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The Measurement of Adolescent Alcohol Problems via Item Response Theory and Their 15-Year Prospective Associations with Alcohol and Other Psychiatric Disorders

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Abstract

Background—A limited number of measures exist to assess alcohol problems during adolescence. Item-response theory modeling was used to scale a measure of adolescent alcohol problems, including drinking and driving, and then related to alcohol and other psychiatric disorders that occurred over a 15-year period.

Methods—High school students ($N=832$) completed the 13-item Alcohol Problems Index (API) at age 18 years as part of a long-term longitudinal study of predictors of alcohol use and alcohol disorders. Frequency of drinking and driving was also measured during adolescence. Lifetime psychiatric disorders, including alcohol disorders, were measured during young adulthood. Rasch modeling was used to scale the severity of alcohol problems, and the scaled total score was used to prospectively predict alcohol disorders. The area under the response operator characteristic (ROC) curve was also computed between the adolescent alcohol problems and alcohol and other psychiatric disorders across a 15-year period.

Results—The prevalence of alcohol disorders was 38.7% (for alcohol dependence it was 27.7%). Rasch modeling indicated that the API assessed a range of severity of alcohol problems and that drinking and driving was among the less severe indicators. Age 18 API scores significantly correlated with an alcohol diagnosis (0.34) and ROC analysis indicated that for adolescent alcohol problems scores, the diagnostic accuracy (or area under the curve) for an alcohol diagnosis by age 33 was .70.

Conclusions—Our findings supported the unidimensionality and reliability of the API, and statistically significant prospective prediction of young adult alcohol disorders. The measurement of alcohol problems during adolescence, in addition to drinking and driving, may be beneficial in understanding adverse consequences of drinking during adolescence as well as transitions in alcohol use and alcohol disorders across the lifespan.

Keywords

Adolescent Alcohol Problems; Prospective Study; Alcohol and Psychiatric Disorders; Item Response Theory

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INTRODUCTION

Although most U.S. national surveys on adolescents (e.g., Monitoring the Future Studies, Johnston et al., 2015; Behavioral Risk Surveillance Surveys, Kann et al., 2014) include survey items pertinent to quantity and frequency of alcohol use, as well as heavy drinking episodes (or binge drinking), items about adolescent adverse consequences associated with alcohol use (i.e., alcohol problems) are often non-existent or are limited to driving under the influence (DUI). Studies that have examined the occurrence of alcohol problems among adolescents have indicated a moderate to high prevalence of alcohol problems during this phase of the lifespan (Donovan et al., 1983; White and Labouvie, 1989; Windle and Windle, 2005). Alcohol epidemiology studies of adults typically include a broader range of alcohol-related measures such as quantity and frequency of use, heavy drinking episodes, and alcohol problems (Wilsnack et al., 1991), as do studies of college students (Corbin et al., 2008; Kahler et al., 2005; Read et al., 2007), even though these college measures have not been systematically used with adolescents to permit inferences about measurement equivalence across adolescent and young adult age levels. Furthermore, within the broader alcohol and substance use literature, item response theory (IRT) models have been used to investigate the dimensional structure and psychometric properties (e.g., item characteristic curves) of problems (symptoms) with adult populations (e.g., Kahler and Strong, 2006; Langenbucher et al., 2004), but rarely have such analyses been conducted with adolescent samples (Krueger et al., 2004). Finally, the longer-term predictive validity of an adolescent alcohol problems measure on young adult alcohol disorders has seldom been investigated, though Dick et al. (2011) used receiver operating curve (ROC) analysis in a seven-year follow-up study of adolescents (age 18 years at the initial wave) to predict alcohol dependence in young adulthood. Findings indicated that the area under the curve (AUC) was 74%, that is, diagnostic accuracy of adolescent alcohol problems in predicting alcohol dependence seven years later was 74%.

DUI is an important survey item to measure because it is associated with high rates of mortality and morbidity among adolescents, in addition to its obvious relevance for the adult population. While DUI has been associated with higher levels of alcohol use and binge drinking during adolescence (Hingson and White, 2014), it has not been evaluated intensively within the context of other alcohol problems using an IRT latent trait model. IRT modeling may provide important information on DUI in relation to other alcohol problems such as “missing school because of drinking” or “fighting with parents about drinking.” For example, IRT modeling can provide information about the relative severity of DUI in relation to an underlying latent trait of alcohol problems and in relation to other individual alcohol problem items. This kind of information may be valuable in determining the strengths and limitations of using a single survey item such as DUI to measure adverse alcohol problems among adolescents.

