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Measuring Alcohol Use across the Transition to Adulthood: Racial/Ethnic, Sexual Identity, and Educational Differences

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Abstract

Background—Patterns of alcohol use change from adolescence to adulthood and may differ based on race/ethnicity, sexual identity, and education. If alcohol use measures do not operate consistently across groups and developmental periods, parameter estimates and conclusions may be biased.

Objectives—To test the measurement invariance of a multi-item alcohol use measure across groups defined by race/ethnicity, sexual identity, and college education during the transition to adulthood.

Methods—Using three waves from the National Longitudinal Study of Adolescent to Adult Health, we tested configural, metric, and scalar invariance of a 3-item alcohol use measure for groups defined by race/ethnicity, sexual identity, and college education at three points during the transition to adulthood. We then assessed longitudinal measurement invariance to test the feasibility of modeling developmental changes in alcohol use within groups defined by these characteristics.

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Author Disclosure

Contributors

JN Fish conceptualized the study and all authors were involved in designing the analytic approach. AM Pollitt conducted the statistical analysis with assistance from JN Fish. JN Fish wrote the first draft of the manuscript and all authors contributed to and approved the final manuscript.

Conflict of Interest

All authors declare that they have no conflicts of interest.

Results—Overall, findings confirm notable variability in the construct reliability of a multi-item alcohol use measure during the transition to adulthood. The alcohol use measure failed tests of metric and scalar invariance, increasingly across ages, both between- and within-groups defined by race/ethnicity, sexual identity, and college education, particularly among females.

Conclusions—Measurement testing is a critical step when utilizing multi-item measures of alcohol use. Studies that do not account for the effects of group or longitudinal measurement non-invariance may be statistically biased, such that recommendations for risk and prevention efforts could be misguided.

Keywords

alcohol use; measurement invariance; development; race/ethnicity; sexual identity; college attendance

1. Introduction

Given knowledge on the progression of alcohol use across the transition to adulthood (Britton, Ben-Shlomo, Benzeval, Kuh, & Bell, 2015; Schulenberg, Johnston, O'Malley, Bachman, Miech, & Patrick, 2017; Maggs & Schulenberg, 2004; Schulenberg, Masklowky, & Jager, in press), researchers are focused on groups that demonstrate risky drinking and greater susceptibility for alcohol use disorders (AUDs; Brown et al., 2008; Larimer & Arroyo, 2016; National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2009). Vulnerable groups include racial and ethnic minorities (Delker, Brown, & Hasin, 2016; Chen & Jacobsen, 2012; Whitbrodt, Mulia, Zemore, & Kerr, 2014), sexual minorities (gay/lesbian or bisexual [LGB] people; Hughes et al., 2016; Talley et al., 2016), and college attendees (Chen & Jacobsen, 2013; Merrill & Carey, 2016; Schulenberg & Patrick, 2012; White & Hingson, 2014). Notably, these groups also display differences in alcohol consumption relative to their respective reference groups at different points in the lifespan (Schulenberg et al., 2017; Chen & Jacobsen, 2012, 2013; Fish & Pasley, 2015), thus alcohol use measures may vary not only across groups but also across time or developmental periods.

Studies typically test group differences and trajectories in alcohol use without confirming the equivalence, reliability, or validity of alcohol consumption measures across groups or time (Fish, Pollitt, Schulenberg, & Russell, 2017; c.f., Bullers, Cooper, & Russell, 2001; Corbin, Iwamoto, & Fromme, 2011; Johnson & Chen, 2015; Sher, Wood, Wood, & Raskin, 1996), an oversight that can bias results and inferences drawn from findings (Little, 2013; Little, Card, Preacher, & McConnell, 2009; Widaman, Ferrer, & Conger, 2010). Given the research documenting maturational shifts in (Brown et al., 2008; Schulenberg et al., 2014) and differential risk for (Jacobsen & Chen, 2012, 2013; Marshal et al., 2009) alcohol consumption, it is concerning that measurement invariance testing is not fundamental to studies examining the patterns, antecedents, and consequences of alcohol use from adolescence to adulthood—a critical transition for alcohol use behavior and later health and well-being (Institute of Medicine [IOM], 2015). We briefly discuss research that highlights developmental differences in alcohol use by race/ethnicity, sexual identity, and college education, and then review implications for measurement and measurement invariance testing procedures. Given established differences in alcohol use measurement by gender (see

Fish et al., 2017) we conceptualize measurement differences for males and females separately.

1.1. Race and ethnicity

Differences in alcohol use and the associated consequences across the life course for racial/ethnic groups is exceedingly complex (Kerr, Greenfield, Bond, Ye, & Rehm, 2011; Delker et al., 2015; Whitbrodt et al., 2014). Studies of youth demonstrate that white adolescents drink more than their black peers (Jackson, Sher, Cooper, & Wood, 2003; Paschall, Freisthler, & Lipton, 2005; Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017), with mixed findings when comparing non-Hispanic white to Hispanic adolescents (Johnston, O'Malley, Miech, et al., 2017; Wahl & Eitle, 2010). These differences, however, do not hold over time. In one longitudinal comparison, Hispanic youth demonstrated higher rates of alcohol use during early adolescence but were surpassed by white, non-Hispanic youth by mid-adolescence (Chen & Jacobsen, 2012; see also, Haberstick et al., 2014). Relative to comparisons during adolescence, alcohol related vulnerabilities among black adults appear later in the lifespan due to the persistence and acceleration of frequent or heavy alcohol consumption across the 20s and 30s (Chen & Jacobsen, 2012; Muthén & Muthén, 2000), which elevates risk for problems associated with alcohol use and AUDs as they age (Mulia et al., 2009; Vasilenko, Evans-Polce, & Lanza, 2017).

1.2. Sexual identity

Research on youth and adults consistently demonstrate alcohol-related disparities between sexual minorities and heterosexuals (IOM, 2011; Marshal et al., 2008; McCabe et al., 2009; Tally et al., 2016). Sexual minorities, particularly sexual minority women (Hughes et al., 2016), drink more often, in higher quantities, and have more consequences related to drinking than heterosexuals (Bos et al., 2015; Case et al., 2004; Rosario et al., 2014; Russell, Driscoll, & Truong, 2002; Talley et al., 2010, 2014). Longitudinal studies also document differences in alcohol use trajectories for sexual minorities compared to heterosexuals during the transition to adulthood (Fish & Pasley, 2015; Hatzenbuehler, Corbin, & Fromme, 2008; Marshal et al., 2009, 2012) and sexual minority women, compared to heterosexual women, may be more likely to continue heavy alcohol use as they age (Dermody et al., 2014; Needham, 2012).

