AUDIT-C Alcohol Screening Results and Postoperative Inpatient Health Care Use

Anna D Rubinsky, MS, Haili Sun, PhD, David K Blough, PhD, Charles Maynard, PhD, Christopher L Bryson, MD, MS, Alex H Harris, PhD, Eric J Hawkins, PhD, Lauren A Beste, MD, MS, William G Henderson, PhD, Mary T Hawn, MD, MPH, FACS, Grant Hughes, BS, Michael J Bishop, MD, Ruth Etzioni, PhD, Hanne Tønnesen, MD, DMSC, Daniel R Kivlahan, PhD, Katharine A Bradley, MD, MPH

BACKGROUND: Alcohol screening scores ≥5 on the Alcohol Use Disorders Identification Test–Consumption (AUDIT-C) up to a year before surgery have been associated with postoperative complications, but the association with postoperative health care use is unknown. This study evaluated whether AUDIT-C scores in the year before surgery were associated with postoperative hospital length of stay, total ICU days, return to the operating room, and hospital readmission.

STUDY DESIGN: This cohort study included male Veterans Affairs patients who completed the AUDIT-C on mailed surveys (October 2003 through September 2006) and were hospitalized for nonemergent noncardiac major operations in the following year. Postoperative health care use was evaluated across 4 AUDIT-C risk groups (scores 0, 1 to 4, 5 to 8, and 9 to 12) using linear or logistic regression models adjusted for sociodemographics, smoking status, surgical category, relative value unit, and time from AUDIT-C to surgery. Patients with AUDIT-C scores indicating low-risk drinking (scores 1 to 4) were the referent group.

RESULTS: Adjusted analyses revealed that among eligible surgical patients (n = 5,171), those with the highest AUDIT-C scores (ie, 9 to 12) had longer postoperative hospital length of stay (5.8 [95% CI, 5.0−6.7] vs 5.0 [95% CI, 4.7−5.3] days), more ICU days (4.5 [95% CI, 3.2−5.8] vs 2.8 [95% CI, 2.6−3.1] days), and increased probability of return to the operating room (10% [95% CI, 6−13%] vs 5% [95% CI, 4−6%]) in the 30 days after surgery, but not increased hospital readmission within 30 days postdischarge, relative to the low-risk group.

CONCLUSIONS: AUDIT-C screening results could be used to identify patients at risk for increased postoperative health care use who might benefit from preoperative alcohol interventions. (J Am Coll Surg 2012;214:296–305. © 2012 by the American College of Surgeons)

Disclosure Information: Nothing to disclose.

The research reported here was supported by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development and Health Services Research and Development (IAC 06-021). Ms Rubinsky was also supported by an Agency for Healthcare Research and Quality Institutional National Research Service Award through the University of Washington (T32 HS 013853) when this work was conducted.

The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs.

Abstract presented at the Addiction Health Services Research Annual Meeting in San Francisco, CA, October 2009, and at the AcademyHealth Annual Research Meeting and National Research Service Award Trainees Research Conference, Seattle, WA, June 2011.

Received July 20, 2011; Revised November 18, 2011; Accepted November 21, 2011.

From Health Services Research and Development (Rubinsky, Sun, Blough, Maynard, Bryson, Hawkins, Kivlahan, Bradley), General Medicine Service (Bryson, Beste, Bradley), and Center of Excellence in Substance Abuse Treatment and Education (Hawkins, Kivlahan, Bradley), Department of Veterans Affairs Puget Sound Health Care System, Departments of Health Services (Rubinsky, Maynard, Etzioni, Bradley), Pharmacy (Blough), Psychiatry and Behavioral Sciences (Hawkins, Kivlahan), Anesthesiology (Bishop), Biostatistics (Etzioni), and Medicine (Bradley), University of Washington; Fred Hutchinson Cancer Research Center (Etzioni); Group Health Research Institute (Bradley), Seattle, WA; Center for Health Care Evaluation, Department of Veterans Affairs Palo Alto Health Care System, Menlo Park, CA (Harris); Department of Veterans Affairs Eastern Colorado Healthcare System, Denver (Henderson, Hughes); University of Colorado Health Outcomes Program, Aurora (Henderson), CO; Center for Surgical, Medical, Acute care Research and Transitions (C-SMART), Birmingham Veterans Affairs Medical Center (Hawn); Department of Surgery, University of Alabama at Birmingham, Birmingham, AL (Hawn); and WHO Collaborating Centre for Evidence-Based Health Promotion in Hospitals and Health Services, Bispebjerg University Hospital, Copenhagen, Denmark (Tønnesen).

