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Longitudinal reciprocal associations between anxiety, depression, and alcohol use in adolescent girls

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Abstract

Background.—Depression, anxiety, and alcohol misuse predict adverse social, academic, and emotional outcomes, and their relations to one another increase during adolescence—particularly in girls. However, evidence on the directions of these relations is mixed. Longitudinal models of internalizing problem-alcohol use links may identify promising prevention targets. Accordingly, we examined reciprocal associations between anxiety severity and alcohol use, as well as depression severity and alcohol use, in adolescent girls.

Method.—Data were drawn from a population-based longitudinal study of female adolescents. The current sample comprised 2,100 participants (57.1% Black, 42.9% White) assessed annually between ages 13–17. Girls self-reported depression severity, anxiety severity, and frequency of alcohol use (consumption of 1 full drink) in the past year. Primary caregivers reported on socioeconomic and neighborhood factors; these were included with race, early puberty, and conduct problems (youth-report) as covariates. Anxiety and depression severity were included within a single cross-lagged panel model, along with alcohol use, to isolate their independent and reciprocal links to drinking behavior.

Results.—Higher depression severity modestly predicted increased likelihood of subsequent alcohol use from ages 13 to 17. However, inconsistent relations emerged for the reverse pathway: alcohol use modestly predicted *decreased* depression severity at ages 14 and 16; associations were non-significant in other lagged associations. Anxiety severity and alcohol use were not consistently associated.

Conclusions.—Results highlight the key role of depression, relative to anxiety, in predicting later alcohol use. Future studies may examine whether depression prevention programs yield secondary reductions in alcohol use in adolescent girls.

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Keywords

Adolescence; anxiety; depression; alcohol use; longitudinal

Introduction

Internalizing problems (depression and anxiety) and alcohol misuse often co-occur, particularly during adolescence (Marmorstein, 2009). Indeed, levels of depression (Lewinsohn, Hops, Roberts, Seeley, & Andrews, 1993), anxiety (Cambell, Brown, & Grisham, 2003), and alcohol use (Colder, Campbell, Ruel, Richardson, & Flay, 2002; Jackson, Sher, Cooper, & Wood, 2002) consistently increase starting between 13 and 15 years of age, and the internalizing problem-alcohol use association may be stronger during adolescence than during other developmental periods (Marmorstein, 2009). However, evidence is conflicting regarding the temporal ordering of this association. Some studies support a pathway whereby adolescents' alcohol consumption is motivated by a desire to relieve emotional distress (Hussong, Jones, Stein, Baucom, & Boeding, 2011; Khantzian, 1985); others suggest that alcohol problems precipitate adolescent internalizing problems (Stice et al., 2004); and some have found a reciprocal association (Deykin et al., 1992; Marmorstein, 2009). Given that adolescent internalizing problems and alcohol use predict a host of adverse outcomes, from academic and interpersonal difficulties to suicide risk (Asselmann, Wittchen, Lieb, & Beesdo-Baum, 2018; Esposito-Smythers & Spirito, 2004), there is a need to ascertain promising prevention targets. By identifying the nature and directions of these links over time, longitudinal models of reciprocal associations between adolescent internalizing problems and alcohol use may help address this need.

Several factors might explain discrepant findings to date on the internalizing problem-alcohol use link, suggesting priorities for research on their longitudinal associations. First, different types of internalizing problems are routinely collapsed in developmental psychopathology research on substance use trajectories (e.g., Colder et al., 2013; Hussong, Ennett, Cox, & Haroon, 2017; Miettunen et al., 2014), obscuring the potentially unique relations of depression and anxiety to alcohol use. Although anxiety and depression are highly associated with one another, theory and research suggest both shared and independent features. For instance, Clark & Watson's (1991) *tripartite model of anxiety and depression* posits that the two share a common 'high negative affect' factor, but that 'physiological hyper-arousal' and 'low positive affect' factors may be specific to anxiety and depression, respectively. These factors have helped differentiate anxiety and depression in clinical and community youth samples (Anderson & Hope, 2008; Chorpita, 2002). Given these distinctions, the internalizing-to-alcohol use pathway may be driven more strongly by depression *or* by anxiety; likewise, alcohol use might differentially influence subsequent levels of depression and anxiety, particularly if drinking shapes factors unique to depression vs. anxiety, or vice versa. Because such differential links remain understudied, there is a need for research isolating the independent, reciprocal associations between different internalizing problem types and alcohol use. Longitudinal models including simultaneous measures of anxiety severity, depression severity, and alcohol use constitute a key step toward this goal.

