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Estimating Risk of Alcohol Dependence Using Alcohol Screening Scores*

Anna D. Rubinsky[1,2], **Daniel R. Kivlahan**[1,3], **Robert J. Volk**[5], **Charles Maynard**[1,2], and **Katharine A. Bradley**[1,2,4]

[1] Northwest Health Services Research and Development Center of Excellence, VA Puget Sound Health Care System, Seattle, Washington 98108 USA

[2] Department of Health Services, University of Washington, Seattle, Washington 91895 USA

[3] Department of Psychiatry and Behavioral Sciences, University of Washington, Seattle, Washington 91895 USA

[4] Department of Medicine, University of Washington, Seattle, Washington 91895 USA

[5] Department of General Internal Medicine, Ambulatory Treatment & Emergency Care, The University of Texas M.D. Anderson Cancer Center, Houston, Texas 77230 USA

Abstract

Brief alcohol counseling interventions can reduce alcohol consumption and related morbidity among non-dependent risky drinkers, but more intensive alcohol treatment is recommended for persons with alcohol dependence. This study evaluated whether scores on common alcohol screening tests could identify patients likely to have current alcohol dependence so that more appropriate follow-up assessment and/or intervention could be offered. This cross-sectional study used secondary data from 392 male and 927 female adult family medicine outpatients (1993–1994). Likelihood ratios were used to empirically identify and evaluate ranges of scores of the AUDIT, the AUDIT-C, two single-item questions about frequency of binge drinking, and the CAGE questionnaire for detecting DSM-IV past-year alcohol dependence. Based on the prevalence of past-year alcohol dependence in this sample (men: 12.2%; women: 5.8%), zones of the AUDIT and AUDIT-C identified wide variability in the post-screening risk of alcohol dependence in men and women, even among those who screened positive for alcohol misuse. Among men, AUDIT zones 5–10, 11–14 and 15–40 were associated with post-screening probabilities of past-year alcohol dependence ranging from 18–87%, and AUDIT-C zones 5–6, 7–9 and 10–12 were associated with probabilities ranging from 22–75%. Among women, AUDIT zones 3–4, 5–8, 9–12 and 13–40 were associated with post-screening probabilities of past-year alcohol dependence ranging from 6–94%, and AUDIT-C zones 3, 4–6, 7–9 and 10–12 were associated with probabilities ranging from 9–88%. AUDIT or AUDIT-C scores could be used to estimate the probability of past-year alcohol dependence among patients who screen positive for alcohol misuse and inform clinical decision-making.

*Supplementary information on the data analytic approach used in this study is available with the online version of this paper at doi:xxx/j.drugalcdep.xxx …

Corresponding Author: Anna DeBenedetti Rubinsky, MS, Northwest HSR&D Center of Excellence, VA Puget Sound Health Care System, 1100 Olive Way, Suite 1400, Seattle, WA 98101, Anna.Rubinsky@va.gov, Phone: 206-277-4156, Fax: 206-768-5343.

Keywords

Alcohol dependence; alcohol screening; stratum specific likelihood ratio; risk stratification; assessment; treatment

1. INTRODUCTION

Alcohol misuse, which includes the spectrum from drinking above recommended limits (called hazardous or risky drinking) to alcohol dependence, is a leading preventable cause of death and disability worldwide (Ezzati et al., 2002; Mokdad et al., 2004; World Health Organization, 2007). More than 15% of adults drink above recommended limits (Grant et al., 2004), placing them at increased risk for alcohol-related problems, and about a quarter of these adults meet criteria for alcohol dependence (National Institute on Alcoholism and Alcohol Abuse, 2006). The U.S. Preventive Services Task Force (USPSTF) recommends screening and brief counseling interventions in primary care settings to reduce alcohol misuse (U.S. Preventive Services Task Force, 2004) but brief interventions may be less effective for patients with alcohol dependence (Kaner et al., 2007; Moyer et al., 2002). Thus, experts recommend that patients with alcohol dependence be offered referral to specialty addictions treatment or, when referral is not possible, that alcohol dependent patients be managed with repeated primary care interventions (Babor et al., 2001; National Institute on Alcohol Abuse and Alcoholism et al., 2007; Willenbring and Olson, 1999). In addition, patients with alcohol dependence can be offered medications combined with medical monitoring (Anton et al., 2006; National Institute on Alcohol Abuse and Alcoholism et al., 2007; Willenbring, 2007).