Correspondence address: Anna D Rubinsky, MS, Health Services Research and Development, VA Puget Sound Health Care System, 1660 South Columbian Way (S-152), Seattle, WA 98108. email: Anna.Rubinsky@va.gov

ISSN 1072-7515/12/$36.00
doi:10.1016/j.jamcollsurg.2011.11.007

Abbreviations and Acronyms

AUDIT-C = Alcohol Use Disorders Identification Test–Consumption
CPT = Current Procedural Terminology
LOS = length of stay
NPCD = National Patient Care Database
OR = operating room
RVU = relative value unit
SHEP = Survey of Healthcare Experiences of Patients
VA = Veterans Affairs
VASQIP = Veterans Affairs Surgical Quality Improvement Program

Alcohol misuse is a potentially modifiable risk factor for postoperative complications.[1-5] In addition, patients who report heavy daily drinking (ie, ≥60 grams of alcohol or >4 US standard drinks) have increased postoperative health care use, including longer stays in the hospital and ICU, and more second operations.[6-16] A randomized controlled trial among patients scheduled for elective colorectal surgery who reported drinking >4 drinks daily found that 1 month of preoperative abstinence reduced postoperative complications by >50%.[17] Because alcohol misuse is often missed by standard clinical assessment,[18-21] experts recommend preoperative alcohol screening of all surgical patients using a validated screening instrument.[18,22-25] Scores from validated alcohol misuse screening questionnaires can identify patients with increased risk of postoperative complications,[4,5,26] but less is known about whether such screening scores also identify patients with increased postoperative health care use. If commonly used brief alcohol screens could identify patients at increased risk for costly postoperative health care use as well as complications, preoperative alcohol interventions might provide a cost-effective approach to decrease postoperative resource use 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[4] are also associated with increased postoperative inpatient health care use. 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 ICU, return to the operating room (OR), and hospital readmission among men admitted to Veterans Affairs (VA) hospitals nationwide for nonemergent, noncardiac major operations.

METHODS

Data sources and sample

This cohort study used VA data from 3 sources, ie, the VA Surgical Quality Improvement Program (VASQIP), Survey of Healthcare Experiences of Patients (SHEP), and National Patient Care Database (NPCD). The study protocol was approved by institutional review boards at VA Puget Sound Health Care System and coauthors' 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 (ie, minor procedures) and procedures rarely performed in VA (eg, transplantation and trauma procedures).[27,28] 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.[29] SHEP includes questions about health behaviors, including the 3-item AUDIT-C alcohol screening questionnaire (Table S1, online only). Additional preoperative risk factors (ie, disability due to military service, past-year diagnoses) and postoperative health care use data (ie, 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 October 1, 2003 to September 30, 2006 and were hospitalized in the subsequent year for at least 1 day after a noncardiac surgery assessed by VASQIP. The first eligible nonemergent surgery after completion of the first AUDIT-C was evaluated. Operations that occurred within 90 days of an earlier surgery or did not occur within the first 3 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 before surgery were used to measure alcohol use. The

AUDIT-C is a validated alcohol screening questionnaire (Table S1, online only) scored 0 to 12 points, with higher scores indicative of greater severity.[30,31] AUDIT-C scores were grouped into 4 risk groups based on the associated age- and smoking-adjusted risk of postoperative complications[4]: 0 (nondrinkers); 1 to 4 (low-risk); 5 to 8 (at-risk); and 9 to 12 (high-risk).

Outcome variables–postoperative inpatient health care use

This study evaluated 4 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 an ICU during postoperative hospitalization and any hospital readmission within 30 days postdischarge 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 the primary analyses.

