN *ET AL.* 2006, 3 PERCENT DISCOUNT RATE)

AIS LEVEL	CATEGORY/ DESCRIPTION	2000 DOLLARS	2007 DOLLARS ^a
1	Minor	\$3,336	\$4,318
2	Moderate	\$9,752	\$12,579
3	Serious	\$29,822	\$39,073
4	Severe	\$69,885	\$91,722
5	Critical	\$99,975	\$130,824
6 ^b	Fatal	\$949,882	\$1,210,449

Source: See Exhibit 3-8.

Notes:

Detail may not add to total due to rounding. Consistent with Lawrence *et al.* (2009), medical costs are inflated to 2007 dollars using the Consumer Price Index, Medical Care (<http://www.bls.gov/cpi/>); work loss costs are inflated using the Employment Cost Index, Total Compensation, Total Private Industry (<http://www.bls.gov/ncs/ect/>), as viewed March 2011.

b. Costs for fatal cases are included in the exhibit for completeness, but are not used in the case studies, which instead rely on the DHS VSL of \$6.3 million.

The following sections illustrate the effect of these approaches on the benefit estimates for our three case studies.

5.2 PERSONAL FLOTATION DEVICES FOR CHILDREN

In 2002, Coast Guard published an interim rule that required that certain children wear personal flotation devices (PFDs). This rule mandated the wearing of Coast Guard-approved life jackets for children under age 13 while aboard recreational vessels that are underway, unless the child is below deck or in an enclosed cabin. It sets a national standard that is applicable in States that do not have their own standards, allowing the States to instead develop or maintain their own requirements.

This rule is not economically-significant, hence an economic analysis was not required under Executive Order 12866. However, the Coast Guard conducted a regulatory evaluation to provide information on the rule's benefits and costs. This evaluation concludes that the regulation does not impose additional monetary costs, because boaters

⁸¹ The other costs included in the NHTSA estimates include insurance administration, workplace costs, and legal costs.

were already required to carry life jackets for each passenger, and the Coast Guard already checked boats for safety equipment.

In those States that did not have related requirements, Coast Guard reports that there were seven drownings, as well as one moderate injury and three critical injuries due to near-drownings, which might have been prevented by the wearing of life jackets between 1996 through 2000. The Coast Guard assumes that these fatal and nonfatal injuries would have been averted by the rule, but notes that some of these drownings might not have been prevented by the use of PFDs. For example, the child might have been pinned down and drowned regardless. The analysis essentially assumes that drownings and near-drownings would occur at the same rate in future years, if the rule was not issued, and does not take into account other factors that may increase or decrease this rate over time.

When the rule was issued, Coast Guard was part of DOT, and followed their guidance for valuation. When the analysis was conducted, DOT (2002) required the use of a VSL of \$3 million for fatality risks. Separate guidance (DOT, 1993) provided factors for calculating the value of nonfatal injuries as percentages of the value of fatalities. (These factors differ from the more recent NHTSA factors reported in Exhibit 3-4.) In Exhibit 5-6, we replicate the results of the original benefits analysis from the *Federal Register* notice for the rule.

EXHIBIT 5-6: RESULTS OF BENEFITS ANALYSIS FOR REGULATION REQUIRING PFD USE BY CHILDREN

SEVERITY CATEGORY OF INJURY	BENEFIT OF AVERTING AN ACCIDENTAL INJURY OR FATALITY	NUMBER OF INJURIES (1996-2000)	BENEFIT IF ACCIDENTAL INJURIES AND FATALITIES ARE AVERTED
Minor	$(\$3,000,000)(0.0020) = \$6,000$	0	$(\$6,000)(0) = 0$
Moderate	$(\$3,000,000)(0.0155) = \$46,500$	1	$(\$46,500)(1) = \$46,500$
Serious	$(\$3,000,000)(0.0575) = \$172,500$	0	$(\$172,500)(0) = 0$
Severe	$(\$3,000,000)(0.1875) = \$562,500$	0	$(\$562,500)(0) = 0$
Critical	$(\$3,000,000)(0.7625) = \$2,287,500$	3	$(\$2,287,500)(3) = \$6,862,500$
<u>Fatal</u>	$(\$3,000,000)(1.000) = \$3,000,000$	<u>7</u>	$(\$3,000,000)(7) = \underline{\$21,000,000}$
Total		11	\$27,909,000

Source: Replication of table titled "Benefit of Averting Accidental Injuries and Fatalities for States Without Existing Rules," Coast Guard (2002), p. 42492.

Note: The injury severity categories are equivalent to AIS categories 1 through 6, as discussed in Chapter 3. The factors in parentheses in column 2 (i.e., 0.0020 through 1.000) are based on DOT (1993).

Before proceeding with our illustration of the effects of applying the results of our review to this case study, several points are worth noting. First, we are uncertain whether the results of our comparison of the BARD data to other sources (in Chapter 2) is applicable to these data. The source of the injury estimates in Exhibit 5-6 is unclear, these data are

for injuries to children rather than individuals of all ages, and they are for earlier years than covered by our review. Second, when applying the injury multipliers from our review, we treat the “zeros” in the third column of Exhibit 5-6 as true zeros, because we have no basis for determining otherwise. However, underreporting may mean that in fact some injuries were averted in these severity categories. Third, the \$3 million value per fatality (2001 dollars) in Exhibit 5-6 is based on old (2002) DOT guidance; DOT now applies a VSL of \$6.0 million in 2008 dollars (DOT, 2009) as discussed in Chapter 3. Because the values of nonfatal injuries are expressed as percentages of the VSL, this change in the VSL would affect all of the values in the exhibit even if the factors for nonfatal injuries were unchanged. Fourth, the factors used to value nonfatal injuries (in parentheses in the second column of Exhibit 5-6, i.e., ranging from 0.0020 to 1.000) are also based on old DOT (1993) guidance; the factors currently used by NHTSA are provided in Exhibit 3-4.⁸² These new factors are generally higher than those in the older guidance, except for the MAIS 5 (critical) injury category. In addition, these factors are based on the distribution of motor vehicle injuries within each category; not on injuries associated with boating in general or near-drownings of children in particular. Finally, the injuries in Exhibit 5-6 cover a five-year period and the values are not discounted to reflect the time value of money. Under current guidance (OMB, 2003), these impacts would be presented undiscounted as well as discounted at 3 and 7 percent.

In the absence of information on the distribution of injuries over time, we first divide the number of injuries in Exhibit 5-6 by five years to estimate an annual injury rate. We then multiply the number of injuries in each category by the factors in Exhibit 5-2 to illustrate the effects of various estimates of underreporting. As noted above, we assume that the “zeros” in the Exhibit are true zeros, which may underestimate the injuries averted in those categories given that some may not be reported. In Exhibit 5-7, we apply the underreporting multipliers from Exhibit 5-2 to the estimates in Exhibit 5-6, to indicate the increases that result. Not surprisingly, given the range of underreporting factors, the effects range from relatively similar results to results that increase overall by a factor of roughly two to more than twelve.

⁸² The factors now applied by NHTSA vary from the factors in the current DOT (2009) guidance (which are the same factors as reported in DOT, 1993), because DOT has not yet revised that guidance to reflect the more recent values. As noted in Chapter 3, DOT is now updating its valuation approach, but the results are not yet available.

EXHIBIT 5-7: POTENTIAL EFFECTS OF INJURY UNDERREPORTING (PFD
REQUIREMENTS FOR CHILDREN)

INJURY SEVERITY	ORIGINAL ANNUAL INJURY RATE ^a	BASED ON LAWRENCE <i>ET AL.</i> (2006)		BASED ON THIS REPORT	
		UNDER-REPORTING FACTORS ^b	ORIGINAL ANNUAL INJURY RATE MULTIPLIED BY UNDERREPORTING FACTORS ^c	UNDER-REPORTING FACTORS ^b	ORIGINAL ANNUAL INJURY RATE MULTIPLIED BY UNDERREPORTING FACTORS ^c
Minor	0	13.6	0	120	0
Moderate	(1÷5 years) = 0.2	1.25-13.6	0.25-2.7	1.5-120	.30-24
Serious	0	1.25	0	1.5-1.7	0
Severe	0	1.25	0	1.5-1.7	0
Critical	(3÷ 5years) = 0.6	1.25	0.75	1.5-1.7	.90-1.0
<u>Fatal</u>	<u>(7÷ 5 years) = 1.4</u>	1.01	<u>1.4</u>	1.0	<u>1.4</u>
Total	(11÷5 years) = 2.2		2.4-4.9		2.6-26

Notes:

Detail may not add to total due to rounding.

Analysis is illustrative only; the appropriate multipliers for nonfatal injuries are highly uncertain.

a. Based on Exhibit 5-6.

b. From Exhibit 5-2. See Chapter 2 and Section 5.1 for more information on these multipliers.

c. Results rounded to two significant digits to reflect uncertainty; intermediate calculations are based on unrounded data.

In Exhibit 5-8, we illustrate the effects of applying different monetary values to this range of injury estimates. To illustrate the possible range, we first multiply the lowest injury estimates (adjusted for underreporting, from Exhibit 5-7) by the lower injury values (the averted cost estimates from Finkelstein *et al.* 2006, as reported in Exhibit 5-5), applying the DHS VSL of \$6.3 million for fatalities. We then multiply the highest injury estimates (again adjusted for underreporting, from Exhibit 5-7) by the higher injury values (the averted cost and monetized QALY estimates from NHTSA, 2009, adjusted for the DHS VSL, as reported in Exhibit 5-4 and discussed in more detail in Appendix D). We compare these values to those in the original regulatory analysis (Coast Guard, 2002).

EXHIBIT 5-8: POTENTIAL EFFECTS OF ALTERNATIVE VALUES (PFD REQUIREMENTS FOR CHILDREN)

INJURY SEVERITY	ORIGINAL ANNUAL VALUES ^a	LOW END VALUES ^b		HIGH END VALUES ^d	
		LOW VALUE PER CASE ^b	LOW UNDERREPORTING MULTIPLIED BY LOW VALUES ^c	HIGH VALUE PER CASE ^d	HIGH UNDERREPORTING MULTIPLIED BY HIGH VALUES ^c
Minor	0	\$4,318	\$0	\$19,650	\$0
Moderate	(\$46,500÷5 years)=\$9,300	\$12,579	\$3,100	\$319,442	\$7,700,000
Serious	0	\$39,073	\$0	\$566,148	\$0
Severe	0	\$91,722	\$0	\$1,446,149	\$0
Critical	(\$6,862,500÷5 years)=\$1,372,500	\$130,824	\$98,000	\$4,834,560	\$4,900,000
Fatal	<u>(\$21,000,000÷5 years)=\$4,200,000</u>	\$6,300,000	<u>\$8,900,000</u>	\$7,514,812	<u>\$11,000,000</u>
Total	(\$27,909,000÷5 years)=\$5,581,800		\$9,000,000		\$23,000,000

Notes:

Detail may not add to total due to rounding.

Analysis is illustrative only; appropriate multipliers and values for nonfatal injuries are uncertain.

a. Based on Exhibit 5-6. Estimates are in 2001 dollars.

b. Based on Finkelstein *et al.* (2006) estimates from Exhibit 5-5, except for fatalities, which are valued using the DHS VSL. Estimates are in 2007 dollars.

c. Low end multipliers for number of injuries are from Lawrence *et al.* (2006) and high end multipliers are from this report, for all categories except fatalities. For fatalities, Lawrence *et al.* provide the higher multiplier. Results rounded to two significant digits to reflect uncertainty; intermediate calculations are based on unrounded data.

d. Based on NHTSA approach adjusted for DHS VSL from Exhibit 5-4. Estimates are in 2007 dollars.

As indicated by the exhibit, the increase in the VSL from \$3 million to \$6.3 million increases the value of fatalities by a large enough amount to increase overall benefits under both the low and high calculations, even though fatal injuries do not appear to be significantly underreported. This effect far outweighs the effect of inflation; solely inflating DOT's \$3 million VSL from 2001 to 2007 dollars (using the Consumer Price Index) would increase it to \$3.5 million. The difference between the two VSL estimates is primarily attributable to the findings of newer research, which now support a higher VSL, as discussed in more detail in Chapter 3.

For nonfatal injuries, the use of low estimates of underreporting and low per case values (reflecting averted medical costs and lost productivity only) reduces total benefits, due to the decrease in the monetary value of each injury. The use of the high underreporting factors and the higher monetary values substantially increases the totals. Overall, total

values for nonfatal injuries range over orders of magnitude due to uncertainty in both the underreporting factors and the monetary values.

As discussed earlier, the above values include injuries to both adults and children, while this regulation only affects children. The NHTSA (2009) values are not broken-out by year of age, but Finkelstein *et al.* (2006, Appendix Table 4-1) provide per case values for children ages 0-4 and ages 5-14, reported by treatment category rather than injury severity. In general, the estimates for nonfatal injuries, which include medical costs and lost productivity, are lower for children than for middle-aged adults. This may result largely because children are not working and do not accrue productivity losses. Finkelstein *et al.* also provide total (rather than per case) cost estimates for nonfatal drownings treated in hospitals or emergency departments, by gender and year of age, but do not report per case costs that can be compared to the costs for other types of injuries or for other age groups.

This comparison highlights another shortcoming of using the averted cost approach as a proxy for WTP for nonfatal injuries, in addition to the more general limitations noted in Chapter 3. There is some evidence that individual WTP for averting fatal or nonfatal risks to children may be higher than WTP to avert similar risks to adults (e.g., Bosworth *et al.*, 2010, Hammitt and Haninger, 2010, Dickie and Messman, 2004), although some studies (e.g., Jenkins *et al.*, 2001) show contrary results. Averted cost measures are not likely to fully capture this age-related difference in value, particularly given that productivity losses are a large proportion of the adult values for nonfatal injuries but less relevant for children.⁸³

5.3 BOAT SAFETY EQUIPMENT

For our second case study, we use an example that is based on a preliminary analysis of boat safety equipment. Because the underlying analysis has not yet been completed, we do not discuss the potential policy or the analysis in detail. Instead, we begin with estimates of injuries averted and related values, and then follow the same approach as in the prior case study.

In Exhibit 5-9, we provide the results of the preliminary analysis, which relies on the DHS VSL of \$6.3 million (2007 dollars) and values nonfatal injuries using the ratios of nonfatal to fatal injuries reported in DOT (1993).

⁸³ Some studies include caretaker productivity losses in estimating averted costs associated with childhood illness or injuries, but more work is needed to fully incorporate these costs (see, for example, Tranmer *et al.* 2005).