Although specialized treatment is recommended for patients with alcohol dependence, there is no practical approach for identifying these patients among those who screen positive for alcohol misuse in routine practice. National Institute on Alcohol Abuse and Alcoholism (NIAAA) guidelines (National Institute on Alcohol Abuse and Alcoholism et al., 2007) suggest that clinicians ask patients seven questions based on Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) criteria (American Psychiatric Association, 1994) to assess alcohol dependence, but primary care providers may not recall or have easy access to the criteria and often do not have time even for such limited assessments. An alternative approach is to use screening scores to identify patients who are most likely to have alcohol dependence. World Health Organization (WHO) guidelines for the Alcohol Use Disorders Identification Test (AUDIT) suggest four “zones” of scores that indicate increasing levels of alcohol-related risk, with Zones III (scores 16–19) and IV (scores 20–40) suggestive of alcohol dependence (Babor and Higgins-Biddle, 2001). However, to our knowledge these zones have not been validated for improved management of primary care patients. Additionally, comparable risk zones for alcohol dependence have not been proposed using other alcohol screening questionnaires.

Most previous validation studies have evaluated alcohol screening questionnaires as dichotomous screening tests, with the sensitivity and specificity of the target disorder estimated for all scores above a specified screening threshold. In contrast, the present study evaluates ranges of screening scores (“risk zones”) to retain additional diagnostic information provided by the score. The likelihood ratio of a given risk zone incorporates the sensitivity and specificity and similarly provides a means for quantifying diagnostic capacity. Furthermore, likelihood ratios for each risk zone can be used to calculate the post-screening probability that a patient has alcohol dependence in clinical settings with varying overall prevalence rates of alcohol dependence.

The purpose of this study was to empirically identify scores on five commonly recommended alcohol screening tests that indicate a high likelihood of alcohol dependence for men and women. Specifically, we identified risk zones of alcohol screening scores that can help estimate the probability of past-year alcohol dependence among men and women who screen positive for alcohol misuse on the following alcohol screening questionnaires: the 10-item AUDIT (Babor et al., 2001), the 3-item AUDIT-C (Bush et al., 1998b), which consists of the alcohol consumption questions from the AUDIT, two single questions that assess the frequency of episodic heavy drinking, and the widely known CAGE questionnaire (Ewing, 1984), which was developed to identify alcohol use disorders rather than the spectrum of alcohol misuse. We further evaluated the likelihood ratios and post-screening probability of past-year alcohol dependence among men and women in each identified risk zone of each questionnaire, as well as in each of the AUDIT zones previously proposed by the WHO.

2. MEASURES AND METHODS

2.1 Study Population

This cross-sectional study used secondary data from a prospective validation study of alcohol screening tests. Study participants were patients with appointments at a family medicine clinic at the University of Texas in Galveston from October 1993 to December 1994. This study was approved by the Institutional Review Boards at Baylor College of Medicine and the University of Washington.

Patients were eligible if they were at least 18 years old, were scheduled to see randomly selected providers at randomly selected appointment times, and self-reported their ethnic/racial background as White, Black or Hispanic. Women and Black and Mexican-American patients were oversampled to achieve adequate sample sizes in each gender-racial group. Details of sampling procedures have been described previously (Volk et al., 1997). After their clinic appointments, participants completed an in-person diagnostic interview with one of four trained non-clinician research staff that included the Alcohol Experiences Module from the Alcohol Use Disorders and Associated Disabilities Interview Schedule (AUDADIS) (Grant and Hasin, 1992), followed by questions about history of alcohol treatment, questions about quantity and frequency of drinking in the past month, and the CAGE and AUDIT alcohol screening questionnaires. The interviewers did not compute scores on the AUDADIS or the screening tests during interviews. All study materials were translated into Spanish and checked by back-translation, and Spanish-speaking interviewers and materials were used with 30 participants (Volk et al., 1997).

2.2 Measures

2.2.1 Alcohol Dependence in the past year – Interview-based Comparison Standard—

The interview comparison standard for this study was alcohol dependence in the past year defined according to DSM-IV criteria. Past-year DSM-IV alcohol dependence was assessed with the AUDADIS, a structured diagnostic interview with demonstrated validity and reliability (Grant et al., 1995; Hasin et al., 1997), designed to be administered by non-clinicians.

2.2.2 Alcohol Screening Tests

Alcohol Use Disorders Identification Test (AUDIT): The full AUDIT is a widely-validated alcohol screening test consisting of 10 questions, including three about alcohol consumption and seven about alcohol-related problems. Each AUDIT question is scored from 0 to 4 points and summed for a total possible AUDIT score ranging from 0 to 40 points. The WHO (Babor and Higgins-Biddle, 2001), NIAAA (National Institute on Alcohol Abuse and Alcoholism et al., 2007) and USPSTF (Whitlock et al., 2004) recommend the AUDIT to screen for alcohol misuse in primary care.

Alcohol Use Disorders Identification Test – Consumption (AUDIT-C): The AUDIT-C consists of the three consumption questions from the AUDIT and scores range from 0 to 12 points. The AUDIT-C has been widely validated (Bradley et al., 2009) and is being used increasingly to screen for alcohol misuse in large health care systems (Bradley et al., 2006; Rose et al., 2008).

