Adolescent sibling associations among alcohol, cannabis, and sexual risk behavior: A test of interdependence

Sarah A. Thomas^{a, b}, Lauren Micalizzi^{c, d}, Samuel N. Meisel^{a, c}, Dayna Price^c, Anthony Spirito^b

^a Bradley Hasbro Children's Research Center, 25 Hoppin St., Box #36, Providence, RI 02903, United States

^b Department of Psychiatry and Human Behavior, Alpert Medical School of Brown University, Providence, RI, United States

^c Center for Alcohol & Addiction Studies, Brown University School of Public Health, Box G-S121-5 Providence, RI 02903, United States

^d Department of Behavioral and Social Sciences, Box G-S121-5, Brown University School of Public Health, Providence, RI 02912, United States

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Correspondence regarding this manuscript should be addressed to Sarah A. Thomas, Bradley Hasbro Children's Research Center, 25 Hoppin St., Box #36, Providence, RI 02903, United States; E-mail: sarah_thomas1@brown.edu

Abstract

Background: Although siblings are conceptualized as a salient social influence during adolescence, few studies have examined how adolescent siblings influence each other's substance use and risky sexual behavior. *Objectives:* In this study, we investigated the influence of alcohol use days, cannabis use days, and cannabis and alcohol co-use days on the sexual risk behavior of siblings while accounting for dyadic influence. *Methods:* At the baseline visit for a randomized controlled trial for adolescents referred due to parents' concerns about their substance use ("referred adolescents"; $n=99$; $M_{age}=15.95$; 38.38% female), we assessed alcohol and cannabis use days as well as sexual risk behavior of the referred adolescents and their sibling ($M_{age}=15.03$; 51.52% female). We computed the number of days in the 30 days prior to the baseline that alcohol and cannabis use occurred on the same day. Using a cross-sectional actor partner interdependence model, we tested two models of how adolescents' substance use is associated with their own ("actor effect") and their siblings' ("partner effect") sexual risk behavior—one model for alcohol and cannabis use, and one model for daily co-use. *Results:* For referred adolescents and their siblings, within an individual, greater alcohol, cannabis, and daily co-use was significantly associated with sexual risk behavior (actor effects). Furthermore, more sibling co-use days was positively associated with referred adolescent sexual risk behavior (partner effect), representing interdependence. *Conclusion:* These findings confirm the influence siblings have on one another's risky behavior in adolescence and have implications for prevention and intervention efforts for adolescent substance use.

Keywords: adolescents; siblings; cannabis; alcohol; sexual risk behavior

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Introduction

Adolescent substance use is associated with negative consequences, including risky sexual behaviors, which increases the likelihood adolescents experience sexually transmitted infections (STIs) and sexual assault (Chung et al., 2021; Espelage et al., 2018; Green et al., 2017). Although siblings are a main source of social influence during adolescence, few studies have considered how sibling substance use behaviors are related to risky sexual behaviors. This is a notable gap in the literature, considering a recent review of incorporating siblings into adolescent substance use treatment emphasized the need to understand sibling influence to determine how involved or removed a sibling should be in treatment (Caspi et al., 2018). Thus, the goal of the present study was to examine the role of an individual's use of a single substance (i.e., alcohol or cannabis on a given day) as well as days when individual's used both alcohol and cannabis on the same day (daily "co-use") on adolescent unprotected sex in a sample containing dyads of treatment-seeking youth and their sibling.

Substance use co-occurs with risky sexual behaviors (i.e., unprotected, multiple partners) both at the event-level (e.g., Poulin & Graham, 2001) and longitudinally (e.g., Stueve & O'Donnell, 2005). Event-level effects may result from impaired decision-making and disinhibition (Poulin & Graham, 2001) and longitudinal associations may be due to individual (e.g., cognitive, behavioral) or social (e.g., trajectories of disadvantage; Green et al., 2017) factors. To illustrate, earlier onset of alcohol use has been associated with lower age at first sexual intercourse (Doran & Waldron, 2017), and later age of sexual debut is linked to lower odds of cannabis use (Cha et al., 2016). Among sexually active high school students, 21.2%

report using alcohol or other drugs before their last sexual intercourse (Szucs et al., 2020). In another study, both adolescent alcohol and cannabis use (separately) were associated with same-day sexual behavior, while cannabis use was associated with increased odds of engaging in unprotected sexual intercourse (Graves et al., 2019). In young adults aged 18-29, 18-24 year-olds were more likely than other ages to report being less sexually safe when experiencing alcohol intoxication (Wells et al., 2010).

