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Optimizing the Use of the AUDIT for Alcohol Screening in College Students

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Abstract

The screening and brief intervention (SBI) modality of treatment for at-risk college drinking is becoming increasingly popular. A key to effective implementation is use of validated screening tools. While the Alcohol Use Disorder Identification Test (AUDIT) has been validated in adult samples and is often used with college students, research has not yet established optimal cut-off scores to screen for at-risk drinking. A total of 401 current drinkers completed computerized assessments of demographics, family history of alcohol use disorders, alcohol use history, alcohol-related problems, and general health. Of the 401 drinkers, 207 met criteria for at-risk drinking. Receiver-operating characteristic (ROC) curve analysis revealed that the AUROC of the AUDIT was 0.86 (95% CI = 0.83-0.90). The AUDIT-C (AUROC = 0.89, 95% CI = 0.86--.92) performed significantly better than the AUDIT in the detection of at-risk drinking in the whole sample, and specifically for females. Gender differences emerged in the optimal cut-off scores for the AUDIT-C. A total score of 7 should be used for males and a score of 5 should be used for females. These empirical guidelines may enhance identification of at-risk drinkers in college settings.

Keywords

alcohol screening; at-risk drinking; gender; college drinking; ROC

Optimizing the Use of the AUDIT for Alcohol Screening in College Students

Excessive rates of alcohol consumption on college campuses continue to pose a public health challenge. Approximately 70% of college students report alcohol use in the past month (O'Malley & Johnston, 2002). Heavy episodic drinking, defined as five or more drinks on one occasion for a male and four or more drinks on one occasion for a female, is commonplace. Nearly half of all college students reporting at least one heavy drinking episode in the past two weeks or month (Substance Abuse and Mental Health Services Administration [SAMHSA], 2006; Wechsler et al., 2002). Importantly, it is these heavy drinking episodes that are linked with alcohol consequences (e.g., Park, 2004). In college samples, heavy drinking episodes (sometimes referred to as binge episodes) are related to academic, relational, and legal problems (Park, 2004), as well as physical injury and unprotected sex (Hingson, Zha, & Weitzman, 2009).

Despite these high rates of heavy alcohol use, college students often do not seek specialty treatment for alcohol problems. Results from the National Epidemiologic Study on Alcohol

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and Related Conditions (NESARC) revealed that though the risk of alcohol use disorders was greater for college students than for their non-college attending peers, college students were significantly less likely to have received treatment (e.g. visited a physician, psychologist or other professional; were seen in an inpatient unit, detoxification facility, emergency department; received treatment by a paraprofessional) in the past year (Blanco et al., 2008). This indicates that alcohol harm reduction services designed for college students should not rely on self-identification.

Implementation of screening and brief intervention (SBI) models can increase case identification and access to treatment for those who are unlikely to seek out specialty health care. In 1990, the Institute of Medicine recommended more widespread use of SBI to prevent alcohol-related problems, especially for those who experience mild to moderate harms related to alcohol. Because college students often report negative psychosocial consequences without severe dependence, this intervention model appears particularly well-suited for the college population. The utility of the SBI approach is, however, predicated upon the criterion validity of the interpretability of scores on the screening measure.

Screening tools serve as the gateway to intervention, and as such, their ability to correctly classify individuals as at-risk or not-at-risk is crucial. A recent review concluded that the Alcohol Use Disorders Identification Test (AUDIT: Saunders, Aasland, Babor, & de la Fuente, 1993) is an effective screening tool for the range of alcohol problems with adults across a variety of clinical settings (Reinart & Allen, 2007). The use of the AUDIT to screen for at-risk college drinkers has begun more recently. Evidence suggests that the AUDIT is a promising tool for use with young adults (e.g., Cook, Chung, Kelly, & Clark, 2005). Research is inconclusive, however, about which cut-off scores best identify at-risk college drinkers.

To date, only two studies have specifically examined the AUDIT for screening at-risk drinking, though neither sought to determine whether gender-specific cut-off scores would improve the criterion validity of the interpretability of scores on the AUDIT (Kokotailo et al., 2004; Adewuya, 2005). Each used a different at-risk criterion measure and had a different sample nationality. Overall, sensitivity in the detection of at-risk drinking refers to the proportion of actual at-risk drinkers who are identified as being at-risk, whereas specificity refers to the proportion of not-at-risk drinkers who are identified as not-at-risk. Kokotailo and colleagues used the National Institute for Alcohol Abuse and Alcoholism (NIAAA) gender-specific definition for high-risk drinking and a sample of American college students. At an AUDIT score of 8, the AUDIT had a sensitivity of 0.82 and a specificity of 0.78 for detecting high-risk drinking (Kokotailo et al., 2004). A cutoff of 6 points or higher on the AUDIT improved detection of at-risk drinkers, with a sensitivity score of 0.91 and a lower specificity of 0.60. The study suggested that scores between 6 and 8 points were optimal (Kokotailo et al., 2004). The second study operationalized at-risk drinking with the World Health Organization (WHO) recommendations (e.g. weekly consumption of 280g for men and 168g for women and/or fulfillment of hazardous drinking criteria (WHO, 2000)) and used a sample of Nigerian university students (Adewuya, 2005). The results indicated that the AUDIT had an area under the receiver operating characteristic curve (AUC) value of 0.933 for hazardous use. A cut-off score of 5 was recommended for screening hazardous alcohol consumption. At a score of 5, sensitivity equaled 0.935 and specificity equaled 0.915 (Adewuya, 2005). Thus, despite the compelling case for the need to identify at-risk college students who are not seeking treatment, there is little research-based guidance for how to best use the AUDIT with this population.

