# AUDIT-C Alcohol Screening Results as a Marker of Alcohol Misuse Severity and Postoperative Risk

Anna F. DeBenedetti Rubinsky

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Reading Committee:

Katharine A. Bradley, Chair

Daniel R. Kivlahan

Ruth Etzioni

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University of Washington

## Abstract

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Anna F. DeBenedetti Rubinsky

Chair of Supervisory Committee:
Associate Professor Katharine A. Bradley
Departments of Health Services and Medicine

Alcohol misuse is a modifiable risk factor for postoperative complications and health care utilization. The AUDIT-C alcohol screening questionnaire is commonly used for routine alcohol screening in primary care and results up to a year before surgery can identify patients with increased postoperative complications. Study 1 investigated whether past-year AUDIT-C screening results can also identify patients with increased postoperative inpatient health care utilization. Using data from a sample of male Veterans Affairs (VA) surgical patients who completed the 3-item AUDIT-C on mailed surveys up to a year prior to surgery, this study demonstrated that past-year AUDIT-C screening results identified a subset of the highest risk drinkers who had increased postoperative health care utilization. Study 2 evaluated whether clinical documentation of risky drinking immediately prior to surgery modified estimates of postoperative complications and health care utilization associated with AUDIT-C results up to a year before surgery in a similar sample of VA men. Associations

between higher AUDIT-C scores and most measures of postoperative risk were found to be limited to those patients who had documented risky drinking immediately prior to surgery. Study 3 investigated the level of alcohol consumption associated with specific AUDIT-C scores in a large U.S. population sample and found that, among older adults of similar age to the VA surgical population, AUDIT-C scores associated with increased postoperative complications (≥ 5 points) and health care utilization (≥ 9 points) reflected drinking > 2 and ≥ 5 drinks per day, respectively. The finding that the combination of AUDIT-C score from up to a year before surgery and clinical documentation of risky drinking in the two weeks prior to surgery provided more information about postoperative risk than either measure alone suggests that in healthcare systems that use the AUDIT-C for routine alcohol screening, such as the VA, patients with a documented prior positive screen could be re-assessed closer to the time of surgery to identify those who continue to drink at risky levels. These patients may be at greatest risk for postoperative complications and increased postoperative health care utilization.

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## Dedication

This dissertation is dedicated to my father, Steve DeBenedetti, who I credit for my work ethic, and interest in scientific research and the pursuit of knowledge. His memory has provided inspiration during the dissertation process and throughout my graduate career.

# Chapter 1: Introduction

## Overview

The goal of this dissertation was to investigate the utility of a commonly used brief alcohol screening questionnaire for identifying surgical patients at increased risk for adverse alcohol-related postoperative outcomes. The Alcohol Use Disorders Identification Test – Consumption (AUDIT-C) questionnaire is widely used for routine alcohol screening and results from up to a year before surgery can identify patients at increased risk for postoperative complications. Study 1 of this dissertation examines the relationship between AUDIT-C alcohol screening results up to a year prior to surgery and postoperative inpatient health care utilization. Study 2 evaluates whether associations between past-year AUDIT-C screening results and adverse postoperative outcomes are modified by clinically documented risky drinking immediately prior to surgery. The final study of this dissertation investigates the level of consumption and severity reflected by individual AUDIT-C alcohol screening scores.

## Alcohol Misuse in the U.S.

*Spectrum of Alcohol Misuse.* Alcohol misuse includes a spectrum of severity, ranging from drinking above recommended limits to meeting diagnostic criteria for alcohol use disorders, including alcohol abuse and alcohol dependence. At-risk drinking is defined as consuming over 4 drinks on any day or over 14 drinks per week for men, and consuming over 3 drinks on any day or over 7 drinks per week for women (National Institute on Alcohol Abuse and Alcoholism, 2007). Drinking at this level is associated with increased risk for several health conditions, including liver disease; cancers of the head and neck, digestive tract, liver and breast;

hemorrhagic stroke; dementia; and hypertensive disease (Corrao, Bagnardi, Zambon, & La Vecchia, 2004; Rehm et al., 2010). According to Diagnostic and Statistical Manual of Mental Disorders – 4th Edition (DSM-IV) specifications, alcohol abuse is characterized by negative consequences due to drinking (e.g., legal problems, job loss or family problems), while alcohol dependence is characterized by experience of impaired control over drinking, withdrawal symptoms or alcohol tolerance (American Psychiatric Association, 1994). Alcohol dependence is the most severe alcohol use disorder and hierarchically supersedes a diagnosis of abuse.

*Public Health and Economic Burden of Alcohol Misuse.* Up to 30% U.S. adults drinks above recommended levels (National Institute on Alcohol Abuse and Alcoholism, 2007), and approximately 7% meet diagnostic criteria for an alcohol use disorder (Grant et al., 2004). The consequences of alcohol misuse have considerable impact on the health and welfare of those afflicted, as well as on their families, employers and society at large (Mokdad, Marks, Stroup, & Gerberding, 2004; Rehm et al., 2009). Over 5% of deaths in the U.S. and 9% of the of the national burden of disease and injury are attributable to alcohol (Rehm et al., 2009). Further, the U.S. spends over $220 billion annually on alcohol-related problems, with over 70% spent on lost productivity and 11% spent directly on medical care for alcohol-related conditions (Bouchery, Harwood, Sacks, Simon, & Brewer, 2011).

*Evidence-based Care for the Spectrum of Alcohol Misuse.* Based on compelling evidence of the effectiveness of screening and brief intervention for reducing at-risk drinking, the U.S. Preventive Services Task Force (USPSTF) (U.S. Preventive Services Task Force, 2004), World Health Organization (WHO) (Babor & Higgins-Biddle, 2001), and National Institute of Alcohol Abuse and Alcoholism (NIAAA) (National Institute on Alcohol Abuse and Alcoholism, 2007) recommend screening followed by brief behavioral counseling in primary care settings as first

steps to reduce alcohol misuse. Further, alcohol screening and brief counseling for adults who drink above recommended limits has been deemed a top U.S. prevention priority (Maciosek et al., 2006; Solberg, Maciosek, & Edwards, 2008) and the Centers for Medicaid and Medicare Services (CMS) have implemented reimbursement for these services (Centers for Medicare and Medicaid Services (CMS), 2011). Brief interventions generally last less than 10 minutes and efficacious components include explicit advice to drink below recommended limits or abstain, and feedback linking drinking to health (Kaner et al., 2009; Whitlock, Polen, Green, Orleans, & Klein, 2004). For patients with the most severe misuse, more intensive interventions may be necessary. Specialist addictions care and pharmacotherapy for alcohol dependence have demonstrated effectiveness and are widely recommended (National Institute on Alcohol Abuse and Alcoholism, 2007; U.S. Preventive Services Task Force, 2004; M.L. Willenbring, 2009). Medication for alcohol dependence combined with brief behavioral support can be appropriately delivered by primary care or general mental health practitioners for persons with mild to moderate dependence, which may be more acceptable than specialized treatment to such patients (Anton et al., 2006; M. L. Willenbring, 2007). For persons with more severe and/or relapsing dependence, referral to specialty addictions services is most appropriate (M. L. Willenbring, 2007).

## Alcohol Misuse among Surgical Patients

*Alcohol Misuse and Postoperative Risk.* Alcohol misuse is also prevalent in surgical populations, ranging from 16% to 34% among general surgery patients (Agabio et al., 2012; K.A. Bradley et al., 2012; Neumann et al., 2011; Shourie et al., 2007) and as high as 50% among patients undergoing surgeries for cancer of the head and neck (A. H. S. Harris, Frey,

DeBenedetti, & Bradley, 2008; C. Spies, Tonnesen, Andreasson, Helander, & Conigrave, 2001; H. Tonnesen, Nielsen, Lauritzen, & Moller, 2009). Moreover, several European studies have found that surgical patients who report heavy daily drinking (i.e., > 4 U.S. standard-sized drinks or ≥ 60 grams of ethanol) prior to surgery have increased risk of postoperative complications and mortality, as well as increased postoperative health care utilization, compared to low-risk drinkers (i.e., < 2 drinks daily or < 25 grams of ethanol) (Delgado-Rodriguez, Gomez-Ortega, Mariscal-Ortiz, Palma-Perez, & Sillero-Arenas, 2003; Delgado-Rodriguez, Mariscal-Ortiz, et al., 2003; C. Spies et al., 2001; H. Tonnesen, 2003; H. Tonnesen et al., 2009). Specifically, this level of consumption has been associated with a 2 to 4-fold increased risk of postoperative complications, 7-24% more deaths, and approximately 2-fold longer stays in the hospital and ICU.

*Pathophysiology and Preoperative Alcohol Intervention.* Surgical trauma combined with alcohol-induced damage to organ systems can lead to postoperative complications including surgical site infections, other infections (e.g, pneumonia), excessive or prolonged bleeding, cardiopulmonary problems and delirium (C. Spies et al., 2001; H. Tonnesen, 2003; H. Tonnesen et al., 2009). Chronic alcohol use can adversely affect the nervous system, cardiovascular system, liver, and immune system, with the extent of dysfunction dependent on the level of use. Research on the effectiveness of preoperative alcohol interventions for reducing the incidence of postoperative complications is scarce but a small randomized controlled trial demonstrated that abstinence supported with disulfuram for four weeks prior to surgery significantly reduced the incidence of myocardial ischemia, arrhythmias, infections and hypoxemia episodes among colorectal surgery patients who reported heavy daily drinking (H Tonnesen et al., 1999). Further, several observational studies have found that immune

competence, wound healing, surgical stress response, hemostasis and cardiac function are improved after several weeks to several months of abstinence from alcohol (H. Tonnesen, 2003; H. Tonnesen et al., 2009). Additionally, awareness of a patient's alcohol misuse allows for expectant management during surgery, including anticipation of heightened stress response and increased anesthesia and analgesia requirements, and can improve postoperative outcomes (Fox, Liu, & Kaye, 2011; Gordon, Olstein, & Conigliaro, 2006; C. Spies et al., 2001).

*Preoperative Alcohol Assessment.* Most European research on alcohol misuse and adverse postoperative outcomes has identified heavy drinkers based on detailed assessments of patients' alcohol consumption. However, comprehensive alcohol assessment based on structured interviews is time consuming, may require training, and often is not practical in busy preoperative settings. Most routine preoperative alcohol assessment is based on simple questions about consumption that have not been validated for identifying alcohol misuse (Shourie et al., 2007) and tend to be insensitive, missing over half of patients with potential alcohol misuse (Kip et al., 2008). Therefore, preoperative alcohol screening of all surgical patients using a validated screening instrument is widely recommended (Alford, 2009; Gordon et al., 2006; Kip et al., 2008; Kork, Neumann, & Spies, 2010; Shourie et al., 2007; C. Spies et al., 2001).

*AUDIT-C Alcohol Screening Results and Postoperative Complications.* While a number of well-validated alcohol screening questionnaires are available, those that are briefest are most practical for routine use in busy preoperative settings. The 3-item Alcohol Use Disorders Identification Test – Consumption (AUDIT-C) and single-item screens that ask about the frequency of heavy drinking are widely used for routine screening for the spectrum of alcohol misuse (K. A. Bradley, Kivlahan, & Williams, 2009), and have recently been shown to identify male VA surgical patients at increased risk of surgical complications (K. A. Bradley et al., 2011;

A. H. Harris et al., 2011). Specifically, scores on the AUDIT-C alcohol screening questionnaire completed on mailed surveys up to a year prior to surgery were associated with increased probability of postoperative complication(s) in a dose-response manner among drinkers (K. A. Bradley et al., 2011; A. H. Harris et al., 2011). Surprisingly, only the highest score on the single-item screen, indicating daily or almost daily heavy drinking, was associated with increased postoperative complications (K. A. Bradley et al., 2011). Further, AUDIT-C scores ≥ 5 identified over five times as many patients at increased risk of complications compared to daily or almost daily heavy drinking reported on the single-item screen (16 vs. 3%) (K. A. Bradley et al., 2011).

*Summary.* Heavy daily drinking, or drinking the equivalent of over 4 U.S. standard drinks per day on average, is associated with up to 4-fold increased risk of postoperative complications, and significantly increased postoperative inpatient healthcare utilization. Recent studies have demonstrated that scores on a brief validated alcohol screening questionnaire commonly used for routine screening in primary care can identify patients at increased risk of postoperative complications. However, it is unknown whether the increased risk of postoperative complications identified by AUDIT-C scores ≥ 5 up to a year prior to surgery translates into increased postoperative health care utilization, whether documented clinical assessment of risky drinking immediately prior to surgery modifies associations between past-year AUDIT-C screening results and postoperative complications and health care utilization, or what specific AUDIT-C scores that are associated with postoperative risk mean in terms of level of alcohol consumption or severity of alcohol-related problems.

**Aims of the Dissertation**

The first study of this dissertation, *AUDIT-C Alcohol Screening Results and Postoperative Inpatient Health Care Utilization*, evaluated whether AUDIT-C alcohol screening results associated with increased risk of postoperative complications also identify patients with increased postoperative health care utilization. Specifically, the study investigated whether AUDIT-C scores from mailed surveys completed up to a year prior to surgery were associated with increased postoperative hospital length of stay (LOS), intensive care unit (ICU) treatment, return to the operating room (OR) and hospital readmission among men admitted to Veterans Affairs (VA) hospitals nationwide for non-emergent, non-cardiac, major surgery.

The second study, *Postoperative Risks Associated with Alcohol Screening Depend on Documented Drinking at the Time of Surgery,* evaluated whether clinical documentation of drinking over two drinks daily in the two weeks prior to surgery modified associations between AUDIT-C scores up to a year before surgery and postoperative complications and health care utilization in a similar sample of VA surgical patients. It was hypothesized that clinical documentation of drinking over two drinks per day at the time of surgery would strengthen associations between past-year AUDIT-C scores and postoperative outcomes.

The final study, *AUDIT-C Scores as a Scaled Marker of Mean Daily Drinking, Alcohol Use Disorder Severity and Probability of Alcohol Dependence in a U.S. General Population Sample of Drinkers,* evaluated the level of alcohol consumption, severity of alcohol use disorders, and probability of alcohol dependence associated with individual AUDIT-C scores in a large, representative, population-based sample of U.S. adults who reported drinking in the past year. This study facilitates interpretation of prior research that has demonstrated associations between AUDIT-C scores and adverse health outcomes, including postoperative risks.

**Conceptual Model**

The overall conceptual model for this dissertation is presented in Figure 1. Alcohol misuse is most common among men, younger adults, and unmarried individuals (Crum, 2009; Grant et al., 2004; Substance Abuse and Mental Health Services Administration, 2011). Alcohol misuse is also associated with race/ethnicity, education and income but these relationships are more complex; individuals of white race/ethnicity, who are more educated and who have higher incomes are more like to use alcohol but less likely to engage in heavy episodic drinking (Crum, 2009; Grant et al., 2004; Substance Abuse and Mental Health Services Administration, 2011). Associations between these patient characteristics and alcohol use are shown on the far left of the model.

As depicted in the model from left to right, excessive alcohol consumption can result in increased risk of postoperative complications by way of increased procedural complexity due to alcohol-related preoperative comorbidity (e.g., liver disease, gastrointestinal conditions, cancers of the head and neck) and/or impaired physiologic response to the surgery (C. Spies et al., 2001; H. Tonnesen, 2003; H. Tonnesen et al., 2009). Further, such complications can result in returns to the OR, ICU treatment, and prolonged hospital LOS (Delgado-Rodriguez, Gomez-Ortega, et al., 2003; Felding, Jensen, & Tonnesen, 1992; C. D. Spies et al., 1995; C. D. Spies et al., 1999; C. D. Spies et al., 1996; C. D. Spies et al., 2004; H. Tonnesen, Pedersen, Jensen, Moller, & Madsen, 1991; H. Tonnesen et al., 1992; H. Tonnesen, Schutten, & Jorgensen, 1987; H. Tonnesen, Schutten, Tollund, Hasselqvist, & Klintorp, 1988). Structural measures (Birkmeyer, Dimick, & Birkmeyer, 2004) that reflect the setting or system in which surgical care is delivered may also influence the incidence of postoperative complications and extent of postoperative inpatient care utilization. Both provider characteristics (e.g., surgeon expertise and experience)

and especially organizational factors (e.g., processes of care and hospital volume) are associated with postoperative outcomes (Birkmeyer et al., 2004; Boudourakis, Wang, Roman, Desai, & Sosa, 2009; Chowdhury, Dagash, & Pierro, 2007; Dimick, 2005; Dimnick & Birkmeyer, 2011; Semel et al., 2010). The AUDIT-C is a validated alcohol screening questionnaire comprising three questions about quantity and frequency of past-year alcohol consumption, with total scores ranging from 0 to 12 points. AUDIT-C scores $\geq 5$ in the year prior to surgery can identify patients with increased postoperative complications (K. A. Bradley et al., 2011). The first study of this dissertation evaluated whether AUDIT-C scores from up to a year before surgery can also identify patients with increased postoperative inpatient health care utilization. Statistical analyses adjusted for important measured confounders and aimed to estimate associations between postoperative health care utilization and AUDIT-C screening results irrespective of differences in surgical procedure type and complexity, and irrespective of differences in opportunity to change drinking between screening and surgery.

Although routine preoperative alcohol assessment without the use of a validated instrument is insensitive (Greenfield & Kerr, 2008; Kip et al., 2008; Shourie et al., 2007), those patients with risky drinking in the two weeks prior to surgery who are identified and documented have increased risk of postoperative complications and longer postoperative hospital stays (Nath et al., 2010). Although clinical documentation of risky drinking in the two weeks prior to surgery is not based on standardized assessment, and is likely to be biased by both the clinician's assessment approach and the severity/recognizability of the patient's alcohol misuse, because the AUDIT-C asks about alcohol consumption in the previous year, it may nonetheless provide additional information about the patient's postoperative risk. Thus, the second study of this dissertation evaluated whether associations between AUDIT-C scores up to a year before surgery

and postoperative risk were modified by medical record documentation of risky drinking in the two weeks prior to surgery.

Although increased postoperative complications and health care utilization is associated with drinking > 4 drinks daily in European studies, we cannot determine the level of consumption associated with postoperative risk in studies of the AUDIT-C. The AUDIT-C is a scaled marker of risk for several alcohol-related health conditions (K. A. Bradley et al., 2004; K. A. Bradley et al., 2011; Kinder, Bryson, Sun, Williams, & Bradley, 2009; Lembke, Bradley, Henderson, Moos, & Harris, 2011; Rubinsky, Kivlahan, Volk, Maynard, & Bradley, 2010; Rubinsky et al., 2012; Williams et al., 2012) but no study to our knowledge has evaluated the level of alcohol consumption associated with individual AUDIT-C scores. Therefore, the final study of this dissertation evaluated the level of alcohol consumption reflected by individual AUDIT-C scores in a U.S. general population sample of drinkers. Further, because the AUDIT-C is commonly used to screen for alcohol misuse in primary care but there is no established practical approach for determining the severity of a patient's misuse so that appropriate treatment can be offered, this study also evaluated alcohol use disorder severity and the probability of dependence indicated by individual AUDIT-C scores. Mean daily drinking, alcohol use disorder severity and probability of alcohol dependence were estimated across individual AUDIT-C scores separately by gender and by age group because the screening performance of the AUDIT-C depends on these factors (K. A. Bradley et al., 2007; Dawson, Grant, Stinson, & Zhou, 2005).

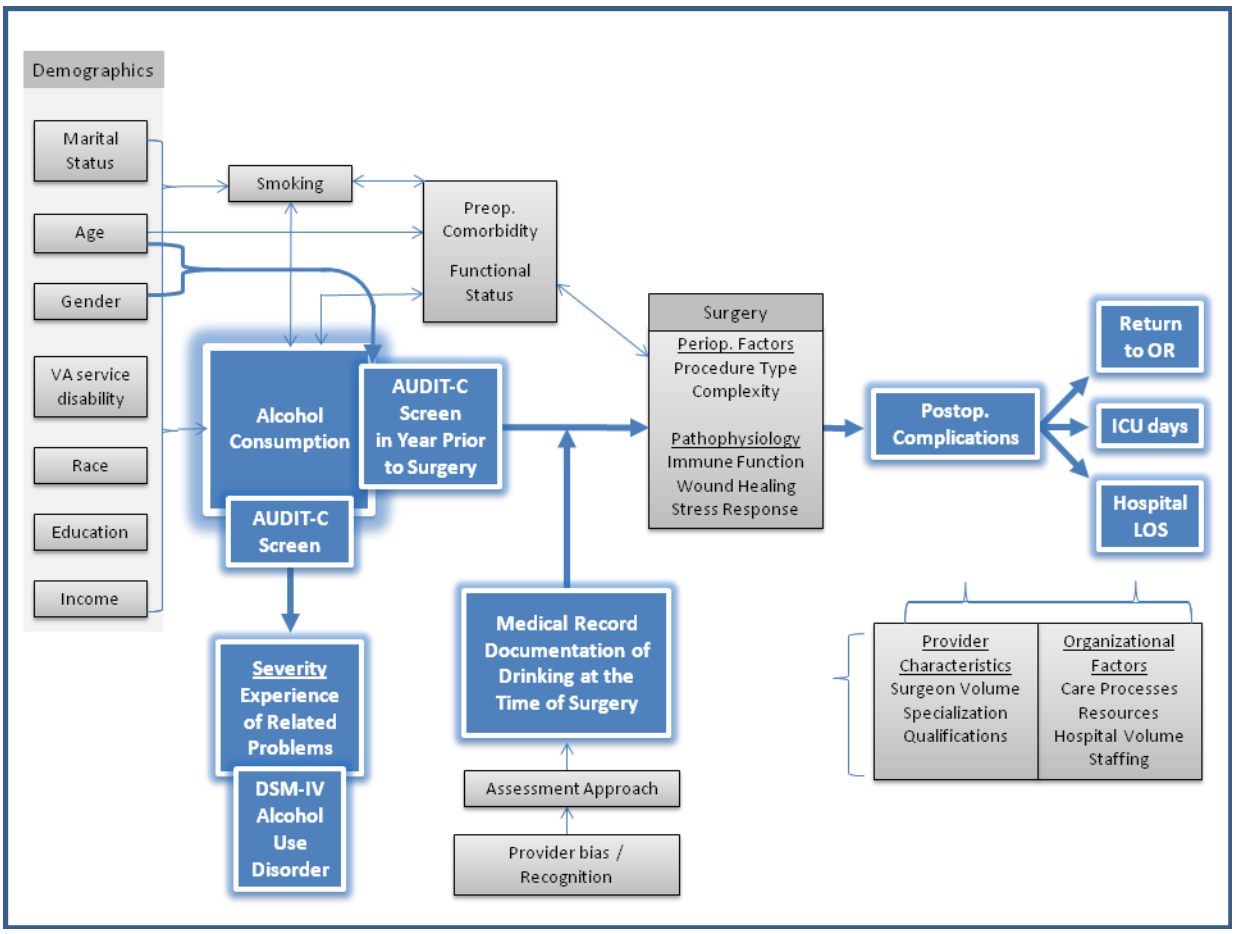


**FIGURE 1.1: Overall Conceptual Model**

## Summary

Practical approaches for identifying patients at high risk for adverse alcohol-related postoperative outcomes are needed. This dissertation evaluates whether scores on a brief alcohol screening questionnaire that are associated with increased postoperative complications can also identify patients with increased postoperative health care utilization, whether documented clinical assessment of alcohol use immediately prior to surgery modifies associations between past-year AUDIT-C scores and postoperative complications and health care utilization, and what AUDIT-C scores associated with postoperative risk mean in terms of level of alcohol consumption and severity of alcohol-related problems.