EXHIBIT 5-9: RESULTS OF BENEFITS ANALYSIS FOR REGULATION REQUIRING BOAT SAFETY EQUIPMENT

INJURY SEVERITY ^a	VALUE PER INJURY AVERTED ^b	NUMBER OF INJURIES AVERTED (ANNUAL)	TOTAL VALUE OF AVERTED INJURIES
Minor	$(\$6,300,000)(0.0020) = \$12,600$	18.6	\$233,906
Moderate	$(\$6,300,000)(0.0155) = \$97,650$	9.8	\$956,189
Serious	$(\$6,300,000)(0.0575) = \$362,250$	19.6	\$7,112,779
Severe	$(\$6,300,000)(0.1875) = \$1,181,250$	2.5	\$2,951,944
Critical	$(\$6,300,000)(0.7625) = \$4,803,750$	0.5	\$2,449,913
<u>Fatal</u>	\$6,300,000	<u>2.8</u>	<u>\$17,640,000</u>
Total		53.8	\$31,344,730

Source: Preliminary analysis of boat safety equipment requirements.

Notes:

Detail may not add to total due to rounding.

a. The injury severity categories are equivalent to AIS categories 1 through 6, as discussed above.

b. The factors in parentheses (i.e., 0.0020 through 1.000) are identical to those in DOT (1993).

In Exhibit 5-10, we use the same approach as in the prior case study to determine the effects of possible underreporting. We apply the underreporting multipliers from Exhibit 5-2 to the estimates in Exhibit 5-9, to illustrate the increases that result. As in the prior case study, the results provide a wide-range of injury estimates due to the variation in the underreporting factors. Because this case study includes injuries in all severity categories, adjusting for underreporting leads to a larger change than in the prior case, increasing the overall injury estimates by factors ranging from roughly 5 to 65, depending on which factors are used from Lawrence *et al.* or this report.

EXHIBIT 5-10: POTENTIAL EFFECTS OF INJURY UNDERREPORTING (BOAT SAFETY EQUIPMENT)

INJURY SEVERITY	ORIGINAL ANNUAL INJURY RATE ^a	BASED ON LAWRENCE <i>ET AL.</i> (2006)		BASED ON THIS REPORT	
		UNDER-REPORTING FACTORS ^b	ORIGINAL ANNUAL INJURY RATE MULTIPLIED BY UNDERREPORTING FACTORS ^c	UNDER-REPORTING FACTORS ^b	ORIGINAL ANNUAL INJURY RATE MULTIPLIED BY UNDERREPORTING FACTORS ^c
Minor	18.6	13.6	250	120	2,200
Moderate	9.8	1.25-13.6	12-130	1.5-120	15-1,200
Serious	19.6	1.25	25	1.5-1.7	29-33
Severe	2.5	1.25	3.1	1.5-1.7	3.7-4.2
Critical	0.5	1.25	0.6	1.5-1.7	0.8-0.9
<u>Fatal</u>	<u>2.8</u>	1.01	<u>2.8</u>	1.0	<u>2.8</u>
Total	54		300-420		2,300-3,400

Notes:

Detail may not add to total due to rounding.

Analysis is illustrative only; the appropriate multipliers for nonfatal injuries are highly uncertain.

a. Based on Exhibit 5-9.

b. From Exhibit 5-2. See Chapter 2 and Section 5.1 for more information on these multipliers.

c. Results are rounded to two significant digits to reflect uncertainty; intermediate calculations are based on unrounded data.

In Exhibit 5-11, we illustrate the effects of applying different monetary values to this range of injury estimates. As in the prior case study, to illustrate the possible range, we first multiply the lowest adjusted injury estimates (from Exhibit 5-10) by the lower injury values (the averted cost estimates from Finkelstein *et al.*, 2006, as reported in Exhibit 5-5 for nonfatal injuries, and the DHS VSL of \$6.3 million for fatalities). We then multiply the highest adjusted injury estimates (from Exhibit 5-10) by the higher injury values (the averted cost and monetized QALY estimates from NHTSA, 2009, adjusted for the DHS VSL, as reported in Exhibit 5-4).⁸⁴ We compare these values to those in the preliminary analysis, as reported in Exhibit 5-10.

⁸⁴ The NHTSA estimates are based on updated (2002) ratios of the value of nonfatal-to-fatal injuries. The original analysis of this rule applies ratios established in DOT's 1993 guidance, which have not yet been revised.

EXHIBIT 5-11: POTENTIAL EFFECTS OF ALTERNATIVE VALUES (BOAT SAFETY EQUIPMENT)

INJURY SEVERITY	ORIGINAL ANNUAL VALUES ^a	LOW END VALUES ^b		HIGH END VALUES ^d	
		LOW VALUE PER CASE ^b	LOW UNDERREPORTING MULTIPLIED BY LOW VALUES ^c	HIGH VALUE PER CASE ^b	HIGH UNDERREPORTING MULTIPLIED BY HIGH VALUES ^c
Minor	\$233,906	\$4,318	\$1,100,000	\$19,650	\$45,000,000
Moderate	\$956,189	\$12,579	\$150,000	\$319,442	\$380,000,000
Serious	\$7,112,779	\$39,073	\$960,000	\$566,148	\$19,000,000
Severe	\$2,951,944	\$91,722	\$290,000	\$1,446,149	\$6,100,000
Critical	\$2,449,913	\$130,824	\$83,000	\$4,834,560	\$4,200,000
<u>Fatal</u>	<u>\$17,640,000</u>	\$6,300,000	<u>\$18,000,000</u>	\$7,514,812	<u>\$21,000,000</u>
Total	\$31,344,730		\$20,000,000		\$480,000,000

Notes:

Detail may not add to total due to rounding.

Analysis is illustrative only; appropriate multipliers and values for nonfatal injuries are uncertain.

a. Based on Exhibit 5-9. Estimates are in 2007 dollars.

b. Based on Finkelstein *et al.* (2006) estimates from Exhibit 5-5, except for fatalities, which are valued using the DHS VSL. Estimates are in 2007 dollars.

c. Low end multipliers for number of injuries are from Lawrence *et al.* (2006) and high end multipliers are from this report, for all categories except fatalities. For fatalities, Lawrence *et al.* provide the higher multiplier. Results rounded to two significant digits to reflect uncertainty; intermediate calculations are based on unrounded data.

d. Based on NHTSA approach adjusted for DHS VSL from Exhibit 5-4. Estimates are in 2007 dollars.

As indicated by the exhibit, the values for fatal injuries are relatively similar, because the change in the number of cases is small. All of the estimates rely on the same VSL, however, the NHTSA-based estimates for fatalities are somewhat higher due to the addition of averted costs. For nonfatal injuries, the use of low estimates of underreporting and low monetary values (reflecting averted medical costs and lost productivity only) reduces total values, because the decrease in per injury values is not outweighed by the underreporting factors. The use of the high underreporting factors and the higher monetary values increases the totals by an order of magnitude. Again, nonfatal injury values vary widely due to uncertainty in both the underreporting factors and monetary values.

5.4 RATIO OF FATAL TO NONFATAL INJURIES

In our third case study, we explore the uncertainty in the underreporting factors from a different perspective, calculating the number of injuries in each severity category that would need to be averted to equal the value of one fatality. This exercise provides useful information for thinking about the extent to which it is worthwhile to invest significantly in reducing the uncertainty associated with underreporting.

In Exhibit 5-12 below, we divide the VSL currently used by DHS (\$6.3 million) by the value per injury following the NHTSA (2009) and Finkelstein *et al.* (2006) approaches. For moderate through critical injuries, the ratios are relatively small when we apply the NHTSA values, and within the range of the underreporting factors found in the Lawrence *et al.* (2006) and current analysis as summarized in Exhibit 5-2. The ratio is much larger for minor injuries. If we instead use the lower Finkelstein *et al.* (2006) values, the ratios are much larger for all severity categories, which is not surprising given the much lower values per case.

EXHIBIT 5-12: RATIO OF VALUES FOR FATAL AND NONFATAL INJURIES (VSL = \$6.3 MILLION IN 2007 DOLLARS)

INJURY SEVERITY	COST PER CASE (NHTSA, 2009) ^a	RATIO OF VSL TO NONFATAL INJURY COST	COST PER CASE (FINKELSTEIN <i>ET AL.</i> 2006)	RATIO OF VSL TO NONFATAL INJURY COST
Minor	\$19,650	321	\$4,318	1,459
Moderate	\$319,442	20	\$12,579	501
Serious	\$566,148	11	\$39,073	161
Severe	\$1,446,149	4	\$91,722	69
Critical	\$4,834,560	1	\$130,824	48

Source: See Exhibits 5-4 and 5-5.

Note:

a. NHTSA values are adjusted for DHS VSL.

This comparison indicates that a large number of minor injuries would need to be averted for their monetary value to be equivalent to the value of one fatality, particularly if the lower Finkelstein *et al.* estimates are used for valuation. To the extent that only limited resources are available for further exploring issues related to underreporting, this comparison suggests that improving the estimates for more severe injuries may have a more significant impact on the benefit estimates for recreational boating safety rules.

5.5 SUMMARY AND CONCLUSIONS

In this chapter, we provide three case studies that illustrate different aspects of the findings in the earlier chapters. For the PFD rule, we find that, because Coast Guard values nonfatal injuries as a proportion of the VSL, the increase in the VSL between 2002 and 2008 substantially affects the benefit estimates. In addition, this case study raises issues related to the appropriate valuation of risks to children. For the boat safety equipment rule, which was assessed originally using the current DHS VSL, we find that adjustment for underreporting and use of different values for nonfatal injuries has substantial effects.

These case studies illustrate the effect of uncertainties in the appropriate adjustment for underreporting and the approach used for valuation. For underreporting, Coast Guard may wish to use a range of estimates while determining whether to undertake additional research. For valuation, given that consistently-estimated WTP estimates are not available for the range of injuries addressed by boating safety rules, Coast Guard faces difficult choices. One option is to continue to use estimates of averted costs and monetized QALYs developed for motor vehicle safety rules, which have not yet been updated to reflect recent best practice recommendations as well as changes in costs over time. Alternatively, Coast Guard could rely on estimates of averted medical treatment costs and lost productivity, which result in much lower values. Neither approach is ideal, but in combination they could be applied to provide information on the possible range of values. The researchers who developed these monetary values may also be able to provide more detailed breakouts that would be useful for future Coast Guard analyses.

CHAPTER 6 | CONCLUSIONS

Coast Guard requires data on the consequences of recreational boating accidents, so that it can compare the costs of alternative regulations, policies, and programs to their benefits. It currently relies largely on accident reports from boat operators for these data, but is concerned about the accuracy and completeness of these reports. In particular, information on the number and characteristics of fatal and nonfatal injuries, and on property damages, is needed for accidents that differ in cause, in the type of vessel involved, and in operator and passenger characteristics. In addition, for comparison to costs, benefits must be valued in monetary terms, which requires information on the value of reducing the risks of injuries of different types.

In this report, we review previous research, evaluate alternative data sources, and explore the implications of these alternative data for estimating the benefits of Coast Guard regulations and policies. We focus on (1) the number and types of fatal and nonfatal injuries associated with recreational boating accidents nationally; (2) the per-case value of these injuries; and (3) the economic costs of accident-related property damages nationally. While, as discussed in Chapter 1, we are primarily concerned with the use of these data for benefit-cost analysis of potential regulations, our findings may also be useful for prioritizing non-regulatory programs and initiatives.

Below, we first summarize our results and conclusions regarding the strengths and limitations of currently available data and methods. Then, we discuss options for applying these results and for further exploring these issues.

6.1 SUMMARY OF CONCLUSIONS

While boat operators are required to submit reports whenever they are involved in accidents meeting established criteria, compliance with these requirements may be limited both because of lack of awareness and because of the difficulties of enforcement. While Coast Guard has undertaken numerous initiatives to improve compliance, in this report we focus on supplementing these reporting requirements with information from other sources.

Our research suggests that the information collected by Coast Guard is the most comprehensive source of these data available. Neither academic research studies nor reports from other governmental or nongovernmental organizations provide detailed national data on these accidents. Thus the question is whether we can use data collected for other purposes to provide some insights into the accuracy and reliability of certain aspects of these data.

Our work builds on several other Coast Guard efforts to better understand the limitations of available data and to determine how to best address these limitations. Our findings are reasonably consistent with the results of these previous efforts, but provide information on recent trends as well as additional insights. Our major findings are as follows.

- 1) **Number of Fatal Injuries:** Previous reports, particularly Lawrence *et al.* (2006), and our analysis of more recent data from national vital statistics reports (in Chapter 2), suggest that the estimates of fatalities in Coast Guard's BARD system are reasonably accurate. The importance of these fatalities encourages reporting by boat operators and investigation by the States and other authorities.
- 2) **Value of Fatal Injuries:** Coast Guard follows a well-established approach for valuing reductions in the risk of fatal injuries. This approach is based on estimates of individual WTP for small risk reductions in a defined time period, converted to a VSL estimate of \$6.3 million (2007 dollars).
- 3) **Number and Severity of Nonfatal Injuries:** Both previous reports and our analysis suggest that nonfatal injuries are substantially underreported, with underreporting increasing as the severity of the injury decreases. In particular:
 - a. Comparison of data on injuries requiring hospitalization in Lawrence *et al.* (2006) to 2002 data in BARD, and our comparison (in Chapter 2) of data from 2005 through 2008, suggests that these injuries are underreported by less than a factor of two. More specifically, the Lawrence *et al.* analysis of 2002 data suggests that BARD estimates would need to be multiplied by about 1.25 to match the data in the State HCUP-SID databases, while our analysis suggests that a factor of about 1.5 to 1.7 would be needed to match data in the national HCUP-NIS database. Our supplementary analysis suggests that the degree of underreporting varies substantially by State.
 - b. Comparison of data on injuries not requiring hospitalization, but treated in emergency departments or outpatient or doctors' offices, suggests much greater underreporting. Lawrence *et al.*'s analysis of HCUP-SID and NHAMCS data suggests that injuries reported to BARD may need to be multiplied by 13.6 to match the data from these sources. Our analysis of 2001 through 2004 NAMCS and NHAMCS data suggests that this factor may be approximately 120.
 - c. The data on underreporting of injuries are consistent with the results of other analyses that suggest that accidents are underreported overall. Over the past 20 years, the annual number of accidents reported in BARD has ranged from 4,730 to 8,061 (Coast Guard, 2010; Coast Guard 1995). However, analysis of 1994 insurance claims identified over 90,000 claims for reportable accidents (MIBF, 1995); this is likely to underestimate the total because many boat owners may not have insurance or may not file insurance claims. Furthermore, a 2002 survey

funded by Coast Guard suggests that more than 270,000 reportable accidents occurred in a single year (SRG, 2003).

- d. The underreporting estimates are highly uncertain, however, with the level of uncertainty increasing as the severity of the injury decreases. These uncertainties result from the difficulty of determining the treatment setting from the BARD data, and from the limitations of the other data sources, which often make it difficult to separate injuries that result from recreational boating from injuries associated with other causes.

4) **Value of Nonfatal Injuries:** Ideally, for benefit-cost analysis, the value of reducing the risk of nonfatal injuries would be based on estimates of individual WTP. Such estimates are lacking for the range of nonfatal injuries averted by recreational boating safety policies. Instead, government agencies and researchers often rely on one of two approaches as rough proxies.