Only one study has examined the use of the AUDIT-C (the first three consumption items of the AUDIT (Cf. Bush, Kivlahan, McDonnell, Fihn, & Bradley, 1998)) with a college-aged sample (Kelly, Donovan, Chung, Bukstein, & Cornelius, 2009). The AUDIT-C performed best with cut-off scores of 6 for males and 5 for females in the prediction of a single, dichotomous indicator of lifetime DSM-IV alcohol use diagnosis (Kelly et al., 2009). Because the full-scale AUDIT was not administered, no direct comparison could be made between two measures. Prediction of sub-diagnostic at-risk drinking was not reported in this study.

Given that the primary goal of the AUDIT is to identify at-risk drinkers in non-treatment seekers, the lack of clear guidelines for use with college students limits effective use with this population. The current study sought to fill the notable gaps regarding the use of the AUDIT with college students, addressing four goals.

First, we sought to determine the criterion validity of AUDIT score interpretability in a college sample using a criterion measure of at-risk drinking and to provide an AUDIT cut-off score for screening at-risk alcohol consumption patterns. At-risk consumption was defined with gender-specific criteria based on modified NIAAA criteria for hazardous drinking. At-risk drinking is defined both by typical weekly consumption and single-day consumption. In a typical week, males who drink at least 14 drinks and females who drink at least 7 drinks are considered at-risk drinkers (NIAAA, 2007). In a single day, males who consume at least 5 drinks and females who consume at least 4 drinks are considered at-risk (NIAAA, 2007; Wechsler et al., 2002). However, given the high rate of *any* binge drinking in college samples, this study uses the same definition of at-risk heavy drinking that was employed in the study by Kokotailo and colleagues (2004): at-risk heavy drinking is defined as having at least 4 heavy drinking days in the past month. Thus for this study, males were considered at-risk drinkers if they consumed 14 or more drinks in a typical week or reported at least 4 heavy drinking episodes in the past month. Females were considered at-risk drinkers if they consume 7 or more drinks in a typical week or reported at least 4 heavy drinking episodes in the past month.

Second, we sought to determine the criterion validity of AUDIT-C score interpretability for the detection of at-risk drinking in a college sample and to provide an AUDIT-C cut-off score for screening at-risk alcohol consumption patterns. Third, we sought to compare the AUDIT and the AUDIT-C as predictors of at-risk status in the whole sample using ROC/AUC analysis. Lastly, we sought to compare the AUDIT and the AUDIT-C as predictors of at-risk drinking separately for males and females using ROC/AUC analysis. For each gender, we sought to provide specific cut-off scores for the measure that was determined to best detect at-risk drinking.

Method

Participants

Participants aged 18-25 were recruited from the psychology subject pool at northeastern university. Recruitment took place during the Spring 2010 semester, and 443 participants completed the assessments. Only current drinkers (N = 405) were included in the data analysis. A current drinker was defined as having consumed at least one drink in the past year. Based on this criterion, 38 participants (10 males; 28 females) were identified as non-drinkers and removed from the sample. Additionally, a total of 4 participants were removed from the sample because their age exceeded the target range (n = 3) or for inconsistent data reporting (n = 1). The final sample included 401 participants.

Procedure

Participants completed assessments in an on-campus computer lab and provided written consent to complete the study. Participants completed assessments in small group sessions of between ten and fifteen participants, and each participant completed all questionnaires on a personal computer. Surveys were identified only by randomly generated identification number. All data were collected anonymously.

Measures

Demographics—Participants provided information regarding age, gender, year in college, race/ethnicity and weight. Family history of alcoholism was assessed with twelve questions from National Epidemiologic Survey on Alcohol and Related Conditions (NESARC; NIAAA 2006). These questions allowed classification of the type of relative with a positive family history into first-degree blood relatives (i.e. biological parents and full siblings) and second-degree blood relatives (i.e. biological grandparents).

Alcohol Use Patterns—For all assessments, a standard drink was defined as a 12 oz. beer; 5 oz. glass of wine; or 1.5 oz. shot of hard liquor either straight or in a mixed drink, all equivalent to approximately .6 oz or 14 grams of pure alcohol (NIAAA, 2010). Measures covered the month prior to and including the day of the assessment. The Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985) used a 7-day grid to assess drinking during a typical week and average drinks per drinking day in the month before the assessment. To establish the number of drinks participants consumed in a typical week, the total number of drinks reported on the 7-day grid was summed. Per the NIAAA definition, males who consumed at least 14 drinks in a typical week and females who consumed at least 7 drinks in a typical week were considered at-risk drinkers. Participants also reported heavy drinking history (defined as consumption of 5 or more drinks in a single occasion by a male and consumption of 4 or more drinks in a single occasion by a female) in the past month (Wechsler, Lee, Kuo, & Lee, 2000b). This information was also used to determine at-risk drinker status. Males and females who reported at least 4 heavy drinking episodes were considered at-risk drinkers. A 7-day grid was used to assess the heaviest week of drinking in the month prior to the assessment; this was used for sample description only. Participants also reported lifetime drinker status. Typical blood alcohol content (BAC) was calculated based on self-reported answers to questions regarding a typical drinking day. Typical BAC was calculated with the following formula: BAC – ([number of drinks/2][gender constant/weight]) – (hours of consumption $*$ 0.016), where the gender constant equals 7.5 for men and 9.0 for women (Matthews & Miller, 1979). Peak BAC was calculated with the same formula using information from questions regarding each participant's heaviest drinking day in the past month.

Alcohol Use Disorders Identification Test (AUDIT: Saunders et al., 1993)—The AUDIT is a 10-item self-administered screening instrument for hazardous and harmful alcohol consumption. It covers the areas of alcohol consumption, drinking behavior, and alcohol-related problems. Responses to each item are scored from 0 to 4, yielding a maximum possible score of 40. The AUDIT-C, or the AUDIT-Consumption, consists of the first three items of the full-scale AUDIT (Bush et al., 1998). The questions assess frequency of drinking, typical drinks consumed on a drinking day, and frequency of heavy drinking. As with all other questions on the AUDIT, responses to each item are scored from 0 to 4, yielding a maximum possible score on the AUDIT-C of 12.