Second, research suggests that relations of anxiety and depression to alcohol use differ by age (Marmorstein, 2009; Schuler, Vasilenko, & Lanza, 2015), and that these relations are significantly stronger in girls than in boys (Marmorstein, 2009; Poulin et al., 2005). For example, Schuler and colleagues (2015) observed that the strength of the association between heavy drinking and depression severity peaked during adolescence but was non-significant at other developmental stages (Schuler et al., 2015). Separately, Marmorstein (2009) found that the depression-alcohol use association was stronger for early adolescent girls than same-aged boys, and Poulin and colleagues (2005) observed that alcohol use predicted depression severity increases in girls but not boys. Another study found a significant link between the presence of any anxiety disorder and increased drinking in adolescent girls, but not boys (Wu et al., 2009). These results suggest the need to model the internalizing problem-alcohol use links within specific developmental stages, and the need to parse gender-specific pathways of those associations. A focus on adolescent girls might be particularly warranted, given higher rates of anxiety and depression severity in girls compared to boys beginning in adolescence (Hankin, Abramson, Moffitt, Silva, McGee, & Angell, 1998); stronger associations between internalizing problems and alcohol use in adolescent girls versus boys (Poulin et al., 2005); and evidence for potentially different relations between internalizing problems and alcohol use for girls (Marmorstein, White, Chung, Hipwell, Stouthamer-Loeber, & Lober, 2010) and for boys (Marmorstein, White, Loeber, & Stouthamer-Loeber, 2010).

Third, despite high comorbidity between adolescent externalizing, internalizing, and alcohol-related problems, relatively few studies on the internalizing problem-alcohol use link have considered co-occurring externalizing symptoms (Hussong et al., 2017). Across studies that have controlled for externalizing problems, results have again been mixed (see Hussong et al., 2017 for a review). Depression severity and alcohol use have shown positive associations in some instances (Cerda, Bordelois, Keyes, Galea, Koenen, & Pardini, 2013; Wu et al., 2008), but not others (Kumpaleinen & Roine, 2002); and anxiety severity has shown positive, negative, and non-significant links to alcohol use after accounting for externalizing problems (Beiderman, 1996; Cerda et al., 2013; Marmorstein, White, et al., 2010). The variability of these findings likely results from widely varying ages, gender distributions, sample types (clinical vs. community), and measurement approaches across studies; further, anxiety and depression were not typically included in the same models, leaving independent associations to alcohol use largely unexplored. This highlights the need for developmentally targeted, gender-specific models that test relations of anxiety and depression with alcohol use, independent of co-occurring behavioral problems.

Fourth, some evidence suggests that internalizing problems and alcohol use may differ across ethnic/racial minority and non-minority youths, as well as socioeconomically disadvantaged and advantaged youths (Chen & Jacobson, 2012; McLaughlin, Hilt, & Nolen-Hoeksema, 2007). Mean differences do not necessarily imply differences in these variables' relations; nonetheless, possible differences in internalizing problem-alcohol use links by socioeconomic status and race may remain important to consider. For instance, Black adolescents are more likely than White adolescents, and low-income families are more likely than higher income families, to reside in communities with a high number of alcohol outlets and aggressive alcohol advertising (LaVeist & Wallace, 2000; Pollack, Cubbin, Ahn, &

Winkleby, 2005). These differences may increase the likelihood of Black adolescents, or those from low income families, to drink in response to psychological distress (e.g., depression and anxiety; Huckle, Huakau, Sweetsur, Huisman, & Casswell, 2008). Further, compared to White adolescents, Black adolescents are less likely to receive any kind of outpatient treatment for depression or anxiety, independent of family income and insurance status (Cumplings & Druss, 2011). Thus, a higher proportion of Black youth and socioeconomically disadvantaged youth might be left vulnerable to developing subsequent alcohol use-related problems. Some studies of internalizing problem-alcohol use relations have accounted for socioeconomic disadvantage, but these studies have largely focused on cross-sectional or unidirectional (versus reciprocal) internalizing-alcohol associations (Goodman & Huang, 2002; Hill & Angel, 2005; Vega, Zimmerman, Warheit, Apospori, & Gil, 1993); failed to account for externalizing problems (Hill & Angel, 2005; Peirce et al., 1994); or included youths spanning multiple developmental stages (e.g., Huckle et al., 2008). Thus, a need remains for models of reciprocal relations between adolescent internalizing distress and alcohol use that account for socioeconomic context.

This study aims to address these limitations by examining prospective, reciprocal associations between (a) anxiety severity and alcohol use and (b) depression severity and alcohol use in a large, community sample of girls from ages 13 to 17. Given our interest in the independent links of anxiety and depression with alcohol use, separate measures of anxiety and depression severity were included within a single cross-lagged panel model, along with a variable indexing consumption of at least one full drink in the previous year (Sartor, Bachrach, Stepp, Werner, Hipwell, & Chung, 2018), using data collected from five annual assessments. We included co-occurring conduct problems, early puberty (which predicts alcohol use trajectories into adulthood; Deardroff, Gonzales, Christopher, Roose, & Millsap, 2005), race, and socioeconomic and neighborhood factors across multiple dimensions (family poverty; parental education level; living in a single-parent home; neighborhood safety and community cohesion), as theoretically relevant covariates in the cross-lagged panel models. This allowed us to account for their influences on internalizing distress and alcohol use and to build a generalizable model of internalizing problem-alcohol use links. We hypothesized that higher anxiety and depression severity would independently predict increased odds of subsequent alcohol use during adolescence—and that higher levels of alcohol use would predict subsequent increases in anxiety and depression severity—over and above the effects of comorbid conduct problems and socioeconomic factors.