Using both alcohol and cannabis confers additional risk for adverse outcomes beyond the use of a single substance on a given day, particularly for psychosocial consequences (Karoly et al., 2020). For instance, using cannabis and alcohol such that the effects overlap (vs. same 30-day time period) was associated with greater use of both substances and more negative consequences in college students across seven countries (Bravo et al., 2021). Additionally, college students' self-reports indicated that using both alcohol and cannabis (either with overlapping effects or overlapping time periods) was associated with sexual behavior that was unplanned, unsafe, and/or regretted, compared to alcohol use alone (Cummings et al., 2019). Further, daily co-use has been associated with young adults' reports of greater negative consequences, including unwanted sex (Sokolovsky et al., 2020). In adults aged 18-60, reporting alcohol use and cannabis use in the past year was associated with increased risk for engaging in misuse of prescription drugs compared to single-substance use (2). Specific to adolescents, using both cannabis and alcohol at a high rate during this time period has also been associated with a significantly higher rate of teen pregnancy, compared to moderate alcohol use alone or no use (Green et al., 2017). Lastly, recent data from 12th graders in the Monitoring the Future Study found use of cannabis and alcohol (such that effects overlapped) was associated with other risk behaviors (e.g., truancy, other illicit drug use; Patrick et al., 2018). Moreover, historical trends

from this data from 1976 to 2016 indicate an increased proportion of adolescents reporting cannabis and alcohol use (overlapping and non-overlapping) in the past 12 months relative to alcohol-only use, suggesting more attention is needed to the consequences of using these two substances.

Substance use onset in adolescence is influenced by adolescents' social environment (e.g., peers, family), which may be driven by both socialization and selection processes (Schuler et al., 2019). The behavioral influence and transmission of similar beliefs and attitudes about both sexual practices and substance use is supported by social learning theory (McHale et al., 2009; McHale et al., 2012), which posits that individuals emulate the behavior of those they value. For adolescents, their peers, parents, and siblings strongly influence their behaviors. For substance use specifically, siblings are one of the most salient influences (Windle et al., 2017), greater than parental influence and approximately equal to peers during adolescence, likely attributable to both the common genetic and environmental factors that siblings share (Low et al., 2012; McHale et al., 2009; McLaughlin et al., 2016; Van der Vorst et al., 2007; Whiteman et al., 2013; Whiteman et al., 2016). For example, Meisel and colleagues (2021) found, in a treatment-seeking sample, that youth engaged in higher levels of cannabis use on days where they spent more time with their cannabis using siblings than on average.

Siblings influence each other's risk behaviors beyond substance use, including sexual risk behavior (Almy et al., 2015; McHale et al., 2009; Whiteman et al., 2017). In one study, adolescents' perceptions of their siblings' sexual behavior influenced their own sexual behavior attitudes and behaviors (Almy et al., 2015). The way siblings influence each other to engage in behaviors considered deviant or risky is referred to as *sibling contagion theory*, given that these behaviors are seen as transmissible (Caspi et al., 2018). Importantly, while qualities of sibling

relationships have been linked to adolescents' substance use and sexual risk behavior independently (e.g., East & Khoo, 2005), to our knowledge, the links between sibling substance use and sexual risk has not yet been investigated together. In light of recent practice recommendations for how to include siblings in substance use treatment in a way that doesn't exacerbate maladaptive sibling influence (Caspi et al., 2018), it is important to understand how siblings' risk behaviors are associated with each other, particularly in the context of adolescents identified as engaging in problematic substance use.