1.3. College education

College students are at greater risk for excessive alcohol use and AUDs during early adulthood compared to those who do not enroll, but risk varies by age (Blanco et al., 2008; Schulenberg et al., 2017; Slutske, 2005). Prior to attending, college-bound youth are less likely to drink to excess compared to those unenrolled (Schulenberg et al., 2017; Timberlake et al., 2007). Youth who matriculate, however, quickly surpass same-aged unenrolled peers, reporting higher rates of heavy drinking during college (Chen & Jacobsen, 2013; Paschal, et al., 2009; Schulenberg & Patrick, 2012). College students also drink differently than their unenrolled counterparts: Those not attending college consume alcohol more frequently but in lower quantities than attenders, although this difference is narrowing (Schulenberg et al., 2017). Researchers also find differences post-graduation. Compared to degree recipients, adults without a degree drink more heavily during their late 20s and early 30s, particularly

those who attended college but withdrew before conferring a degree (Merline, O'Malley, Schulenberg, Bachman, & Johnston, 2004; Chen & Jacobsen, 2013).

1.4. Implications for measurement

The veracity of these subgroup differences partly depends on whether measures are equivalent across subgroups. If the meaning of measures differs across groups, findings may reflect measurement differences or measurement error rather than true mean differences (Little, 2013; Little et al., 2009; Widaman et al., 2010). Latent variable modeling (i.e., structural equation modeling) is a flexible analytic framework that allows researchers to model complex research questions in ways that minimize the influence of measurement error (Kline, 2016; Little, 2013). Additional benefits of latent variable modeling include testing the reliability and operation of measures across groups of interest or for people over time via tests of measurement invariance.

To summarize briefly, assessments of measurement invariance test whether observable items consistently reflect an underlying latent construct for different groups within a population or for individuals over time. For example, in commonly used scales, individual items may have different meaning or may carry different weight across groups with respect to the underlying construct. If measurement invariance is not confirmed, parameter estimates may be biased (Little, 2013; Little, Card, Preacher, & McConnell, 2009; Kern, McBride, Laxman, Dyer, Santos, & Jeans, 2016). Importantly, issues of measurement invariance extend beyond latent variable frameworks: Use of observed measures (i.e., summed or averaged scores across items) can also reflect bias if unexamined (Meredith, 1964; Widaman & Reise, 1997).

Measurement invariance assessments typically occur in four steps, with each step imposing increasing restrictions to examine whether parameter equality constraints degrade the quality of model fit, and thus, reveal model differences across groups or time. First, an unconstrained or configural model is estimated to assess whether the factor structure (i.e., the number and pattern of factor loadings) is equivalent across groups or time. Second, for metric invariance, the factor loadings are constrained to be equal across comparison conditions. If metric invariant, the expected change for each indicator item is the same across groups for every 1-unit change in the latent construct. Third, for scalar invariance testing, equality constraints are imposed on the intercepts of observed indicator variables (along with factor loadings). If scalar invariant, results suggest that mean level differences in the latent variance similarly characterize change in the observed indicators across groups or time. The fourth step, which tests the equivalence of item-specific and random error, is not assessed here given that it is theoretically and empirically unlikely that random error would be equivalent across groups or time (see Little, 2013).

Research documenting developmental differences in alcohol use across groups of interest has challenged assumptions of measurement invariance. For example, differences in initiation and progression of alcohol use between racial/ethnic (Chen & Jacobsen, 2012; Muthén & Muthén, 2000) or sexual identity subgroups (Dermody et al., 2014; Hatzenbuehler et al., 2008) across the transition to adulthood may alter the reliability of alcohol use measures, particularly for research designs that explicitly test group differences. Similarly, differences in drinking frequency and quantity between college students and non-

attendees during the transition to adulthood (Schulenberg et al., 2017; Timberlake et al., 2007) suggest that measures documenting alcohol use function differently across these groups over time—differences that may shift the meaning or reliability of a multi-item alcohol use measure. If ignored, this lack of measurement equivalence can result in inaccurate conclusions about subgroup differences, changes over time, as well as the antecedents and consequences of alcohol use.

Studies that test developmental and group differences in alcohol-related behavior indicate that multi-item alcohol use measures may vary as a function of race/ethnicity, sexual identity, or college attendance across the transition to adulthood. To address this, we used a large, nationally representative panel study that followed youth during the transition to adulthood to assess whether a three item-alcohol use measure demonstrated measurement invariance across groups defined by race/ethnicity, sexual identity, and college education. These groups are of substantive interest because among subgroups there are documented differences in propensity for excessive alcohol use, AUDs, and related consequences (NIAAA, 2009; NIH, 2015; Substance Abuse and Mental Health Services Administration [SAMHSA], 2014). First, we tested measurement models across groups defined by race/ethnicity, sexual identity, and college education at three distinct time points during the transition to adulthood. Second, we assessed the longitudinal invariance of alcohol use across the transition to adulthood within groups defined by these characteristics.

2. Methods

We use data from the National Longitudinal Study of Adolescent to Adult Health (Harris, 2009). Approximately 90,000 7th–12th graders were recruited from a representative sample of schools during 1994–1995. From this sample, 20,745 youth were selected to complete in-home surveys. One year later, 14,738 of the original sample participated in Wave 2. Wave 3 occurred 5–6 years later, when participants were between 18–24 years of age ($n = 15,197$). Wave 4 was conducted 7 years after Wave 3, when participants were between the ages of 24–32 ($n = 15,701$).

Our analytic sample includes original participants from Wave 1, 3 and 4 who were not missing on all alcohol items within a single wave ($N = 11,715$). Given that previous analyses have established limited measurement invariance across gender (Fish et al., 2017), we compare group and longitudinal models for males and females separately.

2.1. Measures

2.1.1. Alcohol use—Based on recommendations from NIAAA (2003), alcohol use was assessed with a three-item measure of past 12-month drinking frequency (*never* = 0 to *everyday* = 7), heavy episodic drinking (HED) frequency (*never* = 0 to *everyday* = 7), and average quantity when drinking (*no drinking* = 0, *1 drink* = 1 to *10 or more drinks* = 10).

2.1.2. Race/ethnicity—Participants reported race and ethnicity. If more than one response was selected, a third item had participants indicate which category best described them. From these items, four groups were created: *white, non-Hispanic*; *black, non-Hispanic*; *Hispanic*; and *Asian/Pacific Islander (A/PI), non-Hispanic*.

2.1.3. Sexual identity—At Wave 3, participants reported their sexual identity as 100% heterosexual, mostly heterosexual, bisexual, mostly homosexual, 100% homosexual, or not sexually attracted to either males or females. Responses were combined into three categories for comparison: *heterosexual*, *mostly heterosexual*, and *lesbian, gay, or bisexual (LGB)*. Given small cell size, those reporting no attraction were dropped for sexual identity comparisons.

2.1.4. College education—In Wave 4, participants reported their highest education level achieved to date and most recent degree received. Responses were recoded to reflect those who *never attended college*, *dematriculated* (i.e., attended but withdrew prior to conferring a degree), graduated with an *associate's degree*, and graduated with a *bachelor's degree* (see Chen & Jacobson, 2013).