- a. DOT and its component agencies (e.g., NHTSA, 2009) combine estimates of averted costs with monetized QALY gains to determine the value of nonfatal injury risk reductions in different severity categories. The strength of this approach is that it provides established estimates based on detailed analysis of injuries of different types. Its limitations include the need to update existing estimates to reflect more current data on treatment costs and recovery periods, as well as more recent recommendations for best practices. In particular, the use of monetized QALYs for benefit valuation has been questioned on both theoretic and empirical grounds. In addition, these estimates address injuries from causes other than recreational boating (e.g., motor vehicles), which may differ in terms of costs and quality of life impacts.
- b. Researchers also use estimates of averted medical costs and lost productivity to value nonfatal injury risk reductions (e.g., Finkelstein *et al.*, 2006). These values are significantly lower than the values used by DOT, because they exclude averted administrative costs and quality of life impacts. The advantage of this approach is that it relies on somewhat more up-to-date data and provides information for all injuries nationally as well as for injuries from particular causes, although values that solely address injuries from recreational boating accidents are not easily accessible. One important limitation of this approach, as well as the DOT approach (which includes averted costs), is that standardized best practices have not yet been established for these types of estimates, and alternative approaches may lead to differing results. In addition, while some research suggests that these estimates may understate individual WTP for risk reductions, the presence of insurance complicates the interpretation of this relationship.

- 5) **Value of Property Damages:** We were unable to locate a comprehensive source of information regarding property damages to compare with BARD. However, previous analysis conducted as part of the R-BAR program (MIBF, 1995), as well as the evidence of significant underreporting of accidents noted above, suggest that property damage estimates in BARD are likely to be understated.

In total, these findings mean that Coast Guard faces a number of challenges when assessing the benefits of its regulations and policies. In general, our analysis suggests that the numbers of nonfatal injuries and the amount of property damages may be significantly understated. In addition, determining the value of nonfatal risk reductions is difficult given the data now available. Fatalities are less prone to uncertainty; the number of fatalities in the BARD system appears reasonably accurate, and the value of reducing fatality risk is based on well-established methods consistent with the benefit-cost analysis framework.

6.2 CONSIDERATIONS FOR NEXT STEPS

In each chapter of this report, we discuss the advantages and limitations of the available data and related analysis in detail. Here, we focus on two issues: (1) priorities for future work; and (2) options for addressing each issue.

6.2.1 PRIORITIES FOR FUTURE WORK

Overall, the estimates of nonfatal injuries and the value of reducing related risks appear to be the areas of greatest uncertainty that may have the most significant impact on the estimates of benefits for Coast Guard policy and regulatory analysis. While the estimates of property damages are also uncertain, these damages are secondary to Coast Guard's goal of reducing boating injuries. Because the estimates of underreporting for hospitalized nonfatal injuries appear somewhat consistent, gaining a better understanding of underreporting for injuries requiring less extensive treatment may be a higher priority. In addition, improving the ability to crosswalk injuries categorized by type of treatment with injuries categorized by severity categories would significantly reduce related uncertainties.

Equally important is the need for enhanced approaches to valuing nonfatal injuries. These values are also highly uncertain, and improved estimates would be useful for a variety of Coast Guard programs (not solely recreational boating), for other DHS components, and for researchers addressing injuries in many other contexts.

6.2.2 OPTIONS FOR IMPROVING INJURY ESTIMATION

The analysis in Chapter 2 indicates substantial uncertainty in the number and types of injuries associated with current boating practices, which in turn affects the estimates of injury risk reductions in regulatory analysis, as indicated in the case studies in Chapter 5. This uncertainty is low for fatalities, but increases as injury severity decreases. For severe and critical injuries (MAIS categories 4 and 5), which are likely to involve hospitalization, the estimates of underreporting are relatively similar. For moderate and

serious injuries (MAIS categories 2 and 3), which could be treated in a hospital, emergency department, and/or outpatient or doctor's office, underreporting is more uncertain but has a potentially larger impact.

Coast Guard has several choices for dealing with this underreporting:

- 1) It could develop standard language to qualitatively discuss the impact of underreporting on the estimates in its analyses.
- 2) It could use the underreporting factors developed in this report to conduct sensitivity analysis.
- 3) It could undertake a more extensive and detailed analysis of underreporting, focusing either on all types of recreational boating-related injuries or only on those where underreporting appears to most significantly affect its analytic results.

The first option requires little time and effort; the second option is similar to the approach followed in our case studies and would require only moderate refinement. However, the results will need to be presented with care to ensure that readers do not misinterpret the degree of uncertainty. The final option requires a higher level of effort, but would have the greatest impact on the reliability and accuracy of the estimates. Under this third option, developing improved multipliers to estimate the number of moderate through critical injuries requires additional research.

For hospitalizations, Coast Guard might consider two alternatives: more detailed state-by-state research, or further analysis of the national data. For example, Coast Guard might consider developing state-by-state estimates using data from HCUP-SIDs, similar to the approach applied by Lawrence *et al.* (2006) for 2002, building on our analysis in Appendix C. The Lawrence *et al.* data is now almost 10 years old, and updating it would allow Coast Guard both to develop a better understanding of current trends and to take advantage of improvements in the underlying data sources. However, data are not available for some States. In addition, due to the relatively small number of such injuries occurring annually, data are likely to be suppressed in certain States in the publicly-accessible data. Care will be needed to develop factors for extrapolating to States for which data are lacking. For comparison, the approach for determining the number of hospitalized injuries reported in BARD also would need refinement.

Another, potentially less costly, approach might involve estimating a single, national multiplier for hospitalizations based on refining and expanding the analysis of HCUP-NIS data discussed in Chapter 2. These multipliers are relatively similar in our analysis and the previous Lawrence *et al.* (2006) analysis, and could be refined with somewhat less effort than would be involved in further review of the state-by-state data. The advantage of this approach is that a single estimate applicable to hospitalized injuries could be developed by looking at a single database; thus, the analysis could be replicated relatively easily in future years, as necessary. However, as shown in Chapter 2, the HCUP-NIS database relies on a national probability sample. Because boating injuries

represent a small proportion of total hospitalizations, data suppression issues require the analysis of multiple injury codes simultaneously. Also, additional research is required to determine whether more detailed data describing the injuries are available to correct for miscoded entries and to remove non-reportable accidents. To the extent that future regulations affect States differently (e.g., Coast Guard may promulgate regulations designed for certain water bodies, such as lakes or bays, or that are applicable only in cases where the States lack similar requirements), adjustment factors would be needed for state-by-state differences, which can be significant as noted in Appendix C. This approach would also require refining how hospitalized injuries are reported in BARD.

Estimating the number of non-hospitalized, nonfatal injuries treated through emergency department and office visits may be more important, given that the Lawrence *et al.* analysis and our analysis in Chapter 2 suggest both significant underreporting and a wide-range of potential adjustment factors. However, refining these estimates would require facing more difficult challenges. Most importantly, BARD does not provide the level of detail necessary to determine which injuries are treated in each of these settings, and an improved approach would be needed for developing these estimates. In addition, the NHAMCS and NAMCS, which represent the best publicly-available national databases for these visits, is also based on a probability sample and subject to some of the same limitations as the HCUP-NIS. Additional research would be needed to determine whether available State data, such as the HCUP-SEDD, would be useful in refining these estimates.

The case studies presented in Chapter 5 suggest that the degree of underreporting related to minor injuries (MAIS category 1) may be less important in regulatory analysis due to their lower per-case value. It is unclear whether better information on these injuries could significantly affect the choice of program or regulatory options. More importantly, injuries in this category are not currently reportable to BARD, because the BAR now excludes injuries not requiring treatment beyond first aid. By definition, and consistent with the MISLE categories, these injuries do not require medical attention.

As an alternative to relying on existing databases to make adjustments to BARD, Coast Guard might consider conducting primary research, such as a survey of recreational boat owners and operators. Depending on how the survey is constructed and implemented, it could collect data on all types of injuries, including those that are not reportable to BARD but that may be reduced as a result of future Coast Guard actions. In addition, the survey could supplement information in BARD regarding the cause of accidents resulting in various types of injuries. Key challenges in conducting primary research include the need to obtain OMB approval of the information collection and the effort required to develop, test, and implement the survey plan so that the results are nationally representative.⁸⁵

⁸⁵ Survey research requires OMB approval of an Information Collection Request (ICR). While the development and implementation of the survey might be accomplished more quickly, the public comment and review process for the ICR are likely to add a minimum of six to 12 months to the process.

Given the effort involved, repeating the survey frequently as baseline boating practices change may not be feasible.

6.2.3 INJURY VALUATION

The discussion in Chapter 3 indicates that approaches for valuing fatal injuries are well-established and consistent with the overall benefit-cost analysis framework, but the choices for valuing nonfatal injuries currently have significant shortcomings.

Coast Guard has several options for dealing with these limitations:

- 1) It could develop standard language to qualitatively discuss the implications of the valuation approach used in its analysis.
- 2) It could use a range of values (e.g., based on its current approach and the alternatives applied in the Chapter 5 case studies) to illustrate the effects of uncertainty.
- 3) It could contact the researchers responsible for the data that underlie the Chapter 5 estimates, to determine whether alternative breakouts of the existing data can be provided without engaging in new research.
- 4) It could conduct new research studies to collect improved information on averted costs and/or WTP estimates.

The first option requires little time and effort; the second option is similar to the approach followed in our case studies and requires only moderate enhancement. However, again, the results will need to be presented with care to ensure that readers do not misinterpret the degree of uncertainty. The third option would be more costly; however, the various studies currently used to value nonfatal injuries rely on similar groups of authors and similar data sources, and the underlying data sets contain more information than provided in the publicly-available reports. Thus it may be worthwhile to contact these authors to discuss options for accessing these data. The cost of acquiring such data is likely to be much less than the cost of new research. In addition, Coast Guard may wish to contact DOT to learn more about its ongoing work to update its approach.

New research under the fourth option could take two forms. Coast Guard could develop new estimates of averted costs, using the boating-related codes in the underlying databases to identify costs associated specifically with recreational boating injuries.⁸⁶ The starting point for this analysis could be the approach used in Finkelstein *et al.* (2006) as well as in Lawrence *et al.* (2009) for the CDC/WISQARS cost calculator. It may be desirable to then update the approach to reflect newer data and research, redesigning it to reflect emerging work on best practices for developing these estimates (e.g., as reflected in Yabroff *et al.*, 2009). While this would be a relatively large undertaking, it would provide Coast Guard with more current estimates directly applicable to its boating safety policies and potentially other programs.

⁸⁶ These databases include many of those discussed in Chapter 2 as well as those summarized in Lund *et al.* (2009).

The second approach would involve conducting new WTP research. This research would provide estimates that are consistent with the framework for benefit-cost analysis and that reflect all aspects of the risk reductions associated with boating safety regulations. As discussed in Robinson (2007) and Chapter 3, these estimates would be useful for many other DHS components as well as other government agencies, as well as for work conducted by nongovernmental organizations and scholars. Such research can be expensive and requires OMB approval for the information collection, which can significantly extend the amount of time needed to complete the research.

6.2.4 PROPERTY DAMAGES

Research conducted under the R-BAR program in the early 1990s provides the only source of information available for comparison to BARD on property damages (MIBF, 1995). Unfortunately, that report does not provide sufficient data to separate the value of property damage insurance claims from claims that also include a component for bodily injury. Therefore, we are unable to make a direct comparison between the value of insurance claims and property damages reported to BARD in 1994.

As discussed in Chapter 5, Coast Guard has several choices for dealing with this issue:

- (1) It could develop standard language to qualitatively discuss the implications of related uncertainties in its analysis.
- (2) It could obtain summary level data on the number and characteristics of accidents from ISO.
- (3) It could conduct a survey of insurance providers to obtain data on property damage claims.
- (4) It could survey boat owners and operators to obtain estimates of property damages.

While a survey of insurance providers would likely be easier to design and implement, associated data on the cause of the accident and/or boating practices taking place when it occurred are unlikely to be available. Therefore, it could be difficult to link damages to the types of activities that would be subject to future policy development or regulatory action. These data could be obtained through a survey of boat owners and operators; however, obtaining a nationally-representative sample of this population would be more complicated and expensive. In addition, OMB approval would be required for these efforts, as discussed above.

6.3 CONCLUSIONS

In this report, we examine data on the consequences of recreational boating accidents, to aid Coast Guard in determining how these data can be enhanced so as to improve its analyses of the benefits of alternative regulations, policies, and programs. Our analysis suggests that the available data on fatalities, and on the value of reductions in fatality risks, is reasonably accurate and appropriate for use in benefit-cost analysis. For nonfatal injuries, the available data are more uncertain. These injuries are underreported, with the degree of underreporting increasing as the severity of the injury decreases. In addition, the approaches used for valuation do not directly address boating-related injuries and rely on rough proxies for WTP for risk reductions. For property damages, more research is needed to determine the accuracy of the available estimates, but they also appear to be subject to significant underreporting.

To address these issues, Coast Guard faces a number of options. The simplest would involve crafting standard language for inclusion in its analyses. The more complex options vary by the type of outcome, but include both minor revisions and major research initiatives. In each case, consideration of the benefits of improved information, in terms of its implications for decisionmaking, will need to be weighed against its costs.

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APPENDIX A: Annotated Bibliography

This Appendix summarizes published articles and reports that describe: (1) the numbers and types of fatal and nonfatal injuries associated with recreational boating accidents; (2) the economic costs of injuries of all types (not only those associated with boating); and/or (3) the monetary value of property damages associated with recreational boating accidents. We include studies cited in the main text of this report, as well as studies that we reviewed but deemed less useful. These latter documents generally focus too narrowly (e.g., on a particular location or accident type) to support national estimates or focus on the effectiveness of particular interventions rather than on baseline incidence. Some of the injury valuation studies listed report results that are not applicable to boating related-accidents, or use approaches that are not consistent with the benefit-cost analysis framework (as described in detail in the main text), but are included here as references.

To identify these studies, we: (1) reviewed related reports previously prepared for Coast Guard; (2) searched Google Scholar as well as several online bibliographic databases; (3) consulted with Coast Guard staff and other researchers; and (4) reviewed the reference lists in all the studies we identified. In general, we focused on studies published in the year 2000 or later, but included a few studies from the 1990s or earlier that are of particular relevance to this effort. We organized the resulting studies into the following categories, mirroring the organization of the main report:

- I. Numbers and Types of Fatal and Nonfatal Boating-Related Injuries
- II. Value of Fatal and Non-Fatal Injuries (all causes)
- III. Boating-Related Property Damages

We first provide the bibliographic information for each document and then provide a brief summary. If sources are applicable to more than one category, the summary appears only in the first category. The main text of the report discusses the implications of these studies for this project.