Potential Single-item Alcohol Screening Questions (SASQs): Validated SASQs that ask about the frequency or recency of binge drinking are increasingly recommended for routine alcohol screening because of their practicality (Bradley et al., 2009; National Institute on Alcohol Abuse and Alcoholism et al., 2007; Seale et al., 2006; Smith et al., 2009; Taj et al., 1998; Williams and Vinson, 2001). This study evaluated two potential SASQs that may perform similarly to validated SASQs. First, AUDIT question #3 (AUDIT Q#3) was evaluated alone. This question asks about the frequency of drinking ≥ 6 drinks on any occasion (scored 0–4, from never to daily/almost daily) and has performed relatively well among general outpatients (Bradley et al., 2003; Bradley et al., 2007; Bush et al., 1998a). Second, a question asking about the number of days that patients drank ≥ 5 drinks in the past month (scored 0–30 days) was also evaluated.

CAGE Questionnaire: The CAGE is a validated screening questionnaire for alcohol use disorders (Buchsbaum et al., 1991) that includes four questions about alcohol-related experiences ever in the patient's life. Each of the CAGE questions is scored 0 or 1 and summed for a total possible score ranging from 0 to 4 points.

2.3 Statistical Analysis

2.3.1 Overview of Stratum-Specific Likelihood Ratio (SSLR) Analysis—This study used stratum-specific likelihood ratios (SSLRs) (Dujardin et al., 1994; Furukawa et al., 2001; Grimes and Schulz, 2005; Peirce and Cornell, 1993; Simel, 1991) to identify and evaluate risk zones of the AUDIT, the AUDIT-C, two potential SASQs and the CAGE questionnaire for identifying patients who met diagnostic criteria for alcohol dependence. Stratum-specific likelihood ratios are ratios of two probabilities: the probability of a given screening result (i.e. range of scores) when alcohol dependence is present, divided by the probability of the same screening result when alcohol dependence is absent (Appendix A)[1]. SSLRs indicate the direction and magnitude of the change in the probability of alcohol dependence from before screening to after screening. A risk zone with an SSLR of 1, or with a confidence interval that includes 1, is considered an indeterminate stratum and indicates no change in probability. SSLRs > 1 indicate increased probability of alcohol dependence after screening, with higher SSLRs indicating greater increase, while SSLRs < 1 indicate decreased probability of alcohol dependence after screening, with smaller SSLRs indicating greater decrease. The SSLR of a patient's alcohol screening risk zone can be used along with the pre-screening probability (i.e. population prevalence) of alcohol dependence to derive his/her post-screening probability of alcohol dependence (Appendix A).

2.3.2 Derivation of Risk Zones for each Alcohol Screening Test—Due to gender differences in the performance of alcohol screening tests (Bradley et al., 2007), all analyses were stratified by gender.

Screening scores were collapsed into strata to provide reliable estimates of increasing risk of alcohol dependence across progressive risk zones. Rules for determining the optimum numbers of risk zones followed guidelines by Peirce and Cornell (Peirce and Cornell, 1993). First, each possible score for each screening questionnaire was compared with the interview comparison

[1]Appendix A is available with the online version of this paper at doi:xxx/j.drugalcdep.xxx …

standard of past-year alcohol dependence to calculate score-specific SSLRs. Scores that did not include patients with and without alcohol dependence were combined with the closest score to permit calculation of a SSLR. Finally, when SSLRs were not monotonically related (i.e. increasing order not preserved across risk zones) or when the 95% confidence interval of a SSLR included an adjacent SSLR, adjacent scores were combined two at a time until optimal risk zones were achieved. SSLRs and 95% confidence intervals were computed using a Microsoft Excel spreadsheet developed by Peirce and Cornell (Peirce and Cornell, 1993).

Receiver operating characteristic (ROC) curves were computed to quantify the ability of the risk zones of each alcohol screening test to discriminate between patients with and without past-year alcohol dependence. ROC curves were also computed for all possible scores of each screening test and areas under the curve (AuROCs) compared using chi-square tests of equality in order to estimate how much information was lost by collapsing scores into risk zones. AuROCs for screening test risk zones and for all possible scores were also compared between men and women, using z-tests for equality of independent ROC curves. AuROCs and corresponding standard errors and 95% confidence intervals were generated by a nonparametric method (DeLong et al., 1988). An AuROC of 1 indicates a perfectly accurate test while an area of 0.5 indicates a test that provides no information beyond chance. All ROC analyses were performed using Stata SE-9 (StataCorp. 2005. Statistical Software: Release Special Edition 9.2. Stata Corporation, College Station, TX) and MedCalc Version 10.4.8 (MedCalc Software, Mariakerke, Belgium).