To investigate sibling influence on risk behaviors like substance use and sexual risk behavior, special statistical models must be implemented that both account for the non-independent nature of that data, which violates typical regression assumptions, and also capitalizes on that non-independence to assess the nature of the dyadic influence. The Actor-Partner Interdependence Model (APIM; Cook & Kenny, 2005) can be used to investigate the influence of one's behavior on one's own outcome ("actor effect"), and on a dyadic partner's outcome ("partner effect"). When both members of a dyad have significant partner effects, it indicates a bidirectional relationship; however, even one partner effect suggests the phenomenon is interdependent (Cook & Kenny, 2005).

Understanding the nature of siblings' influence is an important step in identifying factors to reduce risk behavior among adolescents. In this study, we investigated the intraindividual ("actor effect") and interindividual ("partner effect") associations between adolescent substance use (alcohol and cannabis separately, as well as daily co-use) and unprotected sexual behavior for adolescents identified by parents as engaging in concerning levels of substance use and their sibling at the baseline visit (pre-treatment) of a study testing the efficacy of a brief intervention for substance use on a referred adolescent and their non-referred sibling (Spirito et al., 2017).

Days where adolescents used both alcohol and cannabis were examined as a separate outcome given increasing evidence that the co-use of alcohol and cannabis is associated with worse substance use consequences (Cummings et al., 2019; Sokolovsky et al., 2020). We focus on the risky sexual behavior of unprotected sex since this behavior can result in STIs and/or pregnancy. Based on prior literature linking substance use with sexual risk behavior, as well as sibling contagion theory, we hypothesized that: 1) one's own substance use (referred adolescent or sibling) would be positively associated with one's own unprotected sexual behavior, controlling for the influence of the other dyad member's substance use (actor effect); and 2) one's own substance use would be positively associated with partner's unprotected sexual behavior (partner effect). We used two APIM models to test these hypotheses.

Methods

Participants

Participants in the current study were 99 adolescents whose parents reported concern about their alcohol or cannabis use (hereafter referred to as “referred adolescents”) and their sibling (“sibling”). Referred adolescents were recruited from various locations, including the community, schools, courts, emergency departments, and mental health agencies in the northeastern United States to take part in a randomized controlled trial to test the efficacy of a Family Check-up on the referred adolescent as well as a sibling (Spirito et al., 2017). Referred adolescents were eligible for the study if they: (a) were 12-19 years of age, (b) lived with a parent/guardian willing to participate; (c) reported at least one episode of alcohol and/or cannabis use in the prior three months; and (d) had a sibling within five years of their age. All measures described below include reports for both referred adolescents and siblings.

Procedure

Both university and hospital Institutional Review Boards approved all study procedures before data collection. Research staff screened interested participants in-person or on the phone for eligibility. Families provided written consent/assent. The baseline visit was approximately 45 minutes long. Referred adolescents and siblings met separately with research staff. Only baseline data were analyzed for the present study.

Measures

Demographics. Youth reported on their age, biological sex, and race/ethnicity.

Past 30-day Alcohol and Cannabis Use. At baseline, referred adolescents and siblings reported on *the number of days* in the past thirty days they used cannabis and consumed alcohol (Sobell & Sobell, 1992). Three variables were computed: 1) number of cannabis use days (including co-use days); 2) number of alcohol use days (including co-use days); and 3) number of co-use days.

Sexual Risk Behavior. One item from the Reckless Behavior Questionnaire (Shaw et al., 1992) was used to assess unprotected sexual behavior for referred adolescents and siblings: “Had sex with someone without using contraceptives”. The response options were 0 times (0), once (1), 2-5 times (2), 6-10 times (3), and more than 10 times (4). Responses were dichotomized, such that any endorsement of sex without a contraceptive was coded as present (1), and no endorsement remained coded as 0.

Analytic Strategy

We used R (R Core Team, 2021) for descriptive statistics and preliminary analyses. Adolescent substance use was skewed and therefore log transformed, consistent with the primary outcome analysis (Spirito et al., 2017). Sex and age (both centered) were entered as covariates in APIM models.