Materials and Methods

Participants

The Pittsburgh Girls Study (PGS) is a longitudinal study of 2,450 urban-living girls who were ages 5–8 in the first annual assessment wave. Participants were recruited in 1999–2000, following a city-wide enumeration. In neighborhoods where 25% of families or more were living at or below the poverty line according to 1990 Census information (n=23), all homes were contacted to assess whether an age-eligible girl lived in the home; in other neighborhoods (n=66), 50% of households were enumerated. The enumeration of 103,238

households identified 2,875 eligible families, of whom 85.2% completed the first wave of data collection (for further sampling details, see Hipwell et al., 2002; Keenan et al., 2010).

In the current analyses the small subsample of girls who did not identify as White or Black ($n=145$) were excluded to increase interpretability of the possible distinctions by race in the internalizing problem-alcohol use link, given the documented differences in prevalence of alcohol use between Black and White adolescents (Huckle et al., 2008; Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2017; Malone, Northrup, Masyn, Lamis, & Lamont, 2012). We also excluded girls for whom alcohol use, anxiety, and depression data were all missing between ages 14 through 17 ($n=206$). Thus, the final sample included 2,100 girls (57.71% Black). There were no significant differences in levels of depression, $t(2065)=0.36$, $p=0.72$, anxiety, $t(2065)=-0.05$, $p=.96$, or odds of consuming a full drink at age 13, $\chi^2_{(1)}=0.07$, $p=0.79$, between girls who were included versus excluded in study analyses.

PGS sample retention was high: 88.5% on average over the years that data used in the current analyses were collected (2005–2010), when girls were 13–17 years of age.

Procedure

Written consent from the primary caregiver and verbal assent from the child were obtained prior to data collection. Annual face-to-face interviews were conducted in participants' homes, separately for girls caregivers (94% mothers), by trained research staff. The protocol for maintaining confidentiality was explained to all participants, and the girls received reminders during the interview that their information would not be shared with caregivers. The protocol was approved by the University of Pittsburgh's Institutional Review Board prior to the start of data collection. Families were compensated for their time.

Measures

All variables were assessed annually from ages 13 through 17, either via girls' self-report or primary caregiver report, as indicated below for each measure.

Internalizing symptom severity and alcohol use

Depression severity was assessed using the Adolescent Symptom Inventory–fourth edition (ASI-4; Gadow & Sprafkin, 1997), which assesses the severity of symptoms associated with *DSM-IV* depressive disorders rated on a scale from 0–3 as occurring “never,” “sometimes,” “often,” or “very often.” In this study, 11 depressive symptom items were summed to yield an index of depressive severity (scores could range from 0–33). In this sample, the reliability coefficients for depression severity scale ranged from 0.77–0.84 across the five waves.

Anxiety severity was assessed using adolescent report on the Screen for Child Anxiety and Related Disorders (SCARED; Birmaher, Khetarpal, Brent, Cully, Balach, & Kaufman, 1997). The SCARED is a 41-item questionnaire measure of youth anxiety that has been demonstrated to differentiate between clinically anxious and non-anxious youth (Birmaher et al., 1997). Items are scored using a 3-point Likert scale describing the degree to which statements are true about them; higher total scores index higher anxiety symptom severity. To maximize the developmental sensitivity and cohesiveness of the anxiety variable, we excluded items from the separation anxiety and school anxiety SCARED subscales, since

they may constitute a form of internalizing distress distinct from other types of anxiety (Henningsen, Zimmerman, & Sattel, 2003). We summed scores from the three most common anxiety disorders during adolescence (Beesdo, Knappe, & Pine, 2009), which were represented by the three remaining SCARED subscales—generalized anxiety, social anxiety, and panic disorder—to yield an overall index of adolescent anxiety symptom severity. Internal consistency, test-retest reliability, and construct validity of the SCARED and its subscales are strong (Hale, Raaijmakers, Muris, & Meeus, 2005; Muris, Merckelbach, van Brakel, & Mayer, 1999). In this study, alphas ranged from 0.90–0.92 for the total anxiety severity score (i.e., the summed scores of the 3 subscales).

We chose to focus present analyses on *overall* anxiety severity, rather than specific diagnostic categories, for two primary reasons. First, literature to date does not support disorder-specific hypotheses regarding longitudinal, reciprocal links between adolescent anxiety and alcohol use. Second, our intent in this study is to capture anxiety severity on a continuum—not simply at the clinically elevated level—and limiting analyses to one anxiety sub-type would provide incomplete data on anxiety-related distress.