2.3.3 SSLRs and Post-screening Probability of Alcohol Dependence—SSLRs and 95% confidence intervals were determined for each identified risk zone of the AUDIT, the AUDIT-C, two potential SASQs and the CAGE in men and women. For the AUDIT, risk zones previously recommended by the WHO were also evaluated. Using the prevalence of dependence in the study population and the derived SSLRs, we report the post-screening probability of alcohol dependence for each risk zone of each screening test.

3. RESULTS

Of the 1,445 patients approached about participating in the study, 21 (1.5%) were not one of the racial/ethnic groups included in the study, 82 (5.7%) refused participation, 9 (0.6%) consented but later withdrew and 14 (1.0%) had incomplete alcohol screening data. The resulting study sample of patients (92.6% of those eligible) included 392 (29.7%) men and 927 (70.3%) women with mean ages of 46 and 42 years, respectively. The racial/ethnic distribution roughly mirrored that of the Galveston Island population and included roughly similar proportions of Whites, Blacks and Hispanics (Table 1). Among participants, 48 (12.2%) men and 54 (5.8%) women met criteria for DSM-IV alcohol dependence in the past year based on the interview comparison standard for this study.

3.1 Alcohol Screening Test Risk Zones and Distribution

Empirically identified risk zones for past-year alcohol dependence differed between men and women for all screening tests except the CAGE. AUDIT scores (0–40) were collapsed into 4 risk zones for men (scores 0–4, 5–10, 11–14, 15–40) and 6 for women (scores 0–1, 2, 3–4, 5–8, 9–12, 13–40). AUDIT-C scores (0–12) were collapsed into 5 risk zones for men (scores 0–2, 3–4, 5–6, 7–9, 10–12) and 6 for women (scores 0–1, 2, 3, 4–6, 7–9, 10–12), with the two highest zones the same for both. Scores for AUDIT #3 (0–4) were collapsed into 3 risk zones for men (scores 0, 1–2, 3–4) but were not collapsed for women. Scores for the single question about days drank ≥ 5 drinks in the past month (0–30) were collapsed into 4 risk zones for men (0, 1–2, 3–10, 14–30 days) and 3 for women (0, 1–2, 3–30 days). CAGE scores (0–4) were collapsed into 3 risk zones – the same for men and women (scores 0, 1, 2–4).

Table 2 shows the distribution of patients across risk zones, including the empirically identified zones of each screening test (above) and the AUDIT zones recommended by the WHO. For all screening tests, the majority of men and women fell in the lowest risk zone and the proportion scoring in each zone generally decreased across progressive zones. Table 3 compares AuROCs for identifying past-year alcohol dependence between risk zones and all possible scores for the same screening test. The overall diagnostic ability of the AUDIT, AUDIT-C, potential SASQs and CAGE for identifying past-year alcohol dependence was not significantly reduced by collapsing all possible scores into empirically identified risk zones, in men or women. However, the AuROC for the WHO AUDIT Zones, which were not derived from this dataset, was significantly lower than the AuROC for all possible AUDIT scores, in men and women (p-values<0.0001; Table 3). There were no statistically significant differences in AuROCs between men and women for any of the screening test risk zones or for all possible scores of any screening test. However, there was a trend toward better overall diagnostic ability of the CAGE risk zones among men compared to women (p=0.0582), but when AuROCs for all possible scores of the CAGE were compared, the strength of this trend was reduced (p=0.0831).

3.2 Assessing Risk of Alcohol Dependence using Screening Test Risk Zones

SSLRs of risk zones for all screening tests are presented in Tables 4 (men) and 5 (women) along with post-screening odds and post-screening probabilities of past-year alcohol dependence. The latter are calculated based on the overall prevalence of past-year alcohol dependence in this sample.

WHO AUDIT Risk Zones—SSLRs could not be calculated for WHO AUDIT Zone 20–40 in men or Zone 16–19 in women because these zones included only alcohol-dependent patients. The highest calculable WHO AUDIT zone in men (16–19) and women (20–40) had large SSLRs that raised the post-screening probability of alcohol dependence to 73% and 88%, respectively (Tables 4–5). The intermediate WHO AUDIT zone (8–15) had SSLRs that raised the post-screening probability of dependence to 30% in men and 43% in women.

Empirically Identified AUDIT Risk Zones—The highest empirically identified AUDIT zone in men (15–40) and women (13–40) had SSLRs above 20, which resulted in high post-screening probabilities of alcohol dependence, 87% and 94% respectively (Tables 4–5). The second highest identified AUDIT zone in men (11–14) and women (9–12) resulted in intermediate post-screening probability, 43% and 45% respectively. The next highest zone in men and women increased the post-screening probability of alcohol dependence to a lesser extent (18% and 16%, respectively).

AUDIT-C Risk Zones—The highest AUDIT-C zone in men and women (10–12) had SSLRs above 20, which raised the post-screening probability of past-year alcohol dependence to 75% and 88%, respectively (Tables 4–5). The next highest zone for men and women (7–9) resulted in a post-screening probability of 45% in men and 42% in women, whereas the third highest zone increased the post-screening probability to a lesser extent, 22% in men and 24% in women.