Brief Young Adult Alcohol Consequences Questionnaire (BYAACQ; Kahler, Strong, & Read, 2005)—The BYAACQ is a 24-item self-administered measure to assess problems resulting from drinking. It includes items geared specifically for a collegiate population, including driving while intoxicated and unplanned sexual activity. Participants indicated whether they had or not had experienced each alcohol-related problem on the list in the 30 days prior to the day of assessment. The total number of endorsed items was summed to create a total score. Coefficient alpha for the current sample was 0.86.

Drug Use—Participants provided information about current and past levels of illicit drug use, as well as current health status. Drug use history was assessed with a checklist of illicit drugs for the participants to indicate which they have used in their lifetimes and in the last 30 days.

Data Analytic Plan

Receiver operating characteristic (ROC) curve analysis was utilized to compare AUDIT scores with the reference standards of at-risk drinking (Cf. DeLong, DeLong, & Clarke-Pearson, 1988). For this study, ROC curves plotted sensitivity versus 1 – specificity for at-risk status. To determine the optimal cut-off score for the AUDIT, tables of sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV), as well as the likelihood ratios of a positive test (LR+) and of a negative test (LR−) were generated. The choice of a cut-off score ideally considers the prevalence of the condition in the screened population and the ratio of the net costs of treating patients with false-positive screening results to the net benefits of treating patients with true-positive results (Cantor, Sun, Tortolero-Luna, Richards-Kortum, & Follen, 1999). If no distinction is made between the importance of sensitivity and specificity, Youden's index (J) can determine an appropriate cut-off score:

$$\text{J}=\text{sensitivity}+\text{specificity}-1$$

J can achieve a maximum score of 1.00 if the test is perfect. If the test has no diagnostic predictability, J will be close to 0. For this study, Youden's index was used to calculate a cut-off score that can be applied for at-risk drinking.

ROC analysis also compared the AUDIT and the AUDIT-C as predictors of at-risk status (Cf. Hanley & McNeil, 1983; Obuchowski, 1997). AUC curves were plotted for the AUDIT and the AUDIT-C. A non-parametric Wald test was calculated to determine which better predicted at-risk status.

Finally, ROC analysis also compared the AUDIT and the AUDIT-C as predictors of at-risk status for males and females to determine if there was a significant difference in the ability of the two measures to detect at-risk status within each gender. For each gender, a non-parametric Wald test was calculated to determine which better predicted at-risk status. Tables of sensitivity, specificity, PPV, NPV, LR+, and LR− values were generated for males and females. As before, Youden's index was used to determine the gender-specific cut-off scores.

Results

Sample Characteristics

On average, participants were mostly female (54%, n = 217), freshmen (69%, n = 270), and Caucasian (64%, n = 255). The mean age of the sample was 19.04 (*SD* 1.13). The sample consisted primarily of students who were not in the Greek system (79%, n = 318). Demographic characteristics of this sample are consistent with past research conducted with similar samples at this university (Cf.; DeMartini & Carey, 2009; DeMartini, Carey, Lao, &

Luciano, 2011). A positive family history of alcoholism in at least one first-degree relative was reported by 21% of the sample (n = 85), and 44% of the sample reported a positive family history in at least one second-degree relative (n = 175). Overall, males and females did not differ significantly on any demographic variables.

Participants consumed an average of 10.71 (SD = 10.18) drinks in a typical week. This sample drank an average of 4.02 drinks per drinking day (SD = 3.18) and averaged 2.15 (SD = 1.28) drinking days in a typical week. Mean peak BAC was 0.148 (SD = 0.12) and mean AUDIT score was 8.40 (SD = 5.55). Participants averaged 3.75 binge episodes in the month prior to assessment (SD = 4.05) and reported 5.04 (SD = 4.33) alcohol-related problems in the last month.

Of the 401 participants in the sample, 207 (52%) of the sample met criteria for at-risk status. Of the 207 at-risk participants, 103 (50%) were males and 104 (50%) were females. Of the 184 males in the study, a total of 56% (n = 103) met at-risk criteria, and of the 217 females in the study, a total of 48% (n = 104) met at-risk criteria. As noted, participants could be classified as at-risk based on their typical weekly consumption and/or their total number of heavy drinking episodes in the past month. A total of 167 (42%) participants met criteria for at-risk weekly drinking and 172 (43%) met criteria for at-risk binge drinking. Of the 207 total participants who met criteria for at-risk status, 132 (64%) met at-risk criteria for both weekly drinking and binge drinking, 40 (19%) met criteria for only binge drinking, and 35 (17%) met criteria for only weekly drinking.

All measures of alcohol consumption were significantly different between the drinking groups defined by at-risk status (see Table 1). At-risk drinkers reported significantly more drinks in a typical week (t[395] = 19.27, $p < 0.001$), drinks in a typical drinking day (t[395] = 17.28, $p < 0.001$), binge episodes in the past 30 days (t[395] = 20.23, $p < 0.001$), and peak BAC (t[386] = 12.28, $p < 0.001$). The at-risk group had significantly higher AUDIT scores than the low-risk group (t[398] = 14.19, $p < 0.001$), higher BYAACQ scores (t[397] = 10.99, $p < 0.001$), higher frequency of cigarette use (t[398] = 4.61, $p < 0.001$), and more drugs used in their lifetime (t[399] = 7.95, $p < 0.001$) and in the past 30 days (t[399] = 6.88, $p < 0.001$).