Past year alcohol use was assessed via the Nicotine, Alcohol, and Drug Substance Use measure (Pandina, Labouvie, & White, 1984), a self-report measure that asks about frequency and quantity of alcohol consumption over the past year. To index alcohol use, we created a dichotomous variable reflecting consumption of at least one full drink in the past year (no=0, yes=1) which has been used previously in studies using the PGS sample (Sartor et al., 2018).

Our decision to use a binary alcohol use variable was data-driven rather than theory driven, taking several factors into consideration. First, there were highly truncated distributions of alcohol use within the earliest waves, and more generally among Black girls (see Supplemental Table 1, which presents the distribution of frequencies for prevalence and amount of alcohol by age and race). Second, the strength of point-biserial correlations between full drink consumption and same-age depression severity was significant at each age from 13 through 17—and correlation coefficients fell within a narrow range across years ($r = .16, p < .001$ at age 13; $r = .17, p < .001$ at age 17). This suggests that the binary alcohol use variable related to symptomatology for younger and older adolescents. Third, an alternative strategy for indexing alcohol use—for instance, using different alcohol-related outcomes in early versus late adolescents—would require us to choose a specific “cut-off” age at which graded indicators of alcohol use would be appropriate. No standard cut-offs exist for this purpose, and using multiple alcohol outcomes would pose challenges for interpretation of results. Thus, a binary indicator was the best option given the study goals and the nature of the dataset.

Covariates

Conduct problems were self-reported by girls via the ASI-4 (Gadow and Sprafkin, 1997). The ASI-4 assesses the frequency of past-year conduct disorder (CD) symptoms (e.g., running away overnight, deliberately starting fires, being physically cruel to animals or people). Each symptom is rated on a 4-point scale (0=never to 3=very often) to generate a

severity score (range 0–45). Across assessment points, internal consistency of the conduct problems score was adequate ($\alpha = .70-.75$).

Pubertal timing was defined according to menarche status at age 11 (with menarche by age 11 indicating early puberty) and assessed via a single self-report item on the Pubertal Development Scale (0=no, 1=yes; Petersen et al., 1988).

SES was indexed with primary caregiver reports of primary caregiver's highest level of education (0= 12 or more years, 1= fewer than 12 years), receipt of public assistance (a proxy for family level poverty (0=no, 1=yes)), and single parent headed household status (0=no, 1=yes). Given the high degree of correlation across ages in SES indicators, to create a more parsimonious model, we used age 13 status to represent (time-invariant) SES indicators.

Two neighborhood factors were included in the model. *Low neighborhood safety* was assessed with Your Neighborhood (Loeber, Farrington, Stouthamer-Loeber, & Van Kammen, 1998), a measure in which primary caregivers rate 17 possible problems in their neighborhood (e.g., “delinquent gangs,” “drug use and drug dealing in the open”) on a 3-point Likert scale (“not a problem,” “somewhat of a problem,” “big problem”). Ratings are summed such that higher scores reflecting lower degree of safety. Alphas ranged from .95-.96 for total neighborhood safety score. *Community cohesion* was assessed using the Community Survey (Gorman-Smith, Tolan, & Henry, 2000), a 13-item caregiver-report measure. Items (e.g., “I regularly stop and talk with people in my neighborhood,” “I feel loyal to the people in my neighborhood”) are rated on a 5-point Likert scale (strongly agree to strongly disagree) and summed, with higher scores reflecting higher degree of cohesion. Alphas ranged from .91-.92 for the total community cohesion score.

Analytic approach.

The goal of this study was to examine prospective, reciprocal associations between (a) anxiety severity and alcohol use and (b) depression severity and alcohol use in girls between ages 13 and 17. Toward this aim, we conducted cross-lagged panel models using Mplus (Muthén & Muthén, 2014) with depression, anxiety, and alcohol use data from five annual assessments (see Figure 1 for an overview of the model's structure).¹ Cross-lagged panel models address three types of associations: (1) concurrent associations between variables assessed at the same time point, (2) autoregressive associations indicating temporal stability of variables over time, and (3) cross-lagged associations, indicating the degree to which a variable assessed at one timepoint predicts another variable at a subsequent timepoint, accounting for concurrent and autoregressive effects. Analyses proceeded in three stages, all using a robust maximum likelihood estimation procedure that handles both non-normally distributed data and missing data among endogenous variables. In the first stage, bivariate

¹Alternative modeling approaches to cross-lagged panel analysis have been proposed due to their ability to estimate both within- and between-person effects (e.g. random intercept cross-lagged panel models; Hamaker, Kuiper, & Grasman, 2015). However, existing approaches capable of differentiating within- and between-person effects do not allow for tests of reciprocal relations among multiple outcomes simultaneously. Further, these approaches have been developed for continuous outcomes rather than dichotomous outcomes. Given our focus on simultaneous reciprocal associations among outcomes (anxiety severity and alcohol use, and depression severity and alcohol use) and our use of a dichotomous outcome (alcohol use), we chose to use cross-lagged panel modeling for this study.