Potential Single-item Alcohol Screening Question (SASQ) Risk Zones—For AUDIT #3 (frequency drink ≥ 6 drinks), the SSLR for the highest zone in men raised the post-screening probability of alcohol dependence to 58%, whereas the SSLR of the highest zone in women raised the post-screening probability to 88% (Tables 4–5). Conversely, the SASQ that asked about the number of days of drinking ≥ 5 drinks in the past month had SSLRs for the highest zone that resulted in a post-screening probability of 83% in men but only 38% in women (Tables 4–5).

CAGE Questionnaire Risk Zones—Results of SSLR analysis of the CAGE questionnaire were similar for men and women (Tables 4–5). The SSLRs for the highest CAGE zone (2–4) increased the post-screening probability of past-year alcohol dependence to only 30% in men and 34% in women.

4. DISCUSSION

This study shows the potential utility of using risk zones of alcohol screening tests to estimate the probability of current DSM-IV alcohol dependence among patients who screen positive for alcohol misuse. In this sample, probability of past-year alcohol dependence varied widely across alcohol screening risk zones above the threshold for alcohol misuse. Among men, at least 75% of those with AUDIT scores 15–40, with AUDIT-C scores 10–12, or who reported 14–30 days of drinking 5 or more drinks in the past month met standardized interview criteria for past-year alcohol dependence. Among women, over 85% of those with AUDIT scores 13–40, with AUDIT-C scores 10–12, or who reported drinking ≥ 6 drinks daily or almost daily met criteria for alcohol dependence. Among men and women with scores in the next highest risk zone on these screening tests, 40–50% met criteria for past-year alcohol dependence, whereas only 16–27% of patients in the third highest risk zone met criteria for alcohol dependence. Risk zones of the CAGE questionnaire were less useful for identifying men and women with a high probability of having past-year alcohol dependence. Similarly, AUDIT #3 (frequency of drinking ≥ 6 drinks) was less efficient for risk stratifying men with respect to their likelihood of alcohol dependence, and the question about days drinking ≥ 5 drinks was less efficient for risk stratifying women.

To our knowledge, this is the first study to empirically identify optimal risk zones of scores from recommended alcohol screening tests to risk stratify primary care patients based on their likelihood of having past-year alcohol dependence. Previous studies have used SSLR analysis to evaluate risk zones of the AUDIT and the CAGE for detecting alcohol use disorders (Buchsbaum et al., 1991; Chen et al., 2005), and another study recommended a 2-item secondary assessment instrument for detecting alcohol use disorders among those who screen positive for alcohol misuse (Vinson et al., 2007). In the present study, we focused on alcohol dependence because there is widespread consensus that patients with alcohol dependence should be offered referral to addictions specialists and appropriate medications, but such patients receive recommended care only about 10 percent of the time (McGlynn et al., 2003).

The SSLRs derived in this study can be applied to health care settings with varying prevalence of alcohol dependence and patient case mix, given that likelihood ratios are independent of prevalence and less subject to spectrum bias compared to a dichotomous threshold approach (Furukawa et al., 2001). Thus, the findings of this study have several potential clinical applications. Although most clinicians would be unlikely to use nomograms (Fagan, 1975) to derive multilevel post-screening probabilities of alcohol dependence based on risk zones, they might learn the probabilities of alcohol dependence associated with the highest zones in their setting for one alcohol screening questionnaire. Alternatively, in systems with routine alcohol screening integrated into care using electronic medical records (EMR), such as the Veterans Affairs (VA) healthcare system, the post-screening probability of alcohol dependence based on the SSLRs derived in this study could be provided to clinicians in the EMR at the time of screening, and might be useful for identifying patients in need of intensive intervention or further diagnostic evaluation. This information could then also be used in communicating risk to patients, as in “Over three quarters of patients with your score will have alcohol dependence,” or “Your alcohol screening score suggests that you have a 50/50 chance of having alcohol dependence,” followed by “Patients with alcohol dependence can benefit from medications or specialized treatment. Would you be willing to be assessed further by a specialist?” It is important to note, however, that if patients who score in lower risk zones are ignored due to

low probability of alcohol dependence, a substantial number of alcohol dependent patients (in absolute terms) may be missed because most patients have lower alcohol screening scores. For example, men who score in the highest AUDIT-C zone (scores 10–12) have a high probability of having alcohol dependence (75%) but only 25% of all alcohol dependent patients fall in this risk zone. Further, men who screen positive for alcohol misuse with an AUDIT-C score of 5–6 have a much lower overall probability of alcohol dependence (22%), but because many more patients score in this lower zone, the absolute number of alcohol dependent patients is similar to that in the highest zone (n=11 vs. n=12). Nonetheless, identifying and offering recommend care to alcohol dependent patients who fall in the highest risk zones would be a substantial improvement for most health care providers (McGlynn et al., 2003). Additionally, patients with lower scores who fail to resolve their alcohol misuse in response to brief intervention could subsequently be assessed for alcohol dependence.