Due to a limited number of studies using IRT modeling for adolescent alcohol problems (Krueger et al., 2004), and to the value of evaluating a DUI survey item within the context of other alcohol problems, the goals of this article were threefold. First, we used IRT modeling to evaluate the dimensionality and item-functioning of survey items that assess alcohol problems among adolescents with a measure, the Alcohol Problems Index (API; Windle,

1996), which has demonstrated high reliability, stability, and concurrent validity among adolescents (Davies and Windle, 1997; Windle, 1996; 2000). Second, we used the power of IRT modeling to evaluate how a DUI item was scaled with respect to severity along a latent trait dimension of adolescent alcohol problems. Third, we used both the IRT model of the “adolescent alcohol problem” latent trait and receiver operating curves (ROCs) to evaluate the 15-year prospective predictive relationships between adolescent alcohol problems and a clinical diagnosis of alcohol disorders by ages 33–34 years. To further examine the diagnostic accuracy of the API, we also conducted ROCs for other major psychiatric disorders that often co-occur with alcohol disorders, including other substance disorders, major depressive disorder, and anxiety disorders.

MATERIALS AND METHOD

Participants

The data used in this study were collected as part of a larger, multi-wave panel design focused on risk factors and adolescent substance use and mental health. The initial principal objective of the larger study was to assess the onset, escalation, maintenance, and continuation (or termination) of alcohol and other substance use among 1205 teens during the high-school years (with four waves of assessment at six-month intervals, i.e., Waves 1–4) in relation to a range of risk factors (e.g., temperament, peer substance use, family history of alcoholism). Data were collected within the adolescents’ high school setting and the overall student participation rate was 76%. The sample at baseline consisted of high school sophomores (53%) and juniors (47%) recruited from two homogeneous, non-denominational suburban public high school districts (a total of three high schools) in Western New York, the average age of the respondents was 15.54 years ($SD = 0.66$), and 98% were white.

Sample retention across the first four waves of measurement was uniformly high, in excess of 90%. There was approximately a six-year gap between the Wave 4 assessment in adolescence and the Wave 5 data collection that occurred when the average age of the young adults was 23.5 years, and then five-year gaps between Wave 6 (age=28.5 years) and Wave 7 (age=33.5 years). The Waves 5–7 assessments were modified from Waves 1–4 in that data collection changed from a large group, in-school survey format to individual interviews of the young adults in their homes or at the researchers’ institutional facility. Data were collected from 828 young adults at W5, 779 at W6, and 801 at W7. Note that participants were not excluded if they missed a given wave of measurement; they were re-contacted for participation at the next wave unless they requested to be removed from our participant contact list. Across the course of this longitudinal study, for young adults (YA) 46.8% of subjects participated at all 7-waves, 20.4% at 6-waves, 17.8% at 5-waves, 13% at 4-waves, and less than 2% at less than 4-waves; hence, 85% of the YA sample participated at five or more waves of measurement.

Extensive multivariate and univariate attrition analyses were conducted at W5–W7 to compare participants who provided data during both adolescence and young adulthood and those who provided data during adolescence only. There were significant differences with regard to gender, $\chi^2 = 32.98$, $p < .001$, as proportionally more females (75.4%) than males (61.4%) participated in young adulthood relative to adolescence. Comparisons among

participant and non-participant status groups for separate gender groups were then made with regard to 16 adolescent variables completed at Wave 4: four sociodemographic variables (family income, number of children in the family, and each parent's highest educational attainment), two family variables (family cohesion and perceived family social support), two deviant peer variables (percentage of alcohol and drug using friends), five problem behaviors (tobacco, alcohol, marijuana, other illicit drug use, and general delinquency), emotional functioning (depressive symptoms), academic performance (GPA), and number of stressful life events. Of these 32 comparisons (16 for each of the gender groups), two were statistically significant for males (Participants reported a higher percentage of alcohol using friends [70 vs. 59%] and lower perceived family social support; effect size [ES=.31]), and three were statistically significant for females (Participants reported more stressful events in the last 6 months [7.6 vs. 6.5] and higher average rates of delinquency; ES=.49). In addition, among females, Participants differed significantly from non-participants in reporting a higher GPA (ES= .26). The participation status groups did not differ significantly on the remaining 27 statistical comparisons, and it is thus concluded that attrition bias is quite minimal for males and females. Our conclusion was that minimal systematic differences exist among the retained sample to be used in this study relative to the original sample. Psychiatric disorder data, collected at Waves 5–7, were available for 832 participants.