Implementation of the APIM. We used the APIM to account for the non-independence within sibling dyads and to test hypotheses about the interdependent nature of substance use and unprotected sex among referred adolescents and siblings (Kenny et al., 2006). We ran two APIM models: one testing the association between alcohol and cannabis use (controlling for the effect of the other substance) with unprotected sex, and another model testing the association between daily co-use and unprotected sex. Using APIM, we investigated the unique association between referred adolescent and sibling substance use on their own report of unprotected sex (“actor effect”) and on the report of unprotected sex of the other member of the dyad (“partner effect”). Actor effect estimates control for partner effects, and vice versa (Kenny et al., 2006). Partner effects indicate the interdependent nature of the relationship between substance use and unprotected sex (Kenny et al., 2006). Members of the dyad were treated as “distinguishable”: dyad members differed by referral status (i.e., adolescent identified as using substance use at a concerning level), which enables testing whether effects differ according to a dyad member’s role.

We conducted Structural Equation Modeling (SEM) via a web-based R analysis using lavaan (“APIM_SEM”, available at https://apimsem.ugent.be/shiny/apim_sem/; Rosseel, 2012; Stas et al., 2018). Because dyad members were distinguished by their referral status (referred adolescent vs. sibling), we analyzed actor and partner effects separately by role using SEM, the preferred analytic strategy for these dyads (Ledermann & Kenny, 2017; Stas et al., 2018).

APIM_SEM uses Full Information Maximum Likelihood estimation method to account for missing data (e.g., dyad member is missing a score; (Ledermann & Kenny, 2017). Effect sizes for actor and partner effects are provided as partial correlations. Goodness-of-fit statistics are not provided for APIM_SEM since these models are fully-saturated (i.e., perfectly fit the

date; Ledermann & Kenny, 2017). For both SEM models, there were complete data for substance use; one referred adolescent was missing an unprotected sex report.

Two separate APIM SEM models were tested, in which unprotected sex was predicted from: a) days of alcohol and cannabis use, and b) days of co-use. For each model, we first conducted a test of distinguishability based on the dyad member's referral status (referred adolescent or sibling) by comparing a model with distinguishable dyads to indistinguishable dyads using a chi square statistic. The model including both alcohol and cannabis controlled for the influence of the other substance (i.e., the effect presented for alcohol controls for the influence of cannabis and vice versa).

Results

Demographics

Table 1 summarizes demographics. Referred adolescents were on average about 16 years of age and were almost 2/3 male; siblings were on average about 15 years of age and approximately equal male/female split. About 3/4 of referred adolescents and siblings were White/Caucasian. Referred adolescents were older than siblings in 67.68% of dyads, siblings were older in 27.27% of dyads, and they were the same age in 5.05% of dyads. Referred adolescents were the same biological sex as siblings in 60.61% of dyads.

Preliminary Analyses

The range of cannabis use days in the past thirty days for both referred adolescents and siblings was 0-30; the range of alcohol use days for referred adolescents was 0-15 and for siblings was 0-9; and the range of co-use days for referred adolescents was 0-11 and for siblings was 0-9. Table 2 presents the descriptive statistics for substance use and unprotected sex, along with paired *t*-tests. Results indicated significant differences between referred adolescents and

siblings on days of alcohol use, cannabis use, and daily co-use, with referred adolescents reporting greater use than siblings. There were no significant differences in reports of unprotected sex. Table 3 presents bivariate correlations of referred adolescents and sibling substance use and sexual risk behavior. The relationship of unprotected sex with cannabis, alcohol, and daily co-use was significant for both referred adolescents and siblings.

APIM Analyses Testing the Cross-Sectional Association Between Substance Use and Unprotected Sexual Behavior

Alcohol and Cannabis Use. Participants were distinguishable by referral status ($\chi^2 = 121.73$, $df=35$, $p < 0.001$). There were significant actor effects for both referred adolescents and siblings for alcohol and cannabis use and unprotected sex: more alcohol use days and cannabis use days were associated with engagement in unprotected sex (see Table 4 and Figure 1).