We also compared male and female at-risk drinkers to examine differences in drinking patterns, smoking, and illicit drug use (see Table 2). At-risk male drinkers reported significantly more drinks per week (t[201] = 4.54, $p < 0.001$), drinks per drinking day (t[201] = 4.70, $p < 0.001$), total drinks in heaviest week of drinking (t[202] = 3.66, $p < 0.001$), and total alcohol-related problems (t[204] = 2.69, $p < 0.01$). Both AUDIT (t[204] = 3.09, $p < 0.01$) and AUDIT-C scores (t[201] = 5.00, $p < 0.001$) were higher in at-risk males, and they reported more frequent cigarette usage (t[204] = 3.74, $p < 0.001$) and more total lifetime drugs used (t[205] = 2.51, $p < 0.05$). There were no differences between at-risk males and females on drinking days in a typical week (p = 0.052), total heavy drinking episodes (p = 0.59), peak BAC (p = 0.06), and past 30 day illicit drug use (p = 0.06). At-risk females reported higher typical BACs than at-risk males (t[199] = -4.84, $p < 0.001$). Therefore though at-risk males reported higher rates of consumption and total problems, at-risk males and females reported equivalent rates of heavy drinking and peak BACs.

AUDIT ROC Analysis Results

Using the dichotomous variable for at-risk status, an ROC curve plotted sensitivity versus 1 – specificity for at-risk versus not at-risk drinkers on the full-scale AUDIT. The AUC value for the ROC curve was 0.86 (SE = 0.02), which was significantly greater than the chance value of 0.50 ($p < 0.001$). The 95% CI for the curve was 0.83-0.90. Thus, the AUDIT performed better than chance, and 0.86 can be interpreted as the probability that a person who has a positive at-risk status has a greater AUDIT test score than a person with a negative at-risk status.

Sensitivity and specificity data, LR+ and LR− values, PPV and NPV values, and Youden's Index values were examined to help determine the optimal cut-off score (table available from first author). PPV and NPV values were calculated based on the Bayes' Theorem for determining PPV and NPV values based on prevalence estimates from the current sample. For PPV, the equation is:

$$\text{PPV}=(\text{sensitivity}*\text{prevalence})/[\text{sensitivity}*\text{prevalence}+(1-\text{sensitivity})*(1-\text{prevalence})]$$

where prevalence in the current sample is equal to 0.5162 (207 at-risk participants/401 total participants). For NPV, the equation is:

$$\text{NPV}=(\text{specificity}*\text{prevalence})/[\text{specificity}*(1-\text{prevalence})+(1-\text{specificity})*\text{prevalence}]$$

where, again, the prevalence estimate for at-risk drinkers is equal to 0.5162.

Overall, AUDIT scores below 10 points had sensitivity values above 0.70, indicating high probability of a positive AUDIT for those with positive at-risk status. For AUDIT scores of 1-9, sensitivity values ranged from 0.9951 to 0.7184. An AUDIT score of 8 was associated with the highest Youden's Index value. At a score of 8, Youden's Index was equal to 0.60. At this same AUDIT score, the increase in odds favoring at-risk status (i.e., LR+) is 3.79. Also, a score of 8 is associated with equivalently high PPV and NPV (both > 0.82), suggesting a high probability that the AUDIT is identifying both true positives and true negatives at this cut score. Therefore, it is recommended that a score of 8 is best for the identification of at-risk drinkers using the full AUDIT.

AUDIT-C ROC Analysis Results

Using the dichotomous variable for at-risk status, an ROC curve plotted sensitivity versus 1 – specificity for at-risk versus not at-risk drinkers on the AUDIT-C. The AUC value for the ROC curve was 0.89 (*SE* = 0.02) and had a 95% confidence interval from 0.86-0.92. The AUDIT-C, therefore, performed better than chance and 0.89 is the probability that a person who has a positive at-risk status has a greater AUDIT-C score than a person with a negative at-risk status.

As in the prior analysis, sensitivity and specificity data, LR+ and LR− values, PPV and NPV values, and Youden's Index values were examined to help determine the optimal cut-off score, and PPV and NPV values were calculated (table available from first author). Overall, sensitivity values dropped below 0.70 at AUDIT-C scores above 7, and specificity values increased at AUDIT-C scores at or above 6. Youden's Index was at its peak value, 0.60, at an AUDIT-C score of 6. At this score, the increase in odds favoring at-risk status (LR+) is 4.40. Therefore, in the absence of additional information about the relative weighting of sensitivity or specificity, an AUDIT-C score of 6 should be used.

Comparison of the AUDIT and the AUDIT-C

As stated above, results indicate that the total AUC for the AUDIT-C was 0.89 (*SE* = 0.02; 95% CI: 0.86-0.92). Statistical comparison of this AUC value to the previously reported AUC value of 0.86 for the AUDIT revealed a significant difference in the area under the two curves ($\chi^2(1) = 4.10$, $p < 0.05$). The AUDIT-C performed better than the AUDIT in the detection of at-risk drinking.

Comparison of the AUDIT and the AUDIT-C by Gender

The last goal of the study was to compare the AUDIT and the AUDIT-C as predictors of at-risk drinking within each gender to determine which measure best detects at-risk drinking.

Females Only—Results indicate that the total AUC for the AUDIT was 0.86 (*SE* = 0.03), with a 95% confidence interval from 0.81 to 0.91. The AUDIT-C had a total AUC of 0.90 (*SE* = 0.02), with a 95% confidence interval from 0.87-0.94 (see Figure 1). Statistical comparison of these AUC values revealed a significant difference in the area under the two curves ($\chi^2(1) = 6.44$, $p < 0.05$). The AUDIT-C performed better than the AUDIT in the detection of at-risk drinking females.

Sensitivity, specificity, LR+ and LR− values and Youden's Index values were examined for females to determine the optimal cut-off score for the AUDIT-C (see Table 3; all values also provided for the AUDIT). The prevalence estimate for at-risk female drinkers is equal to 0.4793 (104 at-risk participants/217 total female participants). Overall, AUDIT-C scores below 6 had sensitivity values that were above 0.65, which indicates a high probability of a positive AUDIT-C for those females with a positive at-risk status (see Table 3). The highest Youden's Index (at a value of 0.64) occurred at an AUDIT-C score of 5. At the AUDIT-C score of 5, sensitivity was 0.82 and specificity was 0.82. The increase in odds favoring at-risk status was 4.61. For females, it is recommended that a score of 5 be used.