Procedure

During the adolescent phase (i.e., Waves 1–4), subsequent to receiving informed consent both from a parent and the target adolescent, a trained survey research team administered the survey to adolescents in large groups (e.g., 40–50 students) in their high school setting at each wave. The survey took about 45–50 min to complete and subjects received \$10.00 for their participation. The young adulthood interviews at Waves 5–7 were conducted via one-on-one interviews either in the subjects' homes or at the host institute of the investigators. Subjects were paid \$40 to complete an interview that lasted approximately two hours. Computer-assisted personal interviews were used to collect data. This multiwave study was reviewed and approved by the Institutional Review Board of the University at Buffalo. Signed informed consent was obtained from participants before each wave of assessment. Confidentiality was also assured with a U.S. Department of Health and Human Services Certificate of Confidentiality.

Measures

Sociodemographic variables—Standard demographic data were collected from each participant at each wave, including gender, age, race, religion, current living arrangements, marital status (including cohabitation), parental status, employment status, income, and highest level of educational attainment.

Alcohol Problems Index (API)—In Waves 1–4, thirteen items were used to assess a range of undesirable consequences of drinking alcohol during the previous six months. Items measured experiences during or as a consequence of alcohol use in the domains of school, conflict in social relationships, compulsive drinking style, and loss of behavioral control. Wave 4 data were used in this study. Each item employed a 5-point Likert scale (0 times, 1–

2, 3–5, 6–10, 10+ times). High internal consistency estimates (GE .80) were indicated for each wave of measurement and test-retest reliability coefficients across each of the four adjacent occasions of measurement were .61, .69, and .69.

For purposes of this study each item was scored as either “0”, reflecting no reported alcohol problems, or “1”, reflecting one or more reported alcohol problems. A similarly-scored survey item was collected with regard to frequency of drinking and driving in the last six-months as part of a different module that focused specifically on drinking and driving behaviors (e.g., received a ticket while drinking and driving, had an automobile crash while drinking and driving).

Lifetime alcohol and other substance disorders—*DSM-IV* disorders were derived in the young adulthood interviews via the World Health Organization (WHO) Composite International Diagnostic Interview (WHO-CIDI; WHO, 1997). Reliability data for the WHO-CIDI have been reported (WHO, 1997), and the disorders assessed in this study included alcohol and other substance disorders, major depressive disorder, and several anxiety disorders (phobias, generalized anxiety, and panic).

RESULTS

Dimensionality of alcohol problems items

Much of the literature has supported a unidimensional structure of alcohol symptoms (Harford and Muthén, 2001; Kahler and Strong, 2006; Kreuger et al., 2004), though at least one study using binary items has suggested up to three-factors (Martens, Neighbors, Dams-O'Connor, Lee, & Larimer, 2007). Three methods were used in this study to evaluate the unidimensional structure of the API. First, tetrachoric correlations were computed among the items via Mplus (Muthén and Muthén, 1998–2015) and exploratory factor analytic solutions ranging from 1–3 factors were derived and fit indexes compared. Geomin rotations were used and findings were robust across different rotations (e.g., Promax). The findings from these factor models are provided in Table 1 and, based on the RMSEA, indicate that a one-factor model provides an adequate fit to the data, though the specification of additional factors does increase, to some extent, the statistical fit indexes. However, an inspection of salient factor loadings for the 2- and 3-factor solutions indicated that these factors yielded singlets (i.e., one salient loading) and, in the three-factor case, also an item that double loaded on two factors. Substantively the one-factor solution was the most meaningful and coherent. Second, eigenvalues were plotted and the first six values were 6.19, 1.07, 1.01, 0.85, 0.71, and 0.64. Hence, based solely on the eigenvalues, there is one dominant factor and two additional values slightly above 1.0. Third, because the eigenvalue > 1.0 rule has been recognized as limited in determining the underlying factor structure of data (Bandalos & Boehm-Kaufman, 2009), a parallel analysis was conducted (Horn, 1965). The parallel analysis yielded one eigenvalue that was three times the size of the estimate derived from the parallel analysis for the 95th percentile. With this exception, the remainder of the eigenvalues from the actual data were smaller than those corresponding eigenvalues generated by the parallel analysis based on random data. Based on the findings across all three methods, a unidimensional structure was used for the API in this study.