cross-lagged models between alcohol use (the dichotomous “full drink” variable) and depression severity as well as between alcohol use and anxiety severity, were conducted to evaluate the unconditional associations of depression and anxiety, respectively, with alcohol use. In the second stage, a multivariate cross-lagged model between alcohol use and both anxiety and depression severity simultaneously was conducted to estimate their independent relations with alcohol use. In the third stage, theoretically relevant covariates (conduct problems; early pubertal status; race; socioeconomic indicators; neighborhood factors) were added to the multivariate cross-lagged model. Preliminary analyses testing whether associations between depression severity and alcohol use or anxiety severity and alcohol use significantly differed by race, SES indicators, or neighborhood factors, did not support moderation effects.

Results

Descriptives and correlations

Sociodemographic, psychosocial, and neighborhood characteristics at age 13 are presented for the full sample and by race in Table 1. Compared to White girls, Black girls were more likely to have experienced early puberty, $\chi^2_{(1)}=93.15$, $p < .001$, and their primary caregivers were more likely to endorse indicators of low SES as well as low neighborhood safety and cohesion (p s $< .001$ for all indicators). Table 2 presents year-by-year levels of depression severity, anxiety severity, and conduct problems, and prevalence of consumption of at least one full alcoholic drink. Levels of anxiety and depression severity remained relatively stable over time, whereas prevalence of alcohol consumption steadily increased from ages 13 to 17. Table 3 presents year-by-year correlations among severity of depression, anxiety, and conduct problems. As expected, severity scores in different domains were correlated positively and significantly across ages. Year-by-year frequency of alcohol consumption and mean severity of depression, anxiety, and conduct problems are reported by race in Supplemental Tables 1 and 2, respectively.

Autoregressive path coefficients

The adjusted autoregressive path coefficients from cross-lagged models are shown in the left half of Table 4, with odds ratios reported for dichotomous outcome variables (full drink). All autoregressive paths were significant from ages 13 through 17, indicating consistent year-to-year associations in consumption of at least one full drink, anxiety, and depression severity. (Note that model fit statistics are not available when estimating models with binary or categorical endogenous variables; Muthén & Muthén, 2014).

For cross-lagged models, a likelihood ratio test was conducted to compare the model with and without equality constraints on cross-lagged paths over time. Not all cross-lagged paths emerged as equal $\chi^2_{(12)}=24.95$, $p = .01$. Thus, paths were not constrained in the final model.

Cross-lagged path coefficients: alcohol use and depression

Cross-lagged path coefficients, adjusted for the effects of SES indicators, early puberty status, race, conduct problems, and neighborhood factors, as well as co-occurring anxiety,

are reported in the right half of Table 4. Across all ages, higher depression severity was associated with modest increased odds of consuming at least one full drink in the following year (odds ratios [ORs] ranged from 1.03–1.04). By contrast, the associations between alcohol consumption and subsequent year severity of depression varied across lags. At ages 14 and 16, alcohol consumption significantly predicted *decreases* in subsequent year depression severity (betas = -0.84 , $p = 0.01$, and -0.78 , $p = 0.002$, respectively). Relations between alcohol use and subsequent year depression severity were non-significant for the age 13 to 14 and age 15 to 16 lags.

Cross-lagged path coefficients: alcohol use and anxiety

As shown in Table 4, none of the cross-lagged paths predicting alcohol use from previous-year anxiety emerged as significant (ORs estimated at .98-.99). A similar pattern emerged for the reverse directional pathway: only one of the four cross-lagged paths predicting anxiety from alcohol use emerged as significant. Specifically, consuming at least one full drink at age 14 predicted decreased anxiety severity at age 15 ($\beta = -2.01$, $p < 0.001$).

Discussion

This study examined reciprocal associations between (a) anxiety severity and alcohol use and (b) depression severity and alcohol use in Black and White girls across adolescence, accounting for the effects of socioeconomic and neighborhood factors, early puberty, conduct problems, and race. Results partially supported and partially refuted our hypothesis that girls' depression and anxiety severity would show independent links with higher alcohol use from ages 13 to 17, revealing more complex patterns of associations. As expected, from ages 13 to 16, higher levels of depression severity predicted modestly increased odds of consuming at least one full drink in the following year. However, at ages 14 and 16, alcohol use predicted modest *decreases* in subsequent year depression severity, and anxiety severity and alcohol use showed no consistent associations to each other over time.

