CONCURRENT SUBSTANCE USE AND RELATED PROBLEMS AMONG AFRICAN AMERICAN ADOLESCENTS: A DAILY DIARY STUDY

by

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This work is dedicated to my mother, Suzette Goddard, and to all the women in my life who have contributed to who I am today (Dr. Dev). Thank you for serving as my role models and cheerleaders, for showing me unconditional encouragement, acceptance, and love.

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ABSTRACT

African American adolescents have historically been considered at low risk for substance use relative to the White adolescent majority based on national prevalence estimates. However, during the last decade, African American adolescents' rates of marijuana use—alone and in combination with other substances—have increased disproportionately relative to those of their White peers. Given the strong relationship between marijuana use and other substance use and the functional consequences associated with concurrent substance use during adolescence, the increase in marijuana use among African American youth may contribute to increased substance-related health disparities across the lifespan. Thus, the current study examined daily associations between marijuana use and other substance use among African American adolescents relative to their White peers. It also examined whether those associations differentially predicted behavioral health consequences among African American adolescents. Participants (N = 35; 42.9% African American) were adolescents age 14-18 who reported past 30-day use of marijuana, alcohol, and/or tobacco products. Respondents completed daily diaries reporting their substance use for 14 consecutive days, followed by self-report measures of internalizing symptoms, externalizing symptoms, and substance use problems. Multilevel regression and structural equation models were used to account for the nesting of days within individuals. Participants completed 458 diaries for a completion rate of 93.5%. African American respondents reported greater daily- and individual-level rates of marijuana use and concurrent substance use than White respondents. However, in multilevel models controlling for demographics, marijuana use was not related to concurrent use of alcohol and/or tobacco use and this relationship did not vary by race. Racial differences in the relationship between concurrent substance use and behavioral health consequences were observed such that the relationship was positive among White youth but not African American youth. Findings suggest that African American youth are at high risk for engagement in problematic patterns of substance use but that daily diary methods may not be most appropriate for illuminating these patterns. Despite these unexpected results, disparities in substance-related consequences among African Americans adults persist. Future research should examine long-term rather than proximal consequences of concurrent substance use among African American adolescents.

INTRODUCTION

Substance use during adolescence is a significant health concern due to its association with numerous health and social consequences. Consequences of adolescent substance use include delinquency, psychiatric illness (Flory, Lynam, Milich, Leukefeld, & Clayton, 2004; Tucker, Ellickson, Orlando, Martino, & Klein, 2005), suicidal ideation (Duncan, Alpert, Duncan, & Hops, 1997), poor physical health (Tucker et al., 2005), cognitive deficits (Volkow, Baler, Compton, & Weiss, 2014), and substance use disorder (SUD) (DeWit, Adlaf, Offord, & Ogborne, 2000; Flory et al., 2004; Nelson, Van Ryzin, & Dishion, 2015). Among adolescents, African Americans have historically reported lower rates of substance use than their White peers (Centers for Disease Control and Prevention, 2016; R. M. Johnson et al., 2015; Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2016; Substance Abuse and Mental Health Services Administration, 2015) but those African Americans that do use substances during adolescence have been found more likely than their White peers to progress from substance use to SUD (Finlay, White, Mun, Cronley, & Lee, 2012; Swendsen et al., 2012). This racial disparity in the consequences of substance use is particularly concerning given recent statistics indicating that rates of marijuana use among African Americans have been increasing rapidly relative to those of Whites (R. M. Johnson et al., 2015; Lanza, Vasilenko, Dziak, & Butera, 2015; Miech et al., 2016). In fact, African Americans have gone from the group of adolescents least likely to use marijuana in the 1970s to the group most likely to use marijuana today (Lanza et al., 2015), with their rates of marijuana use significantly exceeding those of Whites for the first time in 2013 (R. M. Johnson et al., 2015; Miech et al., 2016).

Increasing use of marijuana among African American adolescents is alarming not only due to the health and social consequences associated with early marijuana use, but also because marijuana is frequently used concurrently with other substances during adolescence (Lanza et al., 2015; Leatherdale & Ahmed, 2010; Substance Abuse and Mental Health Services Administration, 2015). Marijuana use may indicate risk for concurrent use among African American adolescents in particular as they have been found more likely than their White peers to initiate marijuana use before transitioning to other substances such as alcohol and tobacco (Fairman, Furr-Holden, & Johnson, 2019; Green, Johnson, et al., 2016; Kennedy, Patel, Cheh, Hsia, & Rolle, 2016; Vaughn, Wallace, Perron, Copeland, & Howard, 2008). When these

substances are used in combination, they are associated with increased risk for substance-related consequences. For example, compared to use of only one substance, concurrent substance use—or use of more than one substance in a discrete time period—is associated with more frequent substance use (Chun et al., 2010; Terry-McElrath, O'Malley, & Johnston, 2013), other illicit drug use (Chun et al., 2010), and greater psychological distress among adolescents (Chun et al., 2010; Conway et al., 2013; Kelly, Chan, Mason, & Williams, 2015). These consequences may persist into adulthood, as there is a strong continuity of concurrent substance use from adolescence to adulthood, including high likelihood of transition from concurrent use of two substances to concurrent use of three or more (Merrin, Thompson, & Leadbeater, 2018). Accordingly, research has demonstrated that concurrent substance use during adolescence predicts severe social and functional consequences during the transition to adulthood, including high school non-completion (Kelly, Evans-Whipp, et al., 2015), involvement in the criminal justice system (Green, Musci, et al., 2016; Orlando, Tucker, Ellickson, & Klein, 2005), and SUD relative to single substance use (Green, Musci, et al., 2016; Moss, Chen, & Yi, 2014; Orlando et al., 2005). Given that adolescent marijuana use is strongly related to concurrent alcohol and tobacco use, the current study aims to examine associations between marijuana use and other substance use among African American adolescents relative to their White peers. Given functional consequences related to concurrent substance use during this developmental period, the study also examines whether African American adolescents disproportionately experience consequences of concurrent use relative to their White peers.

Person- and Variable-Centered Approaches to Concurrent Use

Extant research documenting the associations between marijuana and other substance use among adolescents have largely used person-centered approaches such as latent class analysis (LCA), which divides samples into exhaustive classes based on common responses to a set of observed variables (e.g., use of various substances) (Lanza & Rhoades, 2013). Among such studies, most have found that alcohol only use comprises the largest class, making up 15-80% of samples, followed by concurrent alcohol, marijuana, and tobacco use, making up 6-29% (Tomczyk, Isensee, & Hanewinkel, 2016), including among studies that included large proportions of African American adolescents (e.g, Chung, Kim, Hipwell, & Stepp, 2013).

However, few of these studies have examined racial differences in prototypical profiles—or typologies—of single and concurrent substance use.

The few studies examining racial differences in substance use typologies have demonstrated that African American adolescents are less likely to engage in frequent concurrent substance use than no use (Connell, Gilreath, & Hansen, 2009; Gilreath et al., 2015; Lanza, Patrick, & Maggs, 2010; Silveira, Green, Iannaccone, Kimmel, & Conway, 2019) and less likely to engage in typologies characterized by more than two substances (e.g., alcohol, marijuana, and tobacco) than their White peers (Banks et al., 2020; Banks, Rowe, Mpofu, & Zapolski, 2017; Gilreath, Astor, Estrada, Benbenishty, & Unger, 2014). However, variable-centered approaches examining specific typologies of concurrent substance use (e.g., alcohol and marijuana use or marijuana and tobacco use) have shown that African American adolescents may merely demonstrate different patterns of concurrent substance use than their White peers. For example, African American adolescents have been found less likely to concurrently use alcohol and tobacco than their White counterparts (Orlando et al., 2005) but more likely to concurrently use marijuana and tobacco (Aung, Pickworth, & Moolchan, 2004; Ramo, Liu, & Prochaska, 2012; Young & Harrison, 2001).

Recent studies suggest that concurrent marijuana and alcohol use also may be of concern among African American youth. For example, nationally-representative studies have indicated that they are just as likely to use alcohol and marijuana concurrently as they are to use alcohol and tobacco concurrently (Banks et al., 2017; Moss et al., 2014), with one study finding that approximately one quarter of African American adolescents in their sample used alcohol and marijuana concurrently (Green, Musci, et al., 2016). Other studies have found higher rates of alcohol and marijuana use among African American youth relative to their White peers. For example, Lanza et al. (2015) found that the relationship between marijuana use and heavy drinking had been increasing disproportionately among African American adolescents relative to White adolescents. Banks et al. (2020) also found that concurrent alcohol and marijuana use was the most common typology of substance use among African American adolescents whereas the most common typologies among White adolescents were predominant alcohol use and alcohol, tobacco, and marijuana use, in accordance with most previous studies (Tomczyk et al., 2016). Despite this evidence that concurrent alcohol and marijuana use is of increasing concern among African American adolescents, only one study has directly compared rates of concurrent alcohol

and marijuana use by race, finding that African American adolescents were more likely to use alcohol and marijuana concurrently in the past 30 days than their White peers relative to alcohol only use (Banks et al., 2017). Given that African Americans who use substances during adolescence are more likely than their White peers with similar use to progress to SUD during adulthood (Finlay et al., 2012; Swendsen et al., 2012), clarifying the association between marijuana and other substance use among African Americans and examining associated consequences is critical to identifying targets for the prevention of later health disparities.