This study has several limitations. Although to our knowledge this study was the largest U.S. study of alcohol screening tests in a primary care sample, relatively small numbers of patients with scores in the highest zones resulted in SSLR estimates with wide confidence limits. Furthermore, because of small numbers of men and especially women with some screening scores, the identification of the optimal zones remained somewhat subjective after following recommended guidelines. The finding of this study that the zones of the two potential SASQs appear to perform differently for stratifying men and women with respect to likelihood of past-year alcohol dependence was unexpected and likely reflects imprecision in the zones identified, due to small numbers of patients with higher scores. Following guidelines to derive the optimal number of risk zones (Peirce and Cornell, 1993), scores of AUDIT Q#3 were collapsed further among men than women, with drinking ≥ 6 drinks weekly and daily combined in men but not women. Conversely, scores of the question about days of drinking ≥ 5 drinks in the past month were collapsed further among women than men, with the highest zone ranging from three times per month to daily in women, but from twice weekly to daily in men. Not surprisingly, when the highest risk zones included wide-ranges of scores, post-screening probabilities of past-year alcohol dependence were lower. Additionally, because the SSLRs were derived from and applied to the same sample, results should be cross-validated in another sample. Generalizability may be somewhat limited because the sample included patients from a single academic family medicine clinic in Galveston, Texas. As expected, the prevalence of DSM-IV past-year alcohol dependence in this sample (7.7%) is considerably higher than that found in the general population (4.4%, (Grant BF et al., 1994)), but is consistent with other primary care settings (Fleming et al., 2004; Smith et al., 2009). Finally, alcohol screening was conducted by researchers rather than clinical practitioners, patients were assured that providers would not see the results of the screening, and the screening tests were administered following the diagnostic interview, all of which could have affected screening responses. For example, studies have demonstrated that earlier questions about drinking patterns and alcohol-related problems elicit higher levels of endorsement compared to later questions (Bischof et al., 2005; Harford TC, 1994; Steinweg DL and Worth H, 1993). Therefore, because the screening tests were administered after an extensive diagnostic interview, it is possible that screening scores were attenuated and the prevalence of past-year alcohol dependence overestimated at all scores of the screening measures.

This study also has important strengths. The random sampling and high recruitment rate (92.6%) minimized bias in the study sample. Additionally, because this study oversampled women, we were able to conduct SSLR analysis separately in men and women. This study also included five diverse alcohol screening tests, permitting comparison of the utility of their screening scores for estimating the probability of alcohol dependence. Finally, the AUDADIS diagnostic interview used to ascertain DSM-IV alcohol dependence in the past year has proven reliability and validity.

In summary, in this large ethnically diverse U.S. primary care sample, scores on the AUDIT or AUDIT-C could be used to risk stratify patients based on their likelihood of having past-year alcohol dependence. AUDIT scores 15–40 in men and 13–40 in women were associated with post-screening probabilities of past-year alcohol dependence of 87% and 94%, respectively. AUDIT-C scores 10–12 in men and women were associated with post-screening probabilities of past-year alcohol dependence of 75% and 88%, respectively. Patients who score in these highest risk zones may benefit from immediate assessment for alcohol dependence, referral to addictions treatment and/or medications for alcohol dependence. The second highest empirically derived risk zone on these screening tests identified men and women with nearly a 50% probability of having past-year alcohol dependence who may also benefit from further assessment, or diligent follow-up after brief intervention to identify those who do not respond with reduced alcohol consumption.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Study Sample of Outpatients from a Family Medicine Clinic (N=1,319)

	MEN		WOMEN	
	N[a]	(%)	N[a]	(%)
Total	392	(100)	927	(100)
Age (years)				
18–29	71	(18.1)	240	(25.9)
30–44	123	(31.4)	317	(34.2)
45–64	126	(32.1)	282	(30.4)
65+	72	(18.4)	88	(9.5)
Race/Ethnicity				
White	163	(41.6)	339	(36.6)
Black	125	(31.9)	332	(35.8)
Hispanic	98	(25.0)	235	(25.3)
Mixed	6	(1.5)	21	(2.3)
Marital status				
Married	246	(62.8)	418	(45.1)
Not married	146	(37.2)	509	(54.9)
Education				
High school or less	177	(45.4)	389	(42.0)
Some college/vocational	133	(34.1)	418	(45.1)
College graduate	80	(20.5)	120	(12.9)
Income				
< $20,000	173	(44.8)	526	(57.4)
≥$20,000	213	(55.2)	391	(42.6)
Interview reference standard: AUDADIS[b]				
Alcohol misuse[c] in the past year	128	(32.7)	177	(19.1)
DSM-IV[d] alcohol dependence in the past year	48	(12.2)	54	(5.8)

[a] Numbers may not add to total due to missing values.