Alcohol/Cannabis Co-Use. Participants were distinguishable by referral status ($\chi^2 = 68.79$, $df=23$, $p < 0.001$). There were significant actor effects for both referred adolescents and siblings for alcohol/cannabis co-use days and unprotected sex: more co-use was associated with engagement in unprotected sex. There was a significant partner effect for referred adolescents: more sibling alcohol/cannabis co-use days were associated with referred adolescent engagement in unprotected sex (see Table 5 and Figure 2).

Post-hoc moderation. Because sibling social influence may differ as a function of sibling age and sex, sex discordance and age discordance were assessed as possible moderators. Multiple group analyses were conducted to determine whether actor and partner effects differed if siblings were of the same or opposite sex and whether siblings were older or younger than the referred adolescent. Relative to fully constrained models, nested model tests indicated that freeing actor and partner effects for age ($\chi^2[4]=1.62$, $p=.806$) and sex ($\chi^2[4]=2.00$, $p=.736$)

resulted in non-significant increments in model fit. These non-significant nested model tests indicate that there was no evidence of moderation based on age discordance or sex discordance on actor or partner effects.

Discussion

The current study tested the intraindividual and interindividual associations between substance use and engagement in sexual risk behavior, defined as sex without contraceptives, in a sample of adolescents referred for problematic substance use and their sibling at the baseline visit of a randomized controlled trial. One's own days of alcohol use and cannabis use (separately) as well as co-use days were significantly positively associated with their own sexual risk behavior. Moreover, referred adolescents' sexual risk behavior was not only associated with their own co-use, but also with their siblings' co-use.

The finding that substance use is positively associated with engagement in sexual risk behavior is consistent with prior research (Graves et al., 2019; Hendershot et al., 2010; Ritchwood et al., 2015; Szucs et al., 2020). It is notable that although siblings had a significantly lower rate of both alcohol and cannabis use compared to referred adolescents, siblings also had significant associations between alcohol use, cannabis use, and co-use and sexual risk behavior like referred adolescents. Consequently, although parents may be especially concerned about one child's substance use, their other child may be of similar risk for engaging in risky behavior, specifically, sexual behavior that puts them at risk for STIs or pregnancy.

Because our study design is cross-sectional, we cannot infer, and do not suggest, that sibling co-use causes referred adolescents' engagement in sexual risk behavior. Rather, our results, indicating interdependence of referred adolescent and sibling, seem to support the social contagion theory proposed about siblings—that deviant behaviors are transmissible and may

“spread”, especially in the context of the shared interactions, environment, and peers that occurs with siblings (Caspi et al., 2018). Along those lines, prior studies have found that sibling sexual behavior is associated with adolescents’ attitudes and behaviors about sex (Almy et al., 2015), such that if a sibling is perceived to be not engaging in sexual behavior, their adolescent sibling takes on a similar perspective. It has already been demonstrated that adolescents influence each other’s sexual behavior (East & Khoo, 2005), and that adolescent siblings have similar substance use behaviors and attitudes (Whiteman et al., 2016). The contribution of the current study is in showing how days of alcohol use, cannabis use, and co-use are associated with risky sexual behavior in adolescents, controlling for the influence of a sibling.

Alcohol/cannabis co-use, but not separate use, showed sibling interdependence with unprotected sex, such that siblings’ and referred adolescents’ co-use was associated with referred adolescents’ unprotected sex. Evidence for sibling interdependence for co-use, but not separate use, aligns with prior work demonstrating that using both alcohol and cannabis is associated with more serious consequences (greater than either substance alone; (Cummings et al., 2019; Sokolovsky et al., 2020). In a study of justice-involved adolescents, researchers found adolescents who were heavy users of both cannabis and alcohol reported a higher frequency of unprotected sex than those who used only cannabis (Gillman et al., 2018). In late-adolescent women, the highest STI risk was among those who used alcohol and cannabis (Chung et al., 2021). Furthermore, in another study, using both cannabis and alcohol at high rates in adolescence was significantly associated with greater likelihood of teen pregnancy, compared to moderate alcohol use (Green et al., 2017). Therefore, our results add to the prior literature that co-use is associated with risk behaviors, and extends these findings to its association with sexual risk behavior in adolescent sibling dyads. Our results suggest that for some adolescents,