Daily Diary Approach to Concurrent Use

To date, most studies examining typologies of adolescent substance use have identified latent classes based on historical self-report measures of substance use, which carry several limitations. First, the operationalization of substance use among these studies has ranged from use in the past two weeks to lifetime use, with most studies including a measure of lifetime use to identify latent classes (Tomczyk et al., 2016). Measuring lifetime use taps into substance experimentation, which may bias measurement of substance use among African American adolescents as they have been found twice as likely to be experimenters of more than one substance relative to White adolescents, but less likely to engage in frequent concurrent substance use (Gilreath et al., 2015). Studies using LCA to examine general historical patterns of substance use are also not able to differentiate between youth who have used more than one substance within a specified period, such as during the past year or month, and youth who use more than one substance in the same day (i.e., simultaneous substance use). As simultaneous substance use has been shown to comprise the majority of concurrent use (Patrick et al., 2018; Ramo et al., 2012; Subbaraman & Kerr, 2015) and is associated with more detrimental outcomes than single and concurrent substance use, including social and functional consequences, psychological distress, and SUDs (Brière, Fallu, Descheneaux, & Janosz, 2011; Midanik, Tam, & Weisner, 2007; Subbaraman & Kerr, 2015), assessing the temporal relationship between substances is critical to the study of concurrent substance use.

Daily diary assessments of current adolescent substance use address these limitations by allowing for the measurement of discrete substance use occasions. Daily diary methods not only elucidate temporal relationships between substances but also have been shown to elicit greater reports of substance use than historical self-report measures (Phillips, Phillips, Lalonde, &

Dykema, 2014). Previous diary studies of substance use behavior have supported examining concurrent substance use at the daily level of analysis. For example, diary studies among emerging adults have demonstrated that alcohol use on a given day predicts same-day marijuana use (O'Hara, Armeli, & Tennen, 2016; Yeomans-Maldonado & Patrick, 2015). Daily diary assessments of substance use can also be delivered using current technology, such as text messaging. This novel methodology has shown feasibility among diverse, urban samples of young adults (Bonar et al., 2018). Text messaging use among adolescents suggests feasibility among this population as well. For example, 95% of adolescents age 13-17 report having access to a smartphone (Anderson & Jiang, 2018). In 2015, 90% of adolescents in this age group reported text messaging, sending and receiving a median of 30 texts per day (Lenhart, 2015). Although no study, to my knowledge, has elicited daily diary reports of substance use via text messaging on adolescents' personal phones, these data suggest that it is a feasible and accurate way to measure substance use behavior among this population.

Current Study

Given recent increases in marijuana use among African American adolescents, the relationship between marijuana use and other substance use, and the functional consequences associated with concurrent substance use during adolescence, African American youth may be at high risk for concurrent substance use—specifically, concurrent use of marijuana and alcohol or marijuana and tobacco use—and substance-related consequences. There is initial evidence to support this premise as described previously.

To test this premise, the current study's first aim is to examine the association between daily use of marijuana and the other two most frequently used substances among adolescents—alcohol and tobacco—among African American adolescents relative to Whites. Based on previous research, I hypothesize that race will moderate the association of marijuana use with other substance use such that marijuana use will be more strongly associated with tobacco use and alcohol use, and less strongly associated with combined alcohol and tobacco use among African American adolescents relative to White adolescents.

The study's second aim is to determine whether concurrent use of marijuana and other substances is associated with greater substance-related consequences, including internalizing symptoms, externalizing symptoms, and substance use problems among African American

adolescents relative to Whites. I hypothesize that race will moderate the effect of concurrent use such that, relative to other typologies of substance use (i.e., no use, marijuana only use, tobacco/alcohol only use), concurrent marijuana and other substance use will be more strongly related to substance-related consequences among African American adolescents than White adolescents.

METHODS

Participants

Participants were non-Hispanic African American and non-Hispanic White adolescents age 14-18 recruited in the Indianapolis metropolitan area. Participants were recruited from the community and from local schools and after-school programs. Eligible participants were those who were currently enrolled in high school and reported past 30-day use of at least one of three substances: alcohol, marijuana, or tobacco. All participants were also required to have a cell phone for exclusive personal use with text messaging and data services.

Procedures

Participants were recruited from schools and community locations through in-person recruitment and flyers from August 2018 to September 2019. Recruitment occurred in malls, coffee shops, libraries, community centers, etc. Adolescent participants self-referred by calling the contact phone number listed in the recruitment material, after which they were anonymously screened for the inclusion criteria mentioned previously. After passing a brief screener, eligible participants were provided more information about the study and asked to provide their legal guardian's contact information if they were under age 18. The research team then called guardians to describe the study protocol, obtain verbal consent, and schedule an appointment for an in-person orientation for the guardian and their child. During the orientation appointment, guardians (or 18-year-old participants) completed informed consent procedures. Once informed consent from the guardian was obtained, child participants were assented separate from their guardian. Participants were then oriented to the text-message protocol and completed self-report baseline measures.

The daily diary protocol began two days after initial contact and lasted for 14 consecutive days. Surveys were administered through Qualtrics, a software that allows for programming and distribution of SMS (short message service) text message surveys. Each day of the protocol, participants received an SMS prompt at 3:00pm with a link to the daily survey. Participants could initiate the day's survey until 11:59pm local time, after which time entries were no longer recorded. The initial prompt indicated that questions referred to their substance use on the

previous day (e.g., “These questions are about yesterday from the time you woke up until the time you went to sleep”). Participants were also delivered a follow-up reminder prompt via SMS at 7:00pm local time. On the fifteenth day, a follow-up survey, which included measures for substance-related problems, was delivered at 3:00pm. Participants were allowed 48 hours to complete the follow-up survey.

Participants who passed the screener and completed the orientation were given $10. Guardians of child participants and 18-year-old participants were also paid an additional $10 to offset the costs of SMS messaging and data on their personal phones. Participants were further awarded $2 per daily survey and a $5 bonus for completing 6 out of 7 surveys in a week. Participants who completed more than 85% (at least 12) of surveys received an additional $10. Finally, those who completed the follow-up survey received $10 for a maximum compensation of $78 per participant or $68 per participant and $10 per guardian. This compensation structure is based on previous research demonstrating the feasibility of SMS surveys distributed and collected via personal cell phones (Bonar et al., 2018). Earned incentives were delivered in cash after participants’ daily diary protocols were completed.

Measures

Baseline

During the baseline survey, participants were asked about demographics including their age, grade, and race. They were also asked for the highest level of education that their mother or father had completed. Options included some high school, high school degree or GED, technical or trade school degree/certificate, some college or associates degree, 4-year college degree, advanced degree (Master’s, PhD, JD, MD), and unknown. Responses of unknown were treated as missing and parental education was treated as an ordinal variable.

Daily

The SMS survey comprised 11 questions regarding respondent’s marijuana, alcohol, tobacco and other substance use on the day prior (i.e., any use, quantity of use, and method of use; see Appendix A). For the current study respondents indicated whether or not they had used any of the three substances of interest on the previous day.

Follow-up

Internalizing Symptoms

The Center for Epidemiologic Studies Depression Scale Revised (CESD-R) (Eaton, Smith, Ybarra, Muntaner, & Tien, 2004) was used to measure psychological distress. The CESD-R is a 20-item scale that closely reflects the DSM-IV criteria for depression, including symptoms such as "I felt sad," "I lost interest in my usual activities," and "My appetite was poor." Respondents indicate how often they have felt each symptom in response to the stem, "Below is a list of the ways you might have felt or behaved. Please indicate the response that best matches how often you have felt this way in the past week or so." Response categories for each symptom are: "not at all or less than 1 day" (0), "1–2 days" (1), "3–4 days" (2), "5–7 days" (3), "nearly every day for 2 weeks" (4). The range of possible scores is 0-60 with higher scores indicating greater depressive symptomology. The scale has shown strong psychometric properties among adolescents, including high internal consistency and factor loadings, strong convergent, divergent and construct validity, and measurement invariance across gender (Haroz, Ybarra, & Eaton, 2014; Van Dam & Earleywine, 2011). The CESD-R also showed high internal consistency in the current sample ($\alpha = .95$).

Externalizing Symptoms

The Youth Self-Report for Ages 11-18 (YSR), Rule-Breaking Behavior scale is a 14-item subscale of the adolescent self-report measure from the Achenbach System of Empirically Based Assessment (ASEBA), a standardized screening questionnaire to identify behavioral problems among adolescents (Achenbach & Rescorla, 2001). Examples of items include "I break rules at home, school, or elsewhere," "I lie or cheat," and "I hang around with kids who get in trouble." Respondents indicate how much each behavior is true of them in the past 6 months on the following scale: "Not true" (0), "Somewhat or sometimes true" (1), and "Very true or often true" (2). The YSR in general has demonstrated strong psychometric properties among adolescents (Achenbach & Rescorla, 2001). The Rule-Breaking Behavior scale has shown high construct validity in the prediction of disruptive behavior disorders (Ebesutani, Bernstein, Martinez, Chorpita, & Weisz, 2011) above and beyond the predictive validity of the other related YSR scales (Lacalle Sistere, Domenech Massons, Granero Perez, & Ezpeleta Ascaso, 2014) and high

internal consistency with alphas ranging from .70-.78 (Ebesutani et al., 2011). The YSR also showed acceptable internal consistency in the current sample (α = .73). The current study used raw scores rather than T-scores to maintain the full range of variability on the scale as recommended when used in research rather than clinical contexts (Achenbach & Rescorla, 2001; Thurber & Sheehan, 2012).

Substance Problems

A modified version of the Rutgers Alcohol Problem Index (RAPI) (White & Labouvie, 2000; White & Labouvie, 1989), an 18-item self-report screening tool developed for adolescent problem drinking was used to measure substance use problems. The RAPI has also been modified by previous researchers to reliably and validly assess not only for alcohol-related problems, but also drug-related problems (V. Johnson & White, 1995). The current study used such a modified RAPI. Respondents indicate how often during the last year various problems occurred "while you were drinking alcohol, smoking tobacco, or using marijuana, OR as the result of your alcohol, tobacco, or marijuana use." Responses range from 0 (never) to 4 (more than 10 times). Examples of problems include: "Got into fights, acted bad or did mean things," "Tried to cut down on drinking or drug use," and "Felt physically or physiologically dependent on alcohol, tobacco, or marijuana." The RAPI has demonstrated strong discriminant and construct validity and internal consistency (White & Labouvie, 2000) and versions modified to include marijuana have also shown strong internal consistency (V. Johnson & White, 1989). Internal consistency was also strong in the current sample (α = .90).