[b] AUDADIS: Alcohol Use Disorder and Associated Disabilities Interview Schedule

[c] Alcohol Misuse: alcohol use disorder and/or drinking above recommended limits (≥ 3 drinks daily for men or ≥ 2 for women, and ≥ 5 drinks on an occasion for men or ≥ 4 for women)

[d] DSM-IV: Diagnostic and Statistical Manual, 4th edition

Table 2

Distribution of Patients across Alcohol Screening Score Risk Zones

MEN			WOMEN		
Zones	**N**	**(%)**	**Zones**	**N**	**(%)**
Total	392	(100)	Total	927	(100)
WHO AUDIT			*WHO AUDIT*		
0	89	(22.7)	0	320	(34.5)
1–7	220	(56.1)	1–7	547	(59.0)
8–15	63	(16.1)	8–15	46	(5.0)
16–19	11	(2.8)	16–19	6	(0.7)
20–40	9	(2.3)	20–40	8	(0.9)
Empirically Identified AUDIT			*Empirically Identified AUDIT*		
0–4	261	(66.6)	0–1	569	(61.4)
5–10	85	(21.7)	2	118	(12.7)
11–14	23	(5.9)	3–4	111	(12.0)
15–40	23	(5.9)	5–8	79	(8.5)
			9–12	33	(3.6)
			13–40	17	(1.8)
AUDIT-C			*AUDIT-C*		
0–2	218	(55.6)	0–1	607	(65.5)
3–4	70	(17.9)	2	120	(12.9)
5–6	50	(12.8)	3	70	(7.6)
7–9	38	(9.7)	4–6	96	(10.4)
10–12	16	(4.1)	7–9	26	(2.8)
			10–12	8	(0.9)
Frequency drink ≥6			*Frequency drink ≥ 6*		
0	238	(60.7)	0	758	(81.8)
1–2	109	(27.8)	1	110	(11.9)
3–4	45	(11.5)	2	33	(3.6)
			3	18	(1.9)
			4	8	(0.9)

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MEN			WOMEN		
Zones	**N**	**(%)**	**Zones**	**N**	**(%)**
Days drink ≥ 5, past month[a]			*Days drink ≥ 5, past month*		
0	289	(73.7)	0	806	(87.0)
1–2	53	(13.5)	1–2	69	(7.4)
3–10	38	(9.7)	3–30	52	(5.6)
14–30	12	(3.1)			
CAGE Questionnaire			*CAGE Questionnaire*		
0	206	(52.6)	0	725	(78.2)
1	81	(20.7)	1	106	(11.4)
2–4	105	(26.8)	2–4	96	(10.4)

[a] No men reported 11–13 days of drinking in the past month.

Table 3

Comparison of AuROCs[a] for Total Scores and Risk Zones

	AuROCs 95% CI
MEN	
AUDIT (all possible scores)	0.93 (0.89, 0.96)
WHO AUDIT Zones (plus 0)	0.86 (0.81, 0.91)*
Identified AUDIT Zones	0.91 (0.86, 0.95)
AUDIT-C (all possible scores)	0.90 (0.86, 0.94)
AUDIT-C Zones	0.89 (0.84, 0.94)
Frequency drink ≥ 6 (all possible scores)	0.84 (0.78, 0.90)
Frequency drink ≥ 6 Zones	0.84 (0.78, 0.90)
Days drink ≥ 5, past month (all possible scores)	0.81 (0.74, 0.88)
Days drink ≥ 5, past month Zones	0.81 (0.74, 0.88)
CAGE (all possible scores)	0.79 (0.73, 0.85)
CAGE Zones	0.78 (0.72, 0.84)
WOMEN	
AUDIT (all possible scores)	0.94 (0.91, 0.97)
WHO AUDIT Zones (plus 0)	0.86 (0.82, 0.91)*
Identified AUDIT Zones	0.94 (0.91, 0.97)
AUDIT-C (all possible scores)	0.91 (0.86, 0.95)
AUDIT-C Zones	0.90 (0.85, 0.94)
Frequency drink ≥ 6 (all possible scores)	0.83 (0.77, 0.89)
Frequency drink ≥ 6 Zones	0.83 (0.77, 0.89)
Days drink ≥ 5, past month (all possible scores)	0.76 (0.69, 0.83)
Days drink ≥ 5, past month Zones	0.76 (0.69, 0.83)
CAGE (all possible scores)	0.86 (0.81, 0.91)
CAGE Zones	0.86 (0.81, 0.91)