Covariates

Sociodemographic and clinical covariates known to be important potential confounders of the association between alcohol use and postoperative health care use 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 (ie, cardiovascular or thoracic, musculoskeletal, gastrointestinal, genitourinary, or other); a proxy measure of surgical complexity based on quartiles of year-specific work relative value units (RVUs)[32]; 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 causal pathway between alcohol use and postoperative health care use, including several risk factors known to be associated with cirrhosis. The preoperative risk factors evaluated included 39 variables collected by VASQIP with no more than 5% missing values (Table S2, online only) and the Deyo-Charlson comorbidity index[33] constructed from past-year ICD-9 diagnoses from NPCD. Surgical complications were expected to be a primary mediator of the association between alcohol use and postoperative health care use, 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 4 subtypes known to be associated with alcohol use (ie, surgical field; infectious other than at the surgical site; cardiopulmonary; and other, including bleeding, neurologic, thromboembolic, and renal).[1-3] Because delirium is associated with alcohol use[1] 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 outcomes were evaluated using unadjusted and adjusted regression models that included cluster-robust variance estimators to account for correlation between patients undergoing surgery at the same medical center (n = 105). The adjusted primary model included sociodemographic covariates, smoking status, surgical CPT category, surgical RVU, and days from alcohol screening to surgery. Low-risk drinkers (ie, AUDIT-C 1 to 4) served as the referent group because nondrinkers (ie, AUDIT-C 0) tend to have greater comorbidity[34,35] and more postoperative complications.[4]

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,[36-38] sensitivity analyses based on the adjusted model compared the performance of log-transformed linear regression, generalized linear models with log-link and gamma error distribution,[39,40] and an extension of generalized linear models that estimates the link function and variance structure empirically using extended estimating equations.[41] 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 a LOS longer than 90 days). Similarly, total ICU days was evaluated without the a priori restriction to the first 30 postoperative days.

Return to the OR within 30 days after surgery and hospital readmission within 30 days after discharge were evaluated using logistic regression. Predicted probabilities of outcomes were estimated across AUDIT-C risk groups based on the average characteristics for the sample.

Table 1. Characteristics of Men Admitted to a Veterans Affairs Hospital for Nonemergent Major Surgery, by AUDIT-C Risk Group

			Drinkers (n = 2,732; 53%)			
	Total (n = 5,171)	Nondrinkers (AUDIT-C 0) (n = 2,439; 47%)	Low-risk (AUDIT-C 1 to 4) (n = 1,853; 36%)	At-risk (AUDIT-C 5 to 8) (n = 649; 13%)	High-risk (AUDIT-C 9 to 12) (n = 230; 4%)	p Value
Age at surgery, y, mean ± 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)	
Gastrointestinal	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)	
Days AUDIT-C to surgery, mean ± SD	163 ± 104	163 ± 104	162 ± 103	164 ± 104	159 ± 101	0.91
No. of postoperative complications, mean ± SD	0.15 ± 0.53	0.16 ± 0.56	0.11 ± 0.41	0.18 ± 0.58	0.27 ± 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

*Percents do not sum to 100 due to missing values.
AUDIT-C, Alcohol Use Disorder Identification Test Consumption Questionnaire; CPT, Current Procedural Terminology; RVU, relative value units.

Secondary analyses: role of additional covariates

Secondary analyses investigated the impact of variables that might mediate the association of alcohol use with each outcome. First, if at-risk or high-risk drinking was significantly associated with the outcome in the primary adjusted analysis, 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).

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 nonemergent, noncardiac major surgery in the following year (Table 1). The mean number of days between alcohol screening and surgery was

Table 2. Postoperative Inpatient Health Care Use, by AUDIT-C Risk Group

		Drinkers		
	Nondrinkers (AUDIT-C 0)	Low-risk (AUDIT-C 1 to 4)	At-risk (AUDIT-C 5 to 8)	High-risk (AUDIT-C 9 to 12)
Outcomes within 30 days of surgery (95% CI)				
Mean hospital LOS, d				
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)

*$p < 0.05$, compared with low-risk drinkers.
†Adjusted for sociodemographics (ie, age, race/ethnicity, marital status, disability status), smoking status, surgical Current Procedural Terminology category, quartiles of surgical relative value units, and days from alcohol screening to surgery.
‡n = 1,913.
§$p < 0.01$, compared with low-risk drinkers.
‖$p < 0.0005$, compared with low-risk drinkers.
AUDIT-C, Alcohol Use Disorder Identification Test Consumption Questionnaire; LOS, length of stay; OR, operating room.