Depression and anxiety severity: Differential links to adolescent girls' alcohol use

Findings highlight the value of examining *independent* effects of depression and anxiety in models of adolescent alcohol use. After accounting for shared variance between depression and anxiety severity, only depression severity predicted increased likelihood of drinking in the subsequent year. Prior research on internalizing pathways to adolescent alcohol use has emphasized the role of *overall negative affect*—which cuts across anxiety and depression—in predicting drinking behavior (Hussong et al., 2011, 2017). Present results suggest, instead, that depression-specific characteristics—such as low positive affect, hopelessness, or anhedonia—might be key precipitants in the internalizing-to-alcohol-use pathway in adolescent girls. Given sharp increases in girls' depression severity starting early in adolescence (Angold, Costello, & Worthman, 1998; Roza et al., 2003), difficulties linked to depression may grow especially salient and distressing during this developmental stage. In contrast, girls' anxiety tends to onset earlier, in middle to late childhood, and remains stable or increase gradually (rather than sharply) across adolescence (Hale, Raaijmakers, Muris, Van Hoof, & Meeus, 2008; Van Oort, Greaves-Lord, Verhulst, Ormel, & Huizink, 2009). Given that the increase in depression from childhood to adolescence coincides with

increased availability of alcohol (e.g., at social gatherings), increases in depression (relative to anxiety) might uniquely drive adolescent girls' use of drinking to cope with distress. Notably, depression predicted relatively small increases in the odds of alcohol use across all lags in this study, suggesting that additional factors not assessed here explain additional variance in the depression-alcohol use link. Nonetheless, present results do suggest that depression severity appears to be one factor—likely among many—that contributes to alcohol use across adolescence.

The heterogeneity of anxiety may also explain its limited independent links to adolescent alcohol use. Whereas some anxiety components such as excessive worry are thought to overlap largely with depression (e.g., through a shared negative affect factor; Krueger, 1999; Moffitt et al., 2007), other components such as hyper-arousal and evaluation concerns are viewed as relatively distinct from depression (Slade & Watson, 2006). Difficulties such as hypersensitivity to physiological arousal and fears of negative judgment from others may foster *avoidance* of settings where adolescents might access alcohol (e.g., large parties). In turn, if an adolescent with these difficulties (or traits indicating a predisposition towards these difficulties; e.g., behavioral inhibition, Hirshfeld et al., 2009) is inclined to avoid situations where drinking is likely, then factors other than alcohol use may be more likely to influence her anxiety trajectories over time. Indeed, some studies have found non-significant or negative associations between anxiety severity and alcohol use in adolescence, via both directional pathways (Hussong et al., 2017).

Why did alcohol use predict decreases in depression at certain lags?

Notably, some evidence emerged for associations between alcohol use and subsequent depression severity in the opposite direction to hypotheses: at two of four time-points, consuming an alcoholic drink predicted *decreases* in next-year depression severity. These effects were inconsistent across time-points, so interpretations are tentative. However, one potential explanation may involve the study's alcohol use assessment and sample: consumption of *one full drink* at ages 14 and 16 does not necessarily indicate *pathological* alcohol use, particularly in a community (versus a clinic-referred) sample. Rather, low or modest levels of drinking might reflect socially normative adolescent behavior. Perhaps consuming one alcoholic beverage indexed some degree of peer engagement—a factor shown to buffer against adolescent depression onset (Joiner, Lewinsohn, & Seeley, 2002). Although data on quantity of alcohol use were collected, given the low level of use among girls in this age range and the subsequent skewness of drinking data, a binary alcohol use indicator was most appropriate; but in an older or treatment-seeking sample, quantity and frequency indicators may capture the link between depression and alcohol use at a more nuanced level. Separately, data on the *context* of alcohol use that could be obtained through ecological momentary assessment, would be informative. For instance, low levels of drinking in social settings might predict slightly reduced depression, whereas moderate to high levels of drinking—extending beyond social settings, such as drinking in private—might predict increases in depression.

The inconsistency of this particular effect remains notable: at 50% of lags in the model, alcohol use showed no significant effect on subsequent depression severity, which fits with

some studies to date showing no independent links between depression and alcohol use (Kumpaleinen & Roine, 2002). Thus, the possibility remains that alcohol use is not a driving factor in adolescent depression severity—or, rather, that it plays a small role, along with multiple co-occurring variables, in accounting for adolescent depression. Ultimately, additional studies are needed to explore this possibility, and to evaluate the consistency of the effects observed here.

Accounting for externalizing problems in the internalizing pathway to alcohol use

Regardless of the directions of pathways observed, results advance a growing literature on links between trajectories of adolescent internalizing problems and alcohol use. Historically, much of the developmental psychopathology literature has emphasized an *externalizing* pathway to alcohol use (Hussong, Curran, & Chassin, 1998; Iacono, Malone, & McGue, 2008). Considerably less research has examined an *internalizing* pathway (Hussong et al., 2011). This study directly extends work in this domain. In contrast to most prior studies on internalizing-alcohol use links (see Hussong et al., 2017 for a review of existing studies), present analyses accounted for co-occurring conduct problems, *and* the independent effects of anxiety and depression within a single model. This allowed us to isolate the associations between alcohol use and internalizing problems, independent of the effects of conduct problems—which consistently co-occur both with anxiety and depression in adolescents (in this study, $r_s = .10-.16$ for correlations between conduct problems and anxiety severity, and $r_s = .28-.38$ for correlations between conduct problems and depressive severity; all correlations were significant). Findings support continued attention to the complex links between internalizing problems and alcohol use across adolescence. They also suggest the central role of depression in understanding these links in adolescent girls.