2.2. Analytic Procedures

Measurement invariance is established by first assessing model fit by freely estimating model parameters across groups or time (configural invariance, which pertains to same number of factors and pattern of high factor loadings across groups/time) followed by a sequence of systematic equality constraints to assess the equivalence of factor loadings (metric invariance) and intercepts (scalar invariance). Decrement in model fit between freely estimated and constrained models was assessed via CFI—where differences .010 indicates significantly worse model fit (Cheng & Resnold, 2002; Little, 2013). We applied the fixed factor method of latent scaling for within-wave comparisons, which constrains the variance of the latent construct to 1. For longitudinal assessments we used the fixed factor method for the first latent construct but freely estimated subsequent latent variances to minimize the influence of constrained residual invariance on model fit comparisons (for more information see Little, 2013, p. 147). All analyses were weighted and adjusted to account for the complex sampling design of the Add Health data. Longitudinal weights were used to account for participant attrition across waves. Full-information-maximum likelihood estimation was used to account for item missing within-wave.

Tests of measurement invariance proceeded in stages in order to explicate (1) whether non-invariance is due to differences between groups or measurement occasion, and (2) which specific items are non-invariant. First, we established configural invariance for each group at each wave. Second, we compared the measure across groups defined by race/ethnicity, sexual identity, and college attendance within each wave (between-group differences) and then assessed the longitudinal invariance for each group across waves (within-group differences). If models were metric or scalar non-invariant, item-level testing was conducted to assess which specific item(s) contributed to decrements in model fit.

3. Results

Table 1 displays sample characteristics and the average observed score of the three-item alcohol use measure for each group across waves. Due to the large number of comparisons, we provide summary tables of measurement invariance across groups and time.¹

All comparisons met the threshold for configural invariance: The three observed items of alcohol use—alcohol use frequency, HED frequency, and average quantity when drinking—formed a single factor structure, with each item loading highly on the single factor for all groups at all waves. After establishing configural invariance, metric and scalar invariance were tested. Tables of between- and within-group comparisons display results for the overall test of measurement invariance. If this omnibus test failed metric or scalar invariance, we then tested each item loading and/or intercept to identify the source of non-invariance. We note the details of these findings below. We first consider within wave comparisons among males, then among females, followed by longitudinal comparisons.

3.1. Male Between-Group Comparisons within Wave

3.1.1. Race/ethnicity—Comparisons confirmed metric and scalar invariance for males at each wave for white compared to Hispanic, white compared to A/PI, and Hispanic compared to A/PI subgroups (Table 2). Results note metric non-invariance between black and white males for all waves where models for black males had smaller alcohol quantity factor loadings at Wave 1 and HED frequency at Waves 3 and 4, but larger drinking frequency factor loadings for all waves (see Table 4). Models comparing black and Hispanic males were metric non-invariant at Waves 1 and 3 and scalar non-invariant at Wave 4: black males had smaller drinking frequency and alcohol quantity factor loadings at Wave 1, larger drinking frequency loadings at Wave 3, and lower drinking frequency and quantity intercepts at Wave 4 compared to Hispanic males. Models were metric non-invariant between black and A/PI males at Wave 4, where factor loadings for drinking frequency were larger and HED frequency smaller for black males.

3.1.2. Sexual identity—Alcohol use was both metric and scalar invariant across male sexual identity groups for all waves.

3.1.3. College education—Metric and scalar invariance was supported for four of the six subgroup comparisons: no college versus associate's, dematriculated versus associate's, dematriculated versus bachelor's, and associate's versus bachelor's. Males who never attended college, compared to those who dematriculated, were metric and scalar non-invariant for Waves 3 and 4, respectively. Compared to males who never attended college, measurement models for dematriculaters had smaller alcohol quantity and larger HED frequency factor loadings at Wave 3 and higher drinking and HED frequency intercepts at Wave 4. Wave 3 measures for males with a bachelor's degree were metric non-invariant compared to males with no college, where HED frequency loadings were larger and drinking frequency and alcohol quantity smaller for males who obtained a bachelor's degree. At Wave 4, alcohol quantity and HED frequency factor loadings were larger for those who never attended relative to males with a bachelor's degree. Finally, at Wave 4, models for dematriculaters and never attenders had lower drinking frequency intercepts compared to bachelors and associate's degree earners, respectively.

¹Information on fit statistics for all comparisons are available in our online supplement.

3.2. Female Between-Group Comparisons within Wave

3.2.1. Race/ethnicity—Only one set of contrasts confirmed metric and scalar invariance at each of the three waves: White compared to A/PI females (Table 3). Group- and item-level comparisons indicated metric non-invariance between white and black females at Wave 3 and 4 and white and Hispanic females at Wave 4. Compared to white females, latent measures for black females had smaller HED frequency factor loadings at Waves 3 and 4 (see Table 4). Wave 4 models showed larger alcohol quantity and smaller HED frequency factor loadings among Hispanic relative to white females. Measures for black and Hispanic females were metric non-invariant at Wave 3 and scalar non-invariant at Wave 1 and 4. Models for black females had smaller HED frequency loadings at Wave 3, and lower intercept values for all items at Waves 1 and 4. Comparisons between black and A/PI females were metric non-invariant at Wave 3, where HED frequency loadings were smaller for black females. Wave 4 Hispanic and A/PI comparisons failed scalar invariance, where measures for Hispanic females had higher HED frequency and alcohol quantity intercepts, and lower drinking frequency intercepts.

3.2.2. Sexual identity—Heterosexual compared to lesbian/bisexual subgroups were metric and scalar invariant at each wave, though measures for mostly heterosexual females had larger HED frequency factor loadings relative to heterosexuals at Waves 3 and 4. Wave 1 sexual identity comparisons passed scalar invariance, but one-on-one group comparisons between mostly heterosexual and lesbian/bisexual females were only metric invariant: Lesbian/bisexual females had larger drinking frequency and smaller HED frequency loadings.

3.2.3. College education—None of the college education subgroup comparisons yielded metric or scalar invariance across waves. Wave 1 models for females with an associate's degree had smaller drinking and HED frequency loadings than females who did not attend college or dematriculated. Measures for females who received a bachelor's degree compared to those who never attended college were scalar non-invariant at Wave 1 and metric non-invariant at Waves 3 and 4: drinking frequency intercepts were higher at Wave 1, HED frequency loadings were smaller at Wave 3, and quantity loadings were larger at Wave 4 in models for non-college attenders. Wave 3 comparisons were scalar non-invariant between dematriculaters and bachelor's degree earners, though item-level comparisons were invariant. Wave 4 comparisons between dematriculaters and bachelor's degree earners were metric non-invariant, with larger quantity loadings for dematriculaters. Associate's and bachelor's degree earners were metric non-invariant at Wave 3 and scalar non-invariant at Wave 4: Associate's degree earners demonstrated larger quantity and smaller HED frequency loadings at Wave 3, but item-level comparisons at Wave 4 were invariant. Comparisons between females who never attended college and dematriculaters were scalar non-invariant at Wave 4; dematriculaters had higher drinking frequency intercepts.