Rasch model

A one-parameter Rasch model (Rasch, 1960/1980) was estimated via MPlus (Muthén and Muthén, 1998–2015) in which the item discrimination parameters were constrained to equivalence and item difficulties were freely estimated. In studies of psychiatric and substance use symptoms, item difficulties are commonly described as indicative of a severity dimension (Laugenbrucher et al., 2004). Hence, higher item difficulty scores are associated with items that “tap” or assess higher severity of the underlying latent trait dimension of alcohol problems. The estimation procedure used was weighted least squares with mean and variance adjustment (WLSMV). WLSMV is a robust estimator that does not assume normally distributed variables and is useful in the modeling of ordered categorical variables.

The observed item response data of the API fit the Rasch model well (χ^2 with 91 df = 321.588, $RMSEA$ = .055, CFI = .925). The frequency and severity (item difficulties) of the 14 alcohol problems (13 items from the API and one DUI item) are provided in Table 2. Findings indicated that some of the highest severity items were “trouble with the law while drinking” and “drank to get rid of a hangover”. A few of the lowest severity items were “regretted things the next day after using alcohol” and “drinking to forget my troubles”. Drinking and driving was also on the less severe end of the continuum of alcohol problems. Figure 1 provides item characteristic curves for several of the items to further illustrate the relationships between the items and the underlying latent trait. The location for a person to respond “Yes” about 50% of the time (i.e., equal probability of responding Yes vs. No for each of the binary items) for the “regretted” item (the first curve in Figure 1 from left-to-right) is around “0” on the alcohol problems severity trait dimension (the x -axis); the location for a person to respond “Yes” about 50% of the time for the “trouble with law” item is around “1.5” on the alcohol problems severity trait dimension. Hence, a “Yes” response for the “trouble with law” item is associated with greater severity along the latent trait dimension.

Additional data on item and test functioning for the Rasch model are provided in Figures 2 and 3, respectively, via item and test information functions. Information functions provide insight into the precision of items or a test score at various ranges of the latent trait. Figure 2 provides item information functions for the three API items of “regretted things the next day”, “drinking and driving” and “fought with friends”. The item information function for “regretted things the next day” indicated that the item captured wide variation across the alcohol problems trait, whereas “drinking and driving” and “fought with friends” captured the alcohol problems trait more at the upper end of the trait distribution and were less sensitive at the lower end of the trait distribution. Figure 3 provides the test information function for the full 14-item measure that represents the sum of the 14 item information functions in the Rasch model. It indicates greater sensitivity of measurement at the middle and upper end of the trait distribution than the lower end of the distribution. For a scale measure of the alcohol problems trait, the less sensitivity at the lower end of the scale is not surprising because it may capture individuals who drink very little and therefore do not experience many alcohol-related adverse consequences.

Rasch Prediction of Alcohol Disorders

The derived Rasch model was then used to estimate the occurrence of an alcohol disorder across a 15-year period during young adulthood. The data provided an adequate fit for the specified model (χ^2 with 104 $df=345.595$, $RMSEA=.053$, $CFI=.925$). Tetrachoric correlations between each item on the API and the occurrence of a lifetime alcohol disorder are provided in the final column of Table 2 and range in value from .16 to .34 (mean=.22). The overall correlation between the composite API score and the occurrence of a lifetime alcohol disorder was .34. A model was also completed for lifetime alcohol dependence and yielded highly similar findings as for the “any alcohol disorder” outcome.