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## Chapter 2: AUDIT-C Alcohol Screening Results and Postoperative Inpatient Health Care Utilization

Alcohol misuse is a potentially modifiable risk factor for postoperative complications (Bradley et al., 2011; A. H. Harris et al., 2011; A. H. S. Harris, Frey, DeBenedetti, & Bradley, 2008; H. Tonnesen, 2003; H. Tonnesen, Nielsen, Lauritzen, & Moller, 2009). Further, patients who report heavy daily drinking (> 4 U.S. standard drinks) have increased postoperative health care utilization, including longer stays in the hospital and intensive care unit, and more second surgeries (Delgado-Rodriguez, Gomez-Ortega, Mariscal-Ortiz, Palma-Perez, & Sillero-Arenas, 2003; Felding, Jensen, & Tonnesen, 1992; Spies et al., 1995; Spies et al., 1999; Spies et al., 1996; Spies et al., 2004; H. Tonnesen, Pedersen, Jensen, Moller, & Madsen, 1991; H. Tonnesen et al., 1992; H. Tonnesen, Schutten, & Jorgensen, 1987; H. Tonnesen, Schutten, Tollund, Hasselqvist, & Klintorp, 1988). A randomized controlled trial among patients scheduled for elective colorectal surgery who reported drinking over four drinks daily found that one month of preoperative abstinence reduced postoperative complications by over 50% (H Tonnesen et al., 1999). Because alcohol misuse is often missed by standard clinical assessment (Kip et al., 2008; Moore RD et al., 1989; Rumpf, Bohlmann, Hill, Hapke, & John, 2001; Smothers, Yahr, & Ruhl, 2004), experts recommend preoperative alcohol screening of all surgical patients using a validated screening instrument (Alford, 2009; Gordon, Olstein, & Conigliaro, 2006; Kip et al., 2008; Kork, Neumann, & Spies, 2010; Shourie et al., 2007). Scores from validated alcohol misuse screening questionnaires can identify patients with increased risk of postoperative complications (Bradley et al., 2011; A. H. Harris et al., 2011; Poon, Owen, & Gijsbers, 1994) but less is known about whether such screening scores also identify patients with increased postoperative health care utilization. If commonly-used brief alcohol screens could identify

patients at increased risk for costly postoperative health care utilization as well as complications, preoperative alcohol interventions might provide a cost-effective approach to decrease postoperative resource utilization as well as improve patient outcomes.

This study investigated whether scores on a brief alcohol screening questionnaire that have been associated with increased postoperative complications (Bradley et al., 2011) are also associated with increased postoperative inpatient health care utilization. Specifically, this study evaluated whether severity of alcohol use based on Alcohol Use Disorders Identification Test – Consumption (AUDIT-C) scores from up to a year before surgery was associated with increased postoperative hospital length of stay (LOS), days in an intensive care unit (ICU), return to the operating room (OR), and hospital readmission among men admitted to Veterans Affairs (VA) hospitals nationwide for non-emergent, non-cardiac major surgeries.

## METHODS

### Data Sources and Sample

This cohort study used VA data from three sources: the VA Surgical Quality Improvement Program (VASQIP), the Survey of Healthcare Experiences of Patients (SHEP), and the National Patient Care Database (NPCD). The study protocol was approved by Institutional Review Boards at VA Puget Sound Health Care System and co-authors' institutions.

Preoperative, operative and postoperative data were obtained from VASQIP. VASQIP systematically samples procedures performed under general, spinal or epidural anesthesia with the exception of procedures known to have low postoperative morbidity and mortality (i.e., minor procedures) and procedures rarely performed in VA (i.e., transplantation and trauma procedures) (Henderson & Daley, 2009; Henderson et al., 2007). Dedicated VASQIP nurse

reviewers at each medical center use standardized procedures to compile data on preoperative risk factors, operative variables and postoperative complications during hospitalization and up to 30 days after discharge. Approximately 70% of all major procedures performed in VA are assessed by VASQIP. Self-reported demographic and alcohol use data were obtained from the outpatient SHEP, a confidential patient satisfaction survey mailed regularly to random samples of VA patients with recent outpatient visits (Wright, Craig, Campbell, Schaefer, & Humble, 2006). SHEP includes questions about health behaviors, including the 3-item AUDIT-C alcohol screening questionnaire (Figure 2.1). Additional preoperative risk factors (i.e., disability due to military service, past-year diagnoses) and postoperative health care utilization data (i.e., total ICU days, hospital readmission) were obtained from NPCD.

*Inclusion/Exclusion Criteria.* This study included VA patients at least 21 years old who completed the AUDIT-C alcohol screening questionnaire on mailed surveys from 10/1/2003 to 9/30/2006 and were hospitalized in the subsequent year for at least one day following a non-cardiac surgery assessed by VASQIP. The first eligible non-emergent surgery after completion of the first AUDIT-C was evaluated. Surgeries that occurred within 90 days of a prior surgery or did not occur within the first three days of hospitalization, and patients who died during postoperative hospitalization [n=33 (0.6%)] were excluded.

Women were excluded from analyses because of low numbers. Of 280 eligible women, only 14 (5%) had AUDIT-C scores in the highest risk groups.

**Measures**

*Independent Variable – AUDIT-C alcohol screening score.* AUDIT-C scores from mailed surveys returned up to a year prior to surgery were used to measure alcohol use. The

AUDIT-C is a validated alcohol screening questionnaire (Figure 2.1) scored 0-12 points, with higher scores indicative of greater severity (Bradley et al., 2004; Rubinsky, Kivlahan, Volk, Maynard, & Bradley, 2010). AUDIT-C scores were grouped into four risk groups based on the associated age- and smoking-adjusted risk of postoperative complications (Bradley et al., 2011): 0 (nondrinkers); 1-4 (low-risk); 5-8 (at-risk); and 9-12 (high-risk).

*Outcome Variables – postoperative inpatient health care utilization.* This study evaluated four postoperative outcomes: hospital LOS, number of ICU days, return to the OR, and hospital readmission. Hospital LOS, defined as the number of days from the date of surgery to the date of discharge, and any return to the OR within 30 postoperative days were obtained from VASQIP. Total number of days in the ICU during postoperative hospitalization and any hospital readmission within 30 days post-discharge were obtained from NPCD. To avoid results driven by extreme values, an *a priori* decision was made to truncate hospital LOS and total ICU days to the first 30 days of postoperative hospitalization in main analyses.

*Covariates.* Socio-demographic and clinical covariates known to be important potential confounders of the association between alcohol use and postoperative health care utilization were selected *a priori* for inclusion in all adjusted analyses. Age at the time of surgery (truncated to 90 years for confidentiality), self-reported race, and marital status were obtained from SHEP; service-connected disability was obtained from NPCD; and past-year smoking status was obtained from VASQIP. All adjusted analyses also included surgical procedure category based on Current Procedural Terminology (CPT) codes (cardiovascular or thoracic; musculoskeletal; gastro-intestinal; genitourinary; other); a proxy measure of surgical complexity based on quartiles of year-specific work Relative Value Units (RVUs) (Johnson & Newton, 2002); and days from alcohol screening to surgery.

Additional covariates were evaluated in secondary analyses. Possible mediators were identified from 40 preoperative risk factors potentially in the casual pathway between alcohol use and postoperative health care utilization, including several risk factors known to be associated with cirrhosis. The preoperative risk factors included 39 variables collected by VASQIP with no more than 5% missing values (Figure 2.2) and the Deyo-Charlson comorbidity index (Deyo, Cherkin, & Ciol, 1992) constructed from past-year International Classification of Diseases (ICD-9) diagnoses from NPCD. Surgical complications were expected to be a primary mediator of the association between alcohol use and postoperative health care utilization, and the number and type of complications experienced in the first 30 postoperative days were obtained from VASQIP. Complications monitored by VASQIP were categorized into four subtypes known to be associated with alcohol use (surgical field; infectious other than at the surgical site; cardiopulmonary; and other, including bleeding, neurologic, thrombo-embolic, and renal (A. H. S. Harris et al., 2008; H. Tonnesen, 2003; H. Tonnesen et al., 2009)). Because delirium is associated with alcohol use (A. H. S. Harris et al., 2008) but is not monitored by VASQIP, discharge and outpatient ICD-9 diagnoses of delirium within 30 postoperative days were obtained from NPCD.

**Statistical Analysis**

*Descriptive Analyses.* Characteristics of the study sample were compared across AUDIT-C risk groups using chi-square tests for categorical variables and analysis of variance for continuous variables.

*Primary Analyses.* Associations between AUDIT-C risk groups and each outcome were evaluated in unadjusted and adjusted regression models that used cluster-robust variance

estimators to account for correlation between patients undergoing surgery at the same medical center (n=105). The adjusted primary model included socio-demographic covariates, smoking status, surgical CPT category, surgical RVU, and days from alcohol screening to surgery. Low-risk drinkers (AUDIT-C 1-4) served as the referent group because nondrinkers (AUDIT-C 0) tend to have greater comorbidity (Stranges et al., 2006; Williams et al., 2010) and more postoperative complications (Bradley et al., 2011).

Hospital LOS and total ICU days were modeled using linear regression, which tends to be robust to violations of assumptions and often performs well for modeling right-skewed, heteroscedastic data. However, because alternative regression methods can improve model stability and efficiency for such data (Austin, Rothwell, & Tu, 2002; Basu & Manning, 2009; Jones, 2010), sensitivity analyses based on the adjusted model compared the performance of log-transformed linear regression, generalized linear models (GLM) with log-link and gamma error distribution (Blough, Madden, & Hornbrook, 1999; Manning & Mullahy, 2001) and an extension of GLM that estimates the link function and variance structure empirically using extended estimating equations (EEE) (Basu & Rathouz, 2005). Goodness-of-fit was assessed based on the Pregibon Link test, modified Hosmer-Lemeshow test and Pearson's correlation between predicted values and residuals. Additionally, sensitivity analyses evaluated hospital LOS truncated to 90 days rather than 30 because 76 (1.5%) patients had a LOS between 31 and 90 days (4 had LOS > 90). Similarly, total ICU days was evaluated without the *a priori* restriction to the first 30 postoperative days.

Return to the OR within 30 days following surgery and hospital readmission within 30 days following discharge were evaluated using logistic regression. Predicted probabilities of

each outcome were estimated across AUDIT-C risk groups based on the average characteristics for the sample.

*Secondary Analyses – role of additional covariates.* Secondary analyses investigated the impact of variables that might mediate the association between alcohol use and each outcome. First, if at-risk or high-risk drinking was significantly associated with the outcome in primary adjusted analyses, a secondary adjusted model added preoperative risk factors that altered the magnitude of the association by at least 10%. Second, to evaluate whether surgical complications accounted for remaining associations, a final secondary model further adjusted for total number and subtypes of postoperative complications.

All statistical analyses were conducted using Stata/MP 11.1 software (StataCorp., 2009).

## RESULTS

### Characteristics of the Study Sample

This study included 5,171 male VA patients who completed the AUDIT-C alcohol screening questionnaire by mail and were hospitalized for a non-emergent, non-cardiac major surgery in the following year (Table 2.1). The mean number of days between alcohol screening and surgery was 163 (Standard Deviation [SD] 104). The majority of eligible men were White, married, and over 60 years old. Ten percent experienced at least one complication in the 30 postoperative days [range 1-6; mean 1.4 (SD 0.90)], with higher rates among those who had undergone gastro-intestinal (16%) or cardiovascular/thoracic (14%) surgery compared to genitourinary (8%), musculoskeletal (7%) or other (6%) surgery.

More than half of the study sample reported drinking in the past year on the AUDIT-C (Table 2.1), including 1,853 (36%) low-risk drinkers (AUDIT-C 1-4), 649 (13%) at-risk drinkers

(AUDIT-C 5-8), and 230 (4%) high-risk drinkers (AUDIT-C 9-12). Higher risk drinkers were more likely to be younger, unmarried, Hispanic, and past-year smokers, and less likely to be disabled. Higher risk drinking was also associated with greater surgical complexity as measured by work RVUs, and increased number of postoperative complications, including surgical field complications, cardiopulmonary complications and other (i.e., bleeding, neurologic, thrombo-embolic, and renal) complications.

**Postoperative Hospital LOS**

Postoperative hospital LOS ranged from 1 to 142 days, with a mean of 5.5 (95% Confidence Interval [CI], 5.3–5.7) days and a median of 4 days. After truncating LOS to 30 days, the mean was 5.3 (95% CI, 5.1–5.4) days. Patients with high-risk drinking (AUDIT-C 9-12) spent nearly a day longer in the hospital following surgery compared to low-risk drinkers (AUDIT-C 1-4): 5.9 (95% CI, 5.0–6.7) vs. 5.0 (95% CI, 4.7–5.3) days, p=0.06 (Table 2.2). After adjusting for socio-demographics, smoking status, surgical CPT category, surgical RVU, and days from AUDIT-C to surgery, the increased LOS observed among high-risk drinkers was statistically significant (p=0.04). Hospital LOS was not increased among patients with at-risk drinking (AUDIT-C 5-8) but nondrinkers (AUDIT-C 0) had significantly longer LOS in both unadjusted and adjusted analyses [5.4 (95% CI, 5.1–5.7) days].

*Alternative regression methods.* Although hospital LOS data were highly skewed and heteroscedastic, adjusted results were consistent across alternative regression methods. The GLM and EEE models passed all goodness-of-fit tests, but estimates were virtually identical to those from linear regression and efficiency was not substantially improved.

*LOS within 90 postoperative days.* When hospital LOS was truncated to 90 rather than 30 days [mean 5.5 (95% CI, 5.3–5.7)], it remained significantly increased among high-risk drinkers [6.5 (95% CI, 5.2–7.9) days] and nondrinkers [5.6 (95% CI, 5.3–5.9) days] relative to low-risk drinkers [5.2 (95% CI, 4.8–5.5) days] in adjusted analyses.

**Total ICU days**

During postoperative hospitalization, 1,913 men were admitted to the ICU, 95% on the day of surgery. Total ICU days ranged from 1-100 [mean 3.5 (95% CI, 3.2–3.7); median 2] and 75 (4%) of the 1,913 had multiple ICU stays. After restricting ICU days to those occurring in the first 30 days of postoperative hospitalization [mean 3.2 (95% CI, 3.0–3.4)], as specified *a priori*, high-risk drinkers [4.5 (95% CI, 3.2–5.8) days] and nondrinkers [3.2 (95% CI, 2.9–3.6) days] had significantly more ICU days compared to low-risk drinkers [2.8 (95% CI, 2.6–3.1) days] in unadjusted and adjusted analyses (Table 2.2).

*Alternative regression methods.* Results were robust across alternative regression methods. Only the EEE model passed all goodness-of-fit tests, but point-estimates and estimates of variance were virtually identical to those from linear regression.

*Total ICU days not truncated to 30 days.* Sensitivity analyses evaluating ICU days without truncating to the first 30 postoperative days revealed that high-risk drinkers [6.0 (95% CI, 3.3–8.6) days] but not nondrinkers [3.5 (95% CI, 3.0–4.0) days] had significantly more ICU days compared to low-risk drinkers [3.0 (95% CI, 2.6–3.3) days] in adjusted analyses.

**Return to the OR**

A total of 310 (6%) of the 5,171 surgical patients returned to the OR within 30 days of surgery. High-risk drinkers had more than 2-fold greater odds of returning to the OR compared to low-risk drinkers in unadjusted and adjusted analyses. The adjusted predicted probability of return to the OR was 10% (95% CI, 6–13%) among high-risk drinkers compared to 5% (95% CI, 4–6%) among low-risk drinkers (Table 2.2). Nondrinkers also had significantly increased odds of returning to the OR compared to low-risk drinkers in unadjusted and adjusted analyses [adjusted predicted probability: 6% (95% CI, 5–7%)].

**Hospital Readmission**

In the 30 days following discharge, 398 (8%) of 5,171 surgical patients were readmitted to the hospital. Compared to low-risk drinkers, the odds of readmission were increased only among nondrinkers [adjusted predicted probability: 8% (95% CI, 7–9%) vs. 6% (95% CI, 5–7%); Table 2.2].

**Adjustment for Additional Covariates**

Secondary analyses investigating the role of potentially mediating variables revealed that, of the 40 preoperative risk factors evaluated, only Deyo-Charlson comorbidity $\geq 3$ and sodium level $\leq 135$ substantially influenced the adjusted association of high-risk drinking with any outcome. Deyo-Charlson comorbidity and sodium level each altered the association with hospital LOS by at least 10%, and Deyo-Charlson comorbidity alone altered the association with total ICU days by this magnitude. After adjusting for these potential mediators, total ICU days but not hospital LOS remained increased among high-risk drinkers (Table 2.3). No preoperative risk factor substantially altered the association of high-risk drinking with return to the OR.

After further adjusting for number and subtypes of postoperative complications, only return to the OR remained significantly increased among high-risk drinkers (Table 2.3).

## DISCUSSION

This study of VA surgical patients compared postoperative inpatient health care utilization across AUDIT-C risk groups and found that high-risk drinkers (AUDIT-C 9-12) spent on average nearly a day longer in the hospital, had 1.5 more ICU days and were twice as likely to return to the OR compared to low-risk drinkers (AUDIT-C 1-4), after adjusting for socio-demographic variables, smoking status, surgical CPT category, surgical RVU, and time from alcohol screening to surgery. High-risk drinking was not associated with hospital readmission. Lower level at-risk drinking (AUDIT-C 5-8) was not associated with any measure of postoperative health care utilization. Nondrinkers had increased health care utilization on all measures compared with low-risk drinkers but the magnitudes of the differences were relatively small.

Although patients who screen positive for alcohol misuse on the AUDIT-C with scores ≥ 5 in the year prior to surgery have increased risk of postoperative complications compared to low-risk drinkers (AUDIT-C 1-4) (Bradley et al., 2011), this study found increased postoperative inpatient health care utilization only among those with the most severe alcohol misuse (AUDIT-C ≥ 9). This is consistent with previous studies that have reported increased postoperative health care utilization among surgical patients who report heavy daily drinking up to the time of hospital admission but not among those who report drinking at lower levels. Specifically, European studies have found that surgical patients who report drinking ≥ 60 grams of alcohol (> 4 U.S. standard drinks) daily prior to surgery tend to have longer hospital LOS, more ICU

admissions, prolonged ICU stays, and more secondary surgeries compared to those who report drinking < 25 grams of alcohol (< 2 U.S. standard drinks) daily (Felding et al., 1992; Spies et al., 1995; Spies et al., 1999; Spies et al., 1996; Spies et al., 2004; H. Tonnesen et al., 1991; H. Tonnesen et al., 1992; H. Tonnesen et al., 1987; H. Tonnesen et al., 1988). However, drinking > 30 grams of alcohol (≥ 2.5 U.S. standard drinks) daily was not associated with prolonged hospital LOS or increased ICU admissions in a European study of non-cardiac surgery patients (Klasen et al., 2004). In previous studies of VA patients, documentation of drinking ≥ 2 drinks daily in the 2 weeks prior to surgery was associated with prolonged LOS among those undergoing major head and neck surgery (BuSaba & Schaumberg, 2007), but not among those undergoing urologic surgery (Wallner, Dunn, Sarma, Campbell, & Wei, 2008) or major non-cardiac surgery (Collins, Daley, Henderson, & Khuri, 1999). Results are also consistent with a previous study that evaluated alcohol use based on a validated screening questionnaire administered at the time of hospital admission (Poon et al., 1994). The study found that hospital LOS was increased among surgical patients who had very high scores (≥ 20) on the 10-item Alcohol Use Disorders Identification Test (AUDIT) but not among those who screened positive for alcohol misuse with lower scores (8-19).

This study demonstrates associations between routinely collected annual AUDIT-C alcohol screening scores, from up to a year prior to surgery, and three measures of postoperative inpatient health care utilization. The validated 3-item AUDIT-C is practical for routine alcohol screening (Rose et al., 2008), and is required annually for VA outpatients nationwide (Lapham et al., 2010). Many factors may contribute to increased postoperative health care utilization, including surgical complications, more complex operations and preoperative morbidity, all of which are more common among higher risk drinkers. Further, the pathway between high-risk

drinking and increased health care utilization may vary depending on the outcome measure. For example, it is plausible that higher risk drinkers stay longer in the hospital because of psychosocial and socioeconomic factors such as inadequate home care and social support resources or homelessness, rather than increased medical need. In this study, investigation of potential mediators revealed that after adjusting for Deyo-Charlson comorbidity score and low sodium, the association between high-risk drinking and hospital LOS was no longer significant. However, the estimated mean LOS remained more than half a day longer in the high-risk group, suggesting multiple important mediating factors. As expected, postoperative complications emerged as the primary explanatory mechanism, accounting for more than 75% of the remaining difference in mean LOS. The association between high-risk drinking and ICU days was also explained in part by Deyo-Charlson comorbidity score, but only after also adjusting for postoperative complications was the association no longer significant. Somewhat surprisingly, the odds of returning to the OR remained increased among high-risk drinkers even after adjusting for postoperative complications. Although AUDIT-C scores $\geq 5$ from up to a year before surgery have been associated with postoperative complications (Bradley et al., 2011), findings of this study suggest that only the highest AUDIT-C scores (9-12) identify surgical inpatients who are also at risk for increased postoperative health care utilization, including costly ICU care and return to the OR.