3.3. Longitudinal Male and Female Within-Group Comparisons across Wave

Table 5 displays within-group longitudinal assessments of measurement invariance by race/ethnicity, sexual identity, and college education. Given space limitations, we note item-level differences for longitudinal assessments in Table 5, but do not explicitly discuss these

differences here. Results display more evidence of invariance, particularly metric invariance, for Wave 3 versus 4 contrasts than for the other sets of contrasts; we found only sporadic evidence for scalar invariance across all comparisons.

Black and gay/bisexual males were the only male groups to display metric invariance across all waves; no single male group demonstrated scalar-invariant measures across all waves. Comparisons between Wave 1 and 3 indicated that black, Hispanic, mostly heterosexual, gay/bisexual, and non-college attending males were metrically invariant from Waves 1 to 3; no group demonstrated scalar invariance across Wave 1 and 3. All within-group models passed metric invariance from Wave 3 to 4, with the exception of bachelor's degree earners. Wave 3 and 4 measures were scalar invariant for black, Hispanic, mostly heterosexual, and non-college attending males. Wave 1 and 4 measures for black and gay/bisexual males were metric and scalar invariant.

Only black females demonstrated metric invariance across all longitudinal comparisons. No female group demonstrated scalar invariance across all waves. Wave 1 to 3 measures were metric invariant for black, Hispanic, A/PI, lesbian/bisexual, non-college attending, and associate's earning females; no Wave 1 to 3 comparisons were scalar invariant. Wave 3 to 4 measures passed metric invariance, with the exception of A/PI and associate's or bachelor's degree earning females. Wave 3 and 4 measures passed scalar invariance for black and non-college attending females. All Wave 1 to 4 comparisons failed metric invariance, except for black females.

4. Discussion

Using nationally representative longitudinal data, we demonstrate the degree of measurement invariance of a three-item of alcohol use measure from adolescence through early adulthood across groups defined by race/ethnicity, sexual identity, and college education. First, we find that configural invariance prevailed in all contrasts between groups and within groups over time, indicating that the alcohol measure held together as a single factor with high loadings for all three items. This first and basic test of the equivalence of measures indicates that at a fundamental level, the items in this standard alcohol use scale "hang together" across groups and over time. Nonetheless, we found a great deal of variability in metric and scalar invariance across comparisons, suggesting that the reliability and meaning of a multi-item alcohol use measure differ in important ways across groups of interest during the transition to adulthood. Overall, models demonstrated greater measurement invariance across groups at Wave 1 (i.e., during adolescence), with non-invariance between groups defined by race/ethnicity, sexual identity, and college education increasing with age.

Longitudinal comparisons of measurement models indicated the greatest degree of non-invariance from adolescence to adulthood (Wave 1 to 3) relative to comparisons during adulthood (Wave 3 to 4), especially with regards to scalar invariance. None of the Wave 1 to 3 longitudinal comparisons were scalar invariant and only half demonstrated metric invariance, suggesting that measures of alcohol use behavior do not consistently characterize the ways in which young people drink across the transition to adulthood. Findings indicate

that multi-item alcohol use measures may be more robust in studies among adults relative to those that model differences in alcohol use between adolescents and young adults. Notably, measures were less likely to be invariant for women compared to men in longitudinal assessments, particularly during adulthood, suggesting greater variability in alcohol use behaviors with age for women, and revealing more shifts in the relative importance of items over time.

Given documented differences in distinct alcohol use behaviors, it is not surprising that our measure varies in its metric and scale across groups defined by race/ethnicity (Delker et al., 2016; Chen & Jacobsen, 2012; Whitbrodt et al., 2014), sexual identity (Hatzenbuehler et al., 2008; Hughes et al., 2016; Talley et al., 2016), and college education (Chen & Jacobsen, 2013; Merrill & Carey, 2016; White & Hingson, 2014) and at various ages across the transition to adulthood. The primary conclusions of these analyses are not just a matter of the details of our findings, which have been covered at length in the results section: The important point is that variation in metric and scalar invariance yields critical information regarding (1) potential for bias in estimates and inferences when using multi-item measurements of alcohol use, particularly when comparing differences across groups or ages that systematically vary in the construct of interest, and (2) substantive differences in the specific behaviors that reflect an underlying construct, thus illuminating unique trends, risk, and prevention strategies. If the former is true, past results reflecting group (i.e., racial/ethnic, sexual identity, and college education) differences in alcohol use may or may not reflect non-invariance, and in fact, the assumptions made by not testing for invariance is that these groups differences are real and not the product of measurement non-invariance.

Overall, results lead us to conclude that observed items are not always equally related to, nor provide a common scale for, the alcohol use latent construct across groups: that the co-occurrence of drinking behaviors—alcohol use frequency, HED frequency, and average quantity when drinking—are differentially related to the latent construct of alcohol use across race/ethnicity, college education, and to a lesser extent, sexual identity. The use of multi-item measures that demonstrate systematic variation across groups of interest, without taking into account this potential for measurement invariance, can create a critical situation whereby parameter estimates may reflect measurement error rather than true difference. Such error could overestimate or underestimate group and developmental differences and subsequently misguide recommendations for risk assessment and prevention efforts.

To provide an illustration with these data, we show metric non-invariance at Wave 4 for women who never attended college compared to those who obtained a bachelor's degree. If we were to model stress as a predictor of alcohol use, the beta coefficient estimated between stress and alcohol use would reflect an association that operates differently for these two groups of women. That is, if a single unit change in stress is more strongly associated with an increase in alcohol quantity for women who never attended college and alcohol frequency for women who earned a bachelor's, then the association between stress and alcohol use reflects an increase or decrease in a distinct alcohol use behavior for each group. In this example, women who never attended college might drink in greater quantities whereas women who earned a bachelor's degree might drink more frequently as the result of stress. Such bias could lead to miscalculated health risk and misdirected prevention efforts.

Variation in the measurement model across waves also reflects age differences in model equivalence for these groups, further complicating estimates of difference across a critical transition in the life course (IOM, 2015). Given the reliance on multi-item measures of substance (see Chassin, Flora, & King, 2004; Flory, Lynam, Milich, Leukefeld, & Clayton, 2004; Marshal et al., 2009) and alcohol use (see Corbin, Vaughan, & Fromme, 2008; Hatzenbuehler, Corbin, & Fromme, 2008), including studies conducted on these data specifically (see Fish & Pasley, 2015; Goings, Hidalgo, & McGovern, 2016; Dauber, Hogue, Paulson, & Leiferman, 2009; Mays, DePadilla, Thompson, Kushner, & Windle, 2010; Thompson, Sims, Kingree, & Windle, 2008), these findings have important implications for future approaches to measuring and modeling alcohol use in longitudinal and developmental frameworks.