Data Analysis

Preliminary analyses examined scale reliability (i.e., Cronbach's alpha [α] reported in the previous section), missing data, and assumptions of planned analyses. Person-mean imputation was used to replace missing items on the CESD-R, YSR, and RAPI if at least 80% of the items were available. This approach was chosen to increase power while preserving accurate estimates of variances and covariances, as it has been shown to generate similar results to other imputation methods and complete case data (Bono, Ried, Kimberlin, & Vogel, 2007).

Aims were tested using multilevel modeling in Stata 16 to account for the nesting of daily diary responses within persons. For aim 1, a multinomial multilevel mixed-effects model was used to test the association between daily marijuana use and concurrent use of alcohol and tobacco [1 (ref) = no use, 2 = tobacco use, 3 = alcohol use, 4 = tobacco and alcohol use] as well as whether this association varied by race. Concurrent use was estimated using a mixed-effects model with marijuana use entered into the model at the day-level; both fixed- (between-person) and random-effects (within-person) for marijuana use were estimated and allowed to correlate. Race and the interaction between marijuana use and race were entered at the person-level. Fixed effects were also estimated for person-level covariates, which included gender, age, and parental education, and the day-level covariate of weekend (see Figure 1 for demonstration of the estimated model). Likelihood ratio tests comparing nested and un-nested intercept-only models and intraclass correlations (ICCs) were used to examine the appropriateness of multilevel modeling. ICCs were estimated from random intercept-only models separately for each level of the outcome (i.e., tobacco use, alcohol use, and tobacco and alcohol use) relative to no use.

For aim 2, multilevel mixed-effects structural equation models were used to test the association between day-level marijuana use typologies [1 (ref) = no use, 2 = non-marijuana use (e.g., tobacco and/or alcohol), 3 = marijuana only use, 4 = concurrent marijuana use] and three person-level distal outcomes: substance use problems, internalizing symptoms, and externalizing symptoms. Because marijuana use typology was measured at the within-group level whereas the outcome variables were measured at the between-group level, a latent variable approach for micro-macro data was used, which treats values on the within-group independent variable as exchangeable indicators for a latent group-level variable (Croon & van Veldhoven, 2007). This approach has been shown to produce less biased estimates than other micro-macro approaches, such as aggregating within-group predictors to the between-group level (Bennink, Croon, & Vermunt, 2013; Croon & van Veldhoven, 2007). As marijuana use typology was discrete, a multilevel item response model was used to predict the latent variable (Bennink et al., 2013). An indirect latent approach was used as proposed by Bennink, Croon, Kroon, and Vermunt (2016) as daily marijuana use typology was not expected to influence the outcomes directly, but rather indirectly via individual persons. To model the indirect approach, a two-level variance-components model was used whereby persons affect latent individual substance use typology, which in turn, affects daily responses to marijuana use typology (see Figure 2 for demonstration

of the estimated model). Fixed effects were estimated for race and the interaction between marijuana use and race. Gender, age, and parental education were again included as fixed, person-level covariates. Significant interactions were probed by estimating expected values of the outcomes as a function of race and person-mean concurrent use.

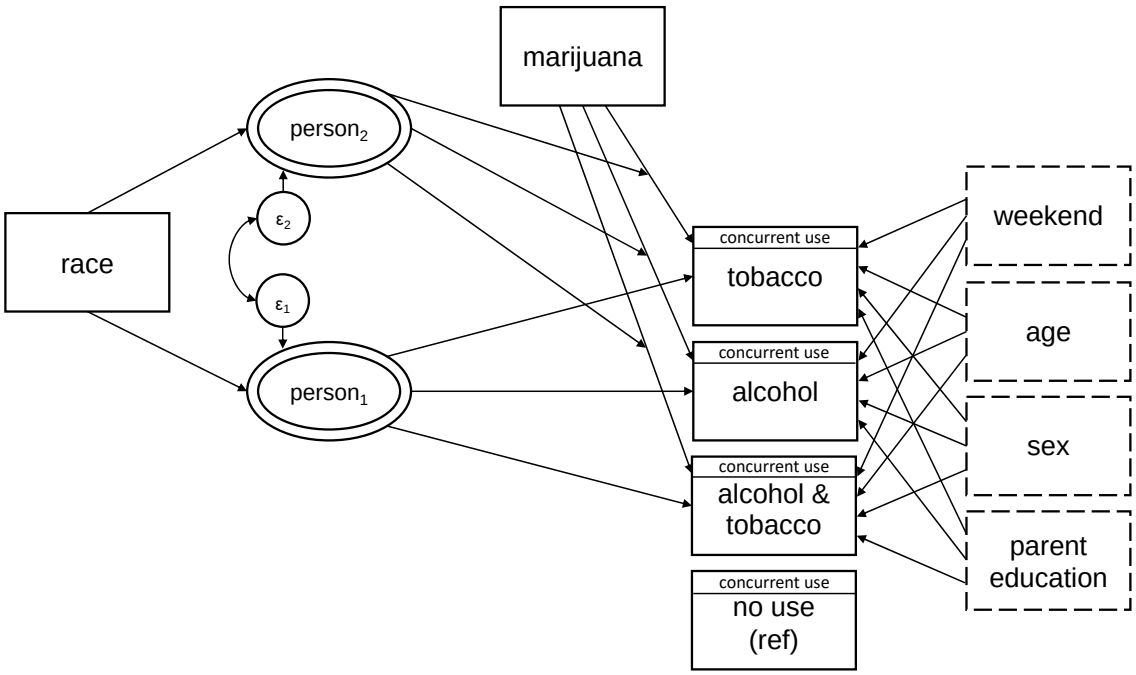

Figure 1. Estimated multilevel model for aim 1. Double-ringed ovals indicate latent variable constant within person. Dashed boxes indicate fixed covariates. Variables in the shaded area vary at the observation (i.e. daily) level.

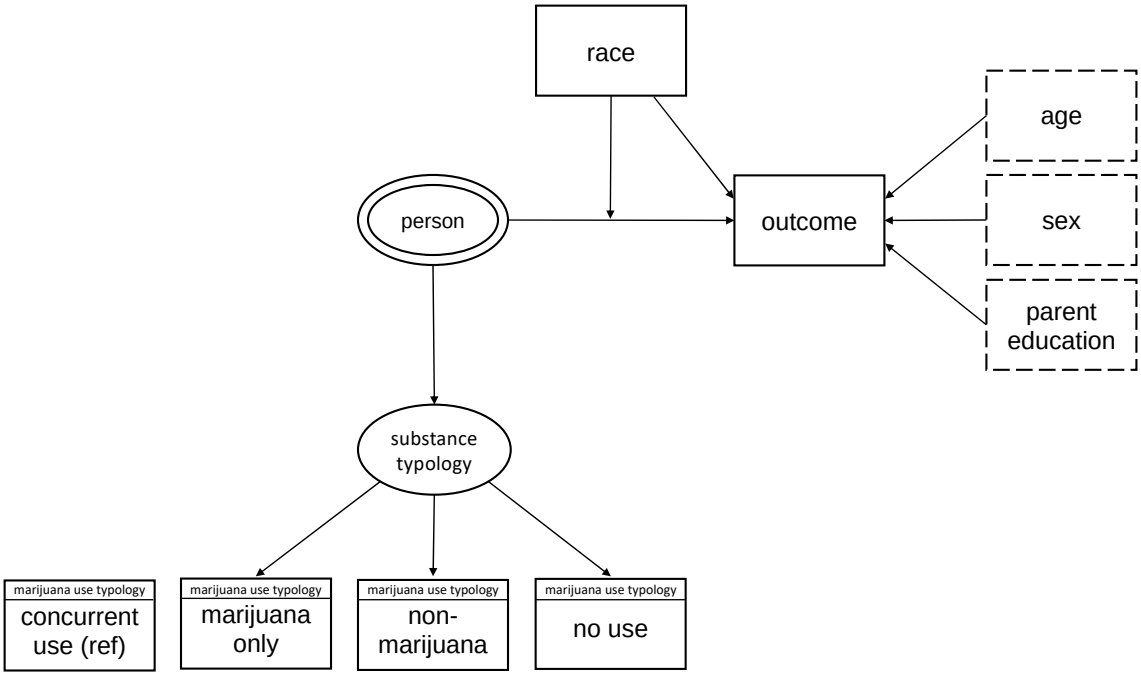

Figure 2. Estimated multilevel structural equation model for aim 2. Ovals indicate latent variables. Double-ringed ovals indicate latent variables constant within person. Dashed boxes indicate fixed covariates. Variables in the shaded area vary at the observation (i.e., daily) level. This model was examined for all three outcomes: internalizing symptoms, externalizing symptoms, and substance use problems.

RESULTS

Preliminary Results

A total of 318 adolescents were screened via phone, 58 (19%) met inclusion criteria and 35 (11%) enrolled. Only 7 (2%) adolescents were excluded for lack of access to a smart-phone (see Figure 3 for flow-chart of participant recruitment). Among included participants (N = 35) slightly more than half identified as White (57%). Most African American participants were male (60%) whereas most White participants were female (65%). The mean age was 16.13 (*SD* = 1.60) for African American and 16.40 (*SD* = 1.43) for White participants.