Several limitations of this study should be noted. The AUDIT-C asks about drinking in the prior year and alcohol screening preceded surgery by up to a year. A modified AUDIT-C administered closer to the time of surgery that asked about drinking in the prior month might have a stronger association with postoperative health care utilization. Additionally, although results were adjusted for several important covariates, some degree of residual and unmeasured

confounding may have persisted. In particular, adjusting for surgical RVU and CPT category may not fully account for variation in procedural complexity, number and subtypes of postoperative complications may not fully capture variation in complication severity, and important psychosocial, socioeconomic or behavioral factors may have been excluded. Further, this study did not evaluate other sources of increased resource utilization among high-risk drinkers (e.g., medications, x-rays, consultations) that could also increase the costs of postoperative care. The generalizability of the results may be limited by the patient population, which was a chance sample of VA patients who returned confidential, mailed patient satisfaction surveys (response rate 62% (Wright et al., 2006)) and underwent non-emergent, non-cardiac major surgery in the following year. The findings may not apply to individuals who receive care from health care systems other than the VA, especially women, racial/ethnic minorities and younger patients. Finally, the generalizability of findings to clinical settings may be limited because the AUDIT-C was completed by mailed survey, which tends to identify greater numbers of patients with alcohol misuse compared to clinical administration (Bradley et al., 2010; Hawkins et al., 2007). Nationwide VA clinical AUDIT-C data were not available at the time this study was conducted and the association between clinical alcohol screening scores and postoperative health care utilization should be confirmed in future research. The survey-based AUDIT-C scores were not available to the surgical care team and there was no systematic alcohol intervention as a consequence of a high score.

However, this study also has potentially important implications. Alcohol misuse is common among surgical patients (A. H. S. Harris et al., 2008; H. Tonnesen, 2003), making increased postoperative health care utilization among high-risk drinkers an important issue for surgical care providers and referring physicians. Although a randomized controlled trial that

demonstrated the efficacy of a month long abstinence-based preoperative intervention for reducing postoperative complications did not find a significant reduction in hospital LOS, it had limited power for detecting the decrease in LOS in the intervention group (H Tonnesen et al., 1999). The present study suggests that AUDIT-C alcohol screening from up to a year before surgery not only identifies surgical patients with an increased risk of postoperative complications (scores 5-12) (Bradley et al., 2011), but also a subset of the highest risk drinkers who have substantially increased postoperative health care utilization (scores 9-12). If preoperative alcohol interventions not only decrease postoperative complications, but also reduce postoperative health care utilization in a subset of patients, it would help offset the costs of screening and intervention. Further research is needed to confirm the efficacy of targeted preoperative alcohol interventions for decreasing postoperative complications, and to evaluate associated utilization and cost implications.

In conclusion, this study suggests that the 3-item AUDIT-C alcohol screening questionnaire can identify not only patients at increased risk of postoperative complications (Bradley et al., 2011), but also a subset of high risk drinkers with increased postoperative health care utilization (scores 9-12). Health care systems are increasingly implementing routine alcohol screening using evidence-based measures and AUDIT-C screening results could be used to identify patients at risk for increased postoperative health care utilization. Future trials are needed to determine whether interventions can reduce postoperative health care utilization and costs as well as complications.

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**TABLE 2.1** Characteristics of Men Admitted to a VA Hospital for Non-Emergent Major Surgery, by AUDIT-C Risk Group

| | TOTAL | NON-DRINKERS | DRINKERS [n=2,732 (53%)] | | | *p value* |
|---|---|---|---|---|---|---|
| | | (AUDIT-C 0) | Low-Risk (AUDIT-C 1-4) | At-Risk (AUDIT-C 5-8) | High-Risk (AUDIT-C 9-12) | |
| | n=5,171 | n=2,439 (47%) | n=1,853 (36%) | n=649 (13%) | n=230 (4%) | |
| Age at surgery, Mean in years ± SD | 65±10 | 67±10 | 65±11 | 63±10 | 60±7 | <0.0005 |
| Race/Ethnicity*, n (%) | | | | | | 0.010 |
| White (non-Hispanic) | 4,224 (82) | 1,977 (81) | 1,552 (84) | 508 (78) | 187 (81) | |
| Black (non-Hispanic) | 420 (8) | 213 (9) | 131 (7) | 59 (9) | 17 (7) | |
| Hispanic | 259 (5) | 113 (5) | 78 (4) | 52 (8) | 16 (7) | |
| Other | 186 (4) | 91 (4) | 64 (3) | 23 (4) | 8 (3) | |
| Married, n (%) | 2,923 (57) | 1,486 (61) | 1,031 (56) | 314 (48) | 92 (40) | <0.0005 |
| > 50% disabled, n (%) | 1,061 (21) | 560 (23) | 357 (19) | 110 (17) | 34 (15) | <0.0005 |
| Past-year smoker, n (%) | 1,619 (31) | 648 (27) | 539 (29) | 291 (45) | 141 (61) | <0.0005 |
| Deyo-Charlson comorbidity index ≥ 3, n (%) | 924 (18) | 474 (19) | 289 (16) | 111 (17) | 50 (22) | 0.004 |
| Surgical CPT Category, n (%) | | | | | | 0.56 |
| Musculoskeletal | 1,801 (35) | 836 (34) | 665 (36) | 220 (34) | 80 (35) | |
| Gastro-intestinal | 1,184 (23) | 571 (23) | 416 (22) | 150 (23) | 47 (20) | |
| Cardiovascular or thoracic | 1,009 (20) | 468 (19) | 342 (18) | 146 (23) | 53 (23) | |
| Genitourinary | 910 (18) | 441 (18) | 331 (18) | 102 (16) | 36 (16) | |
| Other | 267 (5) | 123 (5) | 99 (5) | 31 (5) | 14 (6) | |
| Surgical RVU Quartile, n (%) | | | | | | <0.0005 |
| 0-12.35 | 1,371 (27) | 698 (29) | 483 (26) | 141 (22) | 49 (21) | |
| 12.43-18.67 | 1,282 (25) | 624 (26) | 447 (24) | 164 (25) | 47 (20) | |
| 18.68-21.45 | 1,373 (27) | 630 (26) | 506 (27) | 177 (27) | 60 (26) | |
| 21.47-81.40 | 1,145 (22) | 487 (20) | 417 (23) | 167 (26) | 74 (32) | |
| Time AUDIT-C to surgery, Mean in years ± SD | 163±104 | 163±104 | 162±103 | 164±104 | 159±101 | 0.91 |
| Postoperative complications, Mean in years ± SD | 0.15±0.53 | 0.16±0.56 | 0.11±0.41 | 0.18±0.58 | 0.26±0.80 | <0.0005 |
| Complication Subtypes, n (%) | | | | | | |
| Surgical field | 234 (5) | 103 (4) | 73 (4) | 41 (6) | 17 (7) | 0.011 |
| Infectious other than at surgical site | 238 (5) | 122 (5) | 70 (4) | 31 (5) | 15 (7) | 0.13 |
| Cardiopulmonary | 90 (2) | 51 (2) | 15 (1) | 15 (2) | 9 (4) | <0.0005 |
| Delirium | 224 (4) | 100 (4) | 73 (4) | 40 (6) | 11 (5) | 0.09 |
| Other | 120 (2) | 73 (3) | 26 (1) | 14 (2) | 7 (3) | 0.006 |

AUDIT-C = Alcohol Use Disorder Identification Test Consumption Questionnaire; CPT = Current Procedural Terminology; RVU = Relative Value Units

* Percents do not sum to 100 due to missing values

**TABLE 2.2** Postoperative Inpatient Health Care Utilization, by AUDIT-C Risk Group

| | | DRINKERS | | |
|---|---|---|---|---|
| | NON-DRINKERS (AUDIT-C 0) | Low-Risk (AUDIT-C 1-4) | At-Risk (AUDIT-C 5-8) | High-Risk (AUDIT-C 9-12) |
| ***Outcomes within 30 days of surgery (95% CI)*** | | | | |
| **Mean hospital LOS in days** | | | | |
| Unadjusted Model | 5.4 (5.1,5.7)* | 5.0 (4.7,5.3) | 5.4 (5.0,5.9) | 5.9 (5.0,6.7) |
| Adjusted Model§ | 5.4 (5.1,5.7)* | 5.0 (4.7,5.3) | 5.3 (4.9,5.8) | 5.8 (5.0,6.7)* |
| **Mean ICU days during hospitalization, if admitted‖** | | | | |
| Unadjusted Model | 3.2 (2.9,3.5)* | 2.8 (2.6,3.1) | 3.3 (2.8,3.9) | 4.5 (3.2,5.8)* |
| Adjusted Model§ | 3.2 (2.9,3.6)* | 2.8 (2.6,3.1) | 3.3 (2.8,3.8) | 4.5 (3.2,5.8)† |
| **Predicted probability of return to the OR** | | | | |
| Unadjusted Model | 0.06 (0.05,0.08)* | 0.05 (0.04,0.06) | 0.05 (0.04,0.07) | 0.11 (0.07,0.15)‡ |
| Adjusted Model§ | 0.06 (0.05,0.07)* | 0.05 (0.04,0.06) | 0.05 (0.03,0.07) | 0.10 (0.06,0.13)† |
| ***Outcomes within 30 days of discharge (95% CI)*** | | | | |
| **Predicted probability of hospital readmission** | | | | |
| Unadjusted Model | 0.09 (0.08,0.10)* | 0.07 (0.06,0.08) | 0.07 (0.05,0.09) | 0.08 (0.05,0.11) |
| Adjusted Model§ | 0.08 (0.07,0.09)* | 0.06 (0.05,0.07) | 0.06 (0.04,0.08) | 0.07 (0.04,0.11) |

AUDIT-C = Alcohol Use Disorder Identification Test Consumption Questionnaire; CI = Confidence Interval; LOS = length of stay; ICU = intensive care unit; OR = operating room

* $p<0.05$; †$p<0.01$; ‡$p<0.0005$, compared to low-risk drinkers

§Adjusted for socio-demographics (age, race/ethnicity, marital status, disability status), smoking status, surgical CPT category, quartiles of surgical RVUs, and days from alcohol screening to surgery

‖ N=1,913

**TABLE 2.3** Post-op Health Care Utilization after Further Adjustment* for Potentially Mediating Variables, by AUDIT-C Risk Group

| | NON-DRINKERS (AUDIT-C 0) | DRINKERS Low-Risk (AUDIT-C 1-4) | DRINKERS At-Risk (AUDIT-C 5-8) | DRINKERS High-Risk (AUDIT-C 9-12) |
|---|---|---|---|---|
| ***Outcomes within 30 days of surgery (95% CI)*** | | | | |
| **Mean hospital LOS in days** | | | | |
| Additional preoperative risk factors§ | 5.4 (5.1,5.6) | 5.1 (4.8,5.3) | 5.4 (5.0,5.8) | 5.7 (4.9,6.5) |
| Number & subtypes of postoperative complications‖ | 5.3 (5.1,5.6) | 5.2 (5.0,5.5) | 5.2 (4.9,5.6) | 5.4 (4.7,6.0) |
| **Mean ICU days during hospitalization, if admitted¶** | | | | |
| Additional preoperative risk factors§ | 3.2 (2.9,3.5) | 2.9 (2.6,3.1) | 3.3 (2.8,3.8) | 4.4 (3.1,5.7)† |
| Number & subtypes of postoperative complications‖ | 3.1 (2.9,3.4) | 3.1 (2.9,3.4) | 3.1 (2.7,3.5) | 3.9 (3.1,4.7) |
| **Predicted probability of Return to the OR** | | | | |
| Additional preoperative risk factors§ | 0.06 (0.05,0.07)† | 0.05 (0.04,0.06) | 0.05 (0.03,0.07) | 0.10 (0.06,0.13)‡ |
| Number & subtypes of postoperative complications‖ | 0.05 (0.04,0.05) | 0.04 (0.03,0.05) | 0.03 (0.02,0.05) | 0.07 (0.04,0.10)† |
| ***Outcomes within 30 days of discharge (95% CI)*** | | | | |
| **Predicted probability of hospital readmission** | | | | |
| Additional preoperative risk factors§ | 0.08 (0.07,0.09)† | 0.06 (0.05,0.07) | 0.06 (0.04,0.08) | 0.07 (0.04,0.11) |
| Number & subtypes of postoperative complications‖ | 0.07 (0.06,0.08) | 0.06 (0.05,0.07) | 0.05 (0.04,0.07) | 0.06 (0.03,0.08) |

AUDIT-C = Alcohol Use Disorder Identification Test Consumption Questionnaire; CI = confidence interval; LOS = length of stay; ICU = intensive care unit; OR = operating room

* All models include covariates from primary adjusted model: socio-demographics, smoking status, surgical CPT category, quartiles of surgical RVUs, and days from alcohol screening to surgery

† $p<0.05$; ‡$p<0.01$, compared to low-risk drinkers

§ Additional preoperative risk factors were those that changed the association with high-risk drinking by ≥ 10% -- *Hospital LOS*: sodium > 135 mEq/L, Deyo-Charlson comorbidity ≥ 3; *ICU days*: Deyo-Charlson comorbidity ≥ 3; *Return to OR*: no variable changed association by 10%, results equivalent to primary adjusted model (Table 2.2); *Hospital Readmission*: no association with high-risk drinking, results equivalent to primary adjusted model (Table 2.2)

‖ Total number and subtypes (surgical field; infectious other than at surgical site; cardiopulmonary; delirium; other) of complications in the 30 days following surgery added to fully-adjusted model including any additional preoperative risk factors

¶ N=1,913

**ALCOHOL USE DISORDER IDENTIFICATION TEST CONSUMPTION QUESTIONNAIRE (AUDIT-C)**

1. How often did you have a drink containing alcohol in the past 12 months? Consider a "drink" to be a can or bottle of beer, a glass of wine, a wine cooler, or one cocktail or a shot of hard liquor (like scotch, gin or vodka). (Please mark only one.)
   - ☐ Never *(0 points)*
   - ☐ Monthly or less *(1 point)*
   - ☐ 2-4 times a month *(2 points)*
   - ☐ 2-3 times a week *(3 points)*
   - ☐ 4-5 times a week *(4 points)*
   - ☐ 6 or more times a week *(4 points)*

2. How many drinks containing alcohol did you have on a typical day when you were drinking in the past 12 months?
   - ☐ 0 drinks (Did not drink in the past 12 months) *(0 points)*
   - ☐ 1-2 drinks *(0 points)*
   - ☐ 3-4 drinks *(1 point)*
   - ☐ 5-6 drinks *(2 points)*
   - ☐ 7-9 drinks *(3 points)*
   - ☐ 10 or more drinks *(4 points)*

3. How often did you have 6 or more drinks on one occasion in the past 12 months?
   - ☐ Never *(0 points)*
   - ☐ Less than monthly *(1 point)*
   - ☐ Monthly *(2 points)*
   - ☐ Weekly *(3 points)*
   - ☐ Daily or almost daily *(4 points)*

*Scores from the individual questions are summed for a total score ranging from 0 to 12 points, with scores of 0 indicative of no alcohol use and higher scores indicative of greater severity.*

**FIGURE 2.1** AUDIT-C questions on VA's Survey of Healthcare Experience for Patients (SHEP), and Scoring

**POTENTIALLY MEDIATING PREOPERATIVE RISK FACTORS FROM VASQIP WITH < 5% MISSING**

American Society of Anesthesiology (ASA) Physical Status Classification immediately prior to surgery (mild or no systemic disease [1-2 points], severe systemic disease [3], life-threatening systemic disease [4-5])
Functional status / level of self-care demonstrated at admission to hospital (independent, partially dependent, totally dependent)
History of cerebrovascular accident/stroke with persistent residual neurological deficit
History of cerebrovascular accident/stroke with no current neurological deficit
Hemiplegia
History of transient ischemic attacks
Tumor involving central nervous system (CNS)
Impaired sensorium
Diabetes mellitus controlled with oral agents or insulin
Dyspnea
Ascites
Bleeding disorder
History of severe chronic obstructive pulmonary disease (COPD)
Congestive heart failure (CHF) in 30 days before surgery
Do not resuscitate (DNR) status
Chemotherapy for malignancy in last 30 days
Disseminated cancer
Preoperative sepis in 48 hours before surgery
Radiotherapy for malignancy in last 90 days
Steroid use for chronic condition
Open wound/wound infection
Weight loss > 10% in last 6 months
Current pneumonia
Currently on dialysis
Preoperative acute renal failure
Preoperative serum creatinine > 1.2mg/dl
Preoperative hematocrit ≤ 38
Preoperative serum glutamic oxaloacetic (SGOT) > 40 mU/ml
Preoperative sodium ≤ 135 mEq/L
Preoperative white blood count (WBC) ≤ 4.5 x 1000/mm3)
Preoperative alkaline phosphatase > 125 mU/ml
Preoperative total bilirubin > 1.0 mg/dl
Preoperative Blood Urea Nitrogen (BUN) > 40 mg/dl
Preoperative hematocrit > 45
Preoperative platelet count ≤ 150 x 1000/mm3
Preoperative prothombin time (PT) > 13.27 seconds
Preoperative partial thromboplastin time (PTT) >35 seconds
Preoperative sodium > 145 mEq/L
Preoperative white blood count (WBC) > 11.0 X 1000/mm3

**FIGURE 2.2** Preoperative Risk Factors Evaluated as Potential Mediators

## Chapter 3: Postoperative Risks Associated with Alcohol Screening Depend on Documented Drinking at the Time of Surgery

Alcohol misuse, which includes a spectrum of severity ranging from drinking above recommended limits to diagnosis of alcohol dependence, is common among general surgical patients (13-29%) (Agabio et al., 2012; K.A. Bradley et al., 2012; Neumann et al., 2011; Shourie et al., 2007) and a risk factor for postoperative complications and increased postoperative health care utilization (K. A. Bradley, Rubinsky, et al., 2011; Delgado-Rodriguez, Gomez-Ortega, Mariscal-Ortiz, Palma-Perez, & Sillero-Arenas, 2003; A. H. Harris et al., 2011; A. H. S. Harris, Frey, DeBenedetti, & Bradley, 2008; Nath et al., 2010; Rubinsky et al., 2012; C. Spies, Tonnesen, Andreasson, Helander, & Conigrave, 2001; C. D. Spies et al., 2004; H. Tonnesen, 1999; H. Tonnesen, Nielsen, Lauritzen, & Moller, 2009). A randomized controlled trial among patients scheduled for elective colorectal surgery who reported drinking > 4 drinks (i.e., ≥ 60 grams of ethanol) daily demonstrated that four weeks of preoperative abstinence reduced postoperative complications by over 50% (H Tonnesen et al., 1999). Although routine preoperative clinical assessment of alcohol misuse without the use of a validated instrument identifies patients at increased postoperative risk (Nath et al., 2010), the majority of patients with potential alcohol misuse are missed by this approach (Kip et al., 2008). Thus, alcohol screening of all surgical patients using a validated questionnaire is recommended so that patients at high risk can be identified, advised to reduce their drinking, and managed expectantly (Gordon, Olstein, & Conigliaro, 2006; Kip et al., 2008; Kork, Neumann, & Spies, 2010; Shourie et al., 2007; C. Spies et al., 2001).

Scores from the 3-item Alcohol Use Disorders Identification Test – Consumption questionnaire (AUDIT-C) up to a year prior to surgery can identify surgical patients at risk of

postoperative complications and increased postoperative inpatient health care utilization (K. A. Bradley, Rubinsky, et al., 2011; A. H. Harris et al., 2011; Rubinsky et al., 2012). However, the AUDIT-C asks about consumption in the previous year and alcohol assessment closer to the time of surgery may provide additional information about postoperative risk. The purpose of this study was to evaluate whether clinical assessment of drinking immediately prior to surgery modified estimates of postoperative risk associated with AUDIT-C screening results up to a year before surgery. Specifically, the study evaluated whether postoperative complications and health care utilization differed across groups based on both past-year AUDIT-C score and medical record documentation of drinking > 2 drinks per day in the two weeks prior to surgery ("documented >2d/d"). It was hypothesized that documented >2d/d would potentially strengthen the association between past-year AUDIT-C scores and postoperative outcomes.

## METHODS

### Sample and Data Sources

Veteran's Affairs (VA) patients who had a non-emergent, non-cardiac, major surgery monitored by the VA Surgical Quality Improvement Program (VASQIP) between October 2003 and September 2006 were eligible for this study if they completed the AUDIT-C on the VA's mailed Survey of Healthcare Experiences of Patients (SHEP) in the year prior to surgery. The first eligible surgery after the first AUDIT-C was included. Surgeries that occurred within 90 days after an earlier surgery and inpatient surgeries that did not occur in the three days after admission were excluded because patients undergoing such surgeries may have recently stopped drinking; women were excluded due to small numbers.

Surgical data were obtained from VASQIP, which collects preoperative, intra-operative and postoperative data for approximately 70% of VA surgical procedures performed under general, spinal or epidural anesthesia (Henderson & Daley, 2009; Henderson et al., 2007). VASQIP surgical nurses at each VA medical center review medical records and assess preoperative risk factors, operative variables and postoperative complications during hospitalization or up to 30 days following surgery. Other measures were obtained from the VA's National Patient Care Database (NPCD). AUDIT-C alcohol screening scores and demographic data were obtained from confidential outpatient SHEP surveys mailed regularly by the VA Office of Analytics and Business Intelligence (OABI, formerly the VA Office of Quality and Performance) to stratified random samples of patients with recent outpatient visits to assess patient satisfaction and quality of care (Wright, Craig, Campbell, Schaefer, & Humble, 2006).

The study was approved by institutional review boards at the VA Puget Sound Health Care System and co-authors' institutions.