Males Only—Results indicate that the total AUC for the AUDIT was 0.87 (*SE* = 0.03), with a 95% confidence interval from 0.81 to 0.92. The AUDIT-C had a total AUC of 0.90 (*SE* = 0.02), with a 95% confidence interval from 0.85-0.94 (see Figure 2). Statistical comparison of these AUC values revealed no significant difference between the values ($\chi^2(1) = 1.91$, $p = 0.17$). The AUDIT and the AUDIT-C perform equally in the detection of at-risk drinking in male students.

Nonetheless, because the AUDIT-C may be preferred for both genders because of its efficiency, sensitivity, specificity, PPV, NPV, LR+, and LR− values and Youden's Index for the AUDIT and the AUDIT-C are presented for males (see Table 4). The prevalence estimate for at-risk male drinkers is equal to 0.5598 (103 at-risk participants/184 total male participants). Overall, the highest Youden's Index (at a value of 0.62) occurred at a total AUDIT score of 8. At a total score of 8, sensitivity was 0.89, specificity was 0.73, and the increase in odds favoring at-risk status in males is 3.29. It is recommended, based on Youden's Index, that an AUDIT score of 8 is best for the identification of at-risk male drinkers.

On the AUDIT-C, Youden's Index was optimized (at a value of 0.67) using an AUDIT-C score of 7. At a score of 7, sensitivity was 0.80 and specificity was 0.88. The increase in odds favoring at-risk status was 6.44. Therefore, it is recommended that an AUDIT-C score of 7 be used for screening at-risk drinking in male students.

Discussion

This research was designed, first, to determine the optimal cut-off scores for the AUDIT and the AUDIT-C when using them to screen for at-risk drinking in college and university settings, and to determine which screening measure was able to best predict at-risk status in the whole sample. The study also sought to determine which screening tool, the AUDIT or the AUDIT-C, best detected at-risk drinking in males and females. Three primary findings emerged. First, our results indicated that both the AUDIT and the AUDIT-C perform well in at-risk drinker detection. In the whole sample, however, the AUDIT-C performed significantly better than the AUDIT. Second, the AUDIT-C performs significantly better than the AUDIT when screening at-risk drinking in females. Third, the AUDIT and the AUDIT-C perform equivalently well when screening male students.

Consistent with the *a priori* hypothesis, the AUDIT performed well in the detection of at-risk drinking. A total score of 8 maximized Youden's Index. That score is consistent with the WHO recommendation for using the AUDIT with adult samples (Babor et al., 2001). At a total score of 8, the sensitivity of the AUDIT was 0.82 and specificity was 0.78. These numbers are consistent with the median levels of sensitivity and specificity seen in adult samples (Reinert & Allen, 2007). In the only previous study that examined the use of AUDIT to screen college high-risk drinking, at an AUDIT score of 8, sensitivity was 0.82 and specificity was 0.78 (Kokotailo et al., 2004). Lowering the cut-off score to 6 improved sensitivity to 0.91 and lowered specificity to 0.60. The current study also found that at a total score of 6, sensitivity improved to 0.91 and specificity was decreased to 0.62. Thus, this study represents the first replication of the results of the 2004 study (Kokotailo et al.), generalizing the findings to another university sample. Use of Youden's index as a method to determine the score at which the AUDIT optimally performs extends past results; our study confirms that a score of 8 is optimal for identifying at-risk drinking.

Also consistent with the *a priori* hypothesis, the AUDIT-C performed better than the AUDIT in detecting at-risk drinking in the whole sample. More specifically, the AUDIT-C performed significantly better than the AUDIT in detecting at-risk drinking in female drinkers, and the two measures performed equivalently for male at-risk drinkers. Practically therefore, the AUDIT-C should be used when both genders need to be assessed simultaneously, so as to reduce respondent assessment burden. Consistent with the conclusions of the 2007 review, gender-stratified cut-off scores yield the best screening results (Reinert & Allen, 2007). The results of this study diverged, however, from the recommended scores in the 2007 review, which focused on general adult samples. The present findings suggest that an AUDIT-C score of 7 should be used for males and a score of 5 should be used for females in college settings.

One possible explanation for why these results indicate that higher cut-off scores should be used relates to the methodology used in the past studies on the AUDIT-C. Of the 15 studies examined in the review, none used a college sample (Reinart & Allen, 2007). Numerous studies were conducted with international samples or participants with co-morbid mood or anxiety disorders. Risky drinking was also defined in numerous ways, including total grams of alcohol consumed (Rumpf, Hapke, Meyer, & John, 2002), a combination of total drinks per week and daily binge drinking (Dawson, Grant & Stinson, 2005a), or combining the categories of AUD diagnosis and at-risk drinking (Seale et al., 2006). No study used the at-risk drinking criteria recommended by NIAAA. These variations likely influence the recommended cut-off scores to be used with the AUDIT-C.

An additional explanation lies in the specific composition of this sample. Of the 401 participants in the study, a total of 270 (69%) were freshmen. Lifetime alcohol consumption often peaks during the late teens and early 20s (USDHHS, 1997). In one study, high-risk high school students significantly decreased their alcohol consumption over the course of their four years in college (Baer, Kivlahan, Blume, McKnight, & Marlatt, 2001). Alcohol use in the freshmen year of college also often exceeds classic binge definitions (McCabe, 2002). Thus, this sample likely had a higher prevalence of at-risk drinkers than a sample that is more equally distributed in terms of year in college. It also, therefore, is more likely to have a higher prevalence of at-risk drinkers than a sample drawn from the general adult population.

A final explanation lies in our use of Youden's Index as a tool for selecting cut-off scores. As noted, Youden's Index is designed to weigh equally sensitivity and specificity when no additional site-specific information is available. Each setting that would use the AUDIT or the AUDIT-C is likely to place different significance on the value of a false-positive or a false-negative. For example, given the high overall rate of at-risk drinkers in the college setting, a primary care setting may want to avoid false-positives so as to utilize best minimal resources. Other settings (e.g., using a web-screener to obtain incidence rates only) may be more motivated to avoid false negatives. Thus, our recommendations may differ from past work, because we placed equal value on sensitivity and specificity so as to provide the most easily interpretable results.