I. NUMBERS AND TYPES OF FATAL AND NONFATAL BOATING-RELATED INJURIES

Emergency Nurses Association, Departments of Research, Practice, and the Injury Prevention Institute/ EN CARE. 2007. *Recreational Boating Injuries Treated in U.S. Emergency Departments Final Report: 2001 through 2005*. Prepared for the U.S. Coast Guard.

This report describes the results of a four-year data collection effort conducted for the purpose of making recommendations on how to reduce injuries resulting from recreational boating accidents. In 2001, 2002, 2004 and 2005, voluntary questionnaires were offered to patients admitted to each of 75 participating emergency departments throughout the United States. The resulting sample was analyzed to identify correlating factors in boating accidents. The study concluded that operator error was the most prevalent contributing factor to boating accidents that result in injury. Results also

indicated that boat safety education decreases the incidence of risky behavior in operators, such as speeding, drinking, and not wearing a PFD.

Fiore, D.C. & J. D. Houston. 2001. Injuries in Whitewater Kayaking. *British Journal of Sports Medicine*, 35(4), 235-241.

This report describes whitewater kayaking injuries on a global scale. The authors distributed a survey at whitewater events and club meetings and on the internet in 1997, requesting data on injuries from the previous five years (1992-1997). Injury data included mechanism, activity, and severity. A total of 392 responses were included in the final analysis. The most common mechanisms were striking an object (44%), traumatic stress (25%), and overuse (25%). The most common injuries were abrasions (25%), tendinitis (25%), contusions (22%), and dislocations (17%). The only significant factor relating to likelihood of injury was exposure, measured in the number of days a year that the sport was pursued; other measured but insignificant factors were sex, age, skill level, and years of kayaking experience.

Gabbe, B.J., C.F. Finch, P.A. Cameron, & O.D. Williamson. 2005. Incidence of Serious Injury and Death during Sport and Recreation Activities in Victoria, Australia. *British Journal of Sports Medicine*, 39(8), 573-577.

This article describes the epidemiology of serious injuries sustained in sport/recreation activities, focusing on adults in Victoria, Australia. Patients aged 15 and over with sport/recreation related injury, who presented to hospital for treatment or who died before reaching hospital, were identified from the Victorian State Trauma Registry (VSTR) and the National Coroner's Information Service (NCIS) from July 2001 to June 2003. Water-skiing and power boating accounted for 8.6 percent of the 198 serious injuries and deaths reported. Of the 40 reported deaths, 69 percent were due to drowning, including deaths associated with swimming and other activities that are not necessarily boating-related.

Gabe, T.M. & D. Hite. 2003. The Effects of Boating Safety Regulations. *Coastal Management*, 31, 247-254.

This article investigates the effects of implementing boater education programs and increasing the number of water patrol officers on preventing recreational boating accidents. It focuses on the number of boating accidents rather than injuries. It incorporates data from 49 states and the District of Columbia from 1994 as collected by the Department of Transportation. The findings illustrate that the number of full-time law enforcement officers that patrol State waterways significantly affects the number of boating accidents in a State; an increase of one water patrol officer would prevent about 68 accidents in the average State. The number of hours of boating education was not statistically significant.

Glover, E.D., S. Lane, & M.Q. Wang. 1995. Relationship of Alcohol Consumption and Recreational Boating in Beaufort County, North Carolina. *Journal of Drug Education*, 25(2), 149-157.

This study examines the relationship between alcohol use and recreational boating activities and environmental and social factors such as boater's age, safety education, awareness of the law, and perceptions of alcohol in boating accidents. Researchers gathered data from visitors to public and private docks during the fall and spring seasons through a self-report questionnaire. A total of 211 subjects completed the interview. Results illustrate that 61 percent had previously received boating safety education. A significant relationship was found between receiving safety education and prevalence of alcohol use: boaters with safety education had a higher percentage of alcohol use than boaters without safety education. However, the study does not provide data on related fatal or nonfatal injuries.

Harris, Anna. 2010. *Casting Beyond the Bow: An Examination of Anglers Fishing From Boats. An Addendum to the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*. U.S. Fish & Wildlife Service.

This report provides detailed information on fishing from boats, based on the 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Reported data include information on location, boater demographics, boat characteristics, and other factors. However, the study does not provide data on fatal or nonfatal injuries.

Hostetler, S.G., T.L. Hostetler, G.A. Smith, & H. Xiang. 2005. Characteristics of Water Skiing-related and Wakeboarding-related Injuries Treated in Emergency Departments in the United States, 2001-2003. *American Journal of Sports Medicine*, 33(7): 1065-1070.

This report outlines the number of injuries, injury diagnoses, and body regions injured in water skiing and wakeboarding in the United States. The authors assessed data on injuries from the National Electronic Injury Surveillance System (NEISS), including data provided by 98 hospital emergency departments between the beginning of 2001 and the end of 2003. They focused on cases identified using the consumer product code for water skiing, which captures water skiing, wakeboarding, kneeboarding, tubing, and other water sports. They analyzed 517 cases of water skiing-related injuries and 95 cases of wakeboarding-related injuries. The most common injuries for wakeboarders were head injuries (29 percent), primarily facial lacerations. For water skiers, strains or sprains to the lower extremities were the leading injury diagnoses (34 percent). The study emphasizes the potential positive effect of helmets or other protective head gear for wakeboarders and the use of plastic or foam coating for towropes. For water skiing, it emphasizes the need for physical conditioning and education for participants new to the sport.

Howland, J., G.S. Smith, T. Mangione, R. Hingson, W. DeJong, & N. Bell. 1993. Missing the Boat on Drinking and Boating. *Journal of the American Medical Association*, 270(1), 91-92.

This article addresses two questions: 1) whether emphasizing reducing alcohol use by boat operators alone makes sense, given how many fatal boating events occur; and 2) if not, whether the information on drinking and boating actually places people at greater risk because, by focusing on boat operators, it implies that it is safe for passengers to drink or for skippers to drink at anchor. The data analyzed come from the Coast Guard Recreational Boating Statistics report (1991). Based on their review of this source, Howland *et al.* emphasize that fatalities could be attributed to boat operators in no more than 54 percent of the cases; 46 percent of fatalities occurred when vessels were not under way. While safety programs target the operation of vessels while under the influence of alcohol (drunk driving), only 18 percent of fatalities involved collisions with other vessels or fixed floating objects.

Lawrence, B.A., T.R. Miller, & L. Daniel Maxim. 2006. *Recent Research on Recreational Boating Accidents and the Contribution of Boating Under the Influence: Summary of Results*. Prepared for the U.S. Coast Guard.

This study is discussed in detail in the main body of this report. It estimates the number of recreational boating injuries, with a particular focus on accidents involving alcohol. To address underreporting issues, the authors used data from several databases independent of BARD and found that BARD underreports fatality counts by one percent, non-fatal hospital-admitted boating injuries by 20 percent and non-fatal non-admitted boating injuries by up to 92 percent.

Lunetta, P., A. Penttila, & S. Sarna. 1998. Water Traffic Accidents, Drowning and Alcohol in Finland, 1969-1995. *International Journal of Epidemiology*, 27, 1038-1043.

This study examines age- and sex-specific mortality rates and trends in water traffic accidents and their association with alcohol in Finland. It is based on national data from 1969-1995. Of the 3,473 boating fatalities during this time, 95 percent were due to drowning. Alcohol intoxication was a contributing factor in 63 percent of these incidents. The overall mortality rates in water traffic accidents as well as those associated with alcohol intoxication both declined significantly over the years studied.

Mangione, T.W., J. Howland, S. Stowman, S. Lambou, & D. Tsouderos. 2000. *1998 National Recreational Boating Survey Data Book*. An Aquatic Resources Trust Fund (Wallop-Breaux) report for the U.S. Coast Guard. Prepared by JSI Research & Training, Boston, MA.

This report presents summary tables of the results of a mail survey of licensed boat owners in each State, which was implemented to obtain information on levels and types of boating activity, use of safety devices and safety behaviors, and boaters' opinions on a variety of safety policy initiatives.

Maxim, D.L. 2010. Drownings Avoided by Using Life Jackets: Working Paper.

This working paper discusses approaches for estimating drownings avoided as a result of increased wear rates for life jackets. It presents an extension of a model used by NHTSA for estimating lives saved due to the use of motorcycle helmets or seat belts or the presence of air bags. It relies on data from BARD for open motorboats in 2008 and matching life jacket wear rate data from a survey sponsored by Coast Guard, to estimate the parameters of a function that can be used to predict drownings averted under different conditions.

Molberg, P.J., R.S. Hopkins, J. Paulson, & R.A. Gunn. 1993. Fatal Incident Risk Factors in Recreational Boating in Ohio. *Public Health Reports*, 108(3), 340-346.

The goal of this study is to identify risk factors predicting the involvement of boat operators in incidents resulting in at least one fatality. Data on boating incidents were obtained from BARs compiled by the Ohio Division of Watercraft from 1983-1986. The authors reviewed Ohio death certificates to detect deaths related to water transport that did not appear in BAR. No additional recreational boating fatalities were found in the death certificates and 40 percent of fatal incidents would have been missed by searching solely the death certificates. In addition, the authors collected risk factor data from 759 registered boaters in a mail survey in 1986. Results indicate that operator age (<30 years) and experience (<20 hours) were independently associated with the risk of being in a fatal accident. Training (none vs. some) and boat type were not significantly associated with risk when controlling for age and experience. Hours of experience were significantly more influential than any other factor. Canoes, kayaks, rowboats, and inflatables were associated with a higher fatality rate than motorboats.

Nathanson, A.T., J. Baird, & M. Mello. 2010. Sailing Injury and Illness: Results of an Online Survey. *Wilderness and Environmental Medicine*, 21(4), 291-297.

The purpose of this study was to describe the relative frequency, patterns, and mechanisms of sailing-related injuries in dinghies and keelboats. Data were also collected on risky and risk-averse behaviors of sailors, and on sailing-related illnesses. Information was gathered via an online survey from March through November of 2006 that focused on injuries or illnesses sustained over the past 12 months. Tacking, heavy weather, and jibing were the most common factors contributing to injury. The rates of injury and severe injury in the internet-based survey were 4.6 and 0.57 per 1000 days of sailing,

respectively. Of the total injured, seven 7 percent of sailors reported use of alcohol within the two hours preceding injury.

National Transportation Safety Board. 1998. *Personal watercraft safety, Safety study NTSB/SS-98/01*. Washington, D.C.: NTSB.

The purpose of this study was to investigate the characteristics of injuries and fatalities from accidents specifically for personal watercraft in order to make safety recommendations to Coast Guard, PWC manufacturers, and others. The study, however, was not intended to estimate the frequency of personal watercraft accidents, or to be representative of all personal watercraft accidents, but instead to use a subset of accident data to study unique safety characteristics of this type of recreational boat. The study revealed that there appears to be a high risk of injury with personal watercraft use, that there is a low level of safety instruction and training among operators of personal watercraft, and that a high usage of PFDs seemed to correlate with a low number of drowning fatalities from PWC accidents.

Neville, V. & J.P. Folland. 2009. *The Epidemiology and Aetiology of Injuries in Sailing*. *Sports Medicine*, 39(2), 129-145.

This report provides detailed statistics on the types and causes of sailing-specific injuries, based on work conducted by the School of Sport and Exercise Sciences at Loughborough University in the UK. The data are divided into categories based on level of experience (Olympic-class vs. Novice/recreational), position (e.g., helmsmen vs. mastmen), and type of sailing activity (e.g., windsurfing, offshore racing). Neville and Folland found that injuries are predominantly acute, with contusions and abrasions typically occurring as a result of collisions with the boom or other equipment.

O'Connor, Peter. 2002. *Assessment of Fatal and Non-fatal Injury Due to Boating in Australia*. National Marine Safety Committee, Australia.

This publication presents national statistics on boating injuries and fatalities in Australia, based on data collected from hospitals and the Australian Bureau of Statistics (ABS). Death data from ABS extends from 1979-1998, while the hospital admission statistics are from 1993-94 only. The hospital data is limited to ICD cause codes E830-838 ('water transport accidents') and E910.0 ('accidental drowning and submersion while water skiing'); they include bed-days and average length of stay to facilitate assessment of total healthcare burden per incident. Results are presented graphically, including fatalities and hospital admissions due to injuries. The authors found that fatalities have dropped over the past 20 years, but injuries have remained constant.

Rubin, L.E., P.B. Stein, C. DiScala & B.E. Grottkau. 2003. Pediatric Trauma Caused by Personal Watercraft: A Ten-Year Retrospective. *Journal of Pediatric Surgery*, 38(10): 1525-1529.

This report provides statistics on the causes, types, and results of personal watercraft injuries to minors in the United States. The authors compile data from trauma registry charts on 66 children (age 5-19) hospitalized for personal watercraft-related injuries between 1990 and 1999, based on the National Pediatric Trauma Registry. They find that 70 percent of injuries resulted from collisions with another personal watercraft, boat, or fixed object; 55 percent of injuries involved the head, face, or neck; 72 percent occurred to the operator of the personal watercraft; 83 percent required surgery; and 42 percent required admission to the intensive care unit. Ultimately six percent (4) of the children died, and 42 percent (28) were disabled.

Smith, G.S., C. Coggan, T. Koelmeyer, P. Patterson, V. Fairnie, & A. Gordon. 1999. *The Role of Drowning and Boating Deaths in the Auckland Region: Boating (1980-1997) and All Drownings (1988-1997)*. An updated report to ALAC, Auckland: Injury Prevention Research Center.

The aims of this study are: 1) to document the role of alcohol in drowning deaths in Auckland for the period 1988-1997; 2) to provide more detail on boating deaths for a longer time period (1980-1997); 3) to evaluate the quality of the available data on the relationship between alcohol use and drowning and boating deaths; and 4) to provide background data for planning programs to reduce alcohol-related injuries associated with aquatic activities. The researchers identified possible drownings in the Auckland area between 1988 and the end of 1997 from the records of the Auckland University Department of Pathology. A total of 112 boating cases were included. Among boating fatalities involving victims 15-64 years of age, they found that 43.2 percent had a positive blood alcohol content and 27.3 percent had a blood alcohol content over the legal driving limit in New Zealand. For falls overboard in recreational boating, 67 percent were intoxicated, which was almost two and a half times higher than for all boating fatalities.

Smith, G.S., P.M. Keyl, J.A. Hadley, C.L. Bartley, R.D. Foss, W.G. Tolbert, & J. McKnight. 2001. Drinking and Recreational Boating Fatalities: A Population-Based Case-Control Study. *Journal of the American Medical Association*, 286(23), 2974-2980.