## Measures

**AUDIT-C alcohol screening in the year prior to surgery.** The independent variable of interest was AUDIT-C alcohol screening completed on mailed surveys up to a year before surgery. The AUDIT-C comprises three questions about the quantity and frequency of past-year drinking and is a well-validated screen for the spectrum of alcohol misuse. The AUDIT-C is scored 0-12 points, with a score of 0 indicating no past-year consumption and a score of 12 indicating the highest level of severity. AUDIT-C scores in the year prior to surgery have been associated with increased risk of postoperative complications (AUDIT-C $\geq$ 5) and increased postoperative inpatient health care utilization (AUDIT-C $\geq$ 9) in previous studies of male VA

surgical patients (K. A. Bradley, Rubinsky, et al., 2011; Rubinsky et al., 2012). Similar to these studies, the present study evaluated four AUDIT-C risk groups: scores 0 (nondrinkers), 1-4 (low-risk), 5-8 (at-risk) and 9-12 (high-risk).

**Documented drinking > 2 drinks/day at the time of surgery.** Drinking over 2 drinks daily exceeds recommended drinking limits (National Institute on Alcohol Abuse and Alcoholism, 2007) and is associated with increased risk of alcohol-related problems and health conditions (Corrao, Bagnardi, Zambon, & La Vecchia, 2004; Dawson, Grant, & Li, 2005; Rehm et al., 2010). Clinical documentation of drinking over 2 drinks per day in the two weeks immediately prior to surgery ("documented >2d/d"), based on medical record review by VASQIP nurses, was evaluated as a potential effect modifier. The primary source for documented >2d/d was the preoperative nursing assessment, which should include assessment of alcohol use. However, when documentation was lacking from this source, VASQIP nurses generally reviewed the following additional sources in order: (1) history and physical, sometimes based on computerized templates that included alcohol history; (2) anesthesia assessments; (3) records from other VAs where the patient received care; and (4) active alcohol abuse listed on the problem list. A "no" on this measure indicated either documented drinking ≤ 2 drinks per day during the two weeks prior to surgery or no new documentation of alcohol use pertaining to this timeframe. The measure has demonstrated reliability (kappa=0.77) (Davis et al., 2007) and is associated with increased postoperative complications and longer hospital stays following surgery (Henderson et al., 2007; Nath et al., 2010).

**Postoperative outcome measures.** Postoperative outcome measures were the same as were used in previous evaluations of the AUDIT-C (K. A. Bradley, Rubinsky, et al., 2011; Rubinsky et al., 2012). Any *postoperative complication(s)* in the 30 days following surgery was

defined as the occurrence of at least 1 of 20 individual complications monitored by VASQIP during the study period (Daley et al., 1997). Any *return to the operating room (OR)* within 30 postoperative days, from VASQIP, indicated surgical procedures that required the patient to be taken to the surgical OR for intervention of any kind. Postoperative *hospital length of stay (LOS)*, also from VASQIP, measured the number of days between the date of surgery and date of discharge. *ICU days*, from NPCD, assessed the total number of days in an ICU during the postoperative hospital stay. Hospital LOS and ICU days were truncated to the first 30 days of postoperative hospitalization to avoid undue influence by extreme values.

**Covariates.** Patient demographics included self-reported age, race and marital status from SHEP. VA service-connected disability rating was obtained from NPCD, and past-year smoking status and VA medical center were obtained from VASQIP. Quartiles of year-specific work relative value units (RVUs) (Johnson & Newton, 2002) and five categories of surgical procedures based on Current Procedural Terminology (CPT) codes (i.e., thoracic, musculoskeletal, gastrointestinal, genitourinary or other) were used to address variation in surgical complexity. Days from AUDIT-C screening to surgery was used to address differences in opportunity to change drinking between completion of the AUDIT-C and surgery.

## Analyses

The probability of any postoperative complication and any return to the OR were evaluated in the total study sample. Hospital LOS was evaluated in the subset of patients who were hospitalized for at least one day following surgery (i.e., inpatients), and total ICU days were evaluated in the subset of inpatients who were admitted to the ICU during postoperative hospitalization. The probability of postoperative admission to the hospital and ICU were not

evaluated because we did not have the ability to distinguish planned and unplanned admissions and, therefore, differences across alcohol risk groups could be largely driven by differential surgical complexity rather than potentially preventable complications. Patients who died during postoperative hospitalization [n=33 (<1%)] were excluded from analyses in the inpatient and ICU samples.

For the total sample and each analytic subsample, initial analyses evaluated differences in sample characteristics across patients with and without documented >2d/d. Differences in categorical variables were tested with chi-square tests and differences in continuous variables with non-parametric Kruskal–Wallis tests. All main analyses used multivariable ordinary least squares logistic (i.e., for any complication and return to OR) or linear (i.e., for hospital LOS and ICU days) regression models that adjusted for demographic variables, past-year smoking status, surgical CPT category, quartile of surgical RVUs and days from AUDIT-C to surgery; and estimated clustered robust standard errors to account for correlated data from the same medical center (n=106). Sensitivity analyses confirmed that using multilevel mixed models with a random effect for medical center did not meaningfully change results.

Post-estimation Wald tests evaluated whether documented >2d/d modified the association between AUDIT-C risk groups and each postoperative outcome. Because power to detect statistically significant interactions was expected to be limited *a priori*, outcomes were estimated and compared across the eight possible combinations formed by AUDIT-C risk group and documented >2d/d, with AUDIT-C scores 1-4 and no documented >2d/d serving as the referent. AUDIT-C 0 was not designated the referent because nondrinkers have worse self-reported health (Williams et al., 2010) and greater surgical risk (K. A. Bradley, Rubinsky, et al., 2011; Rubinsky et al., 2012) compared to low-risk drinkers. The average predicted probability of complication(s)

and return to OR based on postestimation methods are presented in order to reflect not only differences in odds but the magnitude of differences in prevalence across groups.

All analyses were conducted using Stata 12 (StataCorp., 2011).

## RESULTS

### Sample Characteristics

A total of 8,811 male VA patients who underwent a non-emergent, non-cardiac, major surgery assessed by VASQIP during the study period and had completed the AUDIT-C alcohol screening questionnaire on a mailed survey in the previous year were included in this study. Of these patients, 5,171 were hospitalized for at least a day following surgery and included in the inpatient sample; and 1,913 were admitted to the ICU during postoperative hospitalization and included in the ICU sample. Most patients were white and mean age ranged from 64 to 66 years across the three analytic samples. Musculoskeletal and gastrointestinal surgeries were the most common types of surgeries in the total sample, whereas musculoskeletal surgeries were most common in the inpatient sample, and vascular/thoracic surgeries were most common in the ICU sample. Mean surgical RVU, a proxy for surgical complexity (Henderson et al., 2007), was 14 (SD 7), 18 (SD 7), and 21 (SD 7) in the total, inpatient, and ICU samples, respectively. Across samples, 16-19% of patients had AUDIT-C scores ≥ 5, and 4-5% had scores ≥ 9. Less than 10% of patients in each sample had documented >2d/d, although rates were higher among those with AUDIT-C scores 5-8 (25-31%) and 9-12 (46-55%). In the total sample, 629 (7%) patients had a surgical complication in the 30 days following surgery, and 401 (5%) returned to the OR. Among inpatients, the mean hospital LOS was 5.3 (SD 5.5) days, and, among those admitted to the ICU, the mean number of ICU days was 3.2 (SD 4.2).

Table 3.1 compares characteristics of each analytic sample by documented drinking status at the time of surgery. In all samples, patients with documented >2d/d were younger, less likely to be married, more likely to be past-year smokers, and had higher mean surgical RVUs than those with no documented >2d/d. Across samples, the majority (71-76%) of patients with documented >2d/d had AUDIT-C scores ≥ 5 and the majority (87-88%) of patients with no documented >2d/d had AUDIT-C scores < 5.

**Post-op Outcomes by AUDIT-C Risk Group and Drinking Status at the Time of Surgery**

Although there was no statistically significant interaction between AUDIT-C screening results from up to a year before surgery and documented >2d/d at the time of surgery for any outcome, comparisons across groups defined by AUDIT-C risk group and documented drinking status at surgery revealed important differences (Table 3.2). Compared with those who had AUDIT-C scores 1-4 and no documented >2d/d, patients with higher AUDIT-C risk groups and documented >2d/d had increased postoperative complication(s), hospital LOS and ICU days. Specifically, patients with AUDIT-C scores ≥ 5 and documented >2d/d had increased complication(s), and patients with AUDIT-C scores ≥ 9 and documented >2d/d also had increased hospital LOS and ICU days. Further, among patients with documented >2d/d, postoperative risk varied widely depending on AUDIT-C score: probability of complication(s) increased from 6% to 11% to 13% across AUDIT-C scores 1-4, 5-8, and 9-12, respectively, whereas postoperative hospital LOS increased from 5.1 to 5.8 to 6.8 days, and ICU days increased from 2.5 to 3.6 to 5.8 days across these scores.

An unexpected finding was observed with regard to return to OR: compared with patients who had AUDIT-C scores 1-4 and no documented >2d/d, risk was increased only among

those who had AUDIT-C scores 9-12 and no documented >2d/d, and not among any patients who had documented >2d/d, regardless of AUDIT-C score. However, among patients with documented >2d/d, numbers of patients in each AUDIT-C risk group who returned to the OR were very small (Table 3.3).

As expected, estimates of postoperative risk were higher among patients with AUDIT-C scores of 0 compared to those with AUDIT-C scores 1-4. Patients with an AUDIT-C score of 0 and no documented >2d/d had increased complication(s), more returns to the OR and longer hospital LOS compared to those with AUDIT-C scores 1-4 and no documented >2d/d. Among the very small number of patients with an AUDIT-C score of 0 and documented >2d/d, postoperative risk was extremely high on all measures, although confidence intervals were wide and only complication(s) were significantly increased compared to patients with AUDIT-C scores 1-4 and no documented >2d/d.

*Sensitivity analyses.* Results based on unadjusted regression models were similar to those for main analyses, except that return to OR was found to be increased among patients with AUDIT-C scores ≥ 5 and documented >2d/d (as well as among those with AUDIT-C scores ≥ 9 and no documented >2d/d) (Table 3.4).

*Post-hoc exploratory analyses.* Because medical record documentation of drinking over 2 drinks/day at the time of surgery was not based on standardized assessment and identified far fewer patients with alcohol misuse than did AUDIT-C scores ≥ 5, post-hoc exploratory analyses in the total sample investigated whether this measure tended to capture patients with the most severe misuse. The prevalence of any documented alcohol-related diagnosis (e.g., alcohol use disorders, alcohol withdrawal, acute intoxication, cirrhosis, hepatitis) in the year prior to surgery was estimated across groups defined by AUDIT-C risk group and documented >2d/d at surgery.

These exploratory analyses revealed that alcohol-related diagnoses were nearly four times more common among those with documented >2d/d than those without (31% versus 8%), and were highly prevalent among patients who had AUDIT-C scores 9-12 regardless of documented drinking status at surgery (47-51%; Table 3.5).

## DISCUSSION

This study of men who underwent non-emergent, non-cardiac, major surgery in VA demonstrated that the combination of AUDIT-C screening results from up to a year before surgery and medical record documentation of drinking > 2 drinks per day in the two weeks prior to surgery provided more information about postoperative risk than either measure alone. Recent studies among similar populations of VA patients determined that AUDIT-C scores in the year prior to surgery identified patients with increased postoperative complications and returns to OR, longer postoperative hospital stays, and more ICU days (K. A. Bradley, Rubinsky, et al., 2011; A. H. Harris et al., 2011; Rubinsky et al., 2012). This study revealed that associations between higher AUDIT-C risk groups and increased postoperative complications, hospital LOS, and ICU days were limited to those patients with clinically documented drinking > 2 drinks/day at the time of surgery. However, among patients with documented >2d/d, postoperative risk varied widely depending on AUDIT-C risk group. Compared to patients with AUDIT-C scores 1-4 and no documented >2d/d, the probability of complications was nearly doubled among those with AUDIT-C scores ≥ 5, and hospital LOS and ICU days were increased by approximately 2 and 3 days, respectively, among those with AUDIT-C scores ≥ 9.

The finding that patients with the highest AUDIT-C scores but no documented >2d/d at surgery had no significant increase in complications, hospital LOS, or ICU days compared to

those with AUDIT-C scores 1-4 may indicate potential benefits of decreased drinking prior to surgery. However, the measure of medical record documentation of drinking > 2 drinks/day in the two weeks prior to surgery was not based on standardized assessment. Documentation practices likely varied across providers and/or sites, and VASQIP nurses may have used documentation of alcohol abuse as a surrogate when level of consumption in the two weeks prior to surgery was not documented. Further, patients with no new alcohol-related documentation were combined with those who had documented consumption ≤ 2 drinks/day. In these ways, the VASQIP indicator of documented >2d/d may tend to identify only those patients with the most severe, persistent, or easily recognizable alcohol misuse. Exploratory analyses found that, overall, patients with documented >2d/d were almost four times more likely to have an alcohol-related diagnosis in the year prior to surgery than those with no documented >2d/d; however, among patients with AUDIT-C scores 9-12, the prevalence was similar irrespective of documented drinking status at surgery. Thus, it is unclear whether the lack of association between the highest AUDIT-C scores and most postoperative outcomes among patients with no documented >2d/d reflects alcohol misuse that has decreased or resolved and/or is less severe (and therefore unrecognized).

The finding that return to OR was significantly increased only among patients with AUDIT-C scores 9-12 and no documented >2d/d in main analyses was unexpected and may be a spurious finding due to multiple statistical comparisons. The finding could also be explained if patients in this group had decreased their drinking, but not for long enough to have reversed effects of alcohol misuse on wound healing and the immune system (H. Tonnesen, 2003), or if they had persistent alcohol misuse not captured by the indicator of documented drinking status at surgery. Further, because returns to the OR may occur most often following select types of

surgeries, results could reflect differences in the frequency of such procedures across alcohol risk groups. Statistical power may have been insufficient to detect true differences in return to OR among patients with documented >2d/d. Across all AUDIT-C risk groups, only 41 patients with documented >2d/d had a return to the OR, and, in unadjusted analyses, returns to OR were found to be significantly increased among those with documented >2d/d and AUDIT-C scores ≥ 5.

Although very few patients had an AUDIT-C score of 0, indicating no alcohol consumption in the past year, and documented >2d/d, this group had the highest average predicted probability of complication(s) and return to OR, and the longest mean hospital LOS (but with limited precision). This group may have included patients with chronic alcohol dependence who tend to cycle between periods abstinence and relapse. Exploratory analyses confirmed that nearly a third of these patients had an alcohol-related diagnosis in the year prior to surgery.

The finding that most measures of postoperative risk were increased only among patients who had the highest AUDIT-C scores *and* documented >2d/d at the time of surgery may indicate a causal role for alcohol. Several observational studies have found that adverse physiologic effects of alcohol can be reversed after several weeks to several months of abstinence, depending on the organ system involved (H. Tonnesen, 2003; H. Tonnesen et al., 2009). However, documented >2d/d identified less than half as many patients with potential alcohol misuse as did AUDIT-C scores ≥ 5, similar to a study that found routine preoperative clinical alcohol assessment to be insensitive, missing the majority of surgical patients identified by a validated alcohol screening questionnaire (Kip et al., 2008). Therefore, future research should investigate whether a modified version of the AUDIT-C administered closer to the time of surgery that asks about recent (e.g., past month) rather than past-year drinking performs as well as the

combination of AUDIT-C screening results from up to a year prior to surgery and clinically documented drinking status at the time of surgery for identifying patients with high postoperative risk. We hypothesize that such an adaption of the AUDIT-C could provide a scaled marker of postoperative risk, much like the combination of past-year AUDIT-C score and documented >2d/d, but would identify more patients at increased risk.

This study has important limitations. The indictor of drinking > 2 drinks/day in the two weeks prior to surgery was based on clinical findings as documented in the medical record rather than standardized assessment. The indicator may reflect alcohol problems documented prior to the two week window in some cases, and appears to capture only a minority of patients with potential alcohol misuse. Additionally, because of the small numbers of patients with documented >2d/d, the precision of some estimates was limited. Although this study adjusted for important covariates associated with postoperative risk that were not expected to be in the causal pathway with alcohol use, some degree of residual confounding may have persisted. For example, findings could be confounded by intensity and recency of tobacco exposure not captured by the dichotomous measure of current smoking status. Further, given that this study included many surgical procedures, if patients with alcohol misuse were more likely to have high-risk surgeries, study findings could reflect differences in procedural type and complexity not captured by quartiles of surgical RVU and the five broad CPT categories. Although one study has confirmed the AUDIT-C is associated with complications in patients undergoing a single procedure (A. H. Harris et al., 2011), future studies should confirm this study's findings among surgical patients undergoing a single high-risk procedure. The AUDIT-C was administered on confidential mailed surveys, which identify more patients with alcohol misuse compared to AUDIT-Cs administered in clinical VA settings (K. A. Bradley, Lapham, et al.,

2011; Hawkins et al., 2007). Results of the survey-based AUDIT-C were not available to surgical care providers. Surgical risks for survey respondents may differ from non-respondents. The study included predominantly older men, but women and younger men are at increased risk for alcohol-related medical complications at lower levels of consumption (Au, Kivlahan, Bryson, Blough, & Bradley, 2007; Felding, Jensen, & Tonnesen, 1992; Kinder, Bryson, Sun, Williams, & Bradley, 2009; Rehm et al., 2010). Findings should be replicated among other populations, including surgical patients from healthcare systems other than the VA. Finally, postoperative complication(s) may reflect a wide range of severity, and ICU treatment and return to the OR may capture a broad spectrum of indications. These limitations should, however, be viewed in the context of the study's strengths. The AUDIT-C was administered in a standard fashion and was available for a large, national sample of male surgical patients. Additionally, assessment of postoperative outcomes was standardized and abstractors were unaware of the study.

This study has implications for surgical providers and referring physicians. The AUDIT-C is being used increasingly for routine alcohol screening; it is the required screening tool in the VA and over 90% of VA outpatients nationwide are screened annually with the AUDIT-C (K. A. Bradley et al., 2006). Findings of this study suggest that, in healthcare systems using the AUDIT-C, patients who have a documented positive screen in the year prior to surgery could be re-assessed closer to the time of surgery to identify those who continue to drink at risky levels and may be at greatest risk for postoperative complications and increased postoperative health care utilization. Additional research is needed to determine the type and duration of changes in drinking prior to surgery that can modify alcohol-related risks. For example, is abstinence better than reducing drinking $\leq 2$ drinks daily, and what is optimal duration of decreased drinking pre-operatively? A single small randomized controlled trial among heavy daily drinkers

demonstrated that four weeks of pre-operative abstinence reduced the risk of postoperative complications dramatically (H Tonnesen et al., 1999), whereas another study found that less intensive interventions closer to the time of surgery were not effective (Shourie et al., 2006). In order to improve surgical outcomes for patients with alcohol misuse, future research should aim to identify optimal approaches for identifying those at increased risk and continue to address comparative effectiveness of interventions to decrease drinking pre-operatively.

To summarize, this study demonstrated that among patients who screen positive for alcohol misuse on the AUDIT-C in the year prior to surgery with scores associated with increased postoperative risk, only those with medical record documentation of drinking > 2 drinks daily in the two weeks before surgery had increased postoperative complications, hospital LOS, and ICU days. This study cannot confirm whether these patients had poorer postoperative outcomes due to continued alcohol misuse up to the time of surgery or because clinical documentation of drinking > 2 drinks per day immediately prior to surgery identified those with the most severe misuse.