Considering race, socioeconomic status, and model generalizability

Despite known differences by race and socioeconomic factors in mean rates of adolescent alcohol use and internalizing problems (McLaughlin et al., 2007; Johnston et al., 2017, Bobashev, & Folsom, 2007), preliminary analyses did not support racial or socioeconomic status differences in the longitudinal *associations* between them. Thus, pathways that emerged are likely applicable to both Black and White girls in varied socioeconomic contexts. This possibility is consistent with at least one study to date: Using data from the 2005 National Alcohol Survey ($N = 4,080$ adult drinkers), Mulia and Zeng (2012) found no racial differences (in Black and/or Hispanic versus White adults) in links between depression severity and heavy drinking. Of course, there may be pathways through which alcohol use and internalizing problems do relate differentially by race or disadvantage, e.g. through experiences of discrimination or social isolation. Future research may examine such pathways to parse when, and whether, internalizing problem-alcohol use links may differ by socioeconomic context.

Implications for adolescent alcohol use prevention

Findings may also inform efforts to prevent alcohol use in adolescent girls. If depression severity consistently predicts increased alcohol use, might programs designed to prevent adolescent depression also prevent adolescent drinking? Although effective prevention programs for alcohol use have been identified, some are more effective than others—and

even those with large mean effects do not uniformly benefit adolescents who receive them (Hennessey & Tanner-Smith, 2014; Smit, Verdurmen, Monshouwer, & Smit, 2008). If targeting depression *does* reduce problematic alcohol use, depression-focused interventions may complement and strengthen the various alcohol use prevention strategies presently available. Additional research is needed to examine this possibility. In the one published trial (to our knowledge) that assessed alcohol use outcomes following an adolescent depression prevention program, *any* substance use—including alcohol—was collapsed into a single outcome variable (Rhode, Stice, Shaw, & Gao, 2015). Although the authors found no significant intervention effects on “any substance use” one year post-intervention, specific effects on drinking remain unclear. Including and examining alcohol-related outcomes in future adolescent depression prevention trials will help gauge their promise as an alternative prevention approach.

Limitations

This study had several limitations. First, the present sample was comprised of girls living in an urban setting. Different patterns of risk might emerge for girls living in rural settings, where contextual risks for alcohol use and internalizing problems might differ. Second, as noted above, inferences cannot be made regarding links between anxiety and depression and the frequency or quantity of alcohol use across adolescence. Third, this study used a community sample with internalizing problems across the full spectrum of severity; therefore, results may not generalize to samples of clinic-referred adolescents already experiencing significant psychopathology. Fourth, we were unable to distinguish within- from between-person effects, as they cannot be tested at the same time as reciprocal associations with dichotomous outcome data. Finally, although overall retention was generally high and analyses accommodated missing data over follow-up, some differential attrition was observed (White girls were less likely to be followed, but the association of race with missingness was minimal, $r = .07$).

Future directions

Despite these limitations, results have implications for future research and prevention efforts. This study provides the first model of longitudinal, reciprocal links between alcohol use and *both* depressive and anxiety severity in adolescent girls—while also accounting for the effects of numerous relevant variables (conduct problems; early puberty; race; socioeconomic disadvantage). Thus, findings contribute to a more generalizable model of internalizing-alcohol use links in adolescent girls relative to prior research. Results highlight the key role of depression in these associations: from ages 13 to 16, girls experiencing higher levels of depression (but not anxiety) were significantly more likely to drink the following year. They also reveal the possible complexity of predicting depressive severity from alcohol use. Future studies may assess whether low, moderate, and higher levels of alcohol use predict different depression severity trajectories across adolescence. Examining adolescent girls’ motivations for and contexts surrounding alcohol use may further characterize the nature of differential associations between depression, anxiety, and drinking behavior. It is also notable that even significant effects in this study were modest in size, and in some cases, inconsistent across assessment points. These findings highlight the complex nature of links between anxiety, depression, and alcohol use in adolescence; the high

probability that multiple variables not examined here influence these links; the need for replications, both in clinical and community samples, to examine the generalizability and consistency of effects observed here; and the need for more integrated, multifactorial developmental theories to account for changes in these links over time. Finally, results raise the possibility that depression prevention programs might yield secondary benefits for adolescent alcohol use. Examining alcohol use trajectories in randomized depression prevention trials will help assess this strategy's potential to reduce problematic drinking, during and beyond adolescence. Complementary studies with emerging adults may clarify whether pathways observed here apply across development, given differences in access to and norms regarding alcohol use during different developmental stages.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Design of cross-lagged panel model. Correlations across variables are modeled within each age.