Participants completed 458 daily diaries for a completion rate of 93.5% (*M* days = 13.09, *SD* = 1.36). Although Little's MCAR test suggested missing data were missing completely at random (MCAR), $\chi_2(11) = 5.04$, $p = .929$, African American participants completed significantly fewer diaries (n = 185; 88.1%) than White participants (n = 273; 97.5%), $\chi_2(1) = 17.3$, $p < .001$, $V = .188$, so data were considered missing at random (MAR) and were not imputed. Regarding follow-up surveys, 34 participants completed follow-up measures for a completion rate of 97.1%. Among participants who completed the follow-up surveys, there were no missing items on the CESD-R. On the YSR and RAPI, four (11.4%) and two participants (5.7%), respectively, had one missing item. Analyses suggested the missing data were MCAR, $\chi_2(357) = 10.08$, $p = 1.00$, and were not related to any demographic variables, individual substance use, or substance use typology. Thus, missing items were person-mean imputed as described previously.

Daily Substance Use

The following descriptive results are based on completed diaries (n = 458) and are presented in Table 1. Respondents reported use of marijuana, alcohol, and/or tobacco products in 231 diaries (50.4%). Proportion of marijuana, alcohol, and tobacco product use days were 37.8%, 9.3%, and 21.9%, respectively. With regard to substance use typology, 30.7% of substance use days were characterized by use of marijuana and at least one other substance: tobacco (19.0%), alcohol (7.8%), or both alcohol and tobacco (3.9%). Marijuana only use comprised 43.7% of substance use days and alcohol or tobacco product only use comprised 25.5%. Only two days were characterized by concurrent alcohol and tobacco use. Because of low

counts of certain typologies (see Appendix B, Table B.1), the following typologies were used for preliminary analyses and for the outcome of aim 2: concurrent marijuana use, marijuana only use, alcohol and/or tobacco only, no use.

Racial differences were observed in proportion of substance use days. African American respondents reported significantly more substance use days (58.4%) than White respondents (45.1%). African American respondents also reported more marijuana use days (53.3% vs. 27.5%) and drinking days than White respondents (16.3% versus 4.4%). No difference was observed in tobacco product use days (21.1% versus 22.4%, respectively). Among substance use days, African American respondents were more likely to report concurrent marijuana and other use (45.4% versus 17.9%) and marijuana only use (28.0% versus 23.9%), whereas White respondents were more likely to report alcohol and/or tobacco only use (39.0% versus 10.2%).

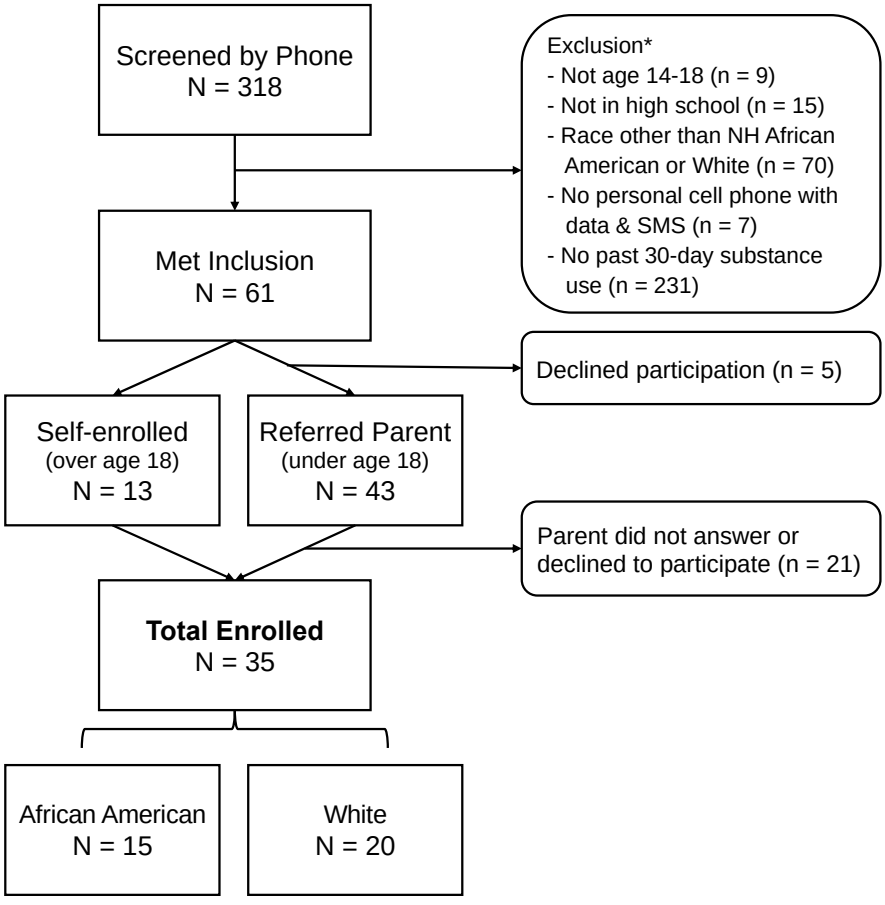

Figure 3. Flow-chart of participant recruitment and inclusion. Exclusion categories are not mutually exclusive.

Individual Substance Use

Among individual respondents, 94.3% reported substance use during the 14-day diary protocol. Frequency of marijuana, alcohol, and tobacco product use among respondents during the protocol were 74.3%, 42.9%, and 48.6%, respectively. Among those reporting substance use, 45.5% reported concurrent marijuana and other use, 39.4% reported marijuana use only and 15.2% reported alcohol or tobacco product use only.

Racial differences were also observed between respondents. African American respondents were more likely to report any marijuana use during the 14-day protocol than White respondents. There were no significant differences in alcohol or tobacco use frequencies by race. Regarding substance use typology, African American respondents were more likely to report concurrent marijuana and other substance use during the protocol whereas White adolescents were more likely to report alcohol and/or tobacco only use (see Table 1 for proportions).

Table 1

Frequency of Substance Use by Race at Daily and Person Levels

	African American	White	Total	Group Differences		
	%	%	%	χ^2	*V*	*p*
Days						
Substance Use	58.4	45.1	50.4	7.83	.131	**.005**
Marijuana	53.3	27.5	37.8	30.97	.261	**<.001**
Alcohol	16.3	4.4	9.3	18.33	.201	**<.001**
Tobacco	21.1	22.4	21.9	0.11	.016	.741
Substance Use Typology				41.83	.302	**<.001**
Marijuana & other	26.5	8.1	15.5	27.29	.303	**<.001**
Marijuana only	25.9	19.4	22.1	5.49	.129	**.019**
Tobacco &/or alcohol only	5.9	17.6	12.9	5.13	.134	**.024**
Persons						
Substance Use	93.3	95.0	94.2	0.04[a]	.036	1.00
Marijuana	93.3	60.0	74.3	4.99	.377	**.048**
Tobacco	46.7	40.0	42.9	0.16	.067	.693
Alcohol	53.3	45.0	48.6	0.24	.083	.625
Substance Use Typology				9.30[a]	.479	**.016**
Marijuana & other	73.3	30.0	48.6	6.44[a]	.429	**.018**
Marijuana only	20.0	30.0	25.7	.45	.113	.700
Tobacco &/or alcohol only	0.0	35.0	20.0	6.56	.433	**.027**

Note: [a]Fisher's exact test statistic

Aim 1 Results

Table 2 displays frequencies of the categorical aim 1 outcome: no use (reference), tobacco use, alcohol use, and tobacco and alcohol use. Preliminary results showed that daily marijuana use was positively associated with daily concurrent use, $\chi_2(3) = 25.43$, $p < .001$, $V = .237$, for tobacco only, $\chi_2(1) = 10.37$, $p = .001$, $V = .159$, alcohol only, $\chi_2(1) = 8.94$, $p = .003$, $V = .159$, and concurrent alcohol and tobacco use relative to no concurrent use, $\chi_2(1) = 12.17$, $p < .001$, $V = .191$. Stratified by race, these relationships held among African American, $\chi_2(3) = 29.42$, $p < .001$, $V = .402$ but not White adolescents, $\chi_2(3) = 1.64$, $p < .651$, $V = .078$. Among African Americans, marijuana use was positively associated with tobacco only use, $\chi_2(1) = 18.67$, $p < .001$, $V = .350$, alcohol only use, $\chi_2(1) = 9.84$, $p = .002$, $V = .262$, and concurrent alcohol and tobacco use relative to no concurrent use, $\chi_2(1) = 8.41$, $p = .004$, $V = .253$.

Table 2

Descriptive Statistics for Aim 1 and Aim 2 Outcomes by Race

	White	African American	Total	Group Differences		
	n (%)	n (%)	n (%)	χ^2	*V*	*p*
Aim 1				19.29	.206	**<.001**
No use (ref)	199 (74.0)	125 (67.6)	324 (71.4)	-	-	-
Tobacco	58 (21.6)	30 (16.2)	88 (19.4)	.59	.038	.441
Alcohol	10 (3.7)	21 (11.4)	31 (6.8)	9.94	.167	**.002**
Alcohol and tobacco	2 (0.7)	9 (4.9)	11 (2.4)	8.29	.157	**.004**
	M (SD)	M (SD)	M (SD)		t or Z	p
Aim 2						
Internalizing symptoms	17.90 (13.94)	13.63 (16.15)	16.15 (14.80)		1.17[a]	.086
Externalizing symptoms	9.04 (4.22)	7.74 (3.35)	8.50 (3.89)		.93	.343
Substance problems	9.75 (13.32)	9.56 (9.79)	9.67 (11.83)		.76[a]	.450

Note: [a]Z-test statistic based on non-parametric Mann-Whitney U test. Bold values indicate significant p -values at $p < .05$

A multinomial mixed-effects (i.e., multilevel) model was used to examine the association of marijuana use with alcohol and tobacco use and the moderating effect of race on this relationship. A likelihood-ratio test suggested there was enough variability between people to favor a mixed effects model over an un-nested model, $\chi_2(3) = 222.13$, $p < .001$. ICCs also supported mixed-effects modeling, indicating that 87% of the variance in tobacco only use, 44% of the variance in alcohol use, and 97% of the variance in alcohol and tobacco use was explained at the person level. Results of the multilevel model showed that the variance of the random intercept was 23.59 (95% CI: 7.29, 76.40) suggesting significant variability in the outcome as a function of person. Specifically, there was significant between-person variation in the likelihood of concurrent tobacco and alcohol use, *OR* = 2.82, *p* = .002 (95% CI: 1.47-5.37), but not in the likelihood of tobacco only, *OR* = .42, *p* = .235 (95% CI: .10-1.75), or alcohol only use, *OR* = .31, *p* = .235 (95% CI: .05-2.13).