behaviors in a shared environment, like their sibling's co-use, can be associated with other decisions they make with regard to risk behavior. Future research is needed to identify the mechanism driving this interdependence.

The strengths of the current study include its focus on a sample of adolescents with problematic substance use whose parents were seeking treatment for them, the inclusion of their adolescent sibling, measurement of co-use, and the multi-method design (i.e., interviewer-facilitated substance use assessment and adolescent-report of sexual risk behavior). Further, the analytic approach benefits from the focus on the interdependent nature of adolescent risk behavior in that the model can test for intraindividual and interindividual effects, while controlling for the influence of each of these effects.

This study had several limitations. Although our sample size was appropriate for the statistical analyses, given that approximately 100 dyads are preferred for SEM analyses (Ledermann & Kenny, 2017), we were unable to test moderators that may influence the relation between substance use and sexual risk behavior. For example, (dis)concordance in the dyads' age and gender could have impacted the findings (Caspi et al., 2018; Whiteman et al., 2016). These additional details would help inform recent practice guidelines for addressing sibling relationships in treatment (Caspi et al., 2018). The cross-sectional nature of our study provides only a snapshot of the dyads at baseline, prior to randomization. Assessing only this time point limits the influence of the treatment, yet precludes understanding how adolescents' and siblings' risk behaviors evolve over time and influence each other. To test this question empirically, the APIM could be extended within the context of a longitudinal observational study. Relatedly, we did not assess whether same-day substance use was associated with same-day sexual behavior, which would have provided more context with regard to the pattern of behavior. Also, because

sexual risk behavior is relatively infrequent, the time frame for the study was the prior year, while substance use was assessed in the prior months. Consequently, the temporal alignment of these different behaviors was not ensured. Nevertheless, these findings indicate that sibling daily co-use and adolescent risky sexual behavior co-occur, which is important information for clinicians seeking to minimize substance-related risk behaviors. Lastly, the mechanism of the partner effect for sibling daily co-use and referred adolescent sexual risk behavior is unknown, which limits our ability to deduce implications for future brief interventions to reduce adolescent risk behaviors. That is, substance use could be a proximal risk factor in that it lowers inhibitions before engaging in unprotected sex; or, substance use and sexual risk behavior could co-exist on a spectrum of general risk behaviors, or both could be true.

In conclusion, the findings confirm the association of alcohol and cannabis use with sexual risk behavior, controlling for the influence of a sibling. Further, our results indicate the link between alcohol/cannabis daily co-use and sexual risk behavior is interdependent for siblings. Our findings have several clinical implications. Because adolescents in this study were referred due to parental concerns about their substance use, our findings lend support to the notion that regardless of the mechanism, adolescents with problematic substance use may be at risk for engaging in other behaviors that could be harmful, and to potentially assess and target this briefly in interventions that focus on substance use. Furthermore, regardless of whether or not an adolescent has been identified due to concern about their substance use, adolescents may engage in behavior that puts themselves at risk for STIs or teen pregnancy that may be linked to their substance use. Prevention efforts to reduce risk behaviors are key to minimizing these potentially maladaptive developmental trajectories. Finally, clinical providers could assess adolescents' perceptions of who influences their substance use and sexual behavior, and based on

that information and other characteristics of the dyad (e.g., age, gender concordance) may determine whether or not an adolescent's treatment may benefit by sibling involvement. Future directions include replicating the results in a community sample to understand the nature of that influence outside the context of a treatment study, and determining more precise temporal associations between sibling substance use and sexual risk behaviors.