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**TABLE 3.1** Characteristics of each Analytic Sample, by Documented Drinking Status at the Time of Surgery

| | **TOTAL SAMPLE** N = 8,811 | | | | **INPATIENTS** N = 5,171 | | | | **ICU** N = 1,913 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Medical Record Documentation of Drinking > 2 Drinks Daily in the 2 Weeks Prior to Surgery** | | | | | | | | | | | |
| | **No** (n = 8,185) | | **Yes** (n = 626) | | **No** (n = 4,770) | | **Yes** (n = 401) | | **No** (n = 1,733) | | **Yes** (n = 180) | |
| | **N** | **(%)** | **N** | **(%)** | **N** | **(%)** | **N** | **(%)** | **N** | **(%)** | **N** | **(%)** |
| Age, mean years ± SD | 64 ± 11 | | 62 ± 9*** | | 66 ± 10 | | 63 ± 8*** | | 67 ± 10 | | 64 ± 8*** | |
| Race | | | | | | | | | | | | |
| White (non-Hispanic) | 6669 | (81) | 524 | (84) | 3890 | (82) | 334 | (83) | 1449 | (84) | 147 | (82) |
| Black (non-Hispanic) | 657 | (8) | 44 | (7) | 389 | (8) | 31 | (8) | 137 | (8) | 18 | (10) |
| Hispanic | 413 | (5) | 31 | (5) | 239 | (5) | 20 | (5) | 67 | (4) | 6 | (3) |
| Other | 327 | (4) | 19 | (3) | 176 | (4) | 10 | (2) | 46 | (3) | 8 | (4) |
| Missing | 119 | (1) | 8 | (1) | 76 | (2) | 6 | (1) | 34 | (2) | 1 | (1) |
| Married | 4769 | (58) | 263 | (42)*** | 2751 | (58) | 172 | (43)*** | 973 | (56) | 69 | (38)*** |
| > 50% service-connected | 1776 | (22) | 93 | (15)*** | 1003 | (21) | 58 | (14)** | 322 | (19) | 24 | (13) |
| Smoker (past year) | 2357 | (29) | 345 | (55)*** | 1402 | (29) | 217 | (54)*** | 572 | (33) | 111 | (62)*** |
| Surgical CPT category | | | | ** | | | | * | | | | |
| Vascular/Thoracic | 1052 | (13) | 113 | (18) | 908 | (19) | 101 | (25) | 730 | (42) | 77 | (43) |
| Musculoskeletal | 2763 | (34) | 200 | (32) | 1675 | (35) | 126 | (31) | 263 | (15) | 31 | (17) |
| Gastrointestinal | 2616 | (32) | 204 | (33) | 1090 | (23) | 94 | (23) | 462 | (27) | 50 | (28) |
| Genitourinary | 1386 | (17) | 92 | (15) | 843 | (18) | 67 | (17) | 172 | (10) | 16 | (9) |
| Other | 368 | (4) | 17 | (3) | 254 | (5) | 13 | (3) | 106 | (6) | 6 | (3) |
| AUDIT-C Screen Score | | | | *** | | | | *** | | | | *** |
| 0 points (nondrinker) | 4035 | (49) | 29 | (5) | 2425 | (51) | 14 | (3) | 885 | (51) | 7 | (4) |
| 1-4 points | 3140 | (38) | 155 | (25) | 1764 | (37) | 89 | (22) | 620 | (36) | 36 | (20) |
| 5-8 points | 810 | (10) | 270 | (43) | 468 | (10) | 181 | (45) | 181 | (10) | 80 | (44) |
| 9-12 points | 200 | (2) | 172 | (27) | 113 | (2) | 117 | (29) | 47 | (3) | 57 | (32) |
| Days AUDIT-C to surgery, mean ± SD | 161 ± 104 | | 161 ± 105 | | 163 ± 103 | | 163 ± 106 | | 166 ± 104 | | 171 ± 103 | |
| Surgical RVU, mean ± SD | 14 ± 7 | | 15 ± 8*** | | 18 ± 7 | | 19 ± 7*** | | 21 ± 7 | | 22 ± 8* | |

*p < 0.05; **p < 0.005; ***p < 0.0005; p-values test for differences between patients with and without documented drinking >2 drinks/day at surgery

**TABLE 3.2** Adjusted 30-day Postoperative Outcomes*, by Past-Year Alcohol Screening Score and Documented Drinking Status at the Time of Surgery

| AUDIT-C Score from Year Prior to Surgery | Medical Record Documentation of Drinking > 2 Drinks/Day at Surgery: No — Probability** (95% CI) | p-value*** | Yes — Probability** (95% CI) | p-value*** |
|---|---|---|---|---|
| *Postoperative Complications* | | | | |
| AUDIT-C 0 | 0.07 (0.07,0.08) | 0.01 | 0.18 (0.05,0.31) | 0.006 |
| AUDIT-C 1-4 | 0.06 (0.05,0.07) | REF | 0.06 (0.03,0.10) | 0.79 |
| AUDIT-C 5-8 | 0.07 (0.05,0.09) | 0.20 | 0.11 (0.07,0.14) | 0.001 |
| AUDIT-C 9-12 | 0.08 (0.04,0.12) | 0.33 | 0.13 (0.09,0.17) | <0.0001 |
| *Return to OR* | | | | |
| AUDIT-C 0 | 0.05 (0.04,0.05) | 0.05 | 0.11 (0.00,0.21) | 0.06 |
| AUDIT-C 1-4 | 0.04 (0.03,0.05) | REF | 0.04 (0.01,0.07) | 0.74 |
| AUDIT-C 5-8 | 0.04 (0.02,0.05) | 0.76 | 0.06 (0.03,0.09) | 0.06 |
| AUDIT-C 9-12 | 0.09 (0.05,0.13) | 0.001 | 0.06 (0.03,0.10) | 0.09 |
| | **Mean (95% CI)** | **p-value*** ** | **Mean (95% CI)** | **p-value*** ** |
| *Hospital LOS (among inpatients)* | | | | |
| AUDIT-C 0 | 5.4 (5.1,5.7) | 0.01 | 8.1 (3.5,12.8) | 0.19 |
| AUDIT-C 1-4 | 5.0 (4.7,5.3) | REF | 5.1 (4.2,5.9) | 0.87 |
| AUDIT-C 5-8 | 5.2 (4.7,5.7) | 0.42 | 5.8 (5.0,6.7) | 0.07 |
| AUDIT-C 9-12 | 4.8 (4.3,5.4) | 0.61 | 6.8 (5.4,8.1) | 0.01 |
| *ICU Days (among inpatients admitted)* | | | | |
| AUDIT-C 0 | 3.2 (2.9,3.5) | 0.06 | 4.0 (1.4,6.6) | 0.38 |
| AUDIT-C 1-4 | 2.8 (2.6,3.1) | REF | 2.5 (1.8,3.2) | 0.31 |
| AUDIT-C 5-8 | 3.2 (2.5,3.9) | 0.36 | 3.6 (2.6,4.6) | 0.16 |
| AUDIT-C 9-12 | 3.0 (2.4,3.7) | 0.51 | 5.8 (3.7,7.8) | 0.006 |

* Based on regression models adjusted for race/ethnicity, marital status, age, service-connected disability > 50%, past-year smoking, quartile of surgical RVU, surgical CPT category and days from AUDIT-C to surgery; and clustered on medical facility.

** Average predicted probability estimated based on logistic regression postestimation techniques.

*** P-values compare regression model coefficients for groups defined by AUDIT-C score and drinking status at surgery to referent (AUDIT-C 1-4 and no documented drinking > 2 drinks/day at surgery).

**TABLE 3.3** Number of Patients who had Surgical Complications and Returned to the OR within 30 Postoperative Days, by Past-Year Alcohol Screening Score and Documented Drinking Status at the Time of Surgery

| | **Documented Drinking > 2 Drinks/Day at Surgery** | | | |
|---|---|---|---|---|
| **AUDIT-C Score from Year Prior to Surgery** | **No** | | **Yes** | |
| | **Outcome N / Total N** | **(%)** | **Outcome N / Total N** | **(%)** |
| | *Postoperative Complications* | | | |
| AUDIT-C 0 | 307/ 4035 | (8) | 5/ 29 | (17) |
| AUDIT-C 1-4 | 177/ 3140 | (6) | 11/ 155 | (7) |
| AUDIT-C 5-8 | 55/ 810 | (7) | 34/ 270 | (13) |
| AUDIT-C 9-12 | 15/ 200 | (8) | 25/ 172 | (15) |
| Total Sample | 554/ 8185 | (7) | 75/ 626 | (12) |
| | *Return to OR* | | | |
| AUDIT-C 0 | 195/ 4035 | (5) | 3/ 29 | (10) |
| AUDIT-C 1-4 | 119/ 3140 | (4) | 7/ 155 | (5) |
| AUDIT-C 5-8 | 28/ 810 | (3) | 19/ 270 | (7) |
| AUDIT-C 9-12 | 18/ 200 | (9) | 12/ 172 | (7) |
| Total Sample | 360/ 8185 | (4) | 41/ 626 | (7) |

**TABLE 3.4** Unadjusted 30-day Postoperative Outcomes*, by Past-Year Alcohol Screening Score and Documented Drinking Status at the Time of Surgery

| AUDIT-C Score from Year Prior to Surgery | Medical Record Documentation of Drinking > 2 Drinks/Day at Surgery: No | | | Yes | | |
|---|---|---|---|---|---|---|
| | Probability** | (95% CI) | p-value*** | Probability** | (95% CI) | p-value*** |
| *Postoperative Complications* | | | | | | |
| AUDIT-C 0 | 0.08 | (0.07,0.09) | 0.002 | 0.17 | (0.04,0.31) | 0.009 |
| AUDIT-C 1-4 | 0.06 | (0.05,0.07) | REF | 0.07 | (0.03,0.11) | 0.43 |
| AUDIT-C 5-8 | 0.07 | (0.05,0.08) | 0.18 | 0.13 | (0.08,0.17) | <0.0001 |
| AUDIT-C 9-12 | 0.07 | (0.03,0.12) | 0.33 | 0.15 | (0.10,0.20) | <0.0001 |
| *Return to OR* | | | | | | |
| AUDIT-C 0 | 0.05 | (0.04,0.06) | 0.03 | 0.10 | (-0.00,0.21) | 0.07 |
| AUDIT-C 1-4 | 0.04 | (0.03,0.04) | REF | 0.05 | (0.01,0.08) | 0.62 |
| AUDIT-C 5-8 | 0.03 | (0.02,0.05) | 0.67 | 0.07 | (0.04,0.10) | 0.004 |
| AUDIT-C 9-12 | 0.09 | (0.05,0.13) | 0.0004 | 0.07 | (0.03,0.11) | 0.04 |
| | **Mean** | **(95% CI)** | **p-value*** ** | **Mean** | **(95% CI)** | **p-value*** ** |
| *Hospital LOS (among inpatients)* | | | | | | |
| AUDIT-C 0 | 5.3 | (5.0,5.6) | 0.04 | 8.6 | (3.6,13.7) | 0.16 |
| AUDIT-C 1-4 | 5.0 | (4.7,5.3) | REF | 5.6 | (4.5,6.7) | 0.28 |
| AUDIT-C 5-8 | 5.2 | (4.7,5.8) | 0.40 | 6.0 | (5.0,6.9) | 0.09 |
| AUDIT-C 9-12 | 4.9 | (4.2,5.6) | 0.78 | 6.8 | (5.3,8.2) | 0.02 |
| *ICU Days (among inpatients admitted)* | | | | | | |
| AUDIT-C 0 | 3.2 | (2.9,3.5) | 0.04 | 3.7 | (0.8,6.6) | 0.54 |
| AUDIT-C 1-4 | 2.8 | (2.6,3.1) | REF | 3.0 | (2.3,3.8) | 0.58 |
| AUDIT-C 5-8 | 3.2 | (2.5,3.8) | 0.33 | 3.8 | (2.7,4.8) | 0.12 |
| AUDIT-C 9-12 | 3.0 | (2.3,3.7) | 0.65 | 5.7 | (3.5,7.8) | 0.009 |

* Based on regression models clustered on medical facility.

** Average predicted probability estimated based on logistic regression postestimation techniques.

*** P-values compare regression model coefficients for groups defined by AUDIT-C score and drinking status at surgery to referent (AUDIT-C 1-4 and no documented drinking > 2 drinks/day at surgery).

**TABLE 3.5** Numbers of Patients with Any Alcohol-Related Diagnosis in the Year Prior to Surgery, by Past-Year Alcohol Screening Score and Documented Drinking Status at the Time of Surgery

| AUDIT-C Score from Year Prior to Surgery | Documented Drinking > 2 Drinks/Day at Surgery: No | | Documented Drinking > 2 Drinks/Day at Surgery: Yes | |
|---|---|---|---|---|
| | Outcome N / Total N | (%) | Outcome N / Total N | (%) |
| | *Any Alcohol-Related Diagnosis* | | | |
| AUDIT-C 0 | 239/ 4035 | (6) | 9/ 29 | (31) |
| AUDIT-C 1-4 | 130 / 3140 | (4) | 27/ 155 | (17) |
| AUDIT-C 5-8 | 142/ 810 | (18) | 79/ 270 | (29) |
| AUDIT-C 9-12 | 106 / 200 | (53) | 81/ 172 | (47) |
| Total | 617/ 8185 | (8) | 196/ 626 | (31) |

# Chapter 4: AUDIT-C Scores as a Scaled Marker of Mean Daily Drinking, Alcohol Use Disorder Severity and Probability of Alcohol Dependence in a U.S. General Population Sample of Drinkers

Alcohol screening followed by brief counseling for those who screen positive for misuse has been deemed a top U.S. prevention priority based on the health impact of alcohol misuse and cost-effectiveness of brief alcohol interventions (Solberg, Maciosek, & Edwards, 2008). Healthcare systems are increasingly implementing alcohol screening and brief counseling in primary care (E.C. Williams et al., 2011). However, providers often lack the necessary time and resources to assess the severity of alcohol misuse (Nilsen, 2010), which ranges from drinking over recommended limits to meeting diagnostic criteria for alcohol dependence.

A variety of preventive and treatment services are recommended for patients with alcohol misuse, depending on the severity (Willenbring, 2009). Clinicians should consider where a patient falls on the spectrum of alcohol misuse severity and be able to respond accordingly with a range of appropriate interventions (National Institute on Alcohol Abuse and Alcoholism, 2007; Willenbring, 2009). Although alcohol screening questionnaires are typically used as dichotomous tests for misuse, the resulting continuous scores capture additional information beyond positive versus negative screening classification. If individual screening scores were calibrated in terms of level of consumption, severity of alcohol use disorders (AUD), and likelihood of dependence, alcohol screening questionnaires might serve as valuable tools for assessing the spectrum of alcohol misuse. Specifically, providers could utilize this information to provide the patient with individualized feedback about alcohol-related risks associated with their particular score and to make more informed decisions about need for further diagnostic assessment.

The 3-item Alcohol Use Disorders Identification Test – Consumption questionnaire (AUDIT-C) is a validated screen for alcohol misuse appropriate for routine screening in primary care (Bradley, Kivlahan, & Williams, 2009). The Veterans Affairs (VA) Healthcare System currently conducts annual screening of all outpatients using the AUDIT-C (Bradley et al., 2006). AUDIT-C scores have been associated with several alcohol-related health risks, including alcohol dependence (Rubinsky, Kivlahan, Volk, Maynard, & Bradley, 2010), severity of problem drinking (Bradley et al., 2004), adverse postoperative outcomes (Bradley et al., 2011; Rubinsky et al., 2012), hospitalizations for gastro-intestinal conditions (Lembke, Bradley, Henderson, Moos, & Harris, 2011), trauma (E. C. Williams et al., 2012) and mortality (Kinder, Bryson, Sun, Williams, & Bradley, 2009), generally in a dose-response manner. However, despite extensive literature establishing the AUDIT-C as a scaled marker of alcohol-related risk, we are not aware of any study that has evaluated the level of alcohol consumption or severity of misuse associated with individual AUDIT-C scores.

The aim of this study was to estimate mean daily drinking, AUD severity and probability of alcohol dependence across individual AUDIT-C scores in a large U.S. population sample using valid, reliable measures. Because the screening performance of the AUDIT-C depends on gender and age (Dawson, Grant, Stinson, & Zhou, 2005), each outcome was estimated separately for men and women and for varying age groups after testing for effect modification by these factors. Additionally, because low-level mean daily drinking can reflect frequent drinking of small quantities or occasional heavy drinking, secondary analyses investigated particular patterns of drinking across AUDIT-C scores.

## MEASURES AND METHODS

## Data Source and Sample

This cross-sectional study used data from the 2001-2002 National Epidemiologic Survey on Alcohol and Related Conditions (NESARC), conducted by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) (Grant & Dawson, 2006; B. F. Grant et al., 2003; Grant, Kaplan, Shepard, & Moore, 2003). The NESARC had an 81% overall response rate and included 43,093 U.S. adults aged 18 years and older. Structured interviews were administered in respondents' homes by trained lay interviewers using computer-assisted personal interviewing software that included built-in skip patterns and consistency safeguards. A final weighting factor was assigned to each respondent to account for oversampling and non-response and to ensure that the data were representative of the U.S. population in terms of demographics and geographic distribution.

The analysis was based on a subsample of 26,546 NESARC respondents who reported having at least one drink in the previous 12 months and answered additional questions about their past-year alcohol consumption, including items that correspond to the AUDIT-C. Of the respondents excluded from these analyses, 16,147 did not report past-year alcohol consumption, 265 did not complete the AUDIT-C items, and 135 did not answer additional questions about consumption that were used as outcome measures in this study.

## Measures

### *Overview*

All outcome measures of alcohol consumption and alcohol use disorders (AUD) were based on the Alcohol Use Disorder and Associated Disabilities Interview Schedule (AUDADIS-IV) (Grant, Dawson, & Hasin, 2001), an in-depth assessment of past-year drinking and associated symptoms with demonstrated reliability (B. F. Grant et al., 2003) and validity

(Dawson, Grant, & Li, 2005; Dawson, Li, & Grant, 2008; Dawson, Saha, & Grant, 2010; Dawson, Smith, Pickering, & Grant, 2012; B. F. Grant et al., 2003; Grant et al., 2007). For each of four specific alcoholic beverage types individually (i.e., coolers, beer, wine, and spirits) as well as all alcoholic beverages combined (total), the NESARC asked about the overall frequency of consumption, typical and largest quantities consumed, frequency of drinking the largest quantity, and frequency of drinking ≥ 5 drinks in a single day. Additionally, women were asked about the frequency of drinking ≥ 4 total drinks in a single day. For each specific beverage type, respondents' typical drink size and brand were also ascertained. To assess AUD, the NESARC included 33 alcohol symptom items that operationalized the four criteria of alcohol abuse and seven criteria of alcohol dependence (11 total AUD criteria) according to Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition (DSM-IV) specifications (American Psychiatric Association, 1994).

In this analysis, consumption of specific beverage types was adjusted for the actual ethanol content of the respondent's drinks. Specifically, the reported number of drinks was multiplied by the ethanol content in ounces, based on the respondent's typical brand and drink size for that beverage type, and converted to U.S. standard-sized drinks containing 0.60 ounces of ethanol (unrounded). In contrast, total consumption of all alcohol combined reflected respondents' reported number of total drinks, unadjusted for drink strength or pour size.

*AUDIT-C alcohol screening score*

The AUDIT-C alcohol screening questionnaire comprises three questions that ask about the quantity and frequency of drinking in the past year (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998). Each question is scored 0 to 4 points and summed for a total score ranging from

1 to 12 points among drinkers. A score of 12 reflects the highest level of severity, and scores ≥ 4 (men) and ≥ 3 (women) indicate positive screens for alcohol misuse, based on the best balance of sensitivity and specificity (Reinert & Allen, 2007).

NESARC AUDIT-C scores were derived from questions in the sequence about total consumption of all alcohol combined. The NESARC AUDIT-C follows standard scoring conventions as closely as possible, but the questions and response options varied somewhat from the most widely validated version (Table 4.1) (Dawson, Grant, Stinson, et al., 2005). Most notably, the NESARC AUDIT-C asked about the frequency of consuming 5 or more drinks, whereas the most widely validated version asks about the frequency of consuming 6 or more drinks (Bush et al., 1998). However, the World Health Organization recommends adjusting questions to reflect country-specific drink sizes and strength (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) and drinks in the U.S. typically contain approximately 14 grams of alcohol, whereas the original question about 6 or more drinks assumed a standard drink contained 10 grams of alcohol. Further, the NESARC AUDIT-C performs well for identifying alcohol misuse and alcohol use disorders (Dawson, Grant, Stinson, et al., 2005), with areas under the receiver operating curve and recommended cut-points similar to those reported for other versions (Reinert & Allen, 2007).

*Primary Outcome Measures*

*Mean daily drinking.* Mean alcohol consumption in drinks per day was computed based on a weighted formula incorporating typical drinking as well as atypical heavy drinking (National Institute on Alcohol Abuse and Alcoholism (NIAAA), 2004). This approach provides a more accurate estimate than those based solely on the quantity and frequency of typical

drinking, which fail to capture alcohol volume consumed during atypical episodes of heavy drinking (Greenfield & Kerr, 2008; Stahre, Naimi, Brewer, & Holt, 2006). Mean drinks per day was based on the larger of (a) reported total drinks of all alcohol or (b) the sum of standard-sized drinks from the four series of beverage-specific questions. Values over 24 drinks per day were reclassified to 24 drinks to avoid undue influence of outliers (affecting < 0.5%).

*Alcohol use disorder severity.* AUD severity was based on the count (0-11) of endorsed DSM-IV AUD criteria for the prior year. A simple count performs as well as dimensional severity measures weighted for the severity of the each endorsed criterion (Dawson et al., 2010).

*Alcohol dependence*. To meet diagnostic criteria for alcohol dependence, at least three of the seven DSM-IV dependence criteria had to be endorsed for the prior year.

*Secondary Outcome Measures – Patterns of Drinking*

Mean daily drinking can obscure important variation in drinking patterns, including differences in maximum quantity consumed and frequency of drinking at levels that exceed recommended daily limits.

*Maximum quantity of drinks.* Similar to mean daily drinking, maximum quantity of drinks consumed on any day in the past year was based on either (a) reported total drinks of all alcohol or (b) standard-sized drinks of any specific beverage type, whichever was greater, and values were top-coded to 24 drinks (affecting < 1%). Maximum quantity of drinks reflects the level of variability in an individual's consumption and has been suggested as an important component in understanding drinking patterns (Dawson, Grant, & Li, 2005; Greenfield, Nayak, Bond, Ye, & Midanik, 2006; National Institute on Alcohol Abuse and Alcoholism (NIAAA), 2003).

*Frequency of heavy drinking.* The number of heavy drinking days per week was based on the highest frequency of either (a) drinking ≥ 5 (men) or ≥ 4 (women) total drinks in a single day or (b) the frequency of drinking the largest quantity of any specific beverage type if the quantity was ≥ 5 (men) or ≥ 4 (women) standard-sized drinks based on standard rounding procedures (e.g., 4.5 rounded to 5). Frequency of heavy drinking is associated with several health consequences (Dawson et al., 2008; Saha, Stinson, & Grant, 2007) and may add risk beyond that associated with volume of mean daily consumption (Rehm, Baliunas, et al., 2010).

*Exceeding recommended drinking limits.* Recommended daily drinking limits were based on NIAAA guidelines for healthy adults aged 65 years or less (National Institute on Alcohol Abuse and Alcoholism, 2007). Exceeding recommended maximum daily drinking limits was defined as drinking ≥ 5 (men) or ≥ 4 (women) drinks (i.e. heavy drinking) at least once in the past year. Exceeding recommended average daily drinking limits was defined as mean daily drinking > 2 (men) or > 1 (women) drinks per day. Although NIAAA suggests lower average daily limits (≤ 1 drink per day) for men over 65 years because of potentially increased sensitivity to the effects of alcohol (National Institute on Alcohol Abuse and Alcoholism, 2007), we used the same threshold for all men so that the measure would be comparable across age groups. Further, recent studies indicate that the risk of mortality, cognitive and physical disability, depression/anxiety, and diminished self-reported health are no greater for older adults who drink >1 drinks daily than for those who drink ≤ 1drink daily (Kirchner et al., 2007; Lang, Guralnik, Wallace, & Melzer, 2007), calling into question the lower suggested limits for older men.

*Demographic Variables.*

Outcome measures were estimated across individual AUDIT-C scores separately for men and women and for four age groups (18-29, 30-44, 45-64, 65+). Self-reported race/ethnicity, marital status and family income were used to further characterize the study sample.

**Statistical Analyses**

Analyses were conducted using Stata/MP 12 software (StataCorp., 2011) and all estimates of variance accounted for NESARC's complex multistage sampling design and final weighting using Taylor series linearization. Pearson chi-square tests of independence were adjusted for the survey design and weighting based on Rao-Scott correction F-statistics.

Sociodemographic characteristics of men and women in the study sample were described overall and across AUDIT-C scores (1-12). Chi-square tests (for categorical variables) and analysis of variance (for continuous variables) were used to evaluate associations between sociodemographic characteristics and AUDIT-C scores.