Results indicated that neither between-person (i.e., fixed) nor within-person (i.e., random) marijuana use was significantly associated with likelihood of concurrent tobacco, alcohol, or tobacco and alcohol use (see Table 3 for complete results). The variance of the random slope for the effect of marijuana use was 4.46 (95% CI: .28, 70.91) indicating no significant difference in the relationship between marijuana use and other use between people. At the person-level, race was not significantly associated with the likelihood of concurrent use. The interaction between race and marijuana use also was not significant.

Table 3

Results of Multinomial Multilevel Regression Predicting Daily Alcohol and Tobacco Use

	Concurrent Substance Use[a]											
	Tobacco Use				Alcohol Use				Tobacco & Alcohol Use			
	OR	*95% CI*		*p*	*OR*	*95% CI*		*p*	*OR*	*95% CI*		*p*
Covariates												
Age	1.51	.52	4.38	.445	1.08	.72	1.63	.699	10.94	1.21	99.11	**.033**
Sex (male)	9.36	.33	265.08	.190	.63	.17	2.35	.497	1117.10	1.70	735632.20	**.034**
Parent Education	2.51	.89	7.09	.082	1.07	.77	1.49	.684	5.59	1.24	25.16	**.025**
Weekend	.71	.30	1.68	.431	3.89	1.49	10.13	**.005**	.74	.11	5.23	.767
Day-level												
Marijuana (fixed)	9.67	.73	128.17	.085	.28	.02	5.06	.394	36.97	.29	4755.61	.145
Marijuana (random)	.42	.10	1.75	.235	.31	.05	2.13	.235	.59	.08	4.09	.590
Person-level[b]												
Race (African American)									.35	.01	11.32	.557
Interaction (Race X Marijuana)									.30	.03	3.53	.341

Note: [a] Categories relative to reference group, no use. [b] Results of person level-variables are not presented for levels of the outcome, but for the latent variable of person (see Figure 2). Bold values indicated significant p-values at $p < .05$

Aim 2 Results

Table 2 displays descriptive statistics for the aim 2 outcomes: internalizing symptoms, externalizing symptoms, and substance use problems. Responses on internalizing symptoms and substance use problems were significantly positively skewed with overdispersion (see Appendix B, Table B.3) so these outcomes were examined using nonparametric tests, including negative binomial structural equation models. Preliminary analyses showed no racial differences in mean levels of any outcome. At the person level, marijuana use typology was not significantly associated with internalizing symptoms, $H(3) = 3.22$, $p = .200$, externalizing symptoms, $F(3, 30) = 1.83$, $p = .164$, or substance use problems, $H(3) = 4.76$, $p = .093$.

Multilevel structural equation models were used to predict behavioral health outcomes from the interaction of race and substance use typology, a person-level latent factor based on daily substance use typology (marijuana only use, non-marijuana use, and no use relative to concurrent marijuana use; see Figure 2). In all three models, observed substance use typology significantly loaded onto the factor variable (see Appendix B, Table B.5 for coefficients). Regarding internalizing symptoms, the substance use typology factor was not significantly associated with symptoms; race was also not significantly associated with symptoms (see Table 4). The interaction between substance use typology and race was significant, $IRR = 1.99$, $p = .034$ (95% CI: 1.05-3.75), such that concurrent use was more strongly associated with internalizing symptoms among White adolescents than African American adolescents relative to marijuana only use, non-marijuana use and no use (see Figure 4 for interactions; see Appendix B, Table B.6 for expected values by race). For externalizing symptoms and substance use problems, race was not significantly associated with either outcome. However, substance use typology was significantly associated with both outcomes such that concurrent use was related to greater reported symptoms. The interaction of substance use typology and race was significantly related to both externalizing symptoms, $b = 3.47$, $p < .001$ (95% CI: 1.54-5.40), and substance use problems, $IRR = 2.28$, $p = .031$ (95% CI: 1.08-4.83), in a similar pattern to that found with internalizing symptoms: the effect of substance use typology was stronger among White adolescents than African American adolescents. See Table 4 for complete results.

Table 4

Results of Multilevel Structural Equation Models Predicting Behavioral Health Outcomes

	Internalizing Symptoms[a]				Externalizing Symptoms				Substance Use Problems[a]			
	IRR	*95% CI*		*p*	*b*	*95% CI*		*p*	*IRR*	*95% CI*		*p*
Age	-.04	-.74	.67	.152	-.04	-.74	.67	.917	1.06	.81	1.40	.676
Sex (male)	.83	.45	1.55	.565	-.67	-2.81	1.48	.544	2.23	.94	5.32	.070
Parent Education	1.15	.96	1.38	.141	.19	-.38	.76	.680	1.24	.99	1.55	.065
Race (AA)	.58	.26	1.28	.177	-2.12	-4.78	.54	.118	.73	.28	1.92	.527
SU Typology	.96	.70	1.33	.825	-2.90	-4.25	-1.56	**<.001**	.56	.35	.89	**.013**
Race X SU	1.99	1.05	3.75	**.034**	3.47	1.54	5.40	**<.001**	2.28	1.08	4.83	**.031**

[a]Results of Posisson regression

Note: Bold values indicated significant p-values at $p < .05$; SU: substance use

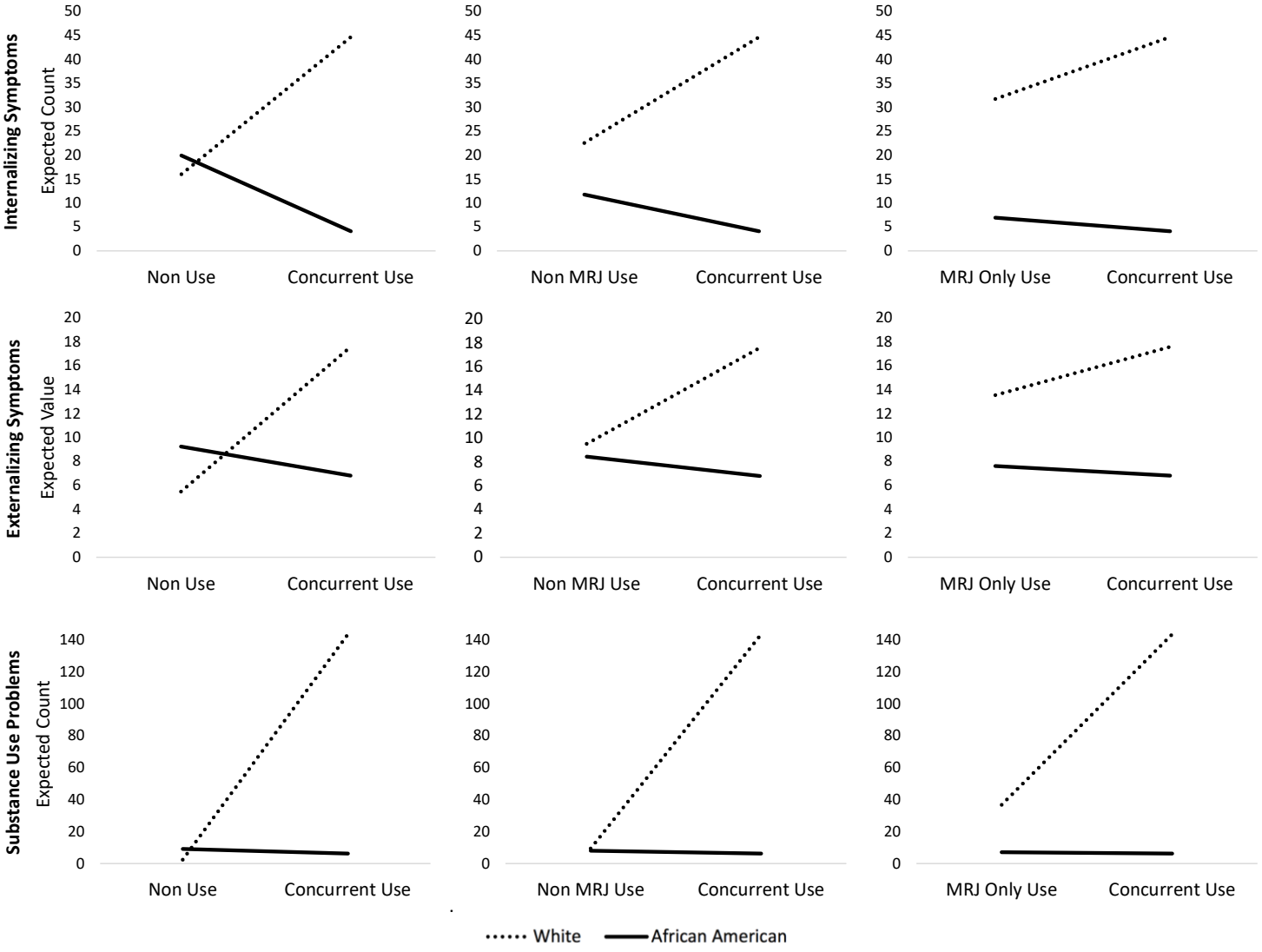

Figure 4. Interaction of race and marijuana use typology on expected values of the behavioral health outcomes.

DISCUSSION

For 30 years after researchers began surveying adolescent substance use at the national level, African American adolescents were considered low risk for substance use relative to the White adolescent majority due to lower reported rates of use (e.g., Miech, Johnston, et al., 2019). However, during the last decade, African American adolescents' rates of marijuana use have increased disproportionately relative to those of other racial/ethnic groups (R. M. Johnson et al., 2015; Lanza et al., 2015; Miech, Terry-McElrath, O'Malley, & Johnston, 2019). These disparate increases could be accompanied by disparate increases in comorbid substance use and behavioral health problems, which may contribute to more severe health disparities for African Americans across the lifespan.