The results of this study should be considered in light of its limitations. The first limitation of the study involves the accuracy of self-report data. Carey and Hustad (2002) have reported that post hoc calculations of BACs are less accurate after subjects reach BACs over 0.08. A BAC of 0.08 is lower than the typical reported BAC of those meeting criteria for the at-risk group. It can be assumed that the reporting of the number of drinks, number of binge episodes, and other related variables included some inaccuracy, particularly for the at-risk drinkers. Overall, however, studies have generally supported the reliability and validity of self-report data on alcohol use in adults (e.g., Babor, Steinberg, Anton, & Del Boca, 2000). This is particularly true given that our screening was conducted with anonymous data collection. It is possible, however, that these results would differ if participants did not have assurances of anonymity, as would be the case in a clinical setting. Future research could investigate differences in the sensitivity and specificity of the AUDIT and the AUDIT-C across these settings.

An additional limitation concerns the generalizability of the sample. The sample consisted primarily of Caucasian, freshmen students. Little research has been conducted on the AUDIT or the AUDIT-C with ethnically diverse samples. Given that alcohol use prevalence rates vary by race, the PPV and NPV values should not be generalized to other racial or ethnic groups before the results of this study are replicated with other groups. Additionally, having a sample of mostly freshmen students could have artificially inflated the rates of drinking in sample and elevated the prevalence rates used to calculate PPV and NPV values. Thus, a heavier drinking sample might result in at-risk drinkers achieving higher AUDIT scores. This could have inflated the cut-off scores that were recommended to identify at-risk college drinkers.

Additional limitations of the study concern the structure of the assessments. The DDQ and other consumption assessments were collected during the same assessment session and with the same method (e.g. online assessment) as the AUDIT. As a clinician-administered interview is the gold-standard for psychological diagnosis, it is possible that participants would have provided more thorough information if consumption assessments had been conducted with in-person interviews. All participants also received the assessment questions in the same order. Demographics items were placed at the beginning of the assessment battery to help participants feel more comfortable with the computerized assessments, but it is possible that the order of assessments may have impacted the observed sensitivity and specificity in this study. Regarding specific assessments, although these variables were not the focus of our study, the overall rates of alcohol consequences and estimates of drug use could be underestimates, due to the use of a 30-day assessment window. Lastly, the response window of our consumption indices was the 30 days prior to the assessment. In contrast, the response window for the AUDIT was at the past year (per the standard instructions for use).

Given that these time-frames are not equivalent, it is possible that typical use in the past month is not representative of typical use in the past year. Given the high ROC levels found for the AUDIT and the AUDIT-C in screening at-risk drinking, this time-frame difference did not have a significant deleterious effect on the results.

In summary, our results provide the first evidence that the AUDIT-C performs better than the AUDIT in the detection of at-risk drinking by college students. Though the AUDIT performed well, as indicated by its high AUC value and high levels of sensitivity and specificity, the briefer AUDIT-C does a better job of identifying at-risk drinking, particularly in females. As a result, this research has practical implications for college alcohol screening. We also found strong support for the use of the AUDIT-C to screen for at-risk drinking in both male and female students. Cut-off scores of 5 for females and 7 for males should be utilized with the AUDIT-C. Additional research is needed to determine the feasibility of incorporating the AUDIT-C or the AUDIT into more broad-scale clinical practice on college and university campuses.

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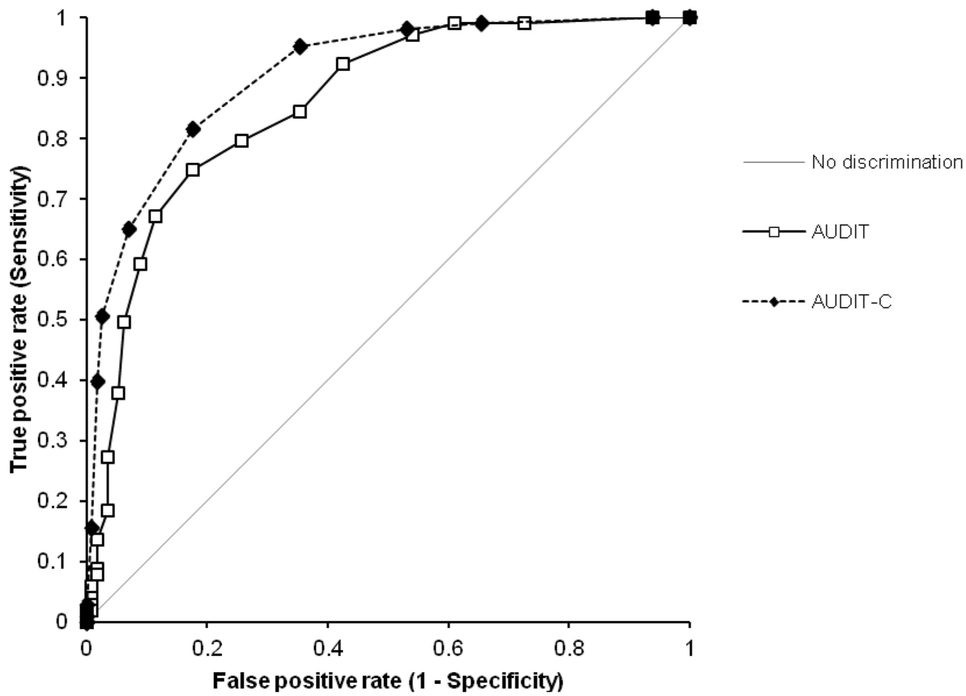

Figure 1. Receiver Operating Characteristic Curves Comparing the AUDIT and the AUDIT-C to Detect Female At-Risk Drinkers