Linear regression models and postestimation methods were used to estimate average values (and 95% confidence intervals [CI]) of mean daily drinking and AUD severity at each AUDIT-C score, after testing for effect modification by gender and age. Logistic regression models and postestimation methods were used to estimate the average predicted probability of alcohol dependence at each AUDIT-C score, after testing for effect modification by gender and age. Each outcome was estimated across individual AUDIT-C scores separately for men and women and for each age group, with differences by gender and age evaluated at each score based on postestimation Wald tests. To allow for non-linear patterns across AUDIT-C scores, individual scores were modeled as separate categorical variables.

Secondary analyses investigated patterns of drinking across AUDIT-C scores using the same statistical approach as for main analyses. Average values of maximum quantity consumed and frequency of heavy drinking were estimated and compared based on linear regression methods. Average predicted probabilities of exceeding recommended daily drinking limits were estimated and compared based on logistic regression methods.

## RESULTS

### *Sample Characteristics*

Of the 26,546 (12,823 men; 13,723 women) past-year drinkers who met all study inclusion criteria, most had AUDIT-C scores considered a negative screen for alcohol misuse (scores 1-3 for men; 1-2 for women), and the number of men and women with each score generally decreased as scores increased (Table 4.2). Individuals with higher AUDIT-C scores were younger, less likely to be married and more likely to have low family incomes (Table 4.2).

### *Mean Daily Drinking*

Mean daily drinking increased exponentially across increasing AUDIT-C scores, from < 0.1 drink per day at a score of 1, to 18 drinks per day at a score of 12 (Table 4.3). Across AUDIT-C scores 2-7, each 1-point increase was associated with an increase in mean daily drinking of approximately 0.5 drinks. This magnitude of increase doubled to approximately 1 drink across scores 7-9, was 3 drinks across scores 9-11 and reached over 6 drinks with a change in score from 11 to 12. The relationship between AUDIT-C score and mean daily drinking was not modified by gender, and estimates for men and women were similar at every score (Figure 4.1; Table 4.4). Age, however, did modify the relationship ($p<0.00005$), with the oldest age

group (65+ years) having the highest mean daily drinking at AUDIT-C scores 4-6 but the lowest consumption at scores 10-12 (Figure 4.1; Table 4.4). Although the oldest group differed most from the other age groups, post-hoc exploratory analyses revealed an interaction also among the three age groups under 65 years ($p<0.00005$), whereby those aged 45-64 had increasingly higher consumption compared to younger individuals across AUDIT-C scores 3-9, but not at higher or lower scores.

*Alcohol Use Disorder Severity*

Only 24% of drinkers endorsed 1 or more AUD criteria and, of these, nearly half endorsed only a single criterion. Mean AUD severity ranged from < 0.1 to 0.5 across AUDIT-C scores 1-4, increased from 1.0 to 3.3 across scores 5-11 and spiked to 5.1 at a score of 12 (Table 4.3). The relationship between AUDIT-C score and AUD severity was modified by both gender and age group (p-values<0.00005). Women had increasingly higher AUD severity compared to men across AUDIT-C scores 4-7 (Figure 4.1; Table 4.5), but gender differences were not significant at higher scores, likely due to the small numbers of women with high scores (and wide confidence intervals). The interaction between AUDIT-C scores and age was relatively complex. AUD severity increased most steeply across AUDIT-C scores among the youngest individuals (18-29 years) and least steeply among the oldest individuals (65+ years) (Figure 4.1; Table 4.5). However, whereas AUD severity increased exponentially across AUDIT-C scores among those aged 18-29, 30-44 and 45-64, reaching 5.9, 5.0 and 4.3, respectively, at a score of 12; it reached a maximum of only approximately 1 among those aged 65 years and over. Post-hoc exploratory analyses revealed that an age interaction persisted among individuals under age

65, whereby AUD severity was similar for those aged 30-44 and 45-64, but higher for those aged 18-29, with differences generally increasing across increasing scores.

*Probability of Alcohol Dependence*

The probability of past-year alcohol dependence followed a similar pattern to AUD severity across AUDIT-C scores, even as a function of gender and age (Figure 4.1), but was not significantly modified by either factor, likely because of small numbers of individuals (especially women and older adults) with dependence at any given score. The probability of dependence was less than 5% among individuals with AUDIT-C scores 1-4, increased to approximately 40% at scores 9-11, and reached 65% at a score of 12 (Table 4.3). The probability of dependence was significantly higher in women than men at scores 4-7, and in the youngest age group compared to the oldest age group at most scores (Figure 4.1; Table 4.6). Among the oldest individuals (65+ years), only 21 of 3,304 (0.6%) had alcohol dependence and the highest probability at any given score was less than 20%.

*Secondary Outcomes: Patterns of Drinking*

Secondary analyses investigating patterns of drinking across AUDIT-C scores revealed that the maximum quantity of drinks consumed in a single day in the past year ranged from < 2 to 20 across increasing AUDIT-C scores (Figure 4.2, Table 4.7). The frequency of heavy drinking (i.e. drinking at levels that exceed recommended maximum daily limits) ranged from approximately 0 days per week at scores 1-2 to nearly 7 days per week at scores 11-12 (Figure 4.2, Table 4.8). Furthermore, over 90% of individuals with a score of 5, and all individuals with scores ≥ 6, drank at this level at least once in the past year (Figure 4.3, Table 4.9). Exceeding

recommended average daily limits was less common, especially among men (Figure 4.3, Table 4.10). Over 50% of women with scores ≥ 4 and nearly 100% with scores ≥ 8 drank at levels that exceeded recommended average daily limits. In contrast, fewer than 25% of men with scores 4-5 drank at levels that exceeded average daily drinking limits and only at scores ≥ 10 did all men drink at these levels.

Both gender and age modified the association between AUDIT-C score and each secondary outcome (p-values<0.00005). Maximum quantity of drinks increased more steeply with increasing scores among men than women, and among younger versus older age groups. In contrast, frequency of heavy drinking increased more steeply across AUDIT-C scores among women than men and among older versus younger age groups. At a given score, women were generally more likely than men to exceed both recommended maximum and average daily drinking limits. However, at a given score, younger individuals were more likely than older individuals to exceed maximum daily drinking limits, whereas older individuals were more likely than younger individuals to exceed average daily drinking limits.

**DISCUSSION**

This study builds on extensive evidence that suggests scores from the same brief alcohol screening questionnaire used for routine screening in primary care may also serve as an excellent marker of alcohol misuse severity. Previous studies have demonstrated associations between AUDIT-C scores and alcohol-related problems (Bradley et al., 2004) and probability of alcohol dependence (Rubinsky et al., 2010), but this is the first study to describe consumption in drinks per day across AUDIT-C scores, and the first study large enough to estimate the severity of alcohol use disorders and probability of alcohol dependence associated with each individual

AUDIT-C score. Consistent with prior research, alcohol consumption, AUD severity, and probability of dependence were found to increase dramatically as AUDIT-C scores increased. Across scores 1 to 12, mean daily drinking ranged from < 0.1 to 18.0 drinks per day, AUD severity ranged from < 0.1 to 5.1 endorsed AUD criteria, and the probability of alcohol dependence ranged from < 1 to 65%.

Mean daily drinking followed an exponential pattern across the range of AUDIT-C scores, increasing with a lower slope across scores 1-7, and most steeply across scores 9-12. These results extend the interpretation of studies that have demonstrated associations between AUDIT-C scores and adverse health outcomes. Health risks that increase exponentially across AUDIT-C scores may be sensitive to increases in mean daily drinking at all levels of consumption, whereas risks that increase more linearly or plateau at higher AUDIT-C scores may reflect a threshold effect as consumption increases. Additionally, findings extend the utility of meta-analyses that have compared the risk of disease across several levels of mean daily drinking (Corrao, Bagnardi, Zambon, & La Vecchia, 2004; Rehm, Baliunas, et al., 2010). Such studies have evaluated the risk of several conditions, including cancers, hypertension, pneumonia and injuries at thresholds of at least 2, 3.5 and 7 U.S. standard-sized drinks per day, compared to light drinking (< 2 drinks/day) (Corrao et al., 2004; Rehm, Baliunas, et al., 2010). Findings of this study suggest that the risks described at these levels of consumption correspond to AUDIT-C scores ≥ 7, 8 and 10, versus 1-6, respectively. This information could be used by clinicians to assess and communicate a patient's alcohol-related health risks based on their AUDIT-C score. Further, health care systems that use electronic decision support systems to prompt and score the AUDIT-C could easily integrate this information so that it would be provided automatically to the clinician alongside the patient’s screening score.

Gender modified the association of AUDIT-C scores with AUD severity, but not mean daily drinking or probability of alcohol dependence. AUD severity was generally higher in women than men, with differences increasing across increasing AUDIT-C scores. This is consistent with previous findings that women develop medical conditions such as liver disease and cardiomyopathy at lower levels of alcohol consumption than men (Fernandez-Sola & Nicolas-Arfelis, 2002; Rehm, Taylor, et al., 2010; Urbano-Marquez A et al., 1995), and with U.S. drinking guidelines that recommend lower thresholds for identifying risky drinking in women (National Institute on Alcohol Abuse and Alcoholism, 2007; U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010).

Although women with moderate AUDIT-C scores experienced greater AUD severity and were more likely to have alcohol dependence compared to men with the same score, women were less likely than men to have these scores. In contrast, at a given AUDIT-C score, younger age groups generally experienced greater AUD severity and higher probability of dependence than older age groups, and, in addition, tended to have higher AUDIT-C scores. Further, younger individuals consumed larger maximum quantities of drinks and were more likely to exceed recommended maximum daily drinking limits compared to older individuals with the same AUDIT-C score. However, older rather than younger age was associated with increasingly greater probability of exceeding recommended average daily limits and higher frequencies of heavy drinking across increasing AUDIT-C scores, suggesting that older individuals may be engaging in more frequent drinking of less extreme quantities at a given AUDIT-C score compared to younger individuals. This is consistent with a recent study of heavy drinking among U.S. adults that found the highest prevalence and intensity among the youngest individuals but the highest frequency among the oldest individuals (MMWR, 2012).

The oldest age group (65+ years) endorsed far fewer AUD criteria than younger groups and had relatively low probability of dependence at every AUDIT-C score. This finding was not attributable to low mean daily drinking as this group drank as much as or more than younger individuals except at the highest scores (AUDIT-C 10-12), where they drank less than younger individuals but still consumed large quantities (7-12 drinks per day). Prior research has found new onset and recurrence of dependence to be relatively rare among older individuals (Verges et al., 2011). One possible explanation is that the diagnostic criteria for DSM-IV alcohol use disorders may be less sensitive to the alcohol-related sequelae of older adults because of differences in life circumstances, physiology, and/or reporting. Several criteria for alcohol abuse and dependence ask about the impact of drinking on activities and responsibilities related to work and family, which may be less applicable to older individuals. Further, the tendency to develop alcohol tolerance diminishes with age (Miller, Belkin, & Gold, 1991), and endorsement of the tolerance criterion decreased across increasing age groups. Severity associated with the expression of several criteria has also been found to vary by age, suggesting age differences in either the experience or reporting of these criteria (Saha, Chou, & Grant, 2006). Alternatively, differential survival favoring heavy drinkers who are less susceptible to the negative consequences of drinking could explain these findings. Finally, although the AUDIT-C has been found to perform equally well among older versus younger individuals for identifying drinking above recommended limits, alcohol use disorders, and alcohol dependence, at any given screening threshold it is less sensitive (and more specific) in older age groups (Dawson, Grant, Stinson, et al., 2005).

A number of limitations of this study should be noted. NESARC's AUDIT-C differed from other versions (Dawson, Grant, Stinson, et al., 2005) and followed a lengthy sequence of

questions about consumption of specific alcoholic beverage types. Because data are based on self-report, results are subject to a range of reporting biases, which could differ by gender and age. Despite the large sample size, numbers of women and older individuals with high AUDIT-C scores were small, resulting in wide confidence intervals for some estimates. Further, this study did not have adequate numbers of individuals with high AUDIT-C scores to stratify analyses by groups defined by both gender and age. Finally, study findings have practical applicability primarily in clinical settings but the study sample was drawn from the general population. The general population could differ from clinical populations in important ways, although the screening performance of the AUDIT-C has been found to be similar in the NESARC sample and in clinical studies (Reinert & Allen, 2007).

This study also has several important strengths. The NESARC's unprecedentedly large sample size and inclusion of valid, reliable measures of alcohol consumption and alcohol use disorders facilitated this first ever evaluation of the level of mean daily drinking, AUD severity and probability of dependence associated with individual AUDIT-C scores. Because of the large sample size, analyses could be conducted separately in men and women, and across age groups. All measures of alcohol consumption and alcohol use disorders were based on structured in-depth interviews and have demonstrated reliability and predictive validity (Dawson, Grant, & Li, 2005; Dawson et al., 2008; Dawson et al., 2010; Dawson et al., 2012; B. F. Grant et al., 2003; Grant et al., 2007). The recommended approach for measurement of alcohol consumption is to ask about total drinks of all alcohol combined as well as a separate series of questions about individual beverage types, and to ascertain typical drink size and strength for each specific beverage type so that reported drinks can be adjusted for ethanol content (Greenfield & Kerr, 2008; Stahre et al., 2006), as was done in the NESARC. This approach can improve recall of

drinking and lead to more accurate estimated volume of consumption. Additionally, the random sampling and high recruitment rate suggest limited bias in the study sample.

Results of this research could be used to directly improve assessment and management of the spectrum of alcohol misuse. Disseminating accurate estimates of the increasing level of mean daily drinking, AUD severity, and probability of dependence associated with each higher AUDIT-C score could help health care providers recognize alcohol misuse as a continuum of severity and interpret the implications of a patient's particular score. Healthcare systems that utilize electronic systems to guide screening and intervention for alcohol misuse could integrate this information so that the level of drinking and severity associated with a patient's score would be provided to the clinician at the time of screening. Providers could then use this information to offer patients personalized feedback about their risk for alcohol-related conditions and prompt diagnostic assessment with those who have scores associated with high AUD severity and/or likelihood of dependence.

To summarize, this study of past-year drinkers found that mean daily drinking increased from < 0.1 to 18.0 drinks per day, AUD severity increased from < 0.1 to 5.1 criteria, and the probability of dependence increased from < 1 to 65% across the range of AUDIT-C scores. Further, at many scores, estimates differed by gender and especially age. As healthcare systems continue to implement alcohol screening using electronic decision support, it will become increasingly easier to tailor interventions based on the patient's screening score and demographic characteristics. In this way, the information provided by this study could be used to inform clinical care for the spectrum of alcohol misuse.

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**TABLE 4.1** Wording and response options from the NESARC's AUDIT-C compared to the most widely validated version (Table adapted from Dawson, Grant, Stinson, & Zhou, 2005)

| AUDIT-C Question and Wording | NESARC Response Categories | (Score) | Standard Equivalent | (Score) |
|---|---|---|---|---|
| **QUESTION 1** | Every day | (4) | Four or more times a week | (4) |
| | Nearly every day | (4) | | |
| NESARC AUDIT-C: | 3 to 4 times a week | (3) | Two to four times a month | (3) |
| During the last 12 months, about how | 2 times a week | (3) | | |
| often did you drink ANY alcoholic | Once a week | (2) | Two to three times a week | (2) |
| beverage? | 2 to 3 times a month | (2) | | |
| | Once a month | (1) | Monthly or less | (1) |
| Standard AUDIT-C: | 7 to 11 times in the last year | (1) | | |
| How often did you have a drink | 3 to 6 times in the last year | (1) | | |
| containing alcohol in the past year? | 1 to 2 times in the last year | (1) | | |
| | Never* | (0) | Never | (0) |
| **QUESTION 2** | Open-ended. | | | |
| | Responses grouped as follows: | | | |
| NESARC AUDIT-C: | | | | |
| Counting all types of alcohol combined, how many drinks did you USUALLY | 1 or 2 | (0) | 1 or 2 | (0) |
| have on days when you drank during the last 12 months? | 3 or 4 | (1) | 3 or 4 | (1) |
| | 5 or 6 | (2) | 5 or 6 | (2) |
| Standard AUDIT-C: | | | | |
| How many drinks did you have on a typical day when you were drinking in | 7 to 9 | (3) | 7 to 9 | (3) |
| the past year? | 10 or more | (4) | 10 or more | (4) |
| **QUESTION 3** | Every day | (4) | Daily or almost daily | (4) |
| | Nearly every day | (4) | | |
| NESARC AUDIT-C: | 3 to 4 times a week | (3) | Weekly | (3) |
| During the last 12 months, about how | 2 times a week | (3) | | |
| often did you drink FIVE OR MORE | Once a week | (3) | | |
| drinks in a single day? | 2 to 3 times a month | (2) | Monthly | (2) |
| | Once a month | (2) | | |
| Standard AUDIT-C: | 7 to 11 times in the last year | (1) | Less than monthly | (1) |
| How often did you have six or more | 3 to 6 times in the last year | (1) | | |
| drinks on one occasion in the past year? | 1 or 2 times in the last year | (1) | | |
| | Never* | (0) | Never | (0) |

***** This response category was determined from a separate screening question rather than by the endorsement of "never" on Question 1.

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**TABLE 4.2** Probability (%) of Selected Characteristics among Past-Year Drinkers, by AUDIT-C Alcohol Screening Score*

| | TOTAL (ALL DRINKERS) | | AUDIT-C SCORE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | N | % | WEIGHTED PROBABILITY** - % | | | | | | | | | | | |
| **MEN** (n) | 12,823 | | (2,994) | (2,017) | (1,936) | (1,778) | (973) | (710) | (709) | (797) | (263) | (451) | (82) | (113) |
| Age | | | | | | | | | | | | | | |
| 18-29 | 2,863 | 24 | 20 | 19 | 20 | 18 | 27 | 34 | 30 | 41 | 54 | 38 | 35 | 37 |
| 30-44 | 4,449 | 34 | 31 | 36 | 33 | 31 | 39 | 36 | 38 | 37 | 28 | 35 | 25 | 36 |
| 45-64 | 3,902 | 31 | 34 | 33 | 35 | 33 | 28 | 24 | 28 | 19 | 16 | 24 | 37 | 25 |
| 65+ | 1,609 | 11 | 14 | 13 | 11 | 19 | 6 | 5 | 4 | 4 | 2 | 3 | 3 | 2 |
| Race/Ethnicity | | | | | | | | | | | | | | |
| White | 7,855 | 74 | 72 | 72 | 75 | 76 | 75 | 77 | 73 | 75 | 68 | 73 | 74 | 79 |
| Black | 1,821 | 9 | 9 | 10 | 10 | 9 | 7 | 6 | 9 | 9 | 6 | 8 | 7 | 10 |
| Hispanic/Latino | 2,582 | 12 | 11 | 11 | 10 | 11 | 13 | 14 | 15 | 12 | 19 | 12 | 13 | 10 |
| Other | 565 | 6 | 8 | 6 | 6 | 4 | 4 | 3 | 4 | 4 | 6 | 6 | 6 | 1 |
| Married/widowed | 7,160 | 62 | 70 | 69 | 66 | 69 | 59 | 52 | 52 | 41 | 34 | 38 | 40 | 36 |
| Family income <$20,000 | 2,465 | 17 | 16 | 15 | 13 | 15 | 15 | 17 | 22 | 23 | 29 | 30 | 35 | 43 |
| **WOMEN** (n) | 13,723 | | (6,269) | (2,692) | (1,858) | (1,406) | (508) | (297) | (250) | (254) | (59) | (90) | (14) | (26) |
| Age | | | | | | | | | | | | | | |
| 18-29 | 3,198 | 24 | 22 | 22 | 22 | 22 | 42 | 42 | 35 | 48 | 66 | 41 | 47 | 34 |
| 30-44 | 4,886 | 34 | 34 | 38 | 35 | 28 | 37 | 36 | 37 | 30 | 21 | 34 | 42 | 47 |
| 45-64 | 3,923 | 30 | 32 | 30 | 32 | 34 | 17 | 19 | 27 | 20 | 13 | 21 | 5 | 18 |
| 65+ | 1,716 | 11 | 13 | 10 | 12 | 16 | 4 | 3 | 1 | 3 | - | 4 | 6 | - |
| Race/Ethnicity | | | | | | | | | | | | | | |
| White | 8,644 | 77 | 74 | 78 | 81 | 82 | 80 | 83 | 81 | 80 | 63 | 68 | 59 | 48 |
| Black | 2,293 | 9 | 10 | 10 | 7 | 8 | 7 | 8 | 6 | 8 | 10 | 9 | 38 | 18 |
| Hispanic/Latino | 2,289 | 9 | 11 | 8 | 8 | 6 | 10 | 6 | 8 | 8 | 18 | 13 | 2 | 9 |
| Other | 497 | 4 | 5 | 4 | 4 | 3 | 3 | 4 | 5 | 4 | 9 | 10 | - | 24 |
| Married/widowed | 7,497 | 63 | 67 | 65 | 64 | 63 | 46 | 39 | 42 | 31 | 26 | 33 | 33 | 25 |
| Family income <$20,000 | 3,476 | 21 | 21 | 17 | 18 | 22 | 30 | 27 | 26 | 34 | 51 | 40 | 46 | 46 |

* Because nondrinkers were not administered the AUDIT-C questions, the study sample includes no individuals with an AUDIT-C score of 0; associations between all characteristics and AUDIT-C score were significant at the $p<0.00005$ level.