To explore this conceivability, the current study examined the relationship between daily marijuana use and other substance use (i.e., alcohol and tobacco product use) among African American adolescents relative to White adolescents. It then examined whether concurrent use of marijuana and other substances was differentially related to comorbid behavioral health problems among African American adolescents relative to their White peers. My first hypothesis, that race would moderate the association of daily marijuana use with alcohol and tobacco product use, was unsupported. Marijuana use was not significantly associated with daily use of either alcohol, tobacco products, or both substances and there was no variation in race among these associations. My second hypothesis, which posited that race would moderate the effect of concurrent marijuana and other substance use on three behavioral health outcomes, was supported but in the opposite direction as hypothesized. Whereas I hypothesized that concurrent use would be more strongly associated with behavioral health problems among African American adolescents, it was actually positively associated with all three outcomes (internalizing symptoms, externalizing symptoms, and substance use problems) among White adolescents, but not their African American counterparts.

Although findings were not supported in the hypothesized directions, the current study extended previous work describing concurrent substance use among adolescents by examining the relationship between substances via a daily diary method. Using a daily diary approach can elucidate the temporal relationships of substances comprising concurrent use. However, through this approach, I found that daily marijuana use was not related to daily use of alcohol and

tobacco when accounting for covariates and between-person variation in substance use. This null effect was surprising, as it is inconsistent with similar work among emerging adults, which demonstrated that daily alcohol use predicts same-day marijuana use (O'Hara et al., 2016; Yeomans-Maldonado & Patrick, 2015). It also contradicts previous work among adolescents that suggests simultaneous (i.e., same-day) concurrent use is more common than non-simultaneous archetypal concurrent use among adolescents (Patrick et al., 2018) and that simultaneous concurrent use is the "rule rather than the exception" among adolescents who use substances (Duhig, Cavallo, McKee, George, & Krishnan-Sarin, 2005, p. 279). These differences in findings between previous studies and the current study may be explained by differences in population and research question. For example, O'Hara et al. (2016) examined whether alcohol use predicted same day marijuana among emerging adults who reported use of both substances, and Duhig et al. (2005) examined concurrent use of alcohol and marijuana among adolescents who reported tobacco use. Yet, for the current study, participants were included regardless of the type of substance they reported. Given that the current null results were based on current users of alcohol, marijuana, *or* tobacco, it is plausible that simultaneous substance use is not generalized, but instead more common among adolescents who engage in certain substance use typologies. Alternatively, it is plausible that simultaneous substance use is common among individuals, but not among instances of substance use. For example, Patrick et al. (2018) found that approximately 75% of adolescents who engaged in past-year concurrent alcohol and marijuana use also engaged in past-year simultaneous alcohol and marijuana use. Taken together, these findings suggest that when examining simultaneous relationships between substances among adolescents, researchers should ensure there is sufficient empirical background or theory to support this methodology among the population of interest. This may warrant more restrictive inclusion criteria for daily diary studies, which was not feasible for the current study.

Findings that the relationship between marijuana and concurrent use of alcohol and/or tobacco products did not vary by race is also inconsistent with previous research demonstrating differences in typologies of concurrent substance use between African American and White adolescents (e.g., Banks et al., 2020; Banks et al., 2017; Chung et al., 2013). However, previous research exploring this topic has relied exclusively on observed historical reports of substance use. Taken with the current results, there may be racial differences in typologies of archetypal substance use but not daily substance use among adolescents. Data from the current study

support this notion: although I observed no differences between African American and White adolescents in the daily relationship of marijuana and other substances, I observed significant differences in their substance use typologies during the two weeks of the study. That is, African American adolescents were more likely to engage in concurrent use of marijuana and other substances during the 14-day study, whereas White adolescents were more likely to engage in alcohol and/or tobacco only use, which is consistent with previous variable-centered research (Banks et al., 2017; Ramo et al., 2012). These differences in univariate and multivariate results are likely explained by the significant between-person variation observed in substance use patterns. Between 44% and 97% of the variation in daily alcohol and tobacco use was explained by differences between individuals, which limited power to detect effects at the daily level. As discussed previously, including participants regardless of type of substance use reported may have contributed to this high between-person variability in substance use patterns.

It is also notable that relative to White adolescents, African American adolescents reported more total substance use days and more substance use days characterized by concurrent marijuana and alcohol or tobacco use, which may indicate more problematic use (e.g., Patrick, Veliz, & Terry-McElrath, 2017). This contradicts previous research, which has shown that African American adolescents are less likely to engage in simultaneous use than White adolescents; however, such studies have been limited to measuring reports of any simultaneous use during the past year (Patrick et al., 2018; Terry-McElrath et al., 2013).Taken together with the current results, these studies suggest both person- and variable-centered approaches to understanding concurrent substance use by race should explore frequency and recency of substance use, as most have relied on dichotomous lifetime, past-year, and/or past-month reports of substance use (Banks et al., 2017; Connell et al., 2009; Gilreath et al., 2014; Gilreath et al., 2015; Silveira et al., 2019). Examining substance use frequency not only illuminates racial differences in substance use typologies (e.g., Banks et al., 2020), but also may indicate which substances drive concurrent substance use. Understanding which substances drive concurrent use could illuminate targets for further investigation (e.g., which patterns are best explored at the daily level) and prevention of related consequences.

Although African American youth were more likely to report concurrent substance use and reported more days of concurrent use, results suggested that concurrent use of marijuana and other substances was related to poorer behavioral health outcomes among White youth but not

their African American peers. African American youth who use substances during adolescence have been found more likely than White youth to progress to substance use problems (Finlay et al., 2012; Swendsen et al., 2012), which makes this finding unexpected. Contrary to previous studies illuminating racial disparities in the relationship between adolescent substance use and young adult behavioral health outcomes, the current study examined the relationship between adolescent substance use and proximal adolescent outcomes. That is, outcomes in the current study were measured only one to two days after the daily substance use protocol and the timeframes of the outcome measures (i.e., past year and past two-weeks) asked participants to report symptoms that were temporally concurrent with the substance use protocol. It is plausible that White adolescents are more likely to experience consequences of their substance use proximally—as in the current study—whereas African Americans are more likely to experience such consequences distally, in emerging adulthood and throughout the life course. There is theoretical and empirical support for this notion. For example, Zapolski, Pedersen, McCarthy, and Smith (2014) postulated that factors that confer protection against substance use for African American youth during adolescence, such as social norms against use, may confer risk for substance use after the transition to adulthood to within-group negative evaluations. This may account for findings that African Americans are more likely to transition from substance use during adolescence to SUDs and psychiatric disorders in adulthood relative to Whites, despite demonstrating lower rates of adolescent substance use than Whites (Gil, Wagner, & Tubman, 2004). In addition to within-group social sanctions, interpersonal and structural racial discrimination, greater alcohol and drug availability in majority-African American neighborhoods, and lower rates of treatment accessibility and utilization among African Americans (Godette, Headen, & Ford, 2006; Zapolski et al., 2014) may help explain why such a disparity persists well into adulthood (Caetano, 2003; Chartier & Caetano, 2010; Sartor et al., 2013; Vasilenko, Evans-Polce, & Lanza, 2017).

Implications

There are several implications of the current study for future research and prevention efforts. With regard to future research, the current study suggested that simultaneous concurrent substance use among adolescents may not be as common as person-centered research has previously suggested (Patrick et al., 2018) and that racial differences in simultaneous use should

be examined both between- and within-person. Given disparate results between this and previous studies using person-centered methods, person-centered methods may most appropriate for improving general understanding typologies of concurrent use among different groups of adolescents whereas nested daily diary methods may be more appropriate for understanding mechanisms of discrete concurrent use decisions (e.g., O'Hara et al., 2016). Regardless of the question, future research exploring adolescent concurrent use should take into account that substance use typologies differ by race. The rates of concurrent use observed among African American adolescents in the current study implies that including race as a covariate in person-centered approaches to understanding concurrent use is insufficient for capturing substance use typologies among this group. Such conclusions based on between-group comparisons assume that African Americans are homogenous and likely obscures the within-group heterogeneity of substance use (e.g., Banks et al., 2020; Godette et al., 2006). Thus, future research should continue to employ both within-group and between-group comparisons to better understand the prevalence and mechanisms of concurrent use among African American youth in an effort to identify targets for prevention of health disparities in later life.

With regard to prevention, the current study demonstrated that despite high rates of general and concurrent substance use relative to their White peers, African American adolescents are still experiencing resilience against substance-related outcomes. Previous research has pointed to religiosity (Watt, 2008), parental disapproval (Pampel, 2008), parental monitoring, and social norms disapproving for use as factors that protect African American youth from substance-related problems during adolescence but dissipate during adulthood (Zapolski et al., 2014). Prevention efforts are needed that for African American youth that focus on bolstering these protective factors and increasing access to resources and social support that facilitate substance use cessation during the transition to adulthood (Pampel, 2008; Watt, 2008). The current study also found that approximately half of adolescents who report current substance use also report concurrent substance use. However, most prevention programs for adolescent substance use target alcohol and tobacco use with a smaller proportion including programming for marijuana use, any substance use, or combined substance use (Das, Salam, Arshad, Finkelstein, & Bhutta, 2016). Alcohol- and tobacco-focused prevention efforts should be supplemented by programming for marijuana use and concurrent substance use, particularly for African American youth, who may be less likely to engage in alcohol and/or tobacco only use.