163 (SD 104). The majority of eligible men were white, married, and older than 60 years. Ten percent experienced at least 1 complication in the 30 postoperative days, with higher rates among those who had undergone gastrointestinal (16%) or cardiovascular/thoracic (14%) surgery compared with 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 1), including 1,853 (36%) low-risk drinkers (AUDIT-C 1 to 4), 649 (13%) at-risk drinkers (AUDIT-C 5 to 8), and 230 (4%) high-risk drinkers (AUDIT-C 9 to 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, cardiopulmonary, and other (eg, bleeding, neurologic, thromboembolic, and renal) complications.

Postoperative hospital LOS

Postoperative hospital LOS ranged from 1 to 142 days, with a mean of 5.5 (95% 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 after surgery compared with low-risk drinkers (AUDIT-C 1 to 4); mean 5.9 (95% CI, 5.0−6.7) vs mean 5.0 (95% CI, 4.7−5.3) days; p = 0.06 (Table 2). After adjusting for sociodemographics, 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 to 8), but nondrinkers (AUDIT-C 0) had significantly longer LOS in both unadjusted and adjusted analyses (mean 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 generalized linear models and extended estimating equations 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 (mean 6.5 [95% CI, 5.2−7.9] days) and nondrinkers (mean 5.6 [95% CI, 5.3−5.9] days) relative to low-risk drinkers (mean 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 to 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] days), as specified a priori, high-risk drinkers (mean 4.5 [95% CI, 3.2−5.8] days) and nondrinkers (mean 3.2 [95% CI, 2.9−3.6] days) had significantly more ICU days compared with low-risk drinkers (mean 2.8 [95% CI, 2.6−3.1] days) in unadjusted and adjusted analyses (Table 2).

Alternative regression methods

Results were robust across alternative regression methods. Only the extended estimating equations 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 (mean 6.0 [95% CI, 3.3−8.6] days), but not nondrinkers (mean 3.5 [95% CI, 3.0−4.0] days) had significantly more ICU days compared with low-risk drinkers (mean 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 >2-fold greater odds of returning to the OR compared with 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 with 5% (95% CI, 4−6%) among low-risk drinkers (Table 2). Nondrinkers also had significantly increased odds of returning to the OR compared with low-risk drinkers in unadjusted and adjusted analyses (adjusted predicted probability: 6% [95% CI, 5−7%]).

Hospital readmission

In the 30 days after discharge, 398 (8%) of the 5,171 surgical patients were readmitted to the hospital. Compared with 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).

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 ≥3 and sodium level ≤135 substantially influenced the adjusted association of high-risk drinking with any outcomes. 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 3). No preoperative risk factor substantially altered the association of high-risk drinking with return to the OR.

After also adjusting for number and subtypes of postoperative complications, only return to the OR remained significantly increased among high-risk drinkers (Table 3).

DISCUSSION

This study of VA surgical patients compared postoperative inpatient health care use across AUDIT-C risk groups and found that high-risk drinkers (AUDIT-C 9 to 12), on average, spent nearly a day longer in the hospital, had 1.5 more ICU days, and were twice as likely to return to the OR compared with low-risk drinkers (AUDIT-C 1 to 4), after adjusting for sociodemographic 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 to 8) was not associated with any measure of postoperative health care use. Nondrinkers had increased health care use 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 before surgery have increased risk of postoperative complications compared with low-risk drinkers (AUDIT-C 1 to 4),[4] this study found increased postoperative inpatient health care use 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 use 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 g alcohol (ie, >4 US standard drinks) daily before surgery tend to have longer hospital LOS, more ICU admissions, prolonged ICU stays, and more secondary operations compared with those who report drinking <25 g alcohol (<2 US standard drinks) daily.[6-14] However, drinking >30 g alcohol (>2 US standard drinks) daily was not associated with prolonged hospital LOS or increased ICU admissions in a European study of noncardiac surgery pa-