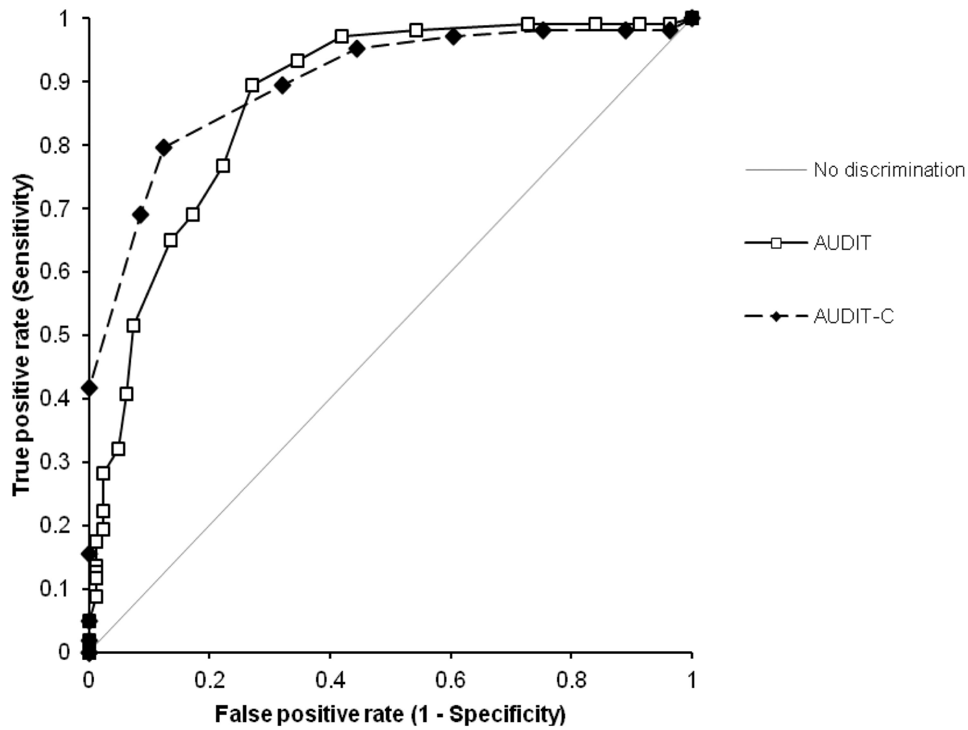

Figure 2. Receiver Operating Characteristic Curves Comparing the AUDIT and the AUDIT-C to Detect Male At-Risk Drinkers

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Table 1

Alcohol Use, Smoking, and Illicit Drug Use Information by At-Risk Drinker Categorization

	At-Risk			
	No (*n* = 194)		Yes (*n* = 207)	
Variable	***M***	***SD***	***M***	***SD***
Drinks - Typical Week	3.47	3.37	17.63	9.68
Drinks - Typical Drinking Day	1.96	1.72	5.99	2.78
Drinking Days - Typical Week	1.31	1.00	2.95	0.98
Typical BAC	0.047	0.05	0.124	0.09
Total Drinks in Heaviest Week	5.20	4.98	24.84	14.15
Binge Episodes/Past 30 Days	0.79	0.99	6.57	3.86
Peak BAC	0.082	0.09	0.207	0.11
AUDIT	5.09	3.98	11.52	5.00
AUDIT-C	3.37	2.10	7.18	2.12
BYAACQ	2.88	3.22	7.06	4.26
Frequency of Cigarette Use	0.14	0.56	0.46	0.81
Lifetime Drug Use Count	0.68	1.02	2.14	2.36
Past 30-Day Drug Use Count	0.21	0.41	0.93	1.34

Note. At-Risk = weekly consumption of 14 or more drinks for a male (7 or more for a female) and/or at least 4 heavy drinking episodes in the past month. BAC = Blood Alcohol Concentration. AUDIT = Alcohol Use Disorders Identification Test. AUDIT-C = Alcohol Use Disorders Identification Test – Consumption items. BYAACQ = Brief Young Adult Alcohol Consequences Questionnaire. All group comparisons were significant.

Table 2

Alcohol Use, Smoking, and Illicit Drug Use Information by Gender for At-Risk Drinkers Only

	Gender				
	Males (n = 103)		Females (n = 104)		
Variable	***M***	***SD***	***M***	***SD***	**Sig.**
Drinks - Typical Week	20.58	10.18	14.70	8.22	***
Drinks - Typical Drinking Day	6.87	2.97	5.12	2.28	***
Drinking Days - Typical Week	3.08	0.94	2.81	1.00	*n.s.*
Typical BAC	0.094	0.06	0.153	0.11	***†
Total Drinks in Heaviest Week	28.32	13.96	21.29	13.50	***
Binge Episodes/Past 30 Days	6.72	3.76	6.43	3.96	*n.s.*
Peak BAC	0.192	0.10	0.222	0.12	*n.s.*
AUDIT	12.57	5.16	10.47	4.62	***
AUDIT-C	7.88	2.03	6.49	1.99	***
BYAACQ	7.84	4.61	6.27	3.73	***
Frequency of Cigarette Use	0.67	0.92	0.26	0.61	***
Lifetime Drug Use Count	2.54	2.75	1.73	1.82	***
Past 30-Day Drug Use Count	1.11	1.55	0.75	1.06	*n.s.*

Note. At-Risk = weekly consumption of 14 or more drinks for a male (7 or more for a female) and/or at least 4 heavy drinking episodes in the past month. BAC = Blood Alcohol Concentration. AUDIT = Alcohol Use Disorders Identification Test. AUDIT-C = Alcohol Use Disorders Identification Test – Consumption items. BYAACQ = Brief Young Adult Alcohol Consequences Questionnaire. *n.s.* = not statistically significant.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

† indicates that females were significantly higher than males in this comparison.