Additionally, given that African American youth are less likely to seek treatment for substance use (Ilgen et al., 2011), prevention efforts are best implemented in school- and primary care-based settings to help reduce long-term health disparities. Such prevention efforts should include screening for not only individual substance use, but also concurrent substance use and susceptibility to future substance use (Pbert et al., 2015). In support for this approach, adolescents in a primary care setting who screened positive for alcohol use were found more likely to report smoking 6 months later and this smoking behavior was explained by smoking intentions at the time of screening (Shadel, Seelam, Parast, Meredith, & D'Amico, 2019). Among African American adolescents, who are more likely to use marijuana and initiate marijuana before other substances (Sartor et al., 2013), primary care providers might similarly assess for smoking and alcohol intentions among those who report marijuana use.

Limitations

Despite the use of empirically-sound, data-informed, and contemporary methodology, the current study has several limitations that should be considered during its interpretation. First, the study used community-based convenience sampling in a mid-sized Midwestern city. Although this method may have helped recruit African American adolescent participants, who are typically underrepresented in similar research (Tomczyk et al., 2016), it limits the generalizability of the study. Second, measurement in the current study spanned just over two weeks. The 14-day daily diary protocol likely contributed to high response rates but may not be representative of typical substance use among the respondents. Additionally, substance-related problems were measured proximal to substance use, which precludes me from making inferences about the temporal ordering of the relationship between concurrent substance use and behavioral health outcomes. Third, although the statistical analyses used were most appropriate for the structure of the data, the small sample size may have contributed to Type II error given that preliminary univariate results often did not correspond with multivariate multilevel results. This limitation particularly applies to the study's second aim, for which outcomes were measured at the person level. Fourth, although the current study aimed to compare relationships by race, the racial groups were not equivalent. Fewer African American participants were recruited than White participants and the gender proportions between the groups were not equal. Rather than selecting a subsample of matched respondents on demographic factors like gender and age or grade, the original sample

was retained to increase power. Relatedly, African American participants were significantly more likely than White participants to have missing data on daily measures of substance use, which may further bias the current results. Finally, due to the small sample size and pattern of responses, some distinct substance use typologies were consolidated into large composite categories. For example, marijuana and alcohol use, marijuana and tobacco use, and marijuana, alcohol, and tobacco use, were considered together. Previous research has demonstrated that these typologies are distinct and vary in prevalence by race (Banks et al., 2020). Thus, the current study was limited as it did not compare all distinct observed typologies by race and was unable to explore if they were differentially related to substance-related consequences.

Conclusion

Using daily diary methods to elucidate the temporal relationship of marijuana and other substance use among substance-using adolescents, the current study found evidence that African American adolescents report more concurrent substance use during a two-week timeframe relative to their White peers. However, no difference between the two groups were observed at the daily level. Racial differences were observed in substance-related consequences, such that White youth experienced more proximal consequences related to concurrent substance use relative to African American youth. Given well-documented disparities in substance-related consequences among African Americans adults, future research should examine the long-term consequences of early concurrent substance use among African American adolescents. Although more research is needed to understand concurrent substance use, its consequences, and how those consequences vary among socio-demographically disadvantaged groups, data from this study suggest that African American youth are not at low risk for engagement in problematic patterns of substance use. Thus, although national estimates continue to conclude that African American youth "have the lowest levels of use of many of the licit and illicit drugs" (Miech, Johnston, et al., 2019), clinicians and researchers should continue to use novel methods to consider unique patterns of concurrent substance use among this population of adolescents.

APPENDIX A. NOVEL MEASURES

Daily Survey

Questions are about YESTERDAY from the time you woke up until you went to sleep. You may skip a question if necessary. We WON'T share your answers.

1. Did you use tobacco yesterday? This includes cigarettes, e-cigarettes, cigars and cigarillos, chewing tobacco (dip) & snus or snuff.
   1 = Yes
   2 = No

2. How many cigarettes, hookahs, cigarillos, snus, e-cigs, etc. did you use yesterday? Add them all up and type your best guess as a number. Type 0 if none.

3. What types of tobacco did you use yesterday? Select all that apply.
   1 = cigarette
   2 = cigarillo/cigar
   3 = e-cigarette
   4 = hookah
   5 = chewing tobacco
   6 = snus or snuff
   7 = did not use

4. Did you drink alcohol yesterday? Do not count if you only had 1 or 2 sips from a drink.
   1 = Yes
   2 = No

5. How many drinks did you have yesterday? 1 drink is a regular 12oz can/bottle of beer, glass of wine, shot of liquor, or mixed drink with 1 shot. Type 0 if none.

6. Did you use marijuana yesterday? This includes smoking hashish or hash oil out of a vaporizer or eating marijuana-infused food (edibles).
   1 = Yes
   2 = No

7. How many grams of marijuana do you think you used yesterday? Reply with the number. Type 0 if none.

8. How did you use marijuana yesterday? Select all that apply.
   1 = blunt (in cigarillo)
   2 = joint (in rolling paper)
   3 = pipe / bong
   4 = vaporizer or vap pen

5 = edibles
6 = did not use

9. Did you use any other drugs yesterday without a doctor's order?
   1 = Yes
   2 = No

10. What other drug or drugs did you use yesterday (without a doctor's order)? Type your response. If none, type "none"

11. Did you use more than one drug at the same time (within the same 4-hour period) yesterday?
    1 = Yes: alcohol and tobacco
    2 = Yes: alcohol and marijuana
    3 = Yes: marijuana and tobacco
    4 = Yes: alcohol, marijuana and tobacco
    5 = Yes: a different combination
    6 = No

APPENDIX B. ADDITIONAL RESULTS IN TABLES

Table B.1

Observed Daily- and Person-Level Substance Use Typologies within Race

	NON	AO	TO	MO	A+T	M+A	M+T	M+A+T
Daily (N =458)[a]								
African American	77 (37%)	6 (3%)	5 (2%)	48 (23%)	1 (<1%)	16 (8%)	24 (11%)	8 (4%)
White	151 (54%)	8 (3%)	38 (14%)	53 (19%)	1 (<1%)	1 (<1%)	20 (7%)	1 (<1%)
Total[a]	228	14	43	101	2	17	44	9
Person (N = 35)								
African American	1 (7%)	0 (0%)	0 (0%)	3 (20%)	0 (0%)	3 (20%)	4 (27%)	4 (27%)
White	1 (5%)	2 (10%)	3 (15%)	6 (30%	2 (10%)	2 (10%)	3 (15%)	1 (5%)
Total	2	2	3	9	2	5	7	5

Note. NON = no use; AO = alcohol only; TO = tobacco only; MO = marijuana only; A = alcohol; T = tobacco; M = marijuana. [a] Total does not include 32 missing diaries

Table B.2

Fit Statistics for Aim 1 Model with and without Random Effects

Model	Log likelihood	AIC	BIC
Random Intercept Only	-255.10	540.20	601.87
Random Effect Only	-292.30	614.61	676.28
Random Intercept and Effect	**-237.74**	**513.48**	**591.60**

Note. Models were run without covariates. Bold values indicated best fitting and selected model.

Table B.3

Descriptive Statistics and Normality Test for Aim 2 Outcome Variables

	M	*SD*	Skewness	Kurtosis	Shapiro-Wilk Test	
					W	*p*
Internalizing	16.14	14.80	1.18	.38	**.85**	**<.001**
Externalizing	8.50	3.89	.78	1.04	.95	.138
Substance Problems	9.67	11.83	**2.03**	**4.61**	**.76**	**<.001**

Note. Bolded values are significant or beyond the cutoff for a normal distribution.

Table B.4

Bivariate Correlations between Aim 2 Covariates and Outcome Variables

	1	**2**	**3**[a]	**4**	**5**[a]	**6**	**7**[a]
1. Age		.17	.27	.04	.17	.06	-.01
2. Sex			.17	.25	.22	.16	-.12
3. Parent Education				.12	.14	-.07	.02
4. Race					.30	.17	-.13
5. Internalizing						.39*	.47**
6. Externalizing							.46**
7. Substance Problems							

Note. *$p < .05$, $p < .01$. [a] Indicates nonparametric correlations using Kendall's Tau-b.

Table B.5

Factor Loadings for Latent Substance Typology Factor in Aim 2 Models by Outcome

	Marijuana Only Use[a,b]			Non-Marijuana Use[a]			Non-Use[a]		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Model Outcome									
Internalizing Symptoms	1	-	-	6.30	.86	<.001	4.12	.61	<.001
Externalizing Symptoms	1	-	-	6.20	.83	<.001	3.96	.55	<.001
Substance Problems	1	-	-	6.17	.83	<.001	3.94	.55	<.001

Note. [a] Categories are relative to reference category, concurrent use. [b]Category was constrained to 1 to help identify the latent variable (see Figure 2).

Table B.6

Expected Values and 95% Confident Intervals of Aim 2 Outcomes by Race and Substance Use Typology

	Internalizing Symptoms		Externalizing Symptoms		Substance Use Problems	
	African American	White	African American	White	African American	White
Concurrent Use	4.11 (.19-8.02)	44.68 (-7.99-97.36)	6.82 (4.00-9.64)	17.58 (13.90-21.27)	6.27 (.28-12.27)	143.72 (-51.25-338.70)
Marijuana Only	6.95 (2.93-10.98)	31.75 (8.00-55.48)	7.63 (5.79-9.47)	13.55 (11.29-15.81)	7.11 (3.08-11.13)	36.83 (6.46-67.21)
Non-Marijuana	11.77 (6.09-17.45)	22.55 (12.46-32.64)	8.44 (6.72-10.16)	9.52 (8.17-10.86)	8.05 (4.03-12.07)	9.44 (4.89-13.99)
Non-Use	19.93 (4.46-35.40)	16.02 (7.06-24.99)	9.25 (6.68-11.83)	5.49 (3.58-7.39)	9.12 (1.50-16.73)	2.42 (.72-4.12)

Note. See Figure 4 for graphical representation of these values.