Table 3. Postoperative Health Care Use after Additional Adjustment* for Potentially Mediating Variables, by AUDIT-C Risk 0 Group

		Drinkers		
	Nondrinkers (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, d				
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)
No. and 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)‖
No. and 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)¶
No. and 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)
No. and 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)

*All models include covariates from primary adjusted model: sociodemographics, smoking status, surgical Current Procedural Terminology category, quartiles of surgical relative value units, and days from alcohol screening to surgery.
†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 the association by 10%, results equivalent to primary adjusted model (Table 2); hospital readmission: no association with high-risk drinking, results equivalent to primary adjusted model (Table 2).
‡Total number and subtypes (ie, surgical field, infectious other than at surgical site, cardiopulmonary, delirium, other) of complications in the 30 days after surgery were added to fully adjusted model, including any additional preoperative risk factors.
§n = 1,913.
‖$p < 0.05$, compared with low-risk drinkers.
¶$p < 0.01$, compared with low-risk drinkers.
AUDIT-C, Alcohol Use Disorder Identification Test Consumption Questionnaire; LOS, length of stay; OR, operating room.

tients.[42] In previous studies of VA patients, documentation of drinking ≥2 drinks daily in the 2 weeks before surgery was associated with prolonged LOS among those undergoing major head and neck surgery,[43] but not among those undergoing urologic surgery[44] or major noncardiac surgery.[45] 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.[26] The study found that hospital LOS was increased among surgical patients who had very high scores (≥20) on the 10-item AUDIT, but not among those who screened positive for alcohol misuse with lower scores (8 to 19).

This study demonstrates associations between routinely collected AUDIT-C alcohol screening scores from up to a year before surgery and 3 measures of postoperative inpatient health care use. The validated 3-item AUDIT-C is practical for routine alcohol screening,[46] and is required annually for VA outpatients nationwide.[47] Many factors can contribute to increased postoperative health care use, including surgical complications, more complex operations, and preoperative morbidity, all of which are more common among higher risk drinkers. In addition, the pathway between high-risk drinking and increased health care use may vary depending on the outcomes measure. For example, it is plausible that high-risk drinkers stay in the hospital longer 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 >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 ≥5 from up to a year before surgery have been associated with postoperative complications,[4] findings of this study suggest that only the highest AUDIT-C scores (9 to 12) identify surgical inpatients who are also at risk for increased postoperative health care use, 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 previous year and alcohol screening preceded surgery by up to 1 year. A modified AUDIT-C administered closer to the time of surgery that asked about drinking in the previous month might have a stronger association with postoperative health care use. Additionally, although results were adjusted for several important covariates, some degree of residual and unmeasured confounding might have persisted. In particular, adjusting for surgical RVU and CPT category cannot fully account for variation in procedural complexity; number and subtypes of postoperative complications cannot fully capture variation in complication severity; and important psychosocial, socioeconomic, or behavioral factors might have been excluded. In addition, this study did not evaluate other sources of increased resource use among high-risk drinkers (eg, medications, x-rays, consultations) that could also increase the costs of postoperative care. The generalizability of the results might be limited by the patient population, which was a chance sample of VA patients who returned confidential, mailed patient satisfaction surveys (response rate 62%[29]) and underwent nonemergent, noncardiac major surgery in the following year. The findings might 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 might be limited because the AUDIT-C was completed by mailed survey, which tends to identify greater numbers of patients with alcohol misuse compared with clinical administration.[48,49] 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 use 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,[1,3] making increased postoperative health care use 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 substantial reduction in hospital LOS, it had limited power for detecting the decrease in LOS in the intervention group.[17] The current 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 (ie, scores 5 to 12),[4] but also a subset of the highest-risk drinkers who have substantially increased postoperative health care use (ie, scores 9 to 12). If preoperative alcohol interventions not only decrease postoperative complications but also reduce postoperative health care use in a subset of patients, it would help offset the costs of screening and intervention. Additional research is needed to confirm the efficacy of targeted preoperative alcohol interventions for decreasing postoperative complications and to evaluate associated health care use and cost implications.