**Weighted for NESARC sampling design and non-response.

**TABLE 4.3** Mean Daily Drinking, AUD Severity and Alcohol Dependence across AUDIT-C Scores among Drinkers (N=26,546)

| | | AUDIT-C SCORE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *TOTAL* | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Mean Drinks/Day*** | ***1.1*** | **0.0**** | **0.2** | **0.6** | **1.3** | **1.5** | **1.7** | **2.2** | **3.7** | **4.4** | **8.4** | **11.6** | **18.0** |
| (95% CI) | *(1.0,1.1)* | (0.0,0.0) | (0.2,0.2) | (0.6,0.6) | (1.2,1.3) | (1.4,1.6) | (1.6,1.7) | (2.0,2.3) | (3.5,3.9) | (4.0,4.8) | (7.9,8.9) | (10.8,12.5) | (16.9,19.0) |
| **AUD Severity***** | ***0.6*** | **0.0** | **0.2** | **0.3** | **0.5** | **1.0** | **1.4** | **1.5** | **2.2** | **2.8** | **3.2** | **3.3** | **5.1** |
| (95% CI) | *(0.5,0.6)* | (0.0,0.0) | (0.2,0.2) | (0.3,0.4) | (0.5,0.6) | (0.9,1.1) | (1.3,1.5) | (1.3,1.6) | (2.1,2.4) | (2.4,3.1) | (2.9,3.5) | (2.6,4.0) | (4.3,5.8) |
| **% Alcohol Dependent****** | ***6*** | **0** | **1** | **2** | **4** | **9** | **14** | **16** | **26** | **35** | **44** | **39** | **65** |
| (95% CI) | *(5,6)* | (0,0) | (1,1) | (1,2) | (3,5) | (7,10) | (12,17) | (13,19) | (23,29) | (29,41) | (38,50) | (26,51) | (55,76) |

* Estimates based on maximum from (1) beverage-specific consumption questions, or (2) questions about all alcohol combined; top-coded to 24 drinks; and adjusted for survey design and nonresponse.

** Estimates of 0.0 reflect values less than 0.05; estimates of 0% reflect values less than 0.5%.

*** Count of endorsed DSM-IV Alcohol Use Disorder (AUD), ranging from 0 to 11; adjusted for survey design and nonresponse.

**** Current DSM-IV Alcohol Dependence; adjusted for survey design and nonresponse.

**TABLE 4.4** Mean Daily Drinking* across AUDIT-C Scores, by Gender and Age Group

| | | **Mean Drinks/Day (95% CI)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **AUDIT-C SCORE** | | | | | | | | | | | |
| | ***TOTAL*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Men** | ***1.5*** | **0.0**** | **0.2** | **0.6** | **1.3** | **1.6** | **1.7** | **2.2** | **3.6** | **4.5** | **8.5** | **11.5** | **17.9** |
| | *(1.4,1.6)* | (0.0,0.0) | (0.2,0.2) | (0.6,0.6) | (1.2,1.4) | (1.5,1.7) | (1.6,1.8) | (2.0,2.4) | (3.4,3.9) | (4.1,5.0) | (7.9,9.0) | (10.6,12.3) | (16.8,19.0) |
| **Women** | ***0.6*** | **0.0** | **0.2** | **0.6** | **1.3** | **1.5** | **1.6** | **2.0** | **3.8** | **3.9** | **7.8** | **13.0** | **18.4** |
| | *(0.6,0.6)* | (0.0,0.0) | (0.2,0.2) | (0.6,0.6) | (1.2,1.4) | (1.3,1.6) | (1.4,1.8) | (1.8,2.2) | (3.4,4.2) | (3.4,4.5) | (6.9,8.8) | (10.4,15.7) | (16.1,20.6) |
| **Age 18-29** | ***1.4*** | **0.0**** | **0.2** | **0.4** | **0.9** | **1.1** | **1.3** | **1.9** | **3.7** | **4.3** | **8.6** | **11.6** | **18.9** |
| | *(1.3,1.5)* | (0.0,0.0) | (0.2,0.2) | (0.4,0.5) | (0.8,1.0) | (1.0,1.3) | (1.2,1.5) | (1.7,2.1) | (3.3,4.0) | (3.8,4.8) | (7.7,9.5) | (10.1,13.1) | (17.3,20.4) |
| **Age 30-44** | ***1.0*** | **0.0** | **0.2** | **0.6** | **1.1** | **1.4** | **1.6** | **1.9** | **3.3** | **4.2** | **8.6** | **12.3** | **17.8** |
| | *(1.0,1.1)* | (0.0,0.0) | (0.2,0.2) | (0.5,0.6) | (1.0,1.1) | (1.3,1.5) | (1.5,1.7) | (1.8,2.1) | (3.1,3.5) | (3.4,4.9) | (7.8,9.3) | (10.3,14.3) | (15.9,19.6) |
| **Age 45-64** | ***1.0*** | **0.0** | **0.2** | **0.7** | **1.5** | **2.1** | **2.0** | **2.7** | **4.2** | **5.3** | **8.1** | **11.2** | **17.5** |
| | *(0.9,1.1)* | (0.0,0.0) | (0.2,0.2) | (0.6,0.7) | (1.4,1.5) | (1.8,2.3) | (1.8,2.2) | (2.4,3.1) | (3.8,4.7) | (4.4,6.2) | (7.4,8.8) | (10.2,12.2) | (15.4,19.5) |
| **Age 65+** | ***0.8*** | **0.0** | **0.2** | **0.7** | **1.7** | **2.8** | **3.0** | **2.7** | **4.5** | **4.9** | **6.7** | **10.3** | **11.6** |
| | *(0.7,0.8)* | (0.0,0.0) | (0.2,0.2) | (0.6,0.7) | (1.6,1.8) | (2.5,3.1) | (2.5,3.6) | (2.1,3.2) | (3.8,5.2) | (4.4,5.4) | (6.2,7.2) | (7.4,13.2) | (10.8,12.3) |

* Estimates based on larger from (a) beverage-specific consumption questions, or (b) questions about all alcohol combined; top-coded to 24 drinks; and adjusted for survey design and nonresponse.

** Estimates of 0.0 reflect values less than 0.05.

**TABLE 4.5** Alcohol Use Disorder (AUD) Severity* across AUDIT-C Scores, by Gender and Age Group

**No. of AUD Criteria (95% CI)**

| | | **AUDIT-C SCORE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***TOTAL*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Men** | ***0.7*** | **0.0**** | **0.2** | **0.3** | **0.5** | **0.9** | **1.3** | **1.4** | **2.2** | **2.7** | **3.1** | **3.2** | **5.0** |
| | *(0.7,0.8)* | (0.0,0.1) | (0.1,0.2) | (0.3,0.4) | (0.4,0.5) | (0.8,1.0) | (1.1,1.4) | (1.2,1.5) | (2.0,2.4) | (2.3,3.0) | (2.8,3.4) | (2.5,3.9) | (4.2,5.7) |
| **Women** | ***0.4*** | **0.0** | **0.2** | **0.4** | **0.6** | **1.3** | **1.7** | **1.8** | **2.3** | **3.2** | **3.9** | **4.2** | **5.6** |
| | *(0.4,0.4)* | (0.0,0.0) | (0.2,0.2) | (0.3,0.4) | (0.6,0.7) | (1.2,1.5) | (1.5,2.0) | (1.5,2.2) | (2.0,2.6) | (2.2,4.2) | (3.1,4.7) | (2.1,6.2) | (3.7,7.4) |
| **Age 18-29** | ***1.1*** | **0.1** | **0.4** | **0.6** | **1.0** | **1.4** | **1.9** | **1.9** | **3.0** | **3.0** | **3.9** | **4.4** | **5.9** |
| | *(1.0,1.2)* | (0.1,0.1) | (0.3,0.4) | (0.5,0.7) | (0.9,1.2) | (1.3,1.6) | (1.6,2.1) | (1.6,2.3) | (2.7,3.4) | (2.5,3.5) | (3.5,4.3) | (3.2,5.7) | (4.9,6.9) |
| **Age 30-44** | ***0.6*** | **0.1** | **0.2** | **0.4** | **0.6** | **1.0** | **1.2** | **1.4** | **1.7** | **2.9** | **3.2** | **2.7** | **5.0** |
| | *(0.5,0.6)* | (0.0,0.1) | (0.2,0.2) | (0.3,0.4) | (0.5,0.7) | (0.8,1.1) | (1.0,1.4) | (1.2,1.6) | (1.5,1.9) | (2.2,3.6) | (2.6,3.8) | (1.6,3.8) | (3.7,6.3) |
| **Age 45-64** | ***0.3*** | **0.0** | **0.1** | **0.2** | **0.4** | **0.8** | **1.1** | **1.1** | **1.7** | **1.9** | **2.4** | **2.8** | **4.3** |
| | *(0.3,0.4)* | (0.0,0.0) | (0.1,0.1) | (0.2,0.3) | (0.3,0.4) | (0.6,1.0) | (0.8,1.3) | (0.8,1.4) | (1.4,2.0) | (1.3,2.4) | (1.9,2.8) | (1.7,3.9) | (3.0,5.6) |
| **Age 65+** | ***0.1*** | **0.0** | **0.0** | **0.1** | **0.2** | **0.3** | **0.7** | **0.7** | **1.3** | **0.6** | **1.1** | **1.3** | **0.8** |
| | *(0.1,0.1)* | (0.0,0.0) | (0.0,0.1) | (0.1,0.2) | (0.1,0.2) | (0.2,0.4) | (0.5,1.0) | (0.4,1.0) | (0.7,2.0) | (0.2,1.0) | (0.5,1.7) | (-0.1,2.6) | (0.4,1.2) |

* Count of endorsed DSM-IV Alcohol Use Disorder (AUD), ranging from 0 to 11; adjusted for survey design and nonresponse.

** Estimates of 0.0 reflect values less than 0.05.

**TABLE 4.6** Probability of DSM-IV Past-year Alcohol Dependence* across AUDIT-C Scores, by Gender and Age Group

| | **Percent Alcohol Dependent (95% CI)** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **AUDIT-C SCORE** | | | | | | | | | | | |
| | ***TOTAL*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Men** | ***8*** | **0**** | **1** | **2** | **3** | **7** | **13** | **14** | **25** | **33** | **42** | **37** | **65** |
| | *(7,8)* | (0,1) | (0,1) | (1,2) | (2,4) | (5,9) | (10,15) | (11,17) | (22,29) | (27,40) | (36,48) | (24,50) | (54,76) |
| **Women** | ***4*** | **0** | **1** | **2** | **6** | **12** | **19** | **23** | **28** | **42** | **54** | **51** | **67** |
| | *(3,4)* | (0,0) | (1,2) | (1,3) | (5,7) | (9,15) | (13,24) | (16,30) | (21,34) | (27,57) | (40,69) | (21,81) | (44,89) |
| **Age 18-29** | ***13*** | **0** | **2** | **5** | **10** | **13** | **20** | **22** | **39** | **41** | **60** | **53** | **75** |
| | *(12,14)* | (0,1) | (1,4) | (3,6) | (7,13) | (10,17) | (15,26) | (17,28) | (34,45) | (32,50) | (50,69) | (32,74) | (61,89) |
| **Age 30-44** | ***5*** | **0** | **1** | **2** | **4** | **8** | **12** | **17** | **15** | **35** | **40** | **31** | **60** |
| | *(5,6)* | (0,1) | (0,1) | (1,3) | (3,5) | (5,10) | (8,15) | (12,21) | (11,19) | (23,46) | (31,50) | (11,50) | (42,78) |
| **Age 45-64** | ***3*** | **0** | **1** | **0** | **3** | **6** | **11** | **10** | **18** | **17** | **28** | **32** | **64** |
| | *(3,3)* | (0,0) | (0,1) | (0,1) | (1,4) | (2,9) | (7,16) | (5,15) | (11,25) | (6,27) | (20,36) | (10,53) | (46,82) |
| **Age 65+** | ***1*** | **0** | **0** | **0** | **1** | **0** | **3** | **3** | **12** | **0** | **11** | **19** | **0** |
| | *(0,1)* | - | - | (0,1) | (0,1) | - | (-1,6) | (-1,6) | (1,22) | - | (0,22) | (-14,53) | - |

* Current DSM-IV Alcohol Dependence; adjusted for survey design and nonresponse.

** Estimates of 0% with 95% CIs reflect values less than 0.5%; 0s with no 95% CI reflect true 0s.

**TABLE 4.7** Maximum Drinks Consumed in a Single Day in the Past Year* across AUDIT-C Scores, by Gender and Age Group

**Max Drinks (95% CI)**

| | | **AUDIT-C SCORE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***TOTAL*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Total** | ***4.8*** | **1.8** | **3.2** | **4.3** | **5.0** | **7.7** | **9.7** | **9.8** | **11.6** | **14.7** | **15.3** | **16.2** | **20.0** |
| | *(4.7,4.9)* | (1.8,1.9) | (3.1,3.3) | (4.1,4.4) | (4.9,5.2) | (7.5,8.0) | (9.3,10.0) | (9.4,10.1) | (11.3,12.0) | (14.0,15.4) | (14.5,16.0) | (14.9,17.5) | (19.0,21.0) |
| **Men** | ***6.0*** | **2.0** | **3.3** | **4.5** | **5.3** | **7.9** | **10.1** | **10.2** | **11.9** | **15.1** | **15.6** | **16.4** | **20.1** |
| | *(5.9,6.2)* | (1.9,2.0) | (3.2,3.4) | (4.3,4.6) | (5.1,5.5) | (7.6,8.3) | (9.7,10.6) | (9.8,10.7) | (11.5,12.4) | (14.3,15.9) | (14.8,16.4) | (15.0,17.8) | (19.0,21.1) |
| **Women** | ***3.5*** | **1.8** | **3.1** | **4.0** | **4.6** | **7.3** | **8.5** | **8.4** | **10.5** | **12.6** | **13.1** | **14.3** | **19.8** |
| | *(3.4,3.6)* | (1.8,1.8) | (3.0,3.2) | (3.9,4.1) | (4.4,4.9) | (6.9,7.6) | (7.9,9.0) | (7.9,9.0) | (9.8,11.2) | (11.4,13.7) | (11.6,14.7) | (12.5,16.1) | (17.6,22.1) |
| **Age 18-29** | ***6.7*** | **2.0** | **3.8** | **5.7** | **6.8** | **8.7** | **11.3** | **11.0** | **13.1** | **15.3** | **17.7** | **16.4** | **21.1** |
| | *(6.5,7.0)* | (2.0,2.1) | (3.6,4.0) | (5.4,5.9) | (6.5,7.2) | (8.3,9.1) | (10.6,12.0) | (10.3,11.8) | (12.5,13.8) | (14.4,16.2) | (16.7,18.8) | (14.2,18.5) | (19.7,22.4) |
| **Age 30-44** | ***5.1*** | **2.0** | **3.5** | **4.6** | **5.8** | **7.8** | **9.3** | **9.8** | **11.2** | **14.8** | **14.9** | **16.2** | **20.2** |
| | *(4.9,5.2)* | (1.9,2.1) | (3.3,3.6) | (4.4,4.8) | (5.5,6.1) | (7.3,8.3) | (8.8,9.8) | (9.3,10.4) | (10.7,11.8) | (13.2,16.4) | (13.7,16.0) | (13.9,18.4) | (18.5,22.0) |
| **Age 45-64** | ***3.9*** | **1.8** | **2.9** | **3.6** | **4.4** | **7.0** | **8.0** | **8.5** | **9.8** | **13.2** | **12.8** | **16.3** | **18.7** |
| | *(3.8,4.0)* | (1.7,1.8) | (2.8,2.9) | (3.5,3.7) | (4.2,4.7) | (6.6,7.4) | (7.5,8.4) | (7.9,9.1) | (9.2,10.4) | (11.8,14.6) | (11.8,13.8) | (14.0,18.6) | (16.7,20.7) |
| **Age 65+** | ***2.4*** | **1.4** | **2.1** | **2.6** | **2.8** | **5.2** | **8.1** | **7.9** | **7.5** | **8.4** | **8.2** | **13.6** | **11.4** |
| | *(2.4,2.5)* | (1.4,1.5) | (2.0,2.2) | (2.5,2.7) | (2.6,3.0) | (4.7,5.7) | (7.0,9.1) | (6.8,9.0) | (6.7,8.3) | (6.7,10.2) | (6.9,9.4) | (8.7,18.5) | (10.6,12.3) |

* Estimates based on larger from (1) beverage-specific consumption questions, or (2) questions about all alcohol combined; top-coded to 24 drinks; and adjusted for survey design and nonresponse.

**TABLE 4.8** Frequency of Heavy Drinking* across AUDIT-C Scores, by Gender and Age Group

**Mean Days/Week (95% CI)**

| | | **AUDIT-C SCORE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***TOTAL*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Total** | ***0.5*** | **0.0**** | **0.0** | **0.1** | **0.2** | **0.5** | **0.7** | **1.2** | **2.4** | **2.6** | **5.0** | **6.5** | **6.7** |
| | *(0.4,0.5)* | (0.0,0.0) | (0.0,0.0) | (0.1,0.1) | (0.2,0.3) | (0.4,0.6) | (0.6,0.7) | (1.1,1.3) | (2.3,2.5) | (2.4,2.8) | (4.8,5.3) | (6.4,6.7) | (6.6,6.8) |
| **Men** | ***0.6*** | **0.0** | **0.0** | **0.1** | **0.1** | **0.3** | **0.5** | **1.1** | **2.3** | **2.5** | **5.0** | **6.5** | **6.7** |
| | *(0.6,0.7)* | (0.0,0.0) | (0.0,0.0) | (0.0,0.1) | (0.1,0.2) | (0.3,0.4) | (0.5,0.6) | (1.0,1.2) | (2.2,2.4) | (2.3,2.8) | (4.7,5.3) | (6.4,6.7) | (6.6,6.8) |
| **Women** | ***0.3*** | **0.0** | **0.0** | **0.1** | **0.4** | **0.9** | **1.1** | **1.6** | **2.9** | **2.7** | **5.2** | **6.7** | **6.7** |
| | *(0.3,0.3)* | (0.0,0.0) | (0.0,0.0) | (0.1,0.2) | (0.3,0.4) | (0.7,1.0) | (0.9,1.2) | (1.4,1.7) | (2.7,3.2) | (2.4,3.1) | (4.7,5.7) | (6.5,7.0) | (6.4,6.9) |
| **Age 18-29** | ***0.7*** | **0.0** | **0.0** | **0.1** | **0.3** | **0.4** | **0.6** | **1.2** | **2.3** | **2.4** | **4** | **6.4** | **6.7** |
| | *(0.6,0.7)* | (0.0,0.0) | (0.0,0.0) | (0.1,0.2) | (0.3,0.4) | (0.4,0.5) | (0.5,0.7) | (1.1,1.3) | (2.2,2.4) | (2.1,2.6) | (3.7,4.4) | (6.2,6.6) | (6.5,6.8) |
| **Age 30-44** | ***0.5*** | **0.0** | **0.0** | **0.1** | **0.2** | **0.5** | **0.7** | **1.1** | **2.4** | **2.5** | **5.5** | **6.6** | **6.6** |
| | *(0.4,0.5)* | (0.0,0.0) | (0.0,0.0) | (0.1,0.1) | (0.2,0.3) | (0.4,0.6) | (0.6,0.8) | (1.0,1.2) | (2.2,2.5) | (2.1,3.0) | (5.2,5.8) | (6.4,6.8) | (6.4,6.7) |
| **Age 45-64** | ***0.4*** | **0.0** | **0.0** | **0.1** | **0.2** | **0.6** | **0.7** | **1.4** | **2.6** | **3.3** | **5.8** | **6.7** | **6.8** |
| | *(0.4,0.4)* | (0.0,0.0) | (0.0,0.0) | (0.1,0.1) | (0.2,0.3) | (0.4,0.7) | (0.5,0.8) | (1.2,1.6) | (2.4,2.9) | (2.8,3.7) | (5.4,6.1) | (6.5,6.9) | (6.7,7.0) |
| **Age 65+** | ***0.2*** | **0.0** | **0.0** | **0.0** | **0.1** | **0.9** | **0.7** | **1.2** | **3.0** | **4.2** | **6.7** | **6.8** | **7.0** |
| | *(0.2,0.2)* | (0.0,0.0) | (0.0,0.0) | (0.0,0.1) | (0.1,0.1) | (0.5,1.3) | (0.3,1.1) | (0.7,1.6) | (2.5,3.6) | (3.3,5.1) | (6.4,7.0) | (6.5,7.1) | (7.0,7.0) |

* Based on highest frequency of drinking ≥ 5 (men) / 4 (women) total drinks, or drinking the largest quantity of any specific beverage type if the largest quantity was ≥ 5 (men) / 4 (women) drinks; and adjusted for survey design and nonresponse.

** Estimates of 0.0 reflect values less than 0.05.

**TABLE 4.9** Probability of Exceeding Recommended Maximum Daily Drinking Limits* across AUDIT-C Scores, by Gender and Age Group

| | | Percent (95% CI) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AUDIT-C SCORE | | | | | | | | | | | |
| | *TOTAL* | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Total** | ***41*** | **5** | **23** | **43** | **55** | **92** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(40,42)* | (5,6) | (22,25) | (41,45) | (53,58) | (90,94) | - | - | - | - | - | - | - |
| **Men** | ***47*** | **3** | **14** | **36** | **52** | **90** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(45,48)* | (2,3) | (11,16) | (34,39) | (49,55) | (88,92) | - | - | - | - | - | - | - |
| **Women** | ***34*** | **7** | **32** | **51** | **60** | **96** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(33,35)* | (6,8) | (29,34) | (48,54) | (56,63) | (94,98) | - | - | - | - | - | - | - |
| **Age 18-29** | ***58*** | **7** | **34** | **70** | **84** | **99** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(56,60)* | (6,9) | (30,37) | (66,74) | (80,87) | (98,100) | - | - | - | - | - | - | - |
| **Age 30-44** | ***46*** | **7** | **29** | **50** | **71** | **95** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(44,47)* | (6,8) | (26,31) | (47,54) | (66,75) | (92,97) | - | - | - | - | - | - | - |
| **Age 45-64** | ***32*** | **4** | **16** | **30** | **47** | **87** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(30,33)* | (3,5) | (14,18) | (27,33) | (43,51) | (83,91) | - | - | - | - | - | - | - |
| **Age 65+** | ***13*** | **1** | **6** | **13** | **14** | **57** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |
| | *(12,15)* | (0,1) | (4,9) | (10,16) | (11,18) | (45,69) | - | - | - | - | - | - | - |

* Drank ≥ 5 (men) / 4 (women) total drinks of any alcohol in a single day in past year, or largest intake of any individual beverage ≥ 5 (men) / 4 (women) drinks; percents adjusted for survey design and nonresponse.