4.1 Recommendations

It is important to note that measurement non-invariance does not preclude the use of multi-item alcohol measures. If non-invariant, partial measurement invariance techniques may offer solutions. In partial invariance assessments, fit is evaluated by imposing equality constraints on invariant parameters while those that demonstrate non-invariance are freely estimated—most often parameter(s) that contribute the most change in overall model fit (Little, 2013). Researchers suggest that at least one item other than the scaling item must be invariant at the metric and scalar level to provide enough stability for meaningful comparisons (Steenkamp & Baumgartner, 1998), although modeling decisions should be theoretically and empirically grounded (Byrne, Shavelson, & Muthén, 1989; Kline, 2016; Little, 2013). The results of our multiple group comparisons indicate that freeing a single item loading and/or intercept estimate could allow researchers to assess predictors and outcomes of a multi-item alcohol use measure without compromising estimates, though the complexity of these models increase across comparisons of more than two groups and more than one time-point.

Notably, measurement invariance assessments across groups and time offer valuable information on between- and within-group differences in the developmental trends of alcohol use and related behaviors. These findings encourage independent investigation of specific drinking behaviors for subpopulations of interest, illuminating previously unexamined differences in risk and associated consequences. In light of our findings, there may be some who conclude that the use of single-item measures may be a more parsimonious approach to understanding risk for alcohol use and related consequences—and there are instances where this is true. Heavy episodic binge drinking, for example, has traditionally been a health risk behavior of interest given the associated short and long-term consequences. Indeed, the investigation of predictors and outcomes captured by single-item measures provides valuable insight into health risk behavior; however, the use of multi-item measures allows researchers to better understand how patterns of alcohol-related behaviors work in concert to confer risk. That is, for example, although heavy episodic drinking may be an important and adequate indicator for injury-related outcomes, the simultaneous measurement of alcohol frequency, average quantity, and HED may better predict vulnerability for alcohol use disorders and long-term health consequences. Ultimately, as with any modeling decisions, the choice to use single- versus multi-item measures should be

grounded by the research questions and the broader empirical literature, but if these considerations suggest the use of multiple-item measures, scholars should consider conducting measurement testing procedures to substantiate their results and address their potential limitations. At the very least, like other preliminary data analysis procedures, testing for measurement invariance would reveal important descriptive data regarding potential differences in alcohol-related behaviors, constellations of alcohol-related behaviors, and their relationship with covariates and outcomes.

4.2 Limitations

Despite the contributions of our study we must note limitations. First, the assessment of alcohol-related behaviors were recorded, on average, six years apart. Ideally, we would have been able to assess within-person rates of change across 1- or 2-year age increments, but this was not possible with the Add Health data. Data assessments of alcohol use across shorter timespans may provide greater specificity as to when alcohol-related behaviors change across the transition to adulthood as well as the quality of the measures that capture them. Second, the data available only follow adults into their early 30s. Given that middle and late adulthood are critical periods for the development of alcohol use disorders (Schulenberg, Patrick, Kloska, Maslowky, Maggs, & O'Malley, 2016), future assessments of alcohol-related measures may yield important findings regarding the utility of multi-item alcohol use measures at these later ages. Third, though our measure reflects recommendations from the NIAAA, there are many other commonly relied upon measures of alcohol use (e.g., the Alcohol Use Disorders Identification Test [AUDIT]), that would benefit from similar testing procedures. Finally, given that our study is a methodological assessment of a multi-item alcohol use measure, we do not assess the interpersonal, psychological, and social factors that may shape alcohol use behaviors for groups defined by race/ethnicity, sexual identity, and college attendance or contribute to within-group differences for these groups during the transition to adulthood.

4.3 Conclusion

Using nationally representative longitudinal data, we demonstrate the measurement invariance of a three-item alcohol use measure across groups defined by race/ethnicity, sexual identity, and college education from adolescence through the early thirties. Findings document configural invariance, suggesting a minimal standard of measurement invariance, but indicate that a multi-item alcohol use measure may introduce biased parameter estimates if models do not account for scalar and metric invariance, especially when investigating differences between groups that have previously established disparities in alcohol use behavior(s). We do not aim to provide a universal recommendation regarding the use of a multi-item alcohol use measure. Instead, we illustrate the importance of testing measurement invariance to call attention to the potential influence of measurement non-invariance in studies that model predictors and outcomes of alcohol use. Assessments of invariance may also illuminate distinct differences in alcohol use risk, behaviors, and consequences, leading to new research questions and intervention strategies. Without this attention the specificity of our focus and approaches to risk and prevention for target populations may be misinformed. Researchers should consider measurement invariance testing in their preliminary data

procedures to strengthen their inferences when measuring alcohol use and other substance across groups or time.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- The measurement invariance of alcohol use varied across key demographic groups.
- Models were more invariant across groups during adolescence than adulthood.
- The alcohol use measure operated differently for youth and young adults.
- Most longitudinal comparisons were scalar non-invariant; half were metric invariant.
- Alcohol use measures that are non-invariant across groups or time may bias results.

Table 1

Sample Demographic Characteristics and Observed Averages of Alcohol Use by Wave

	n	Wave 1 (ages 13–18)		Wave 3 (ages 25–32)		Wave 4 (ages 25–32)	
		% _w	M _{W1} 95% CI	M _{W3} 95% CI	M _{W4} 95% CI		
Males							
Race/Ethnicity							
White, non-Hispanic	2989	67.3	1.51 (1.43, 1.58)	2.94 (2.86, 3.01)	2.67 (2.60, 2.73)		
Black, non-Hispanic	991	15.3	.93 (.83, 1.03)	1.54 (1.43, 1.65)	1.65 (1.54, 1.76)		
Hispanic	859	12.01	1.48 (1.35, 1.61)	2.38 (2.25, 2.51)	2.43 (2.30, 2.56)		
A/PI, non-Hispanic	386	3.56	0.72 (.59, .86)	2.17 (1.98, 2.36)	2.35 (2.17, 2.52)		
Sexual Orientation							
Heterosexual	4973	93.1	1.41 (1.36, 1.47)	2.67 (2.61, 2.73)	2.49 (2.44, 2.54)		
Mostly heterosexual	167	3.27	1.17 (.90, 1.44)	2.22 (1.94, 2.50)	2.38 (2.08, 2.67)		
Lesbian/bisexual	146	2.49	1.10 (.83, 1.37)	2.46 (2.16, 2.76)	2.53 (2.27, 2.78)		
College Education							
No College	1811	36.71	1.50 (1.41, 1.60)	2.31 (2.21, 2.41)	2.33 (2.23, 2.42)		
Dematriculated	1130	20.96	1.52 (1.40, 1.64)	2.75 (2.63, 2.86)	2.60 (2.50, 2.71)		
Associate's degree	358	6.15	1.29 (1.10, 1.48)	2.75 (2.55, 2.95)	2.44 (2.26, 2.63)		
Bachelor's degree	1265	22.51	1.20 (1.10, 1.30)	2.94 (2.84, 3.05)	2.66 (2.57, 2.75)		
Females							
Race/Ethnicity							
White, non-Hispanic	3522	68.17	1.26 (1.21, 1.31)	2.10 (2.05, 2.15)	1.84 (1.79, 1.89)		
Black, non-Hispanic	1432	15.9	.83 (.75, .90)	1.05 (.98, 1.13)	1.11 (1.04, 1.18)		
Hispanic	947	11.35	1.07 (.97, 1.16)	1.60 (1.50, 1.71)	1.47 (1.37, 1.57)		
A/PI, non-Hispanic	376	3.19	0.71 (.58, .84)	1.37 (1.22, 1.51)	1.36 (1.22, 1.50)		
Sexual Orientation							
Heterosexual Mostly	5431	84.23	1.09 (1.05, 1.13)	1.78 (1.74, 1.82)	1.60 (1.56, 1.64)		
Heterosexual	652	10.68	1.57 (1.44, 1.70)	2.37 (2.25, 2.49)	2.13 (2.01, 2.24)		
Lesbian/bisexual	220	3.46	1.57 (1.34, 1.80)	2.56 (2.34, 2.79)	2.28 (2.06, 2.51)		
College Education							
No College	1650	27.27	1.30 (1.21, 1.38)	1.51 (1.43, 1.59)	1.47 (1.39, 1.55)		