Table 3

Sensitivity, Specificity, Youden's Index, LR+, LR−, PPV and NPV Values for the AUDIT and the AUDIT-C in the Identification of At-Risk Female Drinkers

AUDIT-C							
AUDIT-C Score	**Sensitivity**	**Specificity**	**Youden's Index**	**LR+**	**LR−**	**PPV**	**NPV**
1	1.00	0.0619	0.06	1.07	0	1.0000	0.0616
2	0.9903	0.3451	0.34	1.51	0.03	0.9895	0.3351
3	0.9806	0.4690	0.45	1.85	0.04	0.9790	0.4507
4	0.9515	0.6460	0.60	2.69	0.08	0.9475	0.6119
5	**0.8155**	**0.8230**	**0.64**	**4.61**	**0.22**	**0.8027**	**0.7684**
6	0.6505	0.9292	0.58	9.19	0.38	0.6314	0.8602
7	0.5049	0.9735	0.48	22.49	0.51	0.4842	0.8980
8	0.3981	0.9823	0.38	17.55	0.61	0.3784	0.9055
9	0.1553	0.9912	0.15		0.85	0.1447	0.9130
10	0.0291	1.00	0.03		0.97	0.0268	0.9205
11	0.0097	1.00	0.01		0.99	0.0089	0.9205
AUDIT							
AUDIT Score	Sensitivity	Specificity	Youden's Index	LR+	LR−	PPV	NPV
0	1.00	0.00	0.00	1.00		1.00	0.00
1	1.00	0.0619	0.06	1.07	0.00	1.00	0.0616
2	0.9903	0.2743	0.26	1.36	0.04	0.9895	0.2680
3	0.9903	0.3894	0.38	1.62	0.02	0.9895	0.3767
4	0.9709	0.4602	0.43	1.80	0.06	0.9685	0.4426
5	0.9223	0.5752	0.50	2.17	0.14	0.9162	0.5480
6	0.8447	0.6460	0.49	2.39	0.24	0.8335	0.6119
7	0.7961	0.7434	0.54	3.10	0.27	0.7823	0.6985
8	**0.7476**	**0.8230**	**0.57**	**4.22**	**0.31**	**0.7316**	**0.7684**
9	0.6699	0.8850	0.55	5.82	0.37	0.6513	0.8222
10	0.5922	0.9115	0.50	6.69	0.45	0.5721	0.8450
11	0.4951	0.9381	0.43	7.99	0.54	0.4744	0.8678

Note. LR+ = positive likelihood ratio. LR− = negative likelihood ratio. PPV = positive predictive value. NPV = negative predictive value.

Table 4

Sensitivity, Specificity, Youden's Index, LR+, LR−, PPV and NPV Values for the AUDIT and the AUDIT-C in the Identification of At-Risk Male Drinkers

AUDIT-C							
AUDIT-C Score	**Sensitivity**	**Specificity**	**Youden's Index**	**LR+**	**LR−**	**PPV**	**NPV**
1	0.9806	0.0370	0.02	1.01	0.52	0.9847	0.0373
2	0.9806	0.1111	0.09	1.1	0.17	0.9847	0.1138
3	0.9806	0.2469	0.23	1.3	0.08	0.9847	0.2606
4	0.9709	0.3951	0.37	1.6	0.07	0.9770	0.4315
5	0.9515	0.5556	0.51	2.14	0.09	0.9615	0.6304
6	0.8932	0.6790	0.57	2.78	0.16	0.9141	0.7942
7	**0.7961**	**0.8765**	**0.67**	**6.44**	**0.23**	**0.8324**	**1.0785**
8	0.6893	0.9136	0.60	7.98	0.34	0.7383	1.1352
9	0.4175	1.00	0.42		0.58	0.4768	1.2717
10	0.1553	1.00	0.16		0.84	0.1895	1.2717
11	0.0485	1.00	0.05		0.95	0.0609	1.2717
12	0.0194	1.00	0.02		0.98	0.0245	1.2717

AUDIT							
AUDIT Score	Sensitivity	Specificity	Youden's Index	LR+	LR−	PPV	NPV
1	0.9903	0.037	0.03	1.03	0.26	0.9924	0.0373
2	0.9900	0.0864	0.08	1.08	0.11	0.9924	0.0880
3	0.9903	0.1605	0.15	1.18	0.06	0.9924	0.1662
4	0.9903	0.2716	0.26	1.36	0.04	0.9924	0.2883
5	0.9806	0.4568	0.44	1.81	0.04	0.9847	0.5062
6	0.9709	0.5802	0.55	2.31	0.05	0.9770	0.6623
7	0.932	0.6543	0.59	2.70	0.10	0.9457	0.7606
8	**0.8932**	**0.7284**	**0.62**	**3.29**	**0.15**	**0.9141**	**0.8626**
9	0.7670	0.7778	0.54	3.45	0.30	0.8072	0.9328
10	0.6893	0.8272	0.52	3.99	0.38	0.7383	1.0048
11	0.6505	0.8642	0.51	4.79	0.40	0.7030	1.0599

	AUDIT-C						
AUDIT-C Score	Sensitivity	Specificity	Youden's Index	LR+	LR−	PPV	NPV
12	0.5146	0.9259	0.44	6.95	0.52	0.5741	1.1542
13	0.4078	0.9383	0.35	6.61	0.63	0.4669	1.1736
14	0.3204	0.9506	0.27	6.49	0.71	0.3748	1.1929
15	0.2816	0.9753	0.26	11.40	0.74	0.3327	1.2320
16	0.2233	0.9753	0.20	9.04	0.80	0.2677	1.2320
17	0.1942	0.9753	0.17	7.86	0.83	0.2346	1.2320
18	0.1748	0.9877	0.16	14.15	0.84	0.2122	1.2519
19	0.1359	0.9877	0.12	11.01	0.87	0.1667	1.2519
20	0.1262	0.9877	0.11	10.22	0.88	0.1552	1.2519

Note. LR+ = positive likelihood ratio. LR− = negative likelihood ratio. PPV = positive predictive value. NPV = negative predictive value.