This study seeks to better define the relationship between alcohol use and the relative risk of death while boating. The data are from official state boating fatality records and medical examiner files in Maryland and North Carolina, and include all recreational boating deaths classified as “accidental” that occurred from April to October of 1990-1998. Deaths associated with sailboats, rafts, and personal watercraft are excluded; individuals who drowned while swimming from a boat were included. Of the 221 fatality

subjects included in the study, 55 percent had a positive blood alcohol content and less than half were operators. Results demonstrate that the odds ratios for dying by blood alcohol content increased most rapidly at lower blood alcohol content levels. However, when only those persons meeting the official Coast Guard definition of boating accidents were considered (excludes swimmers), there was no significant change in the relative risk of fatality. The majority of fatalities involved falling overboard, and 46 percent of these occurred while the vessel was not underway. The relative risk of death is therefore similar for operators and passengers and increases for both groups as blood alcohol content increases.

Strategic Research Group. 2003. *2002 National Recreational Boating Survey Report*. United States Coast Guard; USCG Office of Boating Safety.

This National Recreational Boating Survey (NRBS) was conducted by SRG in 2001-2002. The final results consist of 25,547 surveys completed by boat operators. The report provides detailed statistics on: boating experience, boating knowledge, most often used boats, activities on boats, boating safety knowledge and experience, PFD usage, boating incidents, predictors of involvement in a boating incident, predictors of participation in a boating safety course, and predictors of PFD use. Less than one percent of boat operators were involved in an accident resulting in property damage; one percent experienced a serious injury. Open motorboats accounted for 37 percent of property damage and 50 percent of injuries requiring treatment beyond first aid. Personal watercraft accounted for 14 percent of property damage and 21 percent of injuries.

Talley, W.K. 1994. *Recreational Boating Fatality Rates and State Anti-Alcohol Boating Laws*. *Transportation Quarterly*, 48(3), 311-314.

This study explores the effectiveness of State anti-alcohol boating laws on recreational boating fatality rates. Talley utilizes the annual fatality rate data for 16 States over an eight-year period, 1980-1987, as obtained through a survey conducted by NASBLA. Results show a reduction in fatality rates ranging from 1.7 percent to 50.1 percent across the 16 States following the enactment of anti-alcohol boating laws, with an average percentage decline of 29.7 percent.

U.S. Coast Guard, U.S. Department of Homeland Security. 1999-present. *Recreational Boating Statistics*. Washington, DC: USCG.

These annual reports (discussed in detail in the main text of this report) contain statistics on recreational boating accidents and State vessel registration. They include data from all States as well as the District of Columbia, Puerto Rico, Guam, the Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands, including

data on fatalities, injuries, and property damage. Statistics cover accident types, causes, and conditions; operator/passenger information; and registration data.

Virk, A. & T.J. Pikora. 2011. Developing a Tool to Measure Safe Recreational Boating Practice. *Accident Analysis and Prevention*, 43, 447-450.

This study develops a boating safety scale to measure safe boating practices and allow the identification of factors influencing safety behavior among recreational boaters. Virk and Pikora draw on a database of all recreational vessels registered in Western Australia. They recruited a sample of 1,002 adult boaters to participate in a telephone survey. Answers to the questionnaire were weighted and calculated as a boating safety scale score, with higher scores indicating a higher level of boating safety behavior. The range of scores was between six percent and 100 percent, with a mean of 68 percent and median of 71 percent. The results indicate offsetting behavior: increased confidence that is gained through experience may result in less cautious behavior among boaters.

Wang, Weiren. 2000. The Effects of State Regulations on Boating Accidents and Fatalities. *Applied Economics Letters*, 7, 373-378.

This source addresses the effectiveness of an array of variables in reducing recreational boating accidents and fatalities. The author analyzes State regulations on recreational boating and Coast Guard boating statistics from 1990-1994 for 49 states (excludes Alaska) and the District of Columbia. The study focuses on boating educational programs, PFDs, and alcohol. The author finds that minimum operating age and school education (public school courses targeting youth) are the most salient variables.

II. VALUE OF FATAL AND NON-FATAL INJURIES (ALL CAUSES)

Blincoe, L., A. Seay, E. Zaloshnja, T. Miller, R. Romano, S. Luchter, R. Spicer. 2002. *The Economic Impact of Motor Vehicle Crashes, 2000*. Washington, D.C.: National Highway Traffic Safety Administration. DOT HS 809 446.

This report summarizes motor vehicle crash costs in the United States in the year 2000. The total economic cost of motor vehicle crashes in 2000 was \$230.6 billion. This includes 41,821 fatalities, 5.3 million non-fatal injuries, and 28 million damaged vehicles. The most significant costs (in 2000 dollars) were associated with lost market productivity (\$61 billion), property damages (\$59 billion), medical expenses (\$33 billion), and travel delays (\$26 billion); several other cost categories were also addressed. Excluding QALY losses, each fatality resulted in an average discounted lifetime cost of \$958,000; nonfatal injury costs range from \$245 per case for very minor injuries to \$1.1 million for the most significant injuries.

Finkelstein, E.A., P.S. Corso, & T.R. Miller & Associates. 2006. *The Incidence and Economic Burden of Injuries in the United States*. New York, New York: Oxford University Press.

This book develops COI estimates for all types of injuries using a systematic approach, as discussed in more detail in the main text of this report. It presents incidence-based estimates of lifetime costs per case for all injuries that occurred in the United States in 2000. It reports these costs by cause (mechanism or source of injury) as well as gender, age, body region, severity (categorized using the AIS), nature of the injury, and whether the individual was hospitalized. The estimates are provided both as national totals and as averages per injury episode. This analysis includes medical costs, lost productivity, and survival probabilities.

Graham, J.D., K.M. Thompson, S.J. Goldie, M. Segui-Gomez, & M.C. Weinstein. 1997. The Cost-Effectiveness of Air Bags by Seating Position. *Journal of the American Medical Association*, 278(17): 1418-25.

This study assesses the cost-effectiveness of driver's side and front passenger air bags, estimating QALY losses and comparing them to costs. The authors combine data on baseline health status from the Beaver Dam Health Outcomes study with quality weights for injuries from the Functional Capacity Index to determine the associated QALY losses.

Grosse, S.D., K.V. Krueger, & M. Mvundura. 2009. Economic Productivity by Age and Sex: 2007 Estimates for the United States. *Medical Care*, 47(7): S94-S103.

This study provides human capital estimates for the United States that can be used to estimate the value of lost production associated with illness, injury and death. The authors report average values for annual and lifetime market and household production by age and gender. They find that the present value of future lifetime production for children under 5 years old is \$1.2 million in 2007 dollars. For adults in their 20s and 30s, the present value of future production is approximately \$1.6 million, declining at older ages. Estimates are higher for males than for females.

Haddix, A.C., S.M. Teutsch, & P.S. Corso. 2003. *Prevention Effectiveness: A Guide to Decisionmaking and Economic Valuation*. Oxford and New York: Oxford University Press.

Appendix I of this textbook (by S.D. Grosse) provides human capital estimates for the United States, that can be used to estimate the value of lost production associated with illness, injury and death. It reports average values for annual and lifetime market and household production by age and gender. The present value of future lifetime production for a child at birth is \$0.9 million in 2000 dollars. For adults in their 20s and 30s, the present value of future production is approximately \$1.4 million, declining at older ages.

Estimates are higher for males than for females. The above reference (Grosse *et al.* 2009) updates these estimates.

Lawrence, B.A., S. Bhattacharya, E. Zaloshnja, P. Jones, & T.R. Miller. 2009. *Medical and Work Loss Cost Estimation Methods for the WISQARS Cost of Injury Module*. Pacific Institute for Research & Evaluation.

This report describes the methods used to estimate the costs of injury in CDC's WISQARS Cost of Injury module, as discussed in more detail in the main text of this report. This module provides cost estimates for injury-related deaths, hospitalizations, and emergency department-treated cases by mechanism and intent of injury and by diagnosis and body region. Cost estimates reflect the severity of injury, grouped into three categories: 1) injuries resulting in death; 2) injuries resulting in hospitalization with survival to discharge; 3) injuries requiring an emergency department visit and not resulting in hospitalization. Cost estimates incorporate lifetime medical costs, facility and non-facility costs, rehabilitation costs, long-term follow-up costs, nursing home costs, transport costs, and lifetime work losses.

Lund, J.L., K.R. Yabroff, Y. Ibuka, L.B. Russell, P.G. Barnett, J. Lipscomb, W.F. Lawrence, & M.L. Brown. 2009. *Inventory of Data Sources for Estimating Health Care Costs in the United States*. *Medical Care*, 47(7.1), S127-S142.

This article inventories data sources for estimating health care costs in the United States to aid researchers in identifying appropriate data sources for their specific research questions. Data sources were identified in three ways: 1) reviewing a series of articles; 2) evaluating websites of Federal government agencies, nonprofit foundations, and related societies that support health care research or provide health care services; and 3) reviewing recently published literature. Information extracted from each data source includes sponsor, website, lowest level of data aggregation, type of data source, population included, cross-sectional or longitudinal data capture, details about the cost elements available, source of diagnosis information, and cost of obtaining the data source. Lund *et al.* identified 88 data sources that can be used to estimate health care costs in the United States, most of which are sponsored by government agencies, are national or nationally representative, and are cross-sectional rather than longitudinal.

Miller, T.R., S. Luchter, & C.P. Brinkman. 1989. "Crash Costs and Safety Investment." *Accident Analysis and Prevention*. 21(4), 303-315.

This study estimates the costs of motor vehicle crashes in the United States, including property damages, medical costs, productivity losses, emergency services, legal and court costs, and other administrative costs. The authors estimate that these costs total about \$425,000 per fatal injury, and range from \$2,900 to \$391,000 per nonfatal injury depending on severity (1986 dollars). However, because individuals are willing to pay far

more than these costs for risk reductions, the authors argue that society should invest more than indicated by these costs to increase safety.

Miller, T.R., N.M. Pindus, J.B. Douglass, & S.B. Rossman. 1995. *Databook on Nonfatal Injury: Incidence, Costs, and Consequences*. Washington, D.C.: The Urban Institute.

This book organizes data available on nonfatal injury incidence, costs, and consequences and summarizes findings in individual data sets by injury code. While the data are from 1979-1988, it describes methods that have been applied (with some refinements) in later studies. Data on injuries were collected from multiple databases; cost data are presented by body region, body part, nature of injury, and hospitalization status.

Ray, D.R. 1993. *Societal Costs of Cigarette Fires*. U.S. Consumer Product Safety Commission. Part 6/6 by the Technical Study Group on Cigarette and Little Cigar Fire Safety. Washington, D.C.

This report summarizes the estimated costs of deaths, injuries and property damage resulting from structural fires started with smoking materials. The authors estimate medical costs, transport costs, productivity losses, lost quality of life (including “pain and suffering”), and legal and health insurance administrative costs. They exclude residential and business interruptions; product liability insurance premiums and administration; professional and volunteer fire services; and fire safety in structures, products and maintenance practices. They conservatively estimate that these costs totaled \$4 billion 1990.

Riley, Gerald. 2009. *Administrative and Claims Records as Sources of Health Care Cost Data*. *Medical Care*, 47(7.1), S51-S55.

The purpose of this study is to describe and compare the strengths and limitations of various administrative and claims databases. Data sources analyzed include claims and enrollment records from Medicare, Medicaid, and private insurers; Veterans’ Health Administration records; State hospital discharge datasets; HCUP hospital databases; managed care plan data systems; and provider cost reports. Results show that administrative data are often available for large, enrolled populations, have detailed information on individual service use, and can be aggregated by service type, episode and patient. Cost estimates can vary substantially by specific measure (payments, charges, cost to charge ratios) and across data sources. Limitations include generalizability, complexity, coverage and benefit restrictions, and lack of coverage continuity.

Robinson, L.A. 2008. *Review of Current Approaches for Valuing Nonfatal Injury Risk Reductions and their Applicability to Homeland Security Rules*. Prepared for U.S.

Customs and Border Protection, Department of Homeland Security, under contract to Industrial Economics, Incorporated.

This report reviews different approaches for valuing reduced injury risks in benefit-cost analysis. It discusses the advantages and limitations of measures based on WTP; averted costs (including the costs of illness); and monetized estimates of QALY gains. It reviews the approaches used in recent regulatory analyses conducted by NHTSA, Federal Motor Carrier Safety Administration, Consumer Product Safety Commission, and OSHA, as well as related academic research. The author concludes that while averted cost estimates are more plentiful, WTP estimates are the preferred measure of value. However, more work is needed to develop willingness to pay estimates for nonfatal injuries.

Robinson, L.A. 2008. *Valuing Mortality Risk Reductions in Homeland Security Regulatory Analyses*. Prepared for U.S. Customs and Border Protection, Department of Homeland Security, under contract to Industrial Economics, Incorporated.

This report develops an approach for estimating the VSL in homeland security regulatory analyses for immediate implementation. It discusses related concepts, reviews the approaches used by other Federal agencies, and evaluates the available scholarly research. Due to the lack of studies of WTP for homeland security-related risks, it recommends transferring values from a study of job-related risks. This approach, which has been applied in subsequent DHS regulatory analyses, results in a value of \$6.3 million for the year 2007.

Robinson, L.A., P. Corso, X. Fang, R. Black, & W. Miller. 2005. *Alternative Approaches For Estimating Health-Related Quality Of Life Impacts: Child Restraints Regulation Case Study*. Prepared for the Institute of Medicine Committee to Evaluate Measures of Health Benefits for Environmental, Health, and Safety Regulation.

This case study explores the application of different approaches for estimating QALY gains attributable to a regulation requiring child restraints in motor vehicles. The authors find that the gains associated with averting fatal and nonfatal injuries total from 4,263 to 5,992 QALYs depending on the approach used, and conclude that improved methods are needed for determining these gains for children.

Robinson, L.A., J.K. Hammitt, J.E. Aldy, A. Krupnick, & J. Baxter. 2010. *Valuing the Risk of Death from Terrorist Attacks*. *Journal of Homeland Security and Emergency Management*, 7(1), 1-25.

This article briefly summarizes the work reported above (in Robinson 2008). While it updates the discussion to include newer studies, the recommendations are unchanged.

Viscusi, W.K., & J.E. Aldy. 2003. The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World. *Journal of Risk and Uncertainty*, 27(1): 5-76.

This article reviews the literature on the value of mortality risk reductions and of nonfatal injury risks, focusing largely on job-related risks. Based on their meta-analyses, the authors conclude that the best estimate of the VSL is about \$7 million (2000 dollars). For nonfatal job-related injuries, their literature review suggests that most studies imply a value in the range of \$20,000–\$70,000.

Zaloshnja, E., & T. Miller. 2007. Unit Costs of Medium and Heavy Truck Crashes. Pacific Institute for Research and Evaluation; U.S. Department of Transportation, Federal Motor Carrier Safety Administration.

This study provides the most recent estimates, by severity, of the costs of highway crashes involving large trucks and buses. The estimated cost per injury for all medium/heavy trucks is \$195,258 (2005 USD), ranging \$62,000-\$325,557 depending on severity, and up to \$3,055,232 per fatality. This includes medically related costs, emergency services costs, property damage costs, lost productivity, and the monetized value of the pain, suffering, and quality of life that the family loses because of a death or injury.