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Table 1

Demographic Data of Referred Adolescents and Siblings

	Referred Adolescents	Siblings
n	99	99
Age		
Mean (SD)	15.95 (1.31)	15.03 (2.22)
Range (years)	13-19	11-21
Female	38 (38.38%)	51 (51.52%)
Race		
Black	27 (27.27%)	28 (28.28%)
White	75 (75.76%)	72 (72.73%)
Native American/Alaskan Native	9 (9.09%)	5 (5.05%)
Native Hawaiian/Pacific Islander	0 (0%)	1 (1.01%)
Asian	5 (5.05%)	4 (4.04%)
Other	7 (7.07%)	5 (5.05%)
Hispanic	30 (30.30%)	30 (30.30%)

Note. Race percentages add to more than 100% because participants could choose more than one race category.

Table 2

Means (M) and Standard Deviations (SD) for Substance Use and Unprotected Sexual Behavior, and t-Tests and Effect Sizes in Between-Group Comparisons of Referred Adolescents and Siblings

Variable	Referred Adolescent	Sibling	$t(df)^h$	95% CI		p	Cohen's d
	$M (SD)$	$M (SD)$		LL	UL		
Cannabis Use	7.45 (10.15)	3.40 (7.75)	4.53 (98)	0.45	1.16	<0.001	0.46
Alcohol	2.01 (2.93)	0.98 (1.72)	3.14(98)	0.38	1.68	0.002	0.32
Cannabis/alcohol co-use	0.85 (2.08)	0.33 (1.19)	2.55(98)	0.07	0.53	0.012	0.26
Unprotected Sexual Behavior	0.38 (0.49)	0.33 (0.47)	0.65(97)	-0.08	0.17	0.519	0.07

Note. Cannabis and alcohol use are measured as days of use in the 30 prior days to the baseline assessment. Cannabis/alcohol co-use is the number of days in the 30 days prior to the baseline assessment teens and siblings reported using both cannabis and alcohol on the same day. Substance use means and standard deviations are untransformed for ease of interpretation; values used in statistical inference tests are log-transformed.

Unprotected sexual behavior is a dichotomous variable indicating whether youth endorsed having sex without contraceptives (0 = never, 1 = yes).

CI = confidence interval of the difference; LL = lower limit of 95% CI; UL = upper limit of 95% CI

Table 3

Bivariate Correlations of Referred Adolescents and Sibling Substance Use and Unprotected Sexual Behavior

	RA Cannabis	Sib Cannabis	RA Alcohol	Sib Alcohol	RA Co-use	Sib Co-use	RA USB	Sib USB
RA Cannabis	—	—	—	—	—	—	—	—
Sib Cannabis	0.19	—	—	—	—	—	—	—
RA Alcohol	0.19	0.17	—	—	—	—	—	—
Sib Alcohol	0.11	0.43**	0.28**	—	—	—	—	—
RA Co-use	0.52**	0.22*	0.56**	0.19	—	—	—	—
Sib Co-use	0.22*	0.59**	0.17	0.52**	0.21*	—	—	—
RA USB	0.37**	0.20	0.36**	0.23*	0.33**	0.28**	—	—
Sib USB	0.08	0.53**	0.14	0.49**	0.05	0.45**	0.16	—

Note. Referred adolescent and sibling substance use values are log-transformed. RA = referred adolescent; Sib = sibling; Co-use = same-day alcohol and cannabis use; USB = unprotected sexual behavior.