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	n	Wave 1 (ages 13–18)		Wave 3 (ages 18–25)		Wave 4 (ages 25–32)	
		% _w	M _{W1} 95% CI	M _{W3} 95% CI	M _{W4} 95% CI	M _{W4} 95% CI	M _{W4} 95% CI
Denatriculated	1187	18.97	1.18 (1.09, 1.27)	1.91 (1.82, 2.01)	1.71 (1.62, 1.79)		
Associates	451	7.2	1.15 (1.01, 1.29)	1.73 (1.59, 1.87)	1.54 (1.41, 1.67)		
Bachelors	1810	27.18	0.98 (.92, 1.05)	2.11 (2.04, 2.18)	1.82 (1.76, 1.89)		

Note. A/PI = Asian, Pacific Islander. Percentages and mean level differences are weighted estimates.

Table 2

Overall and Between-Group Comparisons for **Males** Based on Race/Ethnicity, Sexual Orientation, and College Education

	Wave 1					Wave 3					Wave 4				
	Metric		Item			Metric		Item			Metric		Item		
	CFI	Scalar	DF	AQ	HD	CFI	Scalar	DF	AQ	HD	CFI	Scalar	DF	AQ	HD
Race/Ethnicity	×	.011	—	—	—	✓	.008	✓	.009	—	×	.018	—	—	—
White v. Black	×	.017	—	—	×	×	.010	—	—	×	×	.022	—	—	×
White v. Hispanic	✓	.000	✓	.000		✓	.001	✓	.000		✓	.006	✓	.001	
White v. A/PI	✓	.000	✓	.000		✓	.000	✓	.001		✓	.001	✓	.001	
Black v. Hispanic	×	.013	—	—	×	×	.013	—	—	×	✓	.006	×	.016	×
Black v. A/PI	✓	.003	✓	.003		✓	.000	✓	.005		×	.010	—	—	×
Hispanic v. A/PI	✓	.000	✓	.000		✓	.000	✓	.003		✓	.000	✓	.006	
Sexual Orientation	✓	.000	✓	.000		✓	.000	✓	.004		✓	.001	✓	.004	
Heterosexual v. Mostly heterosexual	✓	.000	✓	.001		✓	.000	✓	.002		✓	.000	✓	.001	
Heterosexual v. Gay/bisexual	✓	.000	✓	.000		✓	.000	✓	.002		✓	.001	✓	.004	
Mostly heterosexual v. Gay/bisexual	✓	.000	✓	.000		✓	.001	✓	.001		✓	.000	✓	.002	
College Education	✓	.004	✓	.007		×	.013	—	—		×	.010	—	—	
No College v. Dematriculated	✓	.004	✓	.001		×	.010	—	—	×	✓	.002	×	.022	×
No College v. Associate's	✓	.002	✓	.005		✓	.006	✓	.004		✓	.000	×	.014	×
No College v. Bachelor's	✓	.005	✓	.008		×	.012	—	—	×	×	.013	—	—	×
Dematriculated v. Associate's	✓	.000	✓	.000		✓	.000	✓	.000		✓	.000	✓	.000	
Dematriculated v. Bachelor's	✓	.000	✓	.000		✓	.002	✓	.002		✓	.005	×	.027	×
Associate's v. Bachelor's	✓	.000	✓	.001		✓	.000	✓	.002		✓	.000	✓	.003	

Note. All models passed configural invariance. Comparisons highlighted in grey reflect omnibus tests of measurement invariance across all groups.

✓ = reflect metric or scalar invariance, thus item loadings and/or intercepts were invariant across comparisons

× = reflect that metric or scalar invariance failed, thus item loadings and/or intercepts were non-invariant across comparisons.

When metric invariance failed for a given comparison, scalar invariance was not tested.

DF = drinking frequency; AQ = average quantity when drinking; HD = heavy episodic drinking. Item columns with × denote statistical differences in loading or intercept across groups at CFI < .010.

Table 3

Overall and Between-Group Comparisons for **Females** Based on Race/Ethnicity, Sexual Orientation, and College Education

	Wave 1						Wave 3						Wave 4					
	Metric			Item			Metric			Item			Metric			Item		
	CFI	Scalar	DF	AQ	HD		CFI	Scalar	DF	AQ	HD		CFI	Scalar	DF	AQ	HD	
Race/Ethnicity	✓	.005	✓	.007			×	.054	—	—			×	.035	—	—		
White v. Black	✓	.006	✓	.008			×	.092	—	—	×		×	.044	—	—	×	
White v. Hispanic	✓	.003	✓	.000			✓	.005	✓	.005			×	.016	—	—	×	
White v. A/PI	✓	.000	✓	.000			✓	.004	✓	.001			✓	.004	✓	.000		
Black v. Hispanic	✓	.008	×	.026	×		×	.022	—	—	×		✓	.007	×	.010	×	
Black v. A/PI	✓	.006	×	.011	×		×	.045	—	—	×		✓	.000	✓	.000		
Hispanic v. A/PI	✓	.000	✓	.000			✓	.000	✓	.005			✓	.000	×	.012	×	
Sexual Orientation	✓	.001	✓	.002			×	.026	—	—			×	.035	—	—		
Heterosexual v. Mostly heterosexual	✓	.001	✓	.000			×	.022	—	—	×		×	.030	—	—	×	
Heterosexual v. Lesbian/bisexual	✓	.000	✓	.002			✓	.006	✓	.002			✓	.008	✓	.002		
Mostly heterosexual v. Lesbian/bisexual	×	.012	—	—	×		✓	.000	✓	.000	×		✓	.000	✓	.000		
College Education	✓	.005	×	.014			×	.016	—	—			×	.047	—	—		
No College v. Dematriculated	✓	.000	✓	.004			✓	.003	✓	.009			✓	.006	×	.019	×	
No College v. Associate's	×	.010	—	—	×		✓	.000	✓	.004	×		✓	.003	✓	.008		
No College v. Bachelor's	✓	.004	×	.016	×		×	.020	—	—	×		×	.086	—	—	×	
Dematriculated v. Associate's	×	.013	—	—	×		✓	.003	✓	.002	×		✓	.000	✓	.000		
Dematriculated v. Bachelor's	✓	.003	✓	.001			✓	.007	×	.041			×	.034			×	
Associate's v. Bachelor's	✓	.000	✓	.008			×	.014	—	—	×		✓	.006	×	.066		

Note. All models passed configural invariance. Comparisons highlighted in grey reflect omnibus tests of measurement invariance across all groups.