**TABLE 4.10** Probability of Exceeding Recommended Average Daily Drinking Limits* across AUDIT-C Scores, by Gender and Age Group

| | | Percent (95% CI) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AUDIT-C SCORE | | | | | | | | | | | |
| | ***TOTAL*** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
| **Total** | ***19*** | **0** | **0** | **8** | **38** | **33** | **42** | **51** | **80** | **88** | **100** | **100** | **100** |
| | *(18,20)* | - | (00,00) | (07,09) | (36,40) | (30,36) | (38,45) | (46,55) | (77,83) | (84,93) | - | - | - |
| **Men** | ***21*** | **0** | **0** | **20** | **22** | **25** | **34** | **43** | **75** | **86** | **100** | **100** | **100** |
| | *(20,22)* | - | - | (01,02) | (19,24) | (22,28) | (30,38) | (39,48) | (71,79) | (81,91) | - | - | - |
| **Women** | ***17*** | **0** | **0** | **15** | **60** | **51** | **63** | **71** | **100** | **100** | **100** | **100** | **100** |
| | *(16,17)* | - | (00,00) | (13,17) | (57,64) | (46,56) | (56,69) | (65,78) | (99,100) | - | - | - | - |
| **Age 18-29** | ***22*** | **0** | **0** | **4** | **20** | **20** | **29** | **44** | **80** | **87** | **100** | **100** | **100** |
| | *(20,23)* | - | (00,01) | (02,05) | (16,24) | (16,24) | (23,35) | (36,51) | (75,84) | (79,94) | - | - | - |
| **Age 30-44** | ***17*** | **0** | **0** | **8** | **28** | **29** | **41** | **44** | **76** | **88** | **100** | **100** | **100** |
| | *(16,18)* | - | (00,00) | (06,10) | (24,31) | (25,34) | (35,47) | (37,51) | (70,82) | (81,95) | - | - | - |
| **Age 45-64** | ***19*** | **0** | **0** | **100** | **45** | **45** | **55** | **65** | **86** | **94** | **100** | **100** | **100** |
| | *(18,20)* | - | - | (08,12) | (41,49) | (39,51) | (48,62) | (58,73) | (81,92) | (87,101) | - | - | - |
| **Age 65+** | ***19*** | **0** | **0** | **6** | **60** | **76** | **82** | **65** | **96** | **100** | **100** | **100** | **100** |
| | *(18,21)* | - | - | (04,09) | (55,64) | (67,86) | (72,93) | (47,84) | (90,103) | - | - | - | - |

* Mean daily drinking > 2 (men) / 1 (women) drink(s) per day; percents adjusted for survey design and nonresponse.
** Estimates of 0% with 95% CIs reflect values less than 0.5%; estimates of 100% with 95%CIs reflect values greater than 99.5%.

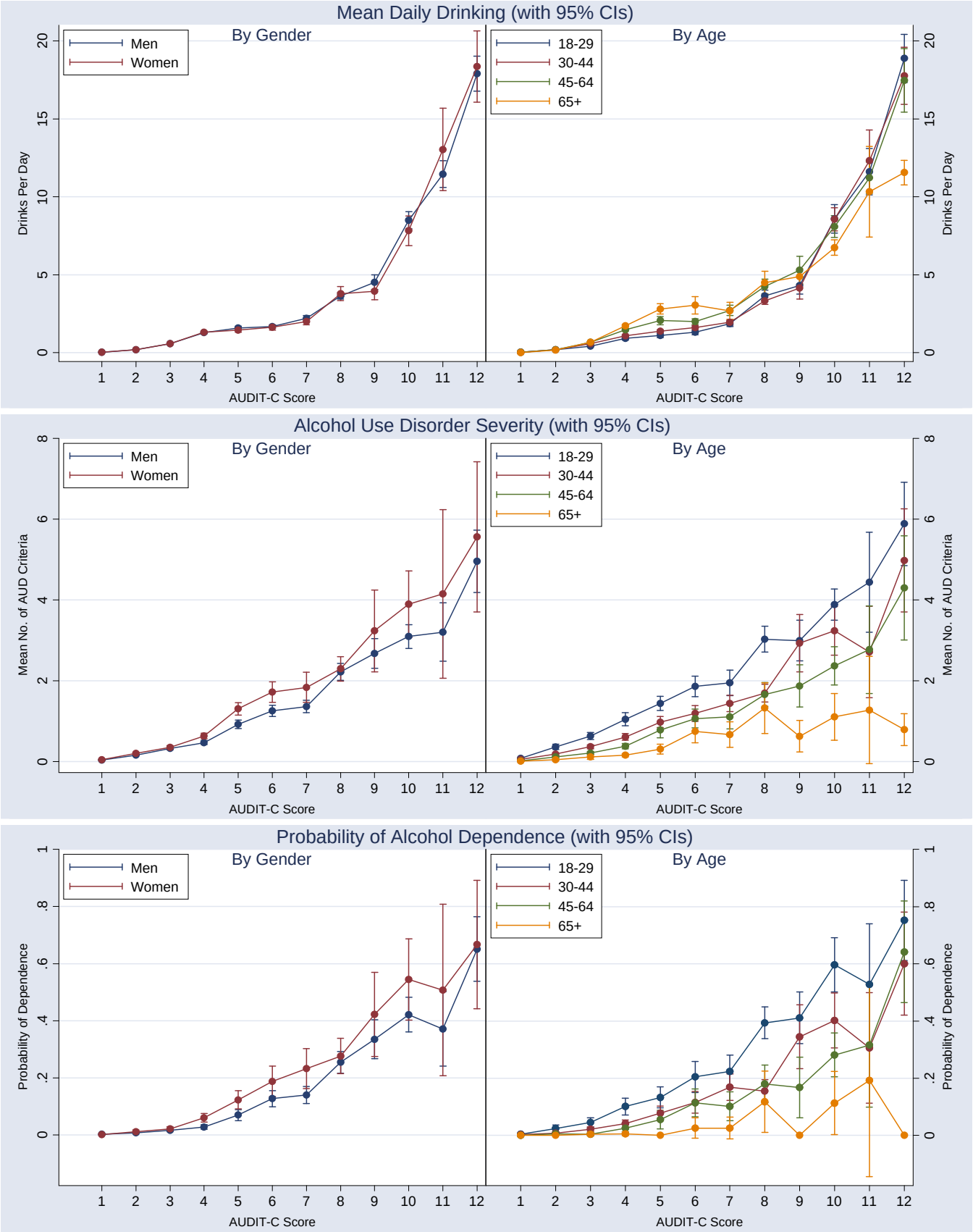


**FIGURE 4.1** Panel 1 - Mean Daily Drinking; Panel 2 - AUD Severity; Panel 3 - Alcohol Dependence

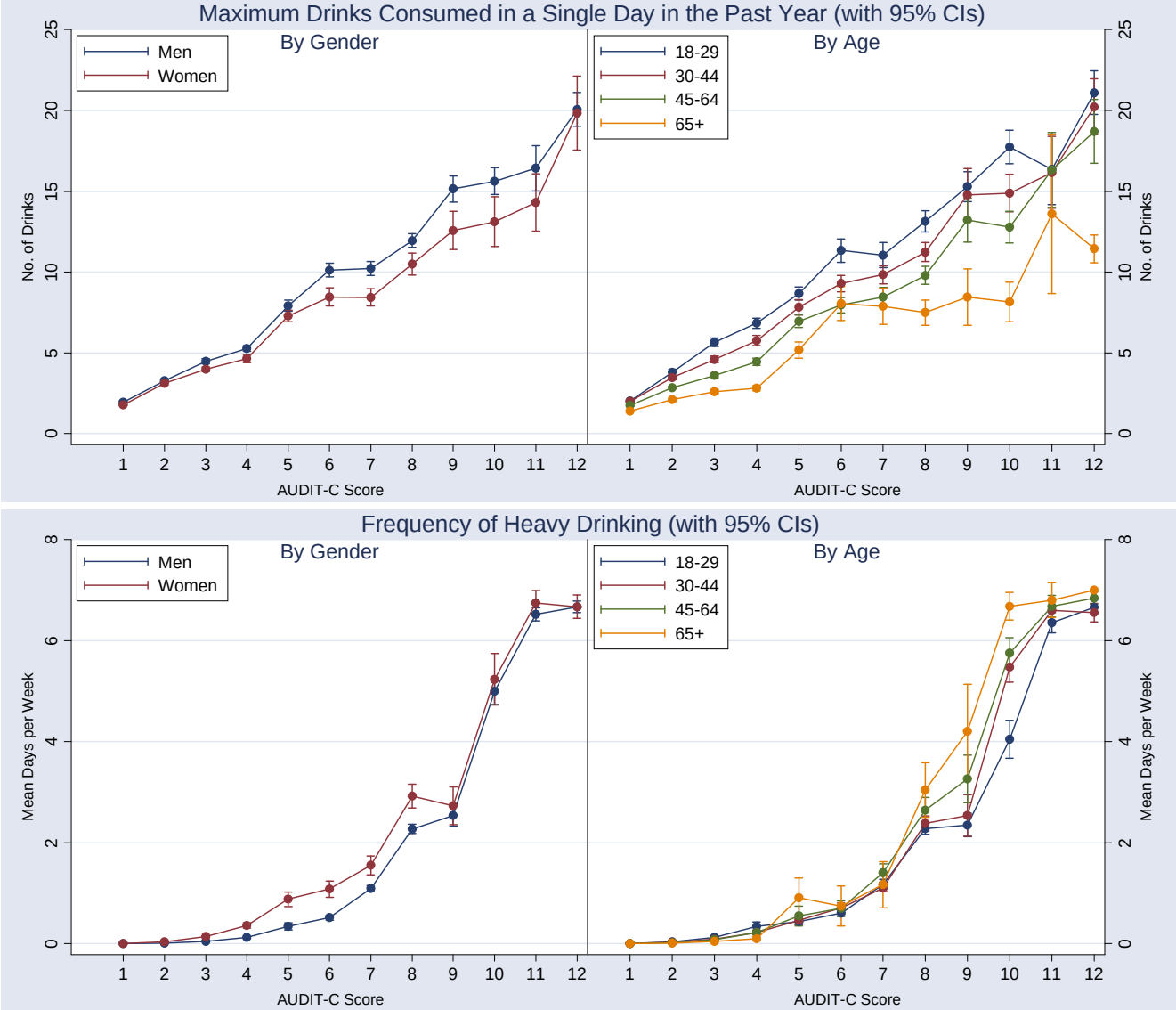


**FIGURE 4.2** Panel 1 - Maximum Quantity of Drinks; Panel 2 - Frequency of Heavy Drinking

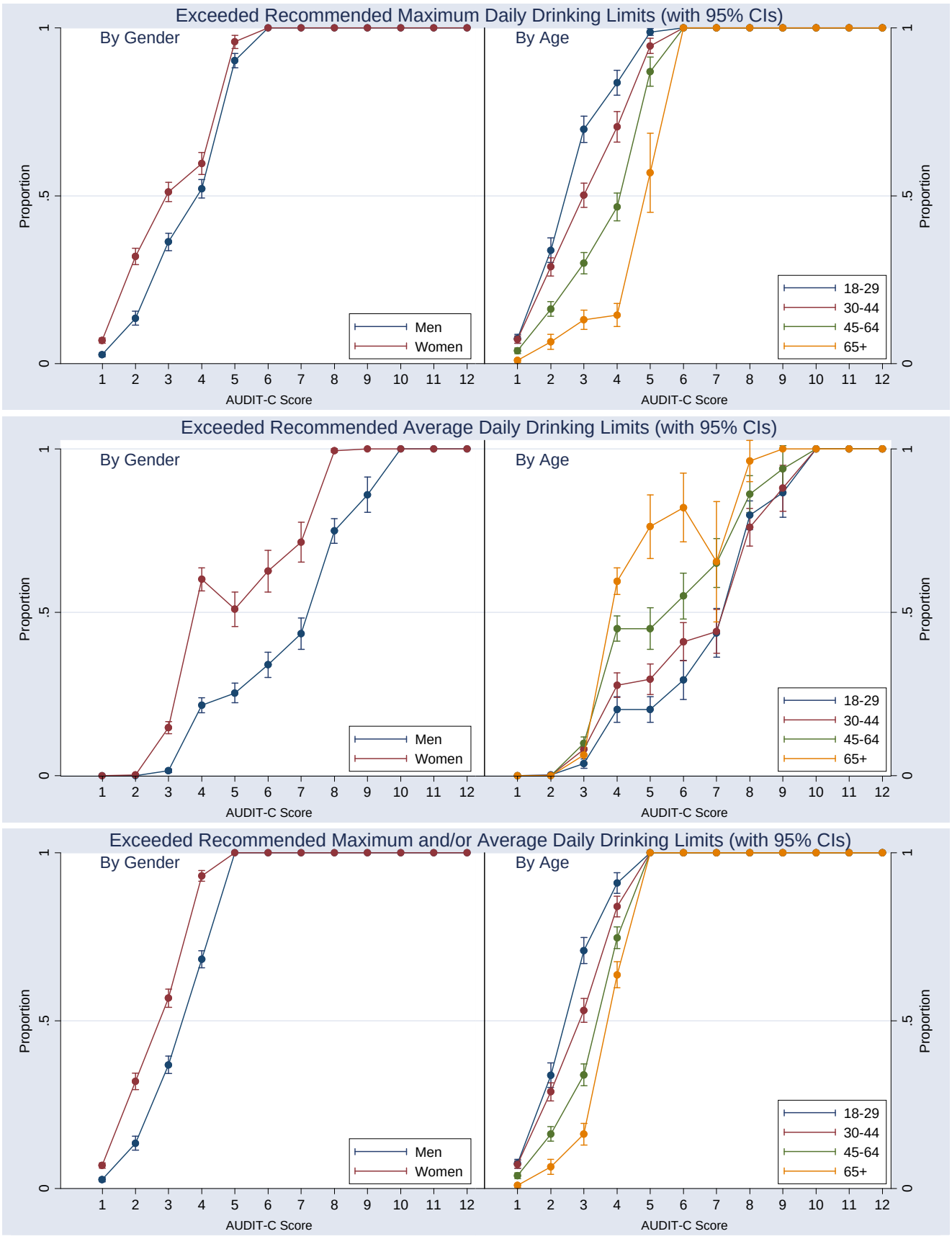


**FIGURE 4.3** Proportion of Drinkers who Exceeded Recommended Daily Drinking Limits

# Chapter 5: Conclusion

This dissertation examined the utility of a commonly used brief alcohol screening questionnaire for identifying surgical patients at increased risk for postoperative complications and increased health care utilization, and investigated the level of alcohol consumption reflected by screening scores associated with increased postoperative risk.

A practical approach for early identification of high risk alcohol use is needed to prevent adverse alcohol-related postoperative outcomes. The adverse physiologic effects of alcohol can be reversed after several weeks to several months of abstinence, depending on the organ system involved (H. Tonnesen, Nielsen, Lauritzen, & Moller, 2009). A randomized controlled trial demonstrated that four weeks of monitored preoperative abstinence significantly reduced the risk of postoperative complications among surgical patients who drank over four drinks daily (H Tonnesen et al., 1999). Identification of patients who might benefit from preoperative alcohol interventions requires a practical way to identify those at high risk for alcohol-related postoperative complications and increased health care utilization, ideally as soon as the patient is referred for surgical consultation or scheduled for surgery. However, nonstandardized preoperative alcohol assessments miss the majority of patients with potential alcohol misuse (Kip et al., 2008). One possible approach to early identification of surgical patients at high alcohol-related risk is to use results of alcohol screening conducted as part of routine primary care. A recent study among male VA surgical patients demonstrated that those who screened positive on the AUDIT-C alcohol screening questionnaire with scores of 5 or more up to a year prior to surgery had increased risk of postoperative complications compared to low-level (K. A. Bradley, Rubinsky, et al.,

2011), suggesting that annual AUDIT-C screening results could be used for early preoperative identification of patients at high risk.

**Summary of Findings**

The first two studies of this dissertation (Chapters 2 and 3) evaluated associations between AUDIT-C alcohol screening results and adverse postoperative outcomes in overlapping samples of male VA surgical patients who underwent non-emergent, non-cardiac, major surgery in fiscal years 2004-2006 and completed the AUDIT-C on a mailed VA patient satisfaction survey in the year prior to surgery. The majority of eligible patients were white, married, and over 60 years old. Over 15% had AUDIT-C scores of 5 or more, whereas 7% had clinical documentation of risky drinking (> 2 drinks daily) immediately prior to surgery.

Although AUDIT-C scores of 5 or more from up to a year prior to surgery are associated with increased risk of postoperative complications, the first study found that postoperative inpatient health care utilization was increased only among the subset of patients with the highest AUDIT-C scores. Specifically, after adjusting for important potential confounders, patients with AUDIT-C scores ≥ 9 spent a day longer in the hospital, had 1.5 more ICU days, and were twice as likely to return to the OR in the 30 days following surgery compared to low-risk drinkers (AUDIT-C scores 1-4). Although several factors related to alcohol use may contribute to increased postoperative health care utilization, including surgical complications, more complex procedures, and increased preoperative morbidity, postoperative complications were found to be the primary explanatory mechanism.

The AUDIT-C asks about drinking in the past year and was completed up to a year before surgery. Thus, it is plausible that a modified AUDIT-C administered closer to the time of surgery (e.g., at the time of referral to surgery) that asked about more recent drinking (e.g., past month) might have a stronger association with postoperative health care utilization. To help address this question, the second study evaluated whether medical record documentation of risky drinking (i.e., > 2 drinks/day) in the two weeks prior to surgery modified the association between past-year AUDIT-C screening results and postoperative complications and health care utilization. This study revealed that associations between higher AUDIT-C risk groups and increased postoperative complications and health care utilization were generally limited to those patients who had clinical documentation of risky drinking in the two weeks prior to surgery. However, among patients with documented risky drinking, postoperative risk varied widely depending on AUDIT-C score. Compared to those with AUDIT-C scores 1-4, the probability of postoperative complications was nearly doubled among those with AUDIT-C scores ≥ 5, and postoperative hospital LOS and ICU days were increased by approximately 2 and 3 days, respectively, among those with AUDIT-C scores ≥ 9. The finding of this study that most measures of postoperative risk were increased only among patients who had the highest AUDIT-C scores *and* documented risky drinking at the time of surgery supports a causal role for alcohol. However, clinical documentation of risky drinking in the two weeks prior to surgery was not based on standardized alcohol assessment and may tend to identify only those patients with the most severe, persistent or easily recognizable alcohol misuse. The measure captured only a minority of patients with potential alcohol misuse and the study cannot confirm whether patients with high AUDIT-C scores and clinically documented risky drinking in the two weeks prior to surgery had

increased postoperative risk due to persistent alcohol misuse that continued up to the time of surgery or because clinical documentation of risky drinking identified those with the most severe misuse. Additionally, findings from this observational study could potentially reflect residual confounding by tobacco exposure, surgical complexity or other factors.

The final study investigated the level of alcohol consumption and severity reflected by individual AUDIT-C scores in a large, representative, U.S. population sample of drinkers. This study found that mean daily drinking, alcohol use disorder (AUD) severity, and probability of alcohol dependence increased dramatically as AUDIT-C scores increased. Across scores 1 to 12, mean daily drinking ranged from approximately 0 to 18 drinks per day, AUD severity ranged from approximately 0 to over 5 endorsed AUD criteria, and the probability of alcohol dependence ranged from <1 to 65%, although estimates generally varied by gender and by age. This was the first study to our knowledge to investigate the level of consumption reflected by individual AUDIT-C scores, and results extend the interpretation of studies that have demonstrated associations between AUDIT-C scores and adverse health outcomes, including postoperative risks. Additionally, disseminating accurate estimates of the increasing level of mean daily drinking, AUD severity, and probability of dependence associated with each higher AUDIT-C score could help health care providers determine where on the spectrum of drinking and severity a patient falls, individualize feedback about the severity of a patient's alcohol misuse, and identify needs for further diagnostic assessment.

**Implications**

Findings of the third study of this dissertation suggest that among individuals age 45 years and above, similar to the VA surgical population, AUDIT-C scores associated with increased risk of postoperative complications (≥ 5 points) and increased postoperative health care utilization (≥ 9 points) indicate drinking > 2 and ≥ 5 drinks per day, respectively. These levels of drinking correspond exactly with what is considered risky daily drinking (> 2 drinks) and heavy episodic drinking (≥ 5 drinks) among men (National Institute on Alcohol Abuse and Alcoholism, 2007), and are each independently associated with several alcohol-related health conditions (Rehm et al., 2010).

Although AUDIT-C scores ≥ 5 indicate drinking over 2 drinks daily, this measure identified twice as many patients with potential alcohol misuse as did medical record documentation of drinking at this level. Therefore, future research should investigate whether a modified version of the AUDIT-C administered closer to the time of surgery that asks about recent rather than past-year drinking performs as well as the combination of AUDIT-C score from up to a year before surgery and medical record documentation of risky drinking in the two weeks prior to surgery for identifying patients with high postoperative risk. Such an adaption of the AUDIT-C might provide a scaled marker of postoperative risk, much like the combination of past-year AUDIT-C score and documented risky drinking, but identify more patients at increased risk.

Findings of this dissertation suggest that healthcare systems using the AUDIT-C for routine alcohol screening, such as the VA, could utilize screening results from up to a year before surgery to identify patients at increased postoperative risk. Patients with a documented positive screen in the year prior to surgery could be re-assessed at the time of

referral to surgery to identify those who continue to drink at risky levels and may be at greatest risk for postoperative complications and increased postoperative health care utilization. Such patients could be advised that four weeks of preoperative abstinence has been found to reduce postoperative complications (H Tonnesen et al., 1999) and counseled to reduce their drinking. Further, these patients could be managed expectantly in surgery.

Additional research is needed to determine exactly the type and duration of changes in drinking prior to surgery that can reduce postoperative complications and whether such changes can also reduce postoperative health care utilization and costs. In order to improve patient outcomes following surgery, future research should also aim to establish optimal approaches for identifying surgical patients with increased alcohol-related risk and continue to evaluate the effectiveness of various interventions to decrease drinking preoperatively.

Notes to Chapter 5

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# VITA

Anna DeBenedetti Rubinsky was born in Three Rivers, California. In 2001, she earned a Bachelor of Arts degree in Psychology at the University of California, Berkeley. She has worked for the Department of Veterans Affairs Health Services Research and Development on research related to implementation of evidence-based care for alcohol misuse since 2003. At the University of Washington, Seattle, she earned a Master of Science in Health Services in 2008 and a Doctor of Philosophy in Health Services in 2012. Currently she calls San Francisco her home.