Receiver operating curve (ROC) analysis

The findings from the ROC analysis for adolescent alcohol problems predicting an alcohol disorder diagnosis by age 33 years indicated diagnostic accuracy of 70%. This is comparable to other ROC studies that have focused on longer-term prediction of alcohol outcomes based on alcohol assessments in adolescence (Dick et al., 2011). We also conducted analyses separately for males and females and the findings were essentially the same as those for the pooled sample. Table 3 summarizes the findings of the ROC analyses for alcohol and other psychiatric disorders. The AUCs for alcohol dependence and for other substance disorders are somewhat lower than for an alcohol disorder, though there is some overlap in their 95% confidence intervals. The AUCs for major depressive disorder and anxiety disorders are at the chance level and their confidence intervals do not overlap with those of the AUC for alcohol disorders.

Ancillary analyses

In addition to the binary IRT model reported in this study, we also conducted analyses using the full-range of ordinal scored responses (responses ranged from 0–5) using the Partial Credit Model (PCM; Masters, 1982). However, both for empirical and practical reasons, we retained the binary IRT model. The vast majority of items were responded to as either “zero” or “1” (this was the case for 93.2% of the item responses; among those who responded nonzero, 71% responded “1”) and thus variation was not compromised much by using the binary response format. The major differences in the distribution of items across ordinal categories also resulted in difficulties in obtaining model fit statistics (e.g., chi-square statistic) for the PCM because of the many zero cells or sparse cells ($n < 5$). We also performed factor analyses using polychoric correlations for the ordinal response variables and one factor was indicated via the parallel test as was the case for the binary items. We also conducted intraclass correlations between the estimated difficulty parameters for the binary and PCM and this yielded a coefficient of .88, thereby suggesting a high degree of similarity in ordering and mean levels across models for the estimated difficulty parameters. Finally, we also conducted ROC analyses with the PCM and it yielded AUC estimates of equal, but not higher, magnitude when compared to the binary IRT model findings. Hence, on a statistical basis we concluded that there were no advantages to using the PCM relative to the binary model, and that there were fewer interpretive difficulties (e.g., sparse data; model fit statistics could be derived).

DISCUSSION

The IRT modeling used in this article demonstrated that the API is a unidimensional measure with high reliability that assesses a range of adverse consequences associated with alcohol use among adolescents. The frequency of positive endorsements of alcohol problems ranged from 6.5% to 47.7%, and the derived severity estimates represented a range from .09 to 2.29, thereby indicating significant variation in responses along the latent trait continuum. This source of variation along the latent trait continuum is of importance for capturing and distinguishing adolescents who have zero or a few problems from those who have more alcohol problems. These distinctions could be important for many purposes, such as screening and referral for what types of services (if any) are needed, or for evaluating the success of a preventive intervention or treatment trial. Prior research with the API during adolescence has demonstrated strong associations with major risk and protective factors of adolescent alcohol use such that higher levels of alcohol problems were significantly correlated with lower family support, a higher percentage of substance-using friends, more stressful life events, more childhood externalizing symptoms (e.g., conduct problems and oppositional behaviors), and a higher prevalence of paternal alcoholism (Davies and Windle, 1997; Windle, 1996). The IRT-modeling findings reported here further support the internal properties of the API measurement instrument.

The scaling of item responses along the alcohol problems severity dimension indicated that the DUI item was on the less severe end of the continuum of problems. This suggests that, in terms of severity, the endorsement of this item during adolescence is more similar to other serious alcohol problems such as “drank to forget troubles” and “drank several days in a row”, but less similar than some other problems such as “drinking to get rid of a hangover” or “missed school due to drinking”. Hence, these IRT-modeling findings support the usefulness of measuring DUI during adolescence not only as a high risk behavior for mortality and morbidity (Hingson and White, 2014) but also as a valuable indicator of adolescent alcohol problems that further demonstrated long-term significant associations with alcohol disorders in young adulthood. In addition, the prevalence of responses for the items of the API and the prediction of alcohol disorders in young adulthood indicated that a more comprehensive assessment of adolescent alcohol problems would facilitate higher long-term prediction and be of potential value in screening and referral.