* $p < .05$. ** $p < .01$

Table 4

Actor-Partner Interdependence Model Estimates for the Relation between Substance Use and Unprotected Sexual Behavior by Role of Referred Adolescent and Sibling

Effect	Role	Estimate	95% CI	<i>p</i> -value	$\hat{\beta}(o)$	$\hat{\beta}(s)$	<i>r</i>
Alcohol							
Intercept	RA	0.53	[0.41, 0.65]	<.001			
Actor		0.09	[0.01, 0.16]	.024	0.77	0.22	0.31
Partner		0.05	[-0.03, 0.13]	.248	0.12	0.11	0.15
Intercept	Sibling	0.54	[0.42, 0.66]	<.001			
Actor		0.10	[0.03, 0.18]	.009	0.25	0.25	0.47
Partner		-0.02	[-0.08, 0.04]	.543	-0.05	-0.05	0.01
Cannabis							
Intercept	RA	0.53	[0.41, 0.65]	<.001			
Actor		0.11	[0.05, 0.17]	<.001	0.32	0.33	0.34
Partner		0.01	[-0.06, 0.08]	.691	0.04	0.04	0.14
Intercept	Sibling	0.54	[0.42, 0.66]	<.001			
Actor		0.10	[0.04, 0.16]	.002	0.29	0.29	0.53
Partner		-0.02	[-0.07, 0.03]	.451	-0.05	-0.06	-0.03

Note. R^2 for referred adolescents is 0.27 and 0.44 for siblings. Results controlled for age and sex. There was a significant effect of sex (i.e., male or female) on unprotected sexual behavior for referred adolescents (0.19, $p = 0.03$), such that being female was associated with engagement in unprotected sexual behavior, controlling for other variables in the model. For siblings, older age was significantly associated with engagement in unprotected sexual behavior (0.07, $p = 0.001$), controlling for other variables in the model. RA = referred adolescent; CI = confidence interval; $\hat{\beta}(o)$ = a standardized estimate using the overall standard deviation across both teens and siblings, which enables comparison of these estimates across teens and siblings; r represents the partial correlation which provides the effect size for individual actor and partner effects.

Table 5

Actor-Partner Interdependence Model Estimates for the Relation between Alcohol/Cannabis Co-use and Unprotected Sexual Behavior by Role of Referred Adolescent and Sibling

Effect	Role	Estimate	95% CI	<i>p</i> -value	$\hat{\beta}(o)$	$\hat{\beta}(s)$	<i>r</i>
Intercept	RA	0.79	[0.57, 1.02]	<.001			
Actor		0.11	[0.03, 0.20]	.011	0.55	0.24	0.29
Partner		0.15	[0.03, 0.26]	.011	0.29	0.24	0.23
Intercept	Sibling	0.60	[0.40, 0.81]	<.001			
Actor		0.19	[0.09, 0.30]	<.001	0.37	0.32	0.45
Partner		-0.04	[-0.12, 0.03]	.238	-0.08	-0.10	-0.05

Note. R^2 for referred adolescents is 0.20 and 0.39 for siblings. Results controlled for age and sex. There was a significant effect of biological sex on sexual risk behavior for referred adolescents (0.19, $p = 0.043$), such that being female was associated with engagement in unprotected sexual behavior, accounting for other variables in the model. For age, there was a significant positive effect on unprotected sexual behavior for siblings (0.10, $p < 0.001$). RA = referred adolescent; CI = confidence interval;

$\hat{\beta}(o)$ = a standardized estimate using the overall standard deviation across both teens and siblings, which enables comparison of these estimates across teens and siblings; r represents the partial correlation which provides the effect size for individual actor and partner effects.

Figure 1. (a) Unstandardized parameter estimates of actor and partner effects for referred adolescent (RA) and sibling days of alcohol use in relation to unprotected sexual behavior, controlling for the effects of referred adolescent and sibling days of cannabis use, age, and sex (age and sex parameters not included in figure; substance use domains depicted separately but originate from one APIM model). (b) Unstandardized parameter estimates of actor and partner effects for RA and sibling days of cannabis use in relation to unprotected sexual behavior, controlling for the effects of RA and sibling days of alcohol use, age, and sex (age and sex parameters not included in figure; substance use domains depicted separately but originate from one APIM model). Standard errors are presented in parentheses. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Figure 2. Unstandardized parameter estimates of actor and partner effects for referred adolescent (RA) and sibling days of alcohol/cannabis co-use in relation to unprotected sexual behavior, controlling for the effects of age and sex (age and sex parameters not included in figure). Standard errors are presented in parentheses. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$