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2018–2019	Director's Travel Award, National Institute on Drug Abuse
2018	Premiere 10 Graduate Student Award, Graduate/Prof. Student Govt, IUPUI
2017–2020	Travel Award, School of Science Graduate Student Council, IUPUI
2017–2018	Student Merit Award, Research Society on Alcoholism
2016–2017	Minority Travel Award, Society for Prevention Research
2015	Early Career Travel Award, Society for Prevention Research
2014–2017	Southern Regional Education Board—State Doctoral Scholars Program Predoctoral Scholar

PEER REVIEWED PUBLICATIONS (alphabetized by year; mentored students underlined)

1. **Banks, D. E.,** Bello, M. S., Crichlow, Q., Leventhal, A. M., Barnes-Najor, J.V., & Zapolski, T. C. B. (2020). Differences in typologies of current substance use among African American and White high-school adolescents: A latent class analysis. *Addictive Behaviors, 106,* 1-7. doi:10.1016/j.addbeh.2020.106356
2. **Banks, D. E.**, Hensel, D. J., & Zapolski, T. C. B. (2020). Integrating individual and contextual factors to explain HIV/STI disparities among heterosexual African American youth: A contemporary literature review and social ecological model. *Archives of Sexual Behavior.* Advance online publication. doi:10.1007/s10508-019-01609-6
3. **Banks, D. E.**, Hershberger, A. R., Pemberton, T., Clifton, R. L., Aalsma, M. C., & Zapolski, T.C.B. (2019). Poly-use of cannabis and other substances among juvenile-justice involved youth: variations in psychological and substance-related problems by typology. *American Journal of Drug and Alcohol Abuse, 45*(3), 313-322. doi:10.1080/00952990.2018.1558450
4. **Banks, D. E.**, Winningham, R. D., Wu, W., & Zapolski, T. C. B. (2019). Examination of the indirect effect of alcohol expectancies on ethnic identity and adolescent drinking outcomes. *American Journal of Orthopsychiatry, 89*(5), 600-608. doi:10.1037/ort0000390

5. Montgomery, L., Zapolski, T. C. B., **Banks, D. E**., & Floyd, A. (2019). Puff, Puff, Drink: The association between blunt and alcohol use among African American adolescents and young adults. *American Journal of Orthopsychiatry*, *89*(5), 609-615. doi:10.1037/ort0000400

6. Winningham, R. D., **Banks, D. E.**, Beutlich, M., & Zapolski, T. C. B. (2019). Substance use disorder and posttraumatic stress disorder symptomology on behavioral outcomes among juvenile justice youth. *American Journal on Addictions, 28*(1), 29-35. doi:10.1111/ajad.12831

7. Zapolski, T. C. B., Clifton, R. L., **Banks, D. E.**, Hershberger, A. R., & Aalsma, M. C. (2019). Family and peer influences on substance attitudes and use among juvenile justice-involved youth. *Journal of Child and Family Studies, 28*(2), 447-456. doi:10.1007/s10826-018-1268-0

8. Zapolski, T. C. B., Yu, T., Barton, A. W., **Banks, D. E.**, & Brody, G. H. (2019). Why now? Examining antecedents for substance use initiation among African American youth from preadolesence to early adulthood. *Development and Psychopathology.* Advance online publication. doi:10.1017/S0954579419000713

9. Zapolski, T. C. B., Rowe, A. T., **Banks, D. E.**, & Faidley, M. T. (2019). Perceived discrimination and substance use: Examining the moderating effect of distress tolerance and negative urgency. *Substance Use and Misuse, 54*(1), 156-165. doi:10.1080/10826084.2018.1512625

10. **Banks, D. E.**, Faidley, M. T., Smith, G. T. & Zapolski, T.C.B. (2018). Racial/ethnic differences in the time-varying association of alcohol expectancies and drinking during the transition from childhood to adolescence. *Journal of Ethnicity in Substance Abuse*. Advance online publication. doi:10.1080/15332640.2018.1520174

11. **Banks, D. E.** & Zapolski, T. C. B. (2018). The crossover effect: A review of racial/ethnic variations in risk for substance use and abuse across development. *Current Addiction Reports, 5*(3), 386-395. doi:10.1007/s40429-018-0220-0

12. Zapolski, T. C. B., **Banks, D. E.**, Lau, K.S., & Aalsma, M. C. (2018). Perceived police injustice, moral disengagement, and aggression among juvenile offenders: Utilizing the general strain theory model. *Child Psychiatry and Human Development, 49*(2), 290-297. doi:10.1007/s10578-017-0750-z

13. **Banks, D. E.**, Rowe, A. T., Mpofu, P., & Zapolski, T.C.B. (2017). Trends in typologies of concurrent alcohol, marijuana and cigarette use among US adolescents: An ecological examination by sex and race/ethnicity. *Drug and Alcohol Dependence, 179,* 71-77. doi:10.1016/j.drugalcdep.2017.06.026
14. **Banks, D. E.** & Zapolski, T. C. B. (2017). Racial differences in the link between alcohol expectancies and adolescent drinking. *Addictive Behaviors, 67,* 34-37. doi:10.1016/j.addbeh.2016.12.005
15. **Banks, D. E.** & Zapolski, T.C.B. (2017). Impulsivity and problem drinking in college: Examining the mediating role of sex-related alcohol expectancies and alcohol use at sex. *Substance Use and Misuse, 52*(8), 992-1002. doi:10.1080/10826084.2016.1268629
16. Zapolski, T. C. B., Baldwin, P., **Banks, D. E.**, & Stump, T. E. (2017). Does a crossover age effect exist for African American and Hispanic binge drinkers? Findings from the 2010-2013 National Study on Drug Use and Health. *Alcoholism: Clinical and Experimental Research, 41*(6), 1129-1136. doi:10.1111/acer.13380
17. Zapolski, T. C. B., Fisher, S., **Banks, D. E.**, Hensel, D. J., & Barnes-Najor, J. V. (2017). Examining the protective effect of ethnic identity on drug attitudes and use among a diverse youth population. *Journal of Youth and Adolescence, 46*(8), 1702-1715. doi:10.1007/s10964-016-0605-0
18. Dir, A. L., **Banks, D. E.**, Zapolski, T. C. B., McIntyre, E., Hulvershorn, L. A. (2016). Negative urgency and emotion regulation predict positive smoking expectancies in non-smoking youth. *Addictive Behaviors, 58,* 47-52. doi:10.1016/j.addbeh.2016.02.014

Submitted Manuscripts

1. **Banks, D. E.**, Clifton, R. L., & Wheeler, P. B. Racial identity, discrimination, and polysubstance use: Examining culturally relevant correlates of substance use profiles among Black young adults.
2. Bernard, D. L., Calhoun, C., Banks, D. E., Halliday-Boykins, C., Hughes-Halbert, C., & Danielson, C. K. Making the "C-ACE" for a culturally informed adverse childhood experiences framework to understand the pervasive impact of racism on Black youth.
3. Clifton, R. L., Rowe, A. T., **Banks, D. E.**, Ashburn-Nardo, L. & Zapolski, T. C. B. Discrepant racial identity: Do discrepancies between implicit and explicit racial identity relate to substance use or psychological distress among black young adults?

4. Crichlow, Q., **Banks, D. E.**, Carson, I., & Zapolski, T. C. B. Racial discrimination substance use among African American youth: Personal and collective self-esteem as mechanisms.

CONFERENCE PRESENTATIONS (mentored students underlined)

Paper and Symposium Presentations

1. **Banks, D. E.,** Bello, M. S., Crichlow, Q., Leventhal, A. M. & Zapolski, T. C. B. (2019, June). Differences in typologies of current substance use among African American and White high-school adolescents: A latent class analysis. In **D. Banks** & A. Haeny (Chairs), *Racial and ethnic health disparities.* Oral communication at the 81st Annual Scientific Meeting of the College on Problems of Drug Dependence, San Antonio, TX.
2. **Banks, D. E.**, & Zapolski, T. C. B. (2018, June). Does racial identity among Black Americans buffer the effect of discrimination on alcohol use? Variations in protective value by identity type. In C. Sartor (Chair), *The development of heavy drinking in African Americans: Understudied risk and protective factors*. Symposium conducted at the 41st Annual Research Society on Alcoholism Scientific Meeting, San Diego, CA.
3. **Banks, D. E.**, Zapolski, T. C. B., & Faidley, M. T. (2017, June). Racial/Ethnic differences in alcohol expectancies and alcohol use from childhood through adolescence. Paper presented at the 25th Annual Meeting of the Society for Prevention Research, Washington, DC.
4. Zapolski, T. C. B., Fisher, S. D., **Banks, D. E.**, Hensel, D. J., & Barnes, J. V. (2017, June). The protective effect of ethnic identity on drug attitudes and use: Does the protective effect exist among all racial/ethnic groups? Paper presented at the 25th Annual Meeting of the Society for Prevention Research, Washington, DC.
5. **Banks, D. E.**, & Zapolski, T. C. B. (2016, June). Integrating impulsivity, expectancies, and drinking to predict risky sex in college: A test of the acquired preparedness model of risk. Paper presented at the 24th Annual Meeting of the Society for Prevention Research, San Francisco, CA.

Poster Presentations

1. **Banks, D. E.**, Halliday-Boykins, C., Adams, Z., Joseph, J., McTeague, L., Hajcak, G.,

Calhoun, C., & Danielson, C. K. (accepted). Developmental differences in the link between racial discrimination and internalizing symptoms among African American youth. Society for Research in Child Development Special Topic Meeting: "Construction of the 'Other': Development, Consequences, and Applied Implications of Prejudice and Discrimination", San Juan, PR.

2. Halliday-Boykins, C., **Banks, D. E.**, Adams, Z., Joseph, J., McTeague, L., Calhoun, C., Hajcak, G.,& Danielson, C. K. (accepted). The effects of racial discrimination on anxiety and depression in African American in the context of interpersonal violence. Society for Research in Child Development Special