✓ = reflect metric or scalar invariance, thus item loadings and/or intercepts were invariant across comparisons

×

When metric invariance failed for a given comparison, scalar invariance was not tested.

DF = drinking frequency; AQ = average quantity when drinking; HD = heavy episodic drinking.
Item columns with X denote statistical differences in loading or intercept across groups at $CFI < .010$.

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Loadings, Intercepts, and Residual Variances for Males and Females by Groups Defined by Race/Ethnicity, Sexual Orientation, and College Education by Wave

Table 4

Race/Ethnicity	Males												Females											
	Wave 1				Wave 3				Wave 4				Wave 1				Wave 3				Wave 4			
	λ	τ	θ		λ	τ	θ		λ	τ	θ		λ	τ	θ		λ	τ	θ		λ	τ	θ	
White, non-Hispanic	DF	1.41	1.21	.41	1.57	2.76	.92	1.44	2.82	1.30	1.20	1.12	.45	1.32	2.20	.79	1.33	2.15	1.02					
	A	2.8	2.5	3.7	2.3	4.1	5.4	1.9	3.5	4.7	2.3	2.0	2.6	1.7	2.9	3.3	1.4	2.3	2.7					
	Q	4	1	7	9	6	5	6	4	8	2	6	5	7	6	9	4	2	5					
	H	1.2			1.6	1.9		1.5	1.6		1.0			1.2	1.1		1.2	1.0						
	D	9	.82	.42	4	0	.39	8	5	.36	2	.61	.38	4	5	.51	5	6	.34					
Black, non-Hispanic	DF	1.44	.90	.23	1.64	1.73	1.01	1.67	1.93	.97	1.22	.88	.53	1.26	1.19	.55	1.31	1.39	.73					
	A	1.9	1.3	2.6	2.0	2.0	2.2	1.9	2.1	2.3	1.7	1.2	2.3	1.9	1.6	2.9	1.4	1.4	1.6					
	Q	1	1	2	3	2	5	9	1	3	5	5	1	5	8	1	3	7	8					
	H	1.1			1.2			1.2																
	D	5	.59	.67	2	.86	.80	1	.91	.83	.76	.35	.57	.58	.30	.47	.74	.48	.56					
Hispanic	DF	1.49	1.22	.37	1.51	2.25	.98	1.60	2.47	.92	1.15	.95	.32	1.29	1.61	.69	1.37	1.61	.70					
	A	2.7	2.4	4.2	2.4	3.4	4.0	2.1	3.3	4.9	2.1	1.7	2.6	2.0	2.5	3.7	1.7	2.0	2.4					
	Q	6	6	5	8	6	2	8	7	0	5	5	9	2	0	0	5	5	0					
	H	1.2			1.4	1.4		1.4	1.4					1.0			1.0							
	D	4	.80	.59	6	5	.64	5	6	.69	.83	.52	.48	1	.72	.43	3	.76	.57					
A/PI, non-Hispanic	DF	1.07	.64	.12	1.57	2.28	.71	1.36	2.60	.89	.97	.65	.35	1.23	1.54	.74	1.43	1.74	.76					
	A	1.8	1.1	1.3	2.3	3.0	3.3	2.0	3.1	3.6	1.8	1.1	1.1	1.7	1.9	1.7	1.4	1.6	2.0					
	Q	9	5	6	0	8	6	3	4	8	1	3	7	6	2	1	0	8	4					
	H				1.3	1.1		1.3	1.3															
	D	.91	.38	.30	6	9	.74	2	0	.50	.80	.35	.17	.92	.65	.47	.90	.64	.52					
Sexual Orientation																								
Heterosexual	DF	1.43	1.17	.40	1.61	2.55	.96	1.52	2.64	1.19	1.17	1.00	.44	1.35	1.87	.70	1.32	1.87	.95					

	Males										Females									
	Wave 1					Wave 3					Wave 1					Wave 3				
	λ	τ	θ	λ	τ	θ	λ	τ	θ		λ	τ	θ	λ	τ	θ	λ	τ	θ	
A	2.7	2.3	3.7	2.4	3.8	4.8	2.0	3.3	4.4	2.1	1.7	2.5	1.9	2.6	3.2	1.5	2.0	2.4	2.4	
Q	4	2	0	8	0	5	9	3	4	8	7	1	2	0	5	5	9	6	6	
H	1.2			1.6	1.6		1.5	1.5					1.0			1.0				
D	7	.78	.47	0	9	.52	2	1	.52	.95	.52	.40	8	.88	.56	7	.84	.44	.44	
Mostly Heterosexual	DF	1.35	.96	.07	1.57	2.45	.91	1.68	2.68	1.23	1.17	1.42	.75	1.19	2.55	1.07	1.31	2.54	1.19	
A	2.4	1.8	2.5	2.0	2.8	2.8	1.9	2.9	3.6	2.4	2.5	2.3	1.4	3.2	3.7	1.1	2.4	2.3	2.3	
Q	0	4	1	5	0	6	4	0	1	5	1	4	2	0	6	4	6	2	2	
H	1.2			1.4	1.4		1.6	1.5		1.0			1.4	1.3		1.4	1.3			
D	7	.71	.29	0	1	.45	8	5	.36	6	.77	.46	5	5	.18	9	9	.09	.09	
Lesbian, gay, or bisexual	DF	1.22	.95	.29	1.44	2.63	1.20	1.37	3.07	1.22	1.36	1.38	.35	1.31	2.66	.99	1.60	2.57	.75	
A	2.3	1.7	2.7	1.9	3.1	3.3	1.4	2.9	2.4	2.3	2.6	4.2	1.6	3.5	4.7	1.3	2.7	3.6	3.6	
Q	3	3	5	5	6	5	7	9	3	1	7	6	2	0	0	4	8	0	0	
H	1.0			1.5	1.6		1.4	1.5					1.4	1.5		1.5	1.5			
D	2	.62	.77	6	0	.20	0	3	.51	.92	.68	.56	5	4	.31	4	0	.79	.79	
College Education																				
No College	DF	1.53	1.21	.33	1.72	2.11	.80	1.71	2.25	.97	1.26	1.09	.44	1.38	1.44	.49	1.42	1.48	.58	
A	2.7	2.4	4.7	2.7	3.4	4.8	2.4	3.3	4.8	2.4	2.1	3.3	2.1	2.3	3.3	1.9	2.1	2.6	2.6	
Q	1	3	0	5	2	5	8	3	9	7	5	7	6	6	1	4	4	8	8	
H	1.4			1.5	1.4		1.6	1.4		1.0			1.0			1.1				
D	0	.90	.48	7	4	.61	2	4	.57	9	.67	.51	7	.75	.55	1	.79	.54	.54	
Dematriculated	DF	1.46	1.24	.47	1.53	2.66	1.11	1.52	2.76	.98	1.19	1.11	.64	1.36	1.96	.73	1.35	1.89	.70	
A	2.8	2.5	3.7	2.1	3.8	5.3	1.9	3.4	4.7	2.1	1.8	2.6	1.9	2.8	3.7	1.6	2.3	2.7	2.7	
Q	9	0	9	8	8	4	0	9	4	8	6	7	0	4	3	2	1	8	8	
H	1.3			1.5	1.7		1.4	1.5		1.0			1.1			1.1				
D	1	.85	.67	8	1	.45	5	6	.66	2	.58	.44	5	.95	.58	4	.91	.48	.48	
Associate's degree	DF	1.35	1.02	.11	1.52	2.66	.88	1.38	2.65	1.22	1.16	.97	.32	1.21	1.75	.54	1.33	1.70	.65	
A	2.5	2.2	4.0	2.1	3.8	5.0	2.0	3.2	3.0	2.1	2.0	3.3	1.8	2.6	3.4	1.4	2.1	2.9	2.9	