CONCLUSIONS

This study suggests that the 3-item AUDIT-C alcohol screening questionnaire can identify not only patients at increased risk of postoperative complications [4], but also a subset of high-risk drinkers with increased postoperative health care use (ie, scores 9 to 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 use. Future trials are needed to determine whether interventions can reduce postoperative health care use and costs as well as complications.

Author Contributions

Study conception and design: Rubinsky, Maynard, Bryson, Kivlahan, Bradley
Acquisition of data: Hughes
Analysis and interpretation of data: Rubinsky, Sun, Blough, Maynard, Bryson, Harris, Hawkins, Beste, Henderson, Hawn, Hughes, Bishop, Etzioni, Tønnesen, Kivlahan, Bradley
Drafting of manuscript: Rubinsky, Bradley
Critical revision: Rubinsky, Sun, Blough, Maynard, Bryson, Harris, Hawkins, Beste, Henderson, Hawn, Hughes, Bishop, Etzioni, Tønnesen, Kivlahan, Bradley

Acknowledgment: The authors greatly appreciate the VA Surgical Quality Data Use Group (SQDUG) and the VA Office of Quality and Performance (OQP), which shared their

data with us for this project. The project would not have been possible without these data. The authors would also like to acknowledge SQDUG for its role as scientific advisors and for the critical review of data use and analysis presented in this article. The authors would also like to thank the data manager at VA Puget Sound Health Services Research and Development, Mr Jeff Todd-Stenberg, for acquisition and merging of data.