Table 1.

Indicators of socioeconomic status, neighborhood factors, and early puberty at age 13 for total sample and by race.

	Total Sample	Black girls	White girls
Primary caregiver education 12 years education	14.59%	16.75%	11.64%
Household receipt of public assistance	33.02%	49.43%	17.64%
Single parent headed household	40.03%	60.61%	20.83%
Early puberty (menses before age 12)	26.11%	35.75%	16.96%
Community cohesion, M (SD)	34.07 (8.94)	30.64 (8.70)	37.25 (7.09)
Low neighborhood safety, M (SD)	22.54 (7.59)	24.50 (8.49)	20.67 (6.10)

Note. All variables are parent-report. Community cohesion and neighborhood safety were included as time-varying covariates in autoregressive and cross-lagged models.

Table 2.

Year-by-year child report of depression severity, anxiety severity, conduct problems, and consumption of one or more full alcoholic drinks in the past year

	13	14	15	16	17
Mean (SD)					
Anxiety severity	14.07 (8.67)	14.35 (9.07)	14.60 (9.46)	14.31 (9.52)	13.74 (9.69)
Depression severity	7.13 (4.64)	7.63 (4.91)	7.21 (4.79)	6.87 (4.83)	6.45 (4.85)
Conduct problems	1.09 (1.86)	1.27 (2.07)	1.38 (2.10)	1.27 (2.07)	1.15 (1.86)
Consumed 1+ full alcoholic drinks	4.83%	11.01%	15.71%	21.66%	33.01%

Table 3.

Year-by-year (concurrent) correlations among depression, anxiety, and conduct problem severity

	13	14	15	16	17
Depression severity – Anxiety severity	0.46 ***	0.48 ***	0.46 ***	0.48 ***	0.50 ***
Depression severity – Conduct problems	0.38 ***	0.34 ***	0.29 ***	0.31 ***	0.33 ***
Anxiety severity – Conduct problems	0.16 ***	0.14 ***	0.10 ***	0.12 ***	0.15 ***

 $p < .001$

Table 4.

Adjusted autoregressive and cross-lagged path coefficients from cross-lagged panel model

Autoregressive Paths					Cross-Lagged Paths				
	Beta	95% CI		p		Beta	95% CI		p
Depression → Depression		Lower Bound	Upper Bound		Full Drink → Depression		Lower Bound	Upper Bound	
13 → 14	0.53***	0.49	0.58	<0.00	13 → 14	−0.65	−1.60	0.30	0.181
14 → 15	0.48***	0.43	0.52	<0.00	14 → 15	−0.84*	−1.51	−0.18	0.013
15 → 16	0.52***	0.48	0.56	<0.00	15 → 16	0.53	−0.03	1.10	0.063
16 → 17	0.49***	0.44	0.53	<0.00	16 → 17	−0.78**	−1.26	−0.29	0.002
Full Drink → Full Drink					Depression → Full Drink (OR)				
13 → 14 (OR)	6.20***	3.69	10.40	<0.00	13 → 14 (OR)	1.07**	1.03	1.11	<0.00
14 → 15 (OR)	5.48***	3.83	7.86	<0.00	14 → 15 (OR)	1.05**	1.01	1.08	0.004
15 → 16 (OR)	6.45***	4.73	8.80	<0.00	15 → 16 (OR)	1.03*	1.00	1.06	0.045
16 → 17 (OR)	4.50***	3.47	5.82	<0.00	16 → 17 (OR)	1.04**	1.02	1.07	0.002
Anxiety → Anxiety					Full Drink → Anxiety				
13 → 14	0.56***	0.52	0.61	<0.00	13 → 14	−0.83	−2.51	0.85	0.331
14 → 15	0.64***	0.60	0.69	<0.00	14 → 15	−2.01**	−3.21	−0.92	<0.00
15 → 16	0.64***	0.59	0.68	<0.00	15 → 16	−0.01	−0.98	0.97	0.998
16 → 17	0.62***	0.58	0.66	<0.00	16 → 17	−0.62	−1.50	0.26	0.166
					Anxiety → Full Drink (OR)				
					13 → 14 (OR)	0.99	0.97	1.01	0.536
					14 → 15 (OR)	0.98	0.97	1.00	0.070
					15 → 16 (OR)	0.99	0.97	1.01	0.182
					16 → 17 (OR)	0.99	0.98	1.00	0.188

*
p<.05;**
p<.01;***
p<.001; CI=Confidence Interval; OR=Odds Ratio. This table reports the results for multivariate models. For each model, covariates included: household receipt of public assistance, single parent household status, primary caregiver education level, early puberty, neighborhood safety, neighborhood belonging, severity of conduct problems, and race (Black vs. White). Conduct problem severity was self-reported by youths; all other covariates were reported by parents. Unstandardized regression coefficients are reported except where indicated otherwise.