III. BOATING-RELATED PROPERTY DAMAGES

Lawrence, B.A., T.R. Miller, & L. Daniel Maxim. 2006. *Recent Research on Recreational Boating Accidents and the Contribution of Boating Under the Influence: Summary of Results*. Prepared for the U.S. Coast Guard.

See Appendix A, Section I.

Marine Index Bureau Foundation, Inc. (MIBF) 1995. *1994 R-BAR Final Report*. Funded under the Wallop-Breaux Trust Fund, administered by the U.S. Coast Guard.

This report is discussed in detail in the main body of this report. It describes the 1994 data collection year results of the R-BAR program, conducted under a grant from Coast Guard. The R-BAR program uses insurance industry claims information collected from 19 participating insurers to provide a supplemental picture of losses from recreational boating accidents. The program focuses specifically on injury and property damage accidents (as opposed to fatalities). The report concludes that there were a significant number of reportable property damage and bodily injury incidents that were not reported to the Coast Guard. The R-BAR project also established that the insurance industry can be a valuable resource for data on property damages and injury from recreational boating accidents.

U.S. Coast Guard. U.S. Department of Homeland Security. 1999-present.
***Recreational Boating Statistics.* Washington, DC: USCG.**

See Appendix A, Section I.

APPENDIX B: Database Descriptions

In this appendix, we provide more detailed information on the databases discussed in Chapter 2 of this report. Exhibit B-1 summarizes the key features of each database that are relevant to this effort, including: source, geographic coverage, ages covered, diagnosis and injury coding, boating related causes of injury, frequency of data collection, and the website that can be used to access the database.

Next, we provide brief descriptions of each database. The databases are listed in the same order as in Exhibit B-1, beginning with the national databases, and then the State and other databases. For each database, we indicate the source, provide a brief overview, and discuss its coverage.

EXHIBIT B-1: DATABASE DESCRIPTIONS

NAME OF DATABASE	SOURCE	GEOGRAPHIC COVERAGE	AGES COVERED	DIAGNOSIS AND INJURY CODING ⁸⁷	BOATING RELATED CAUSES ⁸⁸	FREQUENCY OF COLLECTION	URL
National Databases							
National Vital Statistics System (NVSS) ⁸⁹ ; Multiple Causes of Death (MCOB)	Centers for Disease Control and Prevention (CDC)	US (50 States and District of Columbia)	All	ICD-10-CM	V90-V94	Annual	http://www.cdc.gov/nchs/nvss/about_nvss.htm
National Ambulatory Medical Care Survey (NAMCS) ⁹⁰	CDC	US (50 States and District of Columbia)	All	ICD-9-CM	E830-E838; Not available after 2004	Annual	http://www.cdc.gov/nchs/ahcd/about_ahcd.htm#NAMCS
National Hospital Ambulatory Medical Care Survey (NHAMCS) ⁹¹	CDC	US (50 States and District of Columbia)	All	ICD-9-CM	E830-E838	Annual	http://www.cdc.gov/nchs/ahcd/about_ahcd.htm#NAMCS

⁸⁷ For more information, see http://www.cdc.gov/nchs/injury/injury_matrices.htm.

⁸⁸ The 9th version of the International Statistical Classification of Diseases (ICD-9-CM) includes the following cause-of-injury codes: Accident to watercraft causing submersion (E830); Accident to watercraft causing other injury (E831); Other accidental submersion or drowning in water transport accident (E832); Fall on stairs or ladders in water transport (E833); Other fall from one level to another in water transport (E834); Other and unspecified fall in water transport (E835); Machinery accident in water transport (E836); Explosion, fire, or burning in watercraft (E837); and Other and unspecified water transport accident (E838). Other ICD-9-CM codes may be relevant for this project; including accidental drowning and submersion while water skiing (E910.0). ICD-10 includes the following cause-of-injury codes: Accident to watercraft causing drowning and submersion (V90); Accident to watercraft causing other injury (V91); Water-transport-related drowning and submersion without accident to watercraft (V92); Accident onboard watercraft without accident to watercraft, not causing drowning and submersion (V93); and Other and unspecified water transport accidents (V94).

⁸⁹ Data is publically available from CDC. Fatality data can be accessed using WISQARS (Web-based Injury Statistics Query and Reporting System) at <http://www.cdc.gov/injury/wisqars/index.html> and WONDER (Wide-ranging Online Data for Epidemiologic Research) at <http://wonder.cdc.gov/cmfi-icd10.html>.

⁹⁰ Data is publically available from CDC. The NAMCS database is available for download at http://www.cdc.gov/nchs/ahcd/ahcd_questionnaires.htm.

⁹¹ Data is publically available from CDC. The NHAMCS database is available for download at http://www.cdc.gov/nchs/ahcd/ahcd_questionnaires.htm.

NAME OF DATABASE	SOURCE	GEOGRAPHIC COVERAGE	AGES COVERED	DIAGNOSIS AND INJURY CODING ⁸⁷	BOATING RELATED CAUSES ⁸⁸	FREQUENCY OF COLLECTION	URL
National Hospital Discharge Survey (NHDS)	CDC	US (50 States and District of Columbia)	All	ICD-9-CM	E830-E838 (approx. 20 States)	Annual	http://www.cdc.gov/nchs/nhds/about_nhds.htm
National Health Interview Survey (NHIS)	CDC	US (50 States and District of Columbia)	All	ICD-9-CM	E830-E838 (50 States)	Annual	http://www.cdc.gov/nchs/nhis/about_nhis.htm
Nationwide Inpatient Sample (HCUP-NIS) ⁹²	Agency for Health Care Research and Quality (AHRQ), compiled from State Inpatient Databases (SID)	US (42 States)	All	ICD-9-CM	E830-E838 (approx. 28 States)	Annual	http://www.hcup-us.ahrq.gov/nisoverview.jsp
Nationwide Emergency Department Sample (HCUP-NEDS) ⁹³	AHRQ, compiled from State Emergency Department Databases (SEDD) and SID	US (28 States)	All	ICD-9-CM	E830-E838 (approx. 20 States)	Annual	http://www.hcup-us.ahrq.gov/nedsoverview.jsp
Kids' Inpatient Database (HCUP-KID) ⁹⁴	AHRQ	US (38 States)	Patients 20 years and under	ICD-9-CM	E830-E838 (approx. 26 States)	Every 3 years	http://www.hcup-us.ahrq.gov/kidoverview.jsp

⁹² Data is publically available from AHRQ. National estimates of injuries can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>.

⁹³ Data is publically available from AHRQ. National estimates of injuries can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>. This online search tool is a Beta version.

⁹⁴ Data is publically available from AHRQ. National estimates of injuries can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>.

NAME OF DATABASE	SOURCE	GEOGRAPHIC COVERAGE	AGES COVERED	DIAGNOSIS AND INJURY CODING ⁸⁷	BOATING RELATED CAUSES ⁸⁸	FREQUENCY OF COLLECTION	URL
Medical Expenditure Panel Survey (MEPS) ⁹⁵	AHRQ	US (50 States and District of Columbia)	All	ICD-9-CM	No, drowning only	Annual	http://www.meps.ahrq.gov/mepsweb/
National Electronic Injury Surveillance System (NEISS) ⁹⁶	U.S. Consumer Product Safety Commission (CPSC)	US (approx. 46 States)	All	NEISS	No; only waterskiing, wake boarding, tubing, and surfing	Annual	http://www.cpsc.gov/library/neiss.html
Medicare Hospital Inpatient Prospective Payment System (IPPS)	HHS Centers for Medicare and Medicaid Services (CMS)	US (50 States and District of Columbia)	Medicare Beneficiaries	ICD-9-CM	E830-E838	Semi-annual	https://www.cms.gov/AcuteInpatientPPS/
Medicare Hospital Outpatient Prospective Payment System (OPPS)	HHS; CMS	US (50 States and District of Columbia)	Medicare Beneficiaries	ICD-9-CM	E830-E838	Semi-annual	https://www.cms.gov/LimitedDataSets/06_HospitalOPPS.asp#TopOfPage
State Databases							
State Inpatient Database (HCUP-SID) ⁹⁷	AHRQ	40 States ⁹⁸	All	ICD-9-CM	E830-E838 (approx. 28 States)	Annual	http://www.hcup-us.ahrq.gov/sidoverview.jsp

⁹⁵ Data is publically available from AHRQ. Nationally representative statistics of health care use, expenditures, and sources of payment [can be obtained using web-based queries at http://www.meps.ahrq.gov/mepsweb/data_stats/meps_query.jsp](http://www.meps.ahrq.gov/mepsweb/data_stats/meps_query.jsp).

⁹⁶ Data is publically available from CDC. Non-fatality data can be accessed using WISQARS (Web-based Injury Statistics Query and Reporting System) at <http://www.cdc.gov/injury/wisqars/index.html>.

⁹⁷ Data is publically available from AHRQ. Estimates of injuries for 35 States can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>.

⁹⁸ This number may differ from the number of States reporting in the National database because not all States make SID files available for purchase through the HCUP Central Distributor.

NAME OF DATABASE	SOURCE	GEOGRAPHIC COVERAGE	AGES COVERED	DIAGNOSIS AND INJURY CODING ⁸⁷	BOATING RELATED CAUSES ⁸⁸	FREQUENCY OF COLLECTION	URL
State Emergency Department Database (HCUP-SEDD) ⁹⁹	AHRQ	27 States ¹⁰⁰	All	ICD-9-CM	E830-E838 (approx. 20 States)	Annual	http://www.hcup-us.ahrq.gov/seddoverview.jsp
State Ambulatory Surgery Databases (SASD)	AHRQ	27 States	All	ICD-9-CM	E830-E838 (approx. 20 States)	Annual	http://www.hcup-us.ahrq.gov/sasdoverview.jsp
Other Databases							
The National Pediatric Trauma Registry (NPTR)	Tufts New England Medical Center	US; Voluntary participation by trauma centers	Children and young adults	ICD-9-CM	E830-E838; "PWC" or "Jet Ski" only	Phase 2: 1988-1995; Phase 3: 1995-1999	http://www.hapskids.org/
National Trauma Data Bank (NTDB)	American College of Surgeons Committee on Trauma (ACSCOT)	US (approx. 41 States)	All	ICD-9-CM	E830-E838	Annual	https://www.ntdbdatacenter.com/

⁹⁹ Data is publicly available from AHRQ. Estimates of injuries for 7 States can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>. This online search tool is a Beta version.

¹⁰⁰ This number may differ from the number of States reporting in the National database because not all States make SEDD files available for purchase through the HCUP Central Distributor.

NATIONAL DATABASES

1) NATIONAL VITAL STATISTICS SYSTEM (NVSS)

Source: Centers for Disease Control and Prevention (CDC)

Overview: The National Center for Health Statistics (NCHS) relies on NVSS to collect and disseminate the Nation's official vital statistics.¹⁰¹ Data are based on death certifications from State health departments, using standard data collection forms and procedures. NCHS publishes numerous reports based on these data, including an annual report on U.S. deaths, death rates, life expectancy, leading causes of death, and infant mortality. National fatal injury totals can be obtained using web-based queries at <http://www.cdc.gov/injury/wisqars/index.html> or <http://wonder.cdc.gov/>.

Coverage: NVSS records U.S. fatalities in 50 States and the District of Columbia. The number of fatalities recorded on death certificates is fully reported, however cause of death information is missing for 0.5 percent of records. The most recent publication year is 2007 (a 2008 preliminary report was filed in December 2010). ICD-10 cause-of-injury codes are used to identify drowning and boating-related deaths.

2) NATIONAL AMBULATORY MEDICAL CARE SURVEY (NAMCS)

Source: CDC

Overview: NAMCS is a national survey that provides information on the provision and use of ambulatory medical care services in the United States.¹⁰² It is based on a sample of visits to office-based physicians who are not federally employed and who are engaged primarily in direct patient care. The survey has been conducted annually since 1989. Specially trained interviewers visit the physicians to provide them with survey materials and instruct them in how to complete the forms. Each physician is randomly assigned to a 1-week reporting period. During this period, data for a systematic random sample of visits are recorded by the physician or office staff, including data on patients' symptoms, physicians' diagnoses, and medications ordered or provided. The respondent also provides statistics on the demographic characteristics of patients and the services provided, including diagnostic procedures, patient management, and planned future treatment. The NAMCS database is available for download at http://www.cdc.gov/nchs/ahcd/ahcd_questionnaires.htm.

¹⁰¹ http://www.cdc.gov/nchs/nvss/about_nvss.htm

¹⁰² http://www.cdc.gov/nchs/ahcd/about_ahcd.htm

Coverage: NAMCS is a U.S. national probability sample survey of visits to office-based physicians. In 2004, 25,286 Patient Record Forms were received from physicians at office-based and community health centers. However, cause-of-injury codes (ICD-9-CM) are not reported after 2004, and estimates are in terms of visits and not persons—the survey counts “injury visits” not “injury episodes” (i.e., an episode may entail multiple visits).

3) NATIONAL HOSPITAL AMBULATORY MEDICAL CARE SURVEY (NHAMCS)

Source: CDC

Overview: NHAMCS is designed to collect data on the utilization and provision of ambulatory care services in hospital emergency and outpatient departments.¹⁰³ It is based on a national sample of visits to the emergency departments and outpatient departments of non-institutional general and short-stay hospitals. Specially trained interviewers visit facilities to explain survey procedures, verify eligibility, develop a sampling plan, and train staff in data collection procedures. The survey can be completed in five minutes and is provided in two versions – one for the emergency department and one for the outpatient department, which are completed for a systematic random sample of patient visits during a randomly assigned four-week reporting period. Data are obtained on demographic characteristics of patients, expected source(s) of payment, patients’ complaints, diagnoses, diagnostic/screening services, procedures, medication therapy, disposition, types of providers seen, causes of injury, and certain characteristics of the facility, such as geographic region and metropolitan status. The NHAMCS database is available for download at http://www.cdc.gov/nchs/ahcd/ahcd_questionnaires.htm.

Coverage: NHAMCS is a U.S. national probability sample survey of visits to emergency departments and outpatient departments. Data are collected in 50 States and the District of Columbia. In 2004, 36,589 Patient Record Forms were provided by emergency departments and 31,783 Patient Record Forms were provided by outpatient departments. ICD-9-CM cause-of-injury codes are included for emergency department visits, but are not reported in all cases. After 2005, NHAMCS does not report cause-of-injury codes for visits to outpatient departments. The survey counts “injury visits” not “injury episodes” (i.e., an episode may entail multiple visits).