		Males						Females					
		Wave 1		Wave 3		Wave 4		Wave 1		Wave 3		Wave 4	
		λ	τ	θ	λ	τ	θ	λ	τ	θ	λ	τ	θ
Bachelor's degree	Q	0	6	2	9	9	2	1	0	2	6	0	7
	H	1.1			1.6	1.7		1.4	1.4				1.0
	D	0	.61	.36	1	2	.49	6	7	.54	.79	.47	.31
											.91	.78	.50
Bachelor's degree	DF	1.27	1.05	.40	1.43	2.96	1.01	1.21	3.16	1.42	1.11	.98	.43
	A	2.5	1.9	2.2	2.2	3.9	4.1	1.5	3.2	3.7	2.0	1.5	1.4
	Q	9	6	1	8	5	4	7	2	0	1	5	0
	H	1.0			1.6	1.9		1.4	1.5				
Bachelor's degree	D	9	.60	.29	3	3	.34	7	9	.25	.79	.42	.26

λ = item loading; τ = item residual variance. DF = drinking frequency; AQ = average quantity when drinking; HD = heavy episodic drinking

Table 5
Longitudinal Within-Group Comparisons for Males and Females Based on Race/Ethnicity, Sexual orientation, and College Education.

Wave 1 v. 3										Wave 3 v. 4						Wave 1 v. 4					
Metric	CFI	Scalar	CFI	Item			Metric	CFI	Scalar	CFI	Item			Metric	CFI	Scalar	CFI	Item			
				DF	AQ	HD					DF	AQ	HD					DF	AQ	HD	
Males																					
Race/Ethnicity																					
White, non-Hispanic	×	.030	—	—	×	×	✓	.005	×	.025	×	×	×	.044	—	—	×	×	×		
Black, non-Hispanic	✓	.006	×	.065	×	×	✓	.000	✓	.000	✓	✓	✓	.001	✓	.092	×	×	×		
Hispanic	✓	.008	×	.076	×	×	✓	.003	✓	.009	✓	×	×	.021	—	—	×	×	×		
A/PI, non-Hispanic	×	.020	—	—	×	×	✓	.007	×	.013	×	×	×	.020	—	—	×	×	×		
Sexual Orientation																					
Heterosexual	×	.021	—	—	×	×	✓	.004	×	.015	×	×	×	.030	—	—	×	×	×		
Mostly heterosexual	✓	.005	×	.128	×	×	✓	.006	✓	.003	✓	×	×	.027	—	—	×	×	×		
Gay/bisexual	✓	.009	×	.297	×	×	✓	.000	×	.027	×	×	✓	.004	✓	.451	×	×	×		
College Education																					
No College	✓	.006	×	.060	×	×	✓	.002	✓	.002	✓	×	×	.015	—	—	×	×	×		
Dematriculated	×	.043	—	—	×	×	✓	.001	×	.014	×	×	×	.038	—	—	×	×	×		
Associate's degree	×	.032	—	—	×	×	✓	.002	×	.025	×	×	×	.023	—	—	×	×	×		
Bachelor's degree	×	.042	—	—	×	×	×	.016	×	—	×	×	×	.049	—	—	×	×	×		
Females																					
Race/Ethnicity																					
White, non-Hispanic	×	.031	—	—	×	×	✓	.008	×	.028	×	×	×	.067	—	—	×	×	×		
Black, non-Hispanic	✓	.006	×	.026	×	×	✓	.026	✓	—	✓	✓	✓	.006	×	.045	×	×	×		
Hispanic	✓	.008	×	.091	×	×	✓	.001	×	.015	×	×	×	.037	—	—	×	×	×		
A/PI, non-Hispanic	✓	.002	×	.087	×	×	×	.018	×	—	×	×	×	.037	—	—	×	×	×		
Sexual Orientation																					
Heterosexual	×	.014	—	—	×	×	✓	.008	×	.020	×	×	×	.039	—	—	×	×	×		
Mostly heterosexual	×	.100	—	—	×	×	✓	.006	×	.036	×	×	×	.153	—	—	×	×	×		
Lesbian/bisexual	×	.069	—	—	×	×	✓	.009	×	.023	×	×	×	.124	—	—	×	×	×		
College Education																					
							✓														

	Wave 1 v. 3						Wave 3 v. 4						Wave 1 v. 4					
	Metric			CFI			Scalar			CFI			Metric			CFI		
	Item			DF			AQ			HD			Item			DF		
No College	✓	.005	×	×	.019	×	×	×	×	×	×	×	×	.017	—	—	×	×
Dematriculated	×	.011	—	—	—	×	×	×	×	×	×	×	×	.027	—	—	×	×
Associate's degree	✓	.000	×	×	.087	×	×	×	×	×	×	×	×	.049	—	—	×	×
Bachelor's degree	×	.054	—	—	—	×	×	×	×	×	×	×	×	.138	—	—	×	×

Note. All models passed configural invariance.

✓ = reflect metric or scalar invariance, thus item loadings and/or intercepts were invariant across comparisons

×

 = reflect that metric or scalar invariance failed, thus item loadings and/or intercepts were non-invariant across comparisons.

When metric invariance failed for a given comparison, scalar invariance was not tested.

DF = drinking frequency; AQ = average quantity when drinking; HD = heavy episodic drinking.

Item columns with × denote statistical differences in loading or intercept across waves at CFI < .010.