REFERENCES

1. Harris AHS, Frey MS, DeBenedetti AF, Bradley KA. Alcohol misuse prevalence and associations with post-operative complications in US surgical patients: a review. Open Surg J 2008;2: 50–58.
2. Tonnesen H, Nielsen PR, Lauritzen JB, Moller AM. Smoking and alcohol intervention before surgery: evidence for best practice. Br J Anaesth 2009;102:297–306.
3. Tonnesen H. Alcohol abuse and postoperative morbidity. Dan Med Bull 2003;50:139–160.
4. Bradley KA, Rubinsky AD, Sun H, et al. Alcohol screening and risk of postoperative complications in male VA patients undergoing major non-cardiac surgery. J Gen Intern Med 2011;26: 162–169.
5. Harris AH, Reeder R, Ellerbe L, et al. Preoperative alcohol screening scores: association with complications in men undergoing total joint arthroplasty. J Bone Joint Surg Am 2011;93: 321–327.
6. Spies CD, Emadi A, Neumann T, et al. Relevance of carbohydrate-deficient transferrin as a predictor of alcoholism in intensive care patients following trauma. J Trauma 1995;39: 742–748.
7. Spies CD, Herpell J, Beck O, et al. The urinary ratio of 5-hydroxytryptophol to 5-hydroxyindole-3-acetic acid in surgical patients with chronic alcohol misuse. Alcohol 1999; 17:19–27.
8. Spies CD, Neuner B, Neumann T, et al. Intercurrent complications in chronic alcoholic men admitted to the intensive care unit following trauma. Intensive Care Med 1996;22:286–293.
9. Felding C, Jensen LM, Tonnesen H. Influence of alcohol intake on postoperative morbidity after hysterectomy. Am J Obstet Gynecol 1992;166:667–670.
10. Tonnesen H, Petersen K, Hojgaard L, et al. Postoperative morbidity among symptom-free alcohol misusers. Lancet 1992;340: 334–337.
11. Tonnesen H, Pedersen A, Jensen MR, et al. Ankle fractures and alcoholism. The influence of alcoholism on morbidity after malleolar fractures. J Bone Joint Surg Br 1991;73:511–513.
12. Tonnesen H, Schutten BT, Tollund L, et al. Influence of alcoholism on morbidity after transurethral prostatectomy. Scand J Urol Nephrol 1988;22:175–177.
13. Spies CD, von Dossow V, Eggers V, et al. Altered cell-mediated immunity and increased postoperative infection rate in long-term alcoholic patients. Anesthesiology 2004;100:1088–1100.
14. Tonnesen H, Schutten BT, Jorgensen BB. Influence of alcohol on morbidity after colonic surgery. Dis Colon Rectum 1987;30: 549–551.
15. Delgado-Rodriguez M, Gomez-Ortega A, Mariscal-Ortiz M, et al. Alcohol drinking as a predictor of intensive care and hospital mortality in general surgery: a prospective study. Addiction 2003;98:611–616.
16. Spies CD, Nordmann A, Brummer G, et al. Intensive care unit stay is prolonged in chronic alcoholic men following tumor resection of the upper digestive tract. Acta Anaesthesiol Scand 1996;40:649–656.
17. Tonnesen H, Rosenberg J, Nielsen H, et al. Effect of preoperative abstinence on poor postoperative outcome in alcohol misusers: randomised controlled trial. BMJ 1999;318:1311–1316.
18. Kip MJ, Neumann T, Jugel C, et al. New strategies to detect alcohol use disorders in the preoperative assessment clinic of a German university hospital. Anesthesiology 2008;109:171–179.
19. Moore RD, Bone LR, Geller G, et al. Prevalence, detection, and treatment of alcoholism in hospitalized patients. JAMA 1989; 261:403–407.
20. Rumpf HJ, Bohlmann J, Hill A, et al. Physicians' low detection rates of alcohol dependence or abuse: a matter of methodological shortcomings? Gen Hosp Psychiatry 2001;23:133–137.
21. Smothers BA, Yahr HT, Ruhl CE. Detection of alcohol use disorders in general hospital admissions in the United States. Arch Intern Med 2004;164:749–756.
22. Alford DP. Surgical interventions in the alcohol- or drug-using patient. In: Ries RK, Fiellin DA, Miller SC, eds. Principles of addiction medicine. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2009:1125–1135.
23. Kork F, Neumann T, Spies C. Perioperative management of patients with alcohol, tobacco and drug dependency. Curr Opin Anaesthesiol 2010;23:384–390.
24. Shourie S, Conigrave KM, Proude EM, et al. Pre-operative screening for excessive alcohol consumption among patients scheduled for elective surgery. Drug Alcohol Rev 2007;26:119–125.
25. Gordon AJ, Olstein J, Conigliaro J. Identification and treatment of alcohol use disorders in the perioperative period. Postgrad Med 2006;119:46–55.
26. Poon A, Owen J, Gijsbers AJ. Identification of at-risk drinkers in an orthopaedic inpatient population. Aust N Z J Surg 1994;64: 775–779.
27. Henderson WG, Khuri SF, Mosca C, et al. Comparison of risk-adjusted 30-day postoperative mortality and morbidity in Department of Veterans Affairs hospitals and selected university medical centers: general surgical operations in men. J Am Coll Surg 2007;204:1103–1114.
28. Henderson WG, Daley J. Design and statistical methodology of the National Surgical Quality Improvement Program: why is it what it is? Am J Surg 2009;198(Suppl):S19–S27.
29. Wright SM, Craig T, Campbell S, et al. Patient satisfaction of female and male users of Veterans Health Administration services. J Gen Intern Med 2006;21(Suppl 3):S26–S32.
30. Bradley KA, Kivlahan DR, Zhou XH, et al. Using alcohol screening results and treatment history to assess the severity of at-risk drinking in Veterans Affairs primary care patients. Alcohol Clin Exp Res 2004;28:448–455.
31. Rubinsky AD, Kivlahan DR, Volk RJ, et al. Estimating risk of alcohol dependence using alcohol screening scores. Drug Alcohol Depend 2010;108:29–36.
32. Johnson SE, Newton WP. Resource-based relative value units: a primer for academic family physicians. Fam Med 2002;34:172–176.

33. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 1992;45:613–619.

34. Williams EC, Peytremann-Bridevaux I, Fan VS, et al. The association between alcohol screening scores and health status in male veterans. J Addiction Med 2010;4:27–37.

35. Stranges S, Notaro J, Freudenheim JL, et al. Alcohol drinking pattern and subjective health in a population-based study. Addiction 2006;101:1265–1276.