[a] AuROC: Area under the Receiver Operating Characteristic (ROC) curve

* p-value < 0.0001,

compared to all possible scores on the same screen

Table 4

Risk Zones for Men: SSLRs & Posttest Odds & Probabilities of Alcohol Dependence

	Dependence				Post-screening	
MEN - Zones	**Yes**	**No**	**SSLR**	**(95% CI)**	**Odds**	**Probability**
Total	*48*	*344*				
WHO AUDIT						
1–7	12	208	0.41	(0.25, 0.67)	0.06	0.05
8–15	19	44	3.09	(1.99, 4.80)	0.43	0.30
16–19	8	3	19.11	(5.71, 63.96)	2.67	0.73
20–40	9	0	--	--	--	--
Empirically Identified						
AUDIT						
0–4	3	258	0.08	(0.03, 0.23)	0.01	0.01
5–10	15	70	1.54	(0.97, 2.43)	0.21	0.18
11–14	10	13	5.51	(2.61, 11.65)	0.77	0.43
15–40	20	3	47.78	(16.02, 142.53)	6.67	0.87
AUDIT-C						
0–2	2	216	0.07	(0.02, 0.22)	0.01	0.01
3–4	6	64	0.67	(0.32, 1.42)	0.09	0.09
5–6	11	39	2.02	(1.13, 3.62)	0.28	0.22
7–9	17	21	5.80	(3.33, 10.10)	0.81	0.45
10–12	12	4	21.50	(7.64, 60.51)	3.00	0.75
Frequency drink ≥ 6						
0	6	232	0.19	(0.09, 0.38)	0.03	0.03
1–2	16	93	1.23	(0.80, 1.89)	0.17	0.15
3–4	26	19	9.81	(5.94, 16.20)	1.37	0.58
Days drink ≥ 5, past month						
0	12	277	0.31	(0.19, 0.50)	0.04	0.04
1–2	10	43	1.67	(0.91, 3.05)	0.23	0.19
3–10	16	22	5.21	(2.98, 9.12)	0.73	0.42
14–30	10	2	35.83	(9.33, 137.69)	5.00	0.83
CAGE						

	Dependence				Post-screening	
MEN - Zones	Yes	No	SSLR	(95% CI)	Odds	Probability
0	5	201	0.18	(0.08, 0.39)	0.02	0.02
1	11	70	1.13	(0.65, 1.94)	0.16	0.14
2–4	32	73	3.14	(2.37, 4.17)	0.44	0.30

Table 5

Risk Zones for Women: SSLRs & Posttest Odds & Probabilities of Alcohol Dependence

	Dependence				Post-screening	
WOMEN – Zones	**Yes**	**No**	**SSLR**	**(95% CI)**	**Odds**	**Probability**
Total	*54*	*873*				
WHO AUDIT						
1–7	21	526	0.65	(0.46, 0.90)	0.04	0.04
8–15	20	26	12.44	(7.49, 20.66)	0.77	0.43
16–19	6	0	--	--	--	--
20–40	7	1	113.17	(20.03, 639.35)	7.00	0.88
Empirically Identified AUDIT						
0–1	1	568	0.03	(0.01, 0.14)	0.00	0.00
2	2	116	0.28	(0.08, 0.95)	0.02	0.02
3–4	7	104	1.09	(0.55, 2.17)	0.07	0.06
5–8	13	66	3.18	(1.90, 5.34)	0.20	0.16
9–12	15	18	13.47	(7.27, 24.97)	0.83	0.45
13–40	16	1	258.67	(49.73, 1345.45)	16.00	0.94
AUDIT-C						
0–1	4	603	0.11	(0.04, 0.26)	0.01	0.01
2	3	117	0.41	(0.15, 1.16)	0.03	0.03
3	6	64	1.52	(0.71, 3.24)	0.09	0.09
4–6	23	73	5.09	(3.50, 7.41)	0.32	0.24
7–9	11	15	11.86	(5.82, 24.16)	0.73	0.42
10–12	7	1	113.17	(20.03, 639.35)	7.00	0.88
Frequency drink ≥ 6						
0	13	745	0.28	(0.18, 0.45)	0.02	0.02
1	16	94	2.75	(1.76, 4.30)	0.17	0.15
2	9	24	6.06	(3.02, 12.18)	0.38	0.27
3	9	9	16.17	(6.86, 38.08)	1.00	0.50
4	7	1	113.17	(20.03, 639.35)	7.00	0.88
Days drink ≥ 5, past month						

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	Dependence				Post-screening	
WOMEN – Zones	**Yes**	**No**	**SSLR**	**(95% CI)**	**Odds**	**Probability**
0	21	785	0.43	(0.31, 0.60)	0.03	0.03
1–2	13	56	3.75	(2.22, 6.36)	0.23	0.19
3–30	20	32	10.10	(6.25, 16.33)	0.63	0.38
CAGE						
0	8	717	0.18	(0.10, 0.33)	0.01	0.01
1	13	93	2.26	(1.37, 3.73)	0.14	0.12
2–4	33	63	8.47	(6.17, 11.62)	0.52	0.34