4) NATIONAL HOSPITAL DISCHARGE SURVEY (NHDS)

Source: CDC

Overview: NHDS is a national probability survey that provides information on characteristics of inpatients discharged from non-Federal short-stay hospitals located in the United States. Two data collection procedures are used in the survey. One is a manual system where the data are collected by the U.S. Bureau of the Census; the other is an automated system for which NCHS purchases electronic data files from commercial

¹⁰³ http://www.cdc.gov/nchs/ahcd/about_ahcd.htm

organizations, State data systems, hospitals, or hospital associations. The medical abstract form and the automated data contain items that relate to the personal characteristics of the patient. Administrative items, such as admission and discharge dates (which allow calculation of length of stay), as well as discharge status, are also included.

Coverage: NHDS is a survey of inpatient discharges from short-stay hospitals located in 50 States and the District of Columbia. Beginning in 2008, the sample size was reduced to 239 hospitals from about 500. The target sample size is 250 discharges from hospitals that provide data via the manual system and 2,000 discharges from hospitals that provide data via the automated system. When there are multiple diagnoses, NHDS lists the most likely primary diagnosis first; only first-listed injury diagnoses are reported. ICD-9-CM cause-of-injury codes are included for about 20 States, but are not reported for all cases.

5) NATIONAL HEALTH INTERVIEW SURVEY (NHIS)

Source: CDC

Overview: NHIS is a cross-sectional household interview survey that collects statistical information on the amount, distribution, and effects of illness and disability in the U.S. and the services rendered for or because of such conditions. Its “Core” questionnaire contains four major components: Household, Family, Sample Adult, and Sample Child. It collects data on topics including health status and limitations, injuries, healthcare access and utilization, health insurance, and income and assets. Due to difference in sampling techniques, NHIS injury estimates are approximately 70 percent of NHAMCS estimates for emergency department injury visits and approximately 130 percent of NHDS estimates for hospitalizations.¹⁰⁴

Coverage: NHIS is a large-scale household interview survey of a statistically representative sample of the U.S. civilian non-institutionalized population. Interviewers visit 35,000 to 40,000 households and collect data on about 75,000 to 100,000 individuals in all 50 States and the District of Columbia. ICD-9-CM cause-of-injury codes are included for most records. Although the NHIS sample is too small to provide state-level data with acceptable precision for each State, selected estimates for most States may be obtained by combining data years.

6) NATIONWIDE INPATIENT SAMPLE (HCUP-NIS)

Source: Agency for Health Care Research and Quality (AHRQ)

Overview: HCUP-NIS is the largest all-payer inpatient care database that is publicly available in the United States. It can be used to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes.¹⁰⁵ HCUP-NIS is the only national hospital database with charge information on all patients, regardless of

¹⁰⁴ http://www.cdc.gov/nchs/ppt/nchs2010/31_Chen.pdf

¹⁰⁵ <http://www.hcup-us.ahrq.gov/nisoverview.jsp>

payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured. Inpatient stay records in HCUP-NIS include clinical and resource use information typically available from discharge abstracts. Data elements include patient demographic, clinical, disposition, and diagnostic/procedural information; cause-of-injury (for some States); hospital ID; facility charges; and other facility information. National estimates of nonfatal injuries that resulted in hospitalization can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>.

Coverage: HCUP-NIS contains data from 5 to 8 million hospital stays from about 1,000 hospitals sampled to approximate a 20-percent stratified sample of U.S. community hospitals. In 2008, the HCUP-NIS was drawn from 42 States, which comprise 95 percent of the U.S. population. ICD-9-CM cause-of-injury codes are included for about 28 States.

7) NATIONWIDE EMERGENCY DEPARTMENT SAMPLE (HCUP-NEDS)

Source: AHRQ

Overview: HCUP-NEDS provides national estimates of emergency department visits.¹⁰⁶ NEDS is constructed using records from both the State Emergency Department Databases (SEDD) and the State Inpatient Databases (SID).¹⁰⁷ NEDS contains information about geographic characteristics, hospital characteristics, patient characteristics, and the nature of visits (e.g., common reasons for emergency department visits, including injuries). NEDS includes emergency department charge information for over 75 percent of patients, regardless of payer, including patients covered by Medicaid, private insurance, and the uninsured. NEDS includes emergency department visits that did not result in admission (e.g., treated and released, transferred to another hospital, transferred to another type of health facility, left against medical advice, or died in emergency department). National estimates of nonfatal injuries that resulted in hospitalization can be obtained using web-based queries at <http://hcupnet.ahrq.gov/>.

Coverage: NEDS is the largest all-payer emergency department database in the United States, containing almost 26 million (unweighted) records for emergency department visits for over 950 hospitals sampled to approximate a 20-percent stratified sample of U.S. hospital-based emergency departments. In 2008, 28 States were represented in NEDS. ICD-9-CM cause-of-injury codes are included for about 20 States.

¹⁰⁶ <http://www.hcup-us.ahrq.gov/nedsoverview.jsp>

¹⁰⁷ The SEDD capture information on emergency department visits that do not result in an admission. The SID contain information on patients initially seen in the emergency department and then admitted to the same hospital.

8) KIDS' INPATIENT DATABASE (HCUP-KID)

Source: AHRQ

Overview: HCUP-KID is a database of hospital inpatient stays for patients 20 years and younger. KID is the only all-payer inpatient care database for children in the United States. KID includes charge information on all patients, regardless of payer, including children covered by Medicaid, private insurance, and the uninsured.

Coverage: The 2006 KID contains data drawn from 38 State Inpatient Databases on patients 20 years of age and younger. KID includes a sample of pediatric discharges from over 2,500 to 4,000 U.S. community hospitals. It contains records for two to three million hospital discharges. ICD-9-CM cause-of-injury codes are included for about 26 States. While KID focuses exclusively on patients 20 years and younger, these patients are also sampled in the larger HCUP-NIS.

9) MEDICAL EXPENDITURE PANEL SURVEY (MEPS)

Source: AHRQ

Overview: MEPS provides nationally representative estimates of health care use, expenditures, sources of payment, and health insurance coverage for the U.S. civilian non-institutionalized population. MEPS is a set of large-scale surveys of families and individuals—drawn from a nationally representative subsample of households that participated in the prior year's National Health Interview Survey—their medical providers (doctors, hospitals, pharmacies, etc.), and employers. MEPS collects data on the specific health services that Americans use, how frequently they use them, the cost of these services, and how they are paid for, as well as data on the cost, scope, and breadth of health insurance held by and available to U.S. workers. MEPS currently has two major components: the Household Component (HC) and the Insurance Component (IC). The HC provides data from individual households and their members, which is supplemented by data from their medical providers (e.g., dates of visit, diagnosis and procedure codes, charges, and payments). The IC is a separate survey of employers that provides data on employer-based health insurance. MEPS data files are available at http://www.meps.ahrq.gov/mepsweb/data_stats/download_data_files.jsp and data can be obtained using web-based queries at http://www.meps.ahrq.gov/mepsweb/data_stats/meps_query.jsp.

Coverage: MEPS collects detailed information regarding the use and payment for health care services from a nationally representative sample of Americans. Each annual HC sample size is about 15,000 households. MEPS does not use standard cause-of-injury coding – instead, respondents were asked, "Was the condition due to an accident/injury?" and whether it involved "a motor vehicle, gun, some other weapon, poisoning/poisonous substance, fire/burn, drowning/near drowning, sports injury, fall, or something else."

10) NATIONAL ELECTRONIC INJURY SURVEILLANCE SYSTEM (NEISS)

Source: CPSC

Overview: NEISS provides data on consumer product-related injuries occurring in the United States. NEISS is a national probability sample of hospitals across the country.¹⁰⁸ Patient information is collected from each NEISS hospital for every emergency visit involving an injury associated with consumer products. Injury diagnosis, body parts affected, and a brief narrative description of the incident are included.

Coverage: Injury data are gathered from the emergency departments of 100 hospitals from approximately 46 States selected as a probability sample of all U.S. hospitals with emergency departments. NEISS does not identify the full range of boating-related injuries (only water skiing, wakeboarding, tubing, and surfing).

11) MEDICARE HOSPITAL INPATIENT PROSPECTIVE PAYMENT SYSTEM (IPPS)

Source: HHS; CMS

Overview: IPPS contains costs and payment rates for inpatient services furnished to people with Medicare by acute care hospitals and long-term care hospitals in the United States. IPPS contains claims data submitted by inpatient hospital providers for reimbursement of facility costs. Data include ICD-9-CM diagnosis and procedure codes, dates of service, reimbursement amount, hospital provider, and beneficiary demographic information, as well as cause-of-injury codes in some cases.

Coverage: IPPS collects data from a sample of 3,500 acute care hospitals and 420 long-term care hospitals in 50 States and the District of Columbia. ICD-9-CM cause-of-injury codes are included for some claims. The sample population is limited to Medicare beneficiaries.

12) MEDICARE HOSPITAL OUTPATIENT PROSPECTIVE PAYMENT SYSTEM (OPPS)

Source: HHS; CMS

Overview: OPPS contains claims data submitted by institutional outpatient providers, including hospital outpatient departments, rural health clinics, renal dialysis facilities, outpatient rehabilitation facilities, comprehensive outpatient rehabilitation facilities, and community mental health centers. Data include ICD-9-CM diagnosis and procedure codes, dates of service, reimbursement amount, and beneficiary demographic information. Cause-of-injury codes are provided in some cases. The database includes more than 60 million claims for services paid under the OPPS, including multiple and single claims.

¹⁰⁸ <http://www.cpsc.gov/library/neiss.html>

Coverage: OPPTS provides claims data from 50 States and the District of Columbia. ICD-9-CM cause-of-injury codes are included for some claims. The sample population is limited to Medicare beneficiaries.

STATE DATABASES

13) STATE INPATIENT DATABASES (HCUP-SID)

Source: AHRQ

Overview: HCUP-SID consist of hospital inpatient discharge records from State data organizations.¹⁰⁹ They are composed of annual, state-specific files that share a common structure and common data elements. SID contain clinical and non-clinical information (e.g., charges) on all patients, regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured. In addition to the core set of uniform data elements, SID include state-specific data elements or data elements available only for a limited number of States. Most data elements are coded in a uniform format across all States. Several States do not provide any public data through the HCUP Central Distributor (data for 35 States can be searched using web queries at <http://hcupnet.ahrq.gov/>).

Coverage: SID consist of individual inpatient discharge records from about 40 participating States. Together, SID encompass more than 90 percent of all U.S. hospital discharges. SID contain 100 percent of hospitals and patient discharges from State government and private data agencies with statewide inpatient data systems.¹¹⁰ ICD-9-CM cause-of-injury codes are included for some States. A sample of SID records is included in HCUP-NIS.

14) STATE EMERGENCY DEPARTMENT DATABASE (HCUP-SEDD)

Source: AHRQ

Overview: HCUP-SEDD are a set of databases for participating States that capture discharge information on all emergency department visits that do not result in an admission.¹¹¹ SEDD contain the emergency department encounter abstracts from participating States, translated into a uniform format to facilitate multi-state comparisons and analyses. All of the databases include abstracts from hospital-affiliated emergency department sites. The composition and completeness of data files may vary from State to State. SEDD contain a core set of clinical and non-clinical information on all patients, regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured. In addition to the core set of uniform data elements common to all

¹⁰⁹ <http://www.hcup-us.ahrq.gov/sidoverview.jsp>

¹¹⁰ SEDD capture information on emergency department visits that do not result in an admission. SID contain information on patients initially seen in the emergency department and then admitted to the same hospital.

¹¹¹ <http://www.hcup-us.ahrq.gov/seddoverview.jsp>

SEDD, some State data include other elements. Information on patients initially seen in the emergency department and then admitted to the hospital is included in SID. To enumerate all emergency department visits, SEDD discharges should be combined with SID discharges that originate in the emergency department.

Coverage: Data in SEDD are compiled from 27 States. SEDD contain patient-level discharge abstract data from participating States for 100 percent of discharges from hospital-affiliated emergency departments that do not result in admissions. Data include line item and summary detail for charges. ICD-9-CM cause-of-injury codes are included for many States. The SEDD do not provide a nationwide database, but a sample of records is included in NEDS.

15) STATE AMBULATORY SURGERY DATABASES (HCUP-SASD)

Source: AHRQ

Overview: HCUP-SASD are a set of databases that capture surgeries performed on the same day in which patients are admitted and discharged.¹¹² SASD contain the ambulatory surgery encounter abstracts in participating States, translated into a uniform format to facilitate multi-state comparisons. They contain a core set of clinical and non-clinical information on all patients, regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured.

Coverage: SASD contain data from 28 States. The databases contain patient-level discharge abstract data for 100 percent of discharges from facilities in participating States. States report data for either hospital-based ambulatory surgery centers, freestanding ambulatory surgery centers, or both. ICD-9-CM cause-of-injury codes are provided for some States.

OTHER DATABASES

16) THE NATIONAL PEDIATRIC TRAUMA REGISTRY (NPTR)

Source: Tufts New England Medical Center

Overview: NPTR is a multi-institutional database designed to compile information on all aspects of pediatric trauma care. Data describe the duration and sequencing of the patient's experience with trauma, trauma severity, treatment, and treatment outcomes.

Coverage: Data were provided on a voluntarily basis from trauma centers around the U.S. over several multi-year periods (e.g., Phase 2: 1988-1995; Phase 3: 1995-1999). Boating-related causes are identified only for personal watercraft and jet skis. Before project funding was terminated, NPTR accrued over 100,000 cases between 1985 and 2003 from 80 participating hospitals, but is not nationally representative.

¹¹² <http://www.hcup-us.ahrq.gov/sasdooverview.jsp>

17) NATIONAL TRAUMA DATA BANK (NTDB)

Source: ACSCOT

Overview: NTDB includes information on trauma patients, such as admission and discharge status, patient demographics (e.g., gender, age, race), injury and diagnosis (mechanism, e-code, ICD-9-CM or AIS code), procedure codes, injury severity scores, and outcome variables (e.g., length of stay, ICU days, payment method).

Coverage: NTDB contains over 3 million cases from more than 900 registered trauma centers in approximately 41 States, but is not nationally representative. However, NTDB provides information for the National Sample Project, which is a nationally representative sample of 100 Level I and II trauma centers in the United States. ICD-9-CM cause-of-injury codes are included.

APPENDIX C: Supplemental Analysis of Hospitalization Data for Selected States

In Chapter 2 of this report, we use national data from HCUP-NIS to explore the extent to which hospitalized injuries may be underreported in BARD. In this Appendix, we shift our focus to the State level, and consider the extent to which such underreporting varies by State.

If a proposed regulation will affect States differently, then using a national multiplier to adjust for underreporting may be inappropriate. The characteristics of boating activities and data collection efforts vary by State, and a uniform national multiplier may not be suitable to adjust BARD estimates of boating-related injuries for certain types of policies. An advantage to having data available on a state-by-state basis is that it allows for more accurate assessment of the distributional impacts of proposed interventions that target States with certain bodies of water, vessel types, or other characteristics disproportionately.