36. Basu A, Manning WG. Issues for the next generation of health care cost analyses. Med Care 2009;47(Suppl 1):S109–S114.

37. Austin PC, Rothwell DM, Tu JV. A comparison of statistical modeling strategies for analyzing length of stay after CABG surgery. Health Serv Outcomes Res Methodol 2002;3:107–133.

38. Jones AM. Models for health care. In: Hendry D, Clements M, eds. Oxford handbook of economic forecasting. Oxford: Oxford University Press; 2010:625–654.

39. Blough DK, Madden CW, Hornbrook MC. Modeling risk using generalized linear models. J Health Econ 1999;18:153–171.

40. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? J Health Econ 2001;20:461–494.

41. Basu A, Rathouz PJ. Estimating marginal and incremental effects on health outcomes using flexible link and variance function models. Biostatistics 2005;6:93–109.

42. Klasen J, Junger A, Hartmann B, et al. Excessive alcohol consumption and perioperative outcome. Surgery 2004;136:988–993.

43. BuSaba NY, Schaumberg DA. Predictors of prolonged length of stay after major elective head and neck surgery. Laryngoscope 2007;117:1756–1763.

44. Wallner LP, Dunn RL, Sarma AV, et al. Risk factors for prolonged length of stay after urologic surgery: the National Surgical Quality Improvement Program. J Am Coll Surg 2008;207:904–913.

45. Collins TC, Daley J, Henderson WH, Khuri SF. Risk factors for prolonged length of stay after major elective surgery. Ann Surg 1999;230:251–259.

46. Rose HL, Miller PM, Nemeth LS, et al. Alcohol screening and brief counseling in a primary care hypertensive population: a quality improvement intervention. Addiction 2008;103:1271–1280.

47. Lapham GT, Achtmeyer CE, Williams EC, et al. Increased documented brief alcohol interventions with a performance measure and electronic decision support. Med Care 2010;48:1–8.

48. Hawkins EJ, Kivlahan DR, Williams EC, et al. Examining quality issues in alcohol misuse screening. Subst Abus 2007;28:53–65.

49. Bradley KA, Lapham GT, Hawkins EJ, et al. Quality concerns with routine alcohol screening in VA clinical settings. J Gen Intern Med 2011;26:299–306.

Table S1. Alcohol Use Disorder Identification Test Consumption Questionnaire (AUDIT-C), as included on Veterans Affairs Survey of Healthcare Experience for Patients (SHEP), and Scoring

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 point)
☐ **2–3 times a week**	(3 point)
☐ **4–5 times a week**	(4 point)
☐ **6 or more times a week**	(4 point)

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 point)
☐ **7–9 drinks**	(3 point)
☐ **10 or more drinks**	(4 point)

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 point)
☐ **Weekly**	(3 point)
☐ **Daily or almost daily**	(4 point)

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.

Table S2. Preoperative Risk Factors from the Veterans Affairs Surgical Quality Improvement Program Evaluated as Potential Mediators

Potentially mediating preoperative risk factors from VASQIP with <5% missing
American Society of Anesthesiology Physical Status Classification immediately before 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 CNS
Impaired sensorium
Diabetes mellitus controlled with oral agents or insulin
Dyspnea
Ascites
Bleeding disorder
History of severe COPD
Congestive heart failure in 30 days before surgery
DNR status
Chemotherapy for malignancy in last 30 days
Disseminated cancer
Preoperative sepsis 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 >1.2 mg/dL
Preoperative hematocrit ≤38
Preoperative serum glutamic oxaloacetic >40 mU/mL
Preoperative sodium ≤135 mEq/L
Preoperative WBC ≤4.5 × 1,000/mm^3)
Preoperative alkaline phosphatase >125 mU/mL
Preoperative total bilirubin >1.0 mg/dL
BUN >40 mg/dL
Preoperative hematocrit >45
Preoperative platelet count ≤150 × 1,000/mm^3
Preoperative prothrombin time >13.27 seconds
Preoperative partial thromboplastin time >35 seconds
Preoperative sodium >145 mEq/L
Preoperative WBC > 11.0 × 1,000/mm^3

VASQIP, Veterans Affairs Surgical Quality Improvement Program.