Findings from the ROC analyses that focused on the association between adolescent API scores and lifetime alcohol disorders in young adulthood indicated that diagnostic accuracy of the API was .70. This .70 estimate is similar to that obtained by Dick et al. (2011) over a shorter follow-up interval (7 years relative to our 15 years) and compares favorably to best-performance behavior checklists and inventories that typically yield AUCs in the 0.7–0.8 range (Youngstrom, 2014). Our findings also indicated no sex differences in AUC estimates for males and females. The ROC analyses for Other Substance Use Disorders (SUDs) also yielded an AUC estimate of .65, thereby suggesting that the API was also moderately predictive of these disorders. Given the high rates of co-use of alcohol and other substances during adolescence and young adulthood (Felton et al., 2015), the high rates of co-occurring disorders (Grant et al., 2009), and the common risk factors for alcohol and other substances (Hawkins et al., 1992), it is not surprising that alcohol problems are also predictive of Other

SUDs. However, the ROCs for Major Depressive Disorder (MDD) and Anxiety Disorders were at chance levels thereby indicating that the API was not a useful predictor of these disorders. Although there are reasonably high rates of the co-occurrence of alcohol disorders and MDD and alcohol disorders and Anxiety Disorders (Grant et al., 2009), the findings suggest that there are other factors of higher significance in predicting these disorders, though it is still possible that adolescent alcohol problems may be somewhat predictive of that subset of individuals with comorbid alcohol and MDD or anxiety disorders.

The current study has several limitations. First, the sample was primarily white and selected from racially/ethnically homogenous schools. Generalizability to other racial/ethnic groups and to high risk samples awaits future inquiry. Second, potential unobserved heterogeneity, such as predictors previously associated with the API (e.g., family history of alcoholism, lower family support, higher stressful events) and group characteristics (e.g., race/ethnicity) were not controlled in these IRT analyses and may have impacted the findings. Despite these limitations, the study does provide valuable information on the dimensionality and item functioning of the API and its moderate prediction of alcohol and other substance disorders across a 15-year period.

In summary, our findings indicated that the API assessed an array of adolescent alcohol problems that ranged in severity so as to capture important variability of the underlying latent trait. The DUI item was on the less severe end of the latent continuum of alcohol problems, but still occurred with moderate frequency relative to other problems and was significantly associated with the subsequent development of an alcohol disorder. Predictive accuracy based on ROC analyses provided support for Alcohol and Other SUDs, ranging in values from .65–.70. The API could be used as a broader measure of adolescent alcohol problems than relying solely on DUI items, and has the potential to be used in screening and referral studies as well as etiology studies of the development of alcohol disorders across the lifespan.

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Figure 1.
Severity of individual alcohol problems from the alcohol problems index (API) along an alcohol problem latent trait dimension

Figure 2.
Item information functions for three items from the Alcohol Problems Index

Figure 3.
Test information function for the Alcohol Problems Index

Table 1

Model Fit of Exploratory Factor Models Ranging From One to Three Factors

Number of Factors	$ML \chi^2$	df	RMSEA	SRMR
One-Factor	149.16	65	.039	.074
Two-Factors	101.57	53	.033	.062
Three-Factors	62.27	42	.024	.049

Table 2

Frequency and Item Severity Parameter Estimates for Alcohol Problems Index

Alcohol Problems	Frequency (% Yes)	Severity Estimate ¹	Tetrachoric Correlation ²
Regretted things the next day after using alcohol	47.7	0.09	0.34
Passed out from drinking	29.6	0.81	0.28
Drank several days in a row	28.8	0.84	0.31
Drank to forget my troubles	37.3	0.85	0.17
Drinking and driving	19.4	0.85	0.25
Tried to cut down on drinking	24.5	1.04	0.13
Drank alone	21.5	1.19	0.16
Fought with boyfriend or girlfriend over drinking	16.6	1.47	0.17
Fought with strangers while drinking	16.6	1.47	0.18
Fought with parents over alcohol use	16.2	1.49	0.13
Drank before school	12.3	1.76	0.22
Missed school due to drinking	9.4	1.99	0.27
Drank to get rid of a hangover	7.6	2.17	0.31
Trouble with the law while drinking	6.5	2.29	0.19

¹ Alcohol Problems are in order of severity, from least to most severe.

² Tetrachoric correlation of each item with alcohol disorder.

Table 3

Findings from Receiver Operating Curve Analyses for Relationships between Adolescent Alcohol Problems and Alcohol and Other Psychiatric Disorders

Disorder	AUC ^I	S.E.	C.I.
Any alcohol disorder	.701	.022	.658–.744
Alcohol dependence	.651	.025	.602–.699
Other substance disorder	.650	.025	.601–.699
Major depressive	.494	.025	.444–.544
Anxiety	.503	.025	.453–.553

^I Area Under the Curve