To estimate a potential range of adjustment factors, we compare BARD data to hospital discharge records for a sample of States that provide information publicly through the HCUP Central Distributor. As discussed in Chapter 2 and Appendix B, HCUP is a well-established federal-state-industry partnership that has built a multi-state health data system. It is a family of health care databases containing a core set of clinical and nonclinical information found in a typical discharge abstract, including: all listed diagnoses and procedures (using ICD-9-CM codes); discharge status; patient demographic information; and charges for all patients. Some States also include discharges from specialty facilities, such as psychiatric hospitals.

The state-specific inpatient databases, known as HCUP-SID, consist of individual data files from 43 participating States, encompassing 90 percent of all U.S. hospital discharges.¹¹³ The HCUP-SID contain a complete census of each State's hospital inpatient discharge records, in contrast to a representative sample as in the national HCUP-NIS. We use AHRQ's online query system *HCUPnet*, which provides access to health statistics on hospital utilization based on data from HCUP, to calculate injury estimates.¹¹⁴ Currently, data on hospitalizations are searchable for 35 States.

From this list we select eight States that represent a broad range of sizes and geographic characteristics, including both small and large States. We also include coastal and inland States, as well as States on the Great Lakes. Additionally, while many States use the BARD reporting system, others rely on their own reporting systems for boating-related accidents, which are not directly compatible with BARD. Our sample includes both.

¹¹³ http://www.hcup-us.ahrq.gov/db/state/siddist/Introduction_to_SID.pdf

¹¹⁴ A number of HCUP databases can be queried online, including HCUP-NIS, HCUP-NEDS, HCUP-SID, HCUP-SEDD, and HCUP-KID.

While it might be desirable to extend this analysis to additional States, for some we lack the requisite data, because: 1) not all States participate in the HCUP-SID or provide data through the HCUP Central Distributor, and 2) not all States identify hospitalizations in their records submitted to Coast Guard.

In addition to data on hospitalizations, data on treat-and-release emergency department visits are currently searchable through AHRQ's online query system for 14 States. We do not consider these visits in this Appendix. It is challenging to calculate multipliers for such visits because BARD does not separately identify non-fatal injuries that resulted in treatment in an emergency department from other, less severe injuries (e.g., injuries treated in a doctor's office), as discussed in Chapter 2.

ESTIMATES OF HOSPITALIZATIONS

In Chapter 2 of this report, we compare national estimates of nonfatal boating-related injuries resulting in hospitalization from the HCUP-NIS database to those reported in BARD. We estimate that the number of hospitalized injuries in BARD would have to be multiplied by a factor of about 1.5 to 1.7 to match the 2005 to 2008 data in the national HCUP-NIS database.

To evaluate the reliability of these data at the State level, we compare BARD estimates of hospitalizations to hospital inpatient discharge records in HCUP-SID for selected States. We use the same approach to identify nonfatal, hospitalized cases in BARD as in the analysis summarized in Exhibit 2-5. To identify injuries in HCUP-SID, we conduct a web-based query for boating-related ICD-9-CM cause-of-injury codes each year from 2005 to 2008.¹¹⁵ Because the number of boating-related hospitalizations likely represents a very small percentage of total hospitalizations, one limitation of this search is that AHRQ does not report estimates based on 10 or fewer cases or fewer than two hospitals to protect the confidentiality of patients (AHRQ, 2010). To avoid data suppression we input all ICD-9-CM codes combined into a single query, rather than separately.

In Exhibit C-1, we report the factors by which HCUP-SID estimates exceed the BARD estimates for nonfatal injuries resulting in hospitalization for each State. We report high and low estimates based on comparisons for 2005 to 2008 data. The wide range of multipliers underscores both the state-by-state and year-by-year variability in the data. For four of the eight States, the multipliers are less than or similar to the national factors reported in Exhibit 2-5: for two the HCUP-SID data appear similar to BARD estimates (i.e., a factor of 1.0 to 1.5) and for two the results are within the range of the national multipliers discussed in Chapter 2 (i.e., up to 2.0). Of the remaining States, our analysis identified multipliers significantly above the range of the national results (i.e., 2.0 to 7.0),

¹¹⁵ The boating-related cause-of-injury codes are: E830 (accident to watercraft causing submersion); E831 (accident to watercraft causing other injury); E832 (other accidental submersion or drowning in water transport accident); E833 (fall on stairs or ladders in water transport); E834 (other fall from one level to another in water transport); E835 (other and unspecified fall in water transport); E836 (machinery accident in water transport); E837 (explosion, fire, or burning in watercraft); E838 (other and unspecified water transport accident); and E910.0 (accidental drowning and submersion while water skiing).

and two lead to even larger factors that imply undercounting by an order of magnitude or more.

EXHIBIT C-1: COMPARISON OF STATE MULTIPLIERS FOR ADJUSTING BARD DATA

STATE	HCUP-SID ESTIMATES RELATIVE TO BARD
State A	1.0
State B	1.0 - 1.5
State C	1.3 - 1.8
State D	1.7 - 2.0
State E	2.0 - 3.4
State F	3.5 - 7.0
State G	1.3 - 17.0
State H	35.0*

* In three of the four years, no injuries are reported in BARD for this State even though boating injuries are identified in HCUP-SID; therefore no multiplier can be calculated.

The data suggest that problems with BARD and/or HCUP-SID data collection lead to significant year-to-year variation in relationship of these two data sources in some States. Thus if the factors in Exhibit C-1 are to be used to adjust for underreporting, for some States it may be desirable to apply year-specific multipliers or to use a wide range of adjustment factors to reflect related uncertainties. Although the HCUP-SID data are a census, some States may provide a more reliable estimate of boating-related injuries in BARD than in HCUP-SID, if the latter includes medical coding errors or omissions that result in undercounting. (See Chapter 2 for discussion of how hospitalized cases are identified in BARD and related uncertainties.) In particular, not all States mandate the routine collection of cause-of-injury data, which means that boating-related injuries are not consistently identified in HCUP-SID. As a result, we are somewhat uncertain whether these multipliers are under- or overstated.

CONCLUSIONS

As is the case with the analysis reported in Chapter 2, the multipliers for adjusting BARD estimates of non-fatal injuries presented in this Appendix are preliminary and subject to uncertainty. However, they suggest that the use of national multipliers for policies that disproportionately affect certain States may be inappropriate because they disregard substantial differences in State reporting. Some States appear to capture most nonfatal, boating-related injuries resulting in hospitalization in BARD, while others appear to face greater challenges in collecting reliable data on boating-related injuries.

We find that there is uncertainty about the magnitude of the multipliers for hospitalizations on a state-by-state basis. For some States, these estimates vary

significantly by year, resulting in a wide range of potential multipliers. For example, over four different years, one State's records of hospitalizations submitted to BARD would have to be multiplied by as little as 1.3 or as much as 17.0 to match estimates in HCUP-SID. For this State, in 2005, an estimated 22 boating-related injuries resulting in hospitalization were reported in BARD; applying the adjustment factors would produce a range of estimates from 29 to 374. In 2005, the actual factor was 2.1, towards the bottom of the range for this State.

For other States, the reliability of estimates from HCUP-SID is uncertain because not all States mandate the routine collection of cause-of-injury data. Other coding errors or omissions may also result in undercounting of boating-related injuries. Lawrence *et al.* (2006) also encountered issues of data suppression due to the low number of injuries reported in certain geographic locations. However, HCUP-SID likely provides the best alternative estimate of boating-related injuries to BARD because it is complete census of hospitalizations on a state-by-state basis.

APPENDIX D: Adapting NHTSA's Nonfatal Injury Values for Application in Coast Guard Analyses

To value averted nonfatal injury risks, Coast Guard currently follows an approach developed by the U.S. Department of Transportation (DOT) for application in National Highway Traffic Safety Administration (NHTSA) regulations that reduce the risks of motor vehicle accidents. This approach is introduced in Chapter 3 of this report, then adjusted for application in the case studies in Chapter 5. In this Appendix, we summarize information from both chapters and provide more detailed information on the calculations. We focus on the mechanics; the underlying concepts and the advantages and limitations of this approach are discussed in Chapter 3.

NHTSA's approach involves converting injuries to "equivalent lives saved" (ELS) based on their relative dollar values, including both economic costs and monetized quality of life impacts. The values are derived for injuries categorized using the Abbreviated Injury Scale (AIS). If an individual experiences multiple injuries, the case is scored according to the most life-threatening injury; i.e., the Maximum AIS or MAIS. A score of "0" indicates that there were no injuries, whereas a score of "6" indicates that the injury was likely to be immediately fatal; intermediate scores of 1 through 5 indicate injuries of increasing severity.

The steps in this calculation are described in detail in Chapter 3; the major components include the following.

1. **Estimate economic costs:** these include costs associated with medical treatment, emergency services, lost workplace and household productivity, employer replacement of disabled workers, litigation, and administration of insurance claims.
2. **Estimate quality-adjusted life year (QALY) losses:** these are nonmonetary measures that indicate the effects of impaired health on the quality of life. A zero-to-one scale is used to measure health-related quality of life, with more severe impacts receiving lower scores, and this score is then multiplied by the duration of the health effect.
3. **Assign a value to the QALY losses:** this is a constant monetary value, calculated by dividing the agency's official estimate of the value per statistical life (VSL) by the estimated number of discounted life years remaining for the average individual, commonly referred to as the value per statistical life year (VSLY).
4. **Sum economic costs and monetized QALY losses:** the total (or "comprehensive") value of injuries per case in each MAIS category is determined by adding the results of step (1) and step (3), then dividing by the number of cases to determine the average value per case for that category.

5. **Divide by the VSL:** the ELS fraction is then determined by dividing the result of step (4) by the VSL.¹¹⁶

The resulting ELS is a fractional value that indicates the relationship of nonfatal injuries to fatalities. For example, if an injury has an ELS fraction of 0.05, this means that its dollar value is five percent of the value of a life saved, and averting 20 such injuries would have the same value as averting one fatality. NHTSA calculates ELS fractions for a given year for different MAIS categories (based on data from motor vehicle crashes that occurred in that year), then uses the fractions for each MAIS in its subsequent regulatory analyses.

In recent years, different DOT documents have reported different ELS fractions for motor vehicle-related injuries, leading to some confusion about which are the most appropriate for current use. The 2009 DOT-wide guidance on valuing mortality risks includes outdated ELS fractions (taken from DOT's 1993 guidance), while NHTSA regulatory analyses include newer estimates. The latter are more appropriate for application in current Coast Guard analyses, because they reflect more recent data and trends.

There is also some confusion regarding whether the existing fractions can be applied without adjustment to revised VSL estimates. The 2009 DOT guidance notes that the fractions "are to be multiplied by the current value of preventing a fatality to obtain the values of preventing injuries of the relevant types." (DOT 2009, p. 8). However, this approach does not address the dual role of the VSL in calculating the fractions: as discussed above, it is an input to step (3) -- assigning a value to the QALY losses, as well as the denominator in the calculation in step (5) -- dividing the comprehensive costs by the VSL. Hence adjustment is needed in both steps to reflect changes in the VSL. This is recognized in the approach used in recent NHTSA regulatory analyses, such as NHTSA (2009).

The ELS fractions are periodically updated through new primary data collection. The most recent NHTSA update of the economic costs in step (1) and the QALY estimates in step (2) is provided in Blincoe *et al.* (2002) for the year 2000. NHTSA is now conducting research to again update these estimates, but the results are not yet available.

In the interim, NHTSA has adjusted its year 2000 estimates for inflation and for changes in the VSL. For example, in NHTSA (2009), the monetary values are updated to 2007 dollars and reflect a DOT VSL of \$5.8 million. DOT has since updated its VSL to \$6 million in 2008 dollars (DOT 2009), somewhat less than the \$6.3 million in 2007 dollars currently used by Coast Guard.

In Exhibit D-1, we illustrate the results of adjusting the NHTSA estimates to reflect the VSL used by Coast Guard and other DHS agencies, based on the approach discussed in Appendix C of NHTSA (2009). The information in the first four columns, (A) through (D), is taken directly from NHTSA (2009), and the formulae used in the calculations in the remaining columns, (E) through (G), are reflected in the column headings. To adjust

¹¹⁶ Prior to calculating this fraction, DOT typically adjusts the VSL to reflect changes in productivity over time.

for Coast Guard's VSL, we started with the ratio of monetized QALYs to the VSL reported by NHTSA (in column D), and applied these ratios to the VSL used by Coast Guard (in column E). This is the same approach that NHTSA (2009) uses to adjust the estimates for changes in DOT's VSL. While it is conceptually similar to recalculating the VSLY based on the Coast Guard VSL and then applying it to the QALY estimates (as described in Step 3 above), it is computationally simpler. It does not require that we back-calculate the non-monetized QALYs for each MAIS category (which are not reported by NHTSA). We did not need to further inflate the economic cost estimates, because NHTSA (2009) provides estimates inflated to the year 2007. Inflation to future years involves applying the appropriate indices for each cost component, generally available through the Bureau of Labor Statistics' Consumer Price Index website: <http://www.bls.gov/cpi/>.

EXHIBIT D-1: APPLICATION OF NHTSA RELATIVE FATALITY APPROACH TO DHS VSL
(VSL = \$6.3 MILLION IN 2007 DOLLARS)

AIS LEVEL (A)	CATEGORY/ DESCRIPTION (B)	AVERTED COSTS ^a (C)	QALY INJURY- TO- FATALITY RATIO (D)	MONETIZED QALYS (E)=(D)* (\$6.3 MILLION VSL) ^{b,c}	TOTAL (F)=(C)+(E)	RELATIVE FATALITY RATIO (G)=(F)/ (\$7,514,812)
1	Minor	\$7,680	0.003	\$18,900	\$26,580	0.004
2	Moderate	\$79,412	0.047	\$296,100	\$375,512	0.050
3	Serious	\$228,468	0.105	\$661,500	\$889,968	0.118
4	Severe	\$434,999	0.266	\$1,675,800	\$2,110,799	0.281
5	Critical	\$1,388,460	0.593	\$3,735,900	\$5,124,360	0.682
6	Fatal	\$1,214,812	1	\$6,300,000	\$7,514,812	1.000

Source: Costs (column C) from NHTSA (2009), Table C-2; QALY ratios (column D) from DOT 2011.

Notes:

Detail may not add to total due to rounding.

a. Includes injury-related costs only; excludes motor vehicle-related property damage and travel delay.

b. Applies DOT QALY ratios to DHS VSL of \$6.3 million, rather than to the DOT VSL.

c. NHTSA adjusts the DOT VSL for changes in productivity. We do not make this adjustment here, because the rationale for this adjustment is unclear and because NHTSA does not report the details of its calculations.

The comprehensive cost estimates in column F of Exhibit D-1 are higher than the NHTSA (2009 & 2011) values (see Chapter 3), and the relative fatality ratios in column G are somewhat lower, because of the use of a higher VSL to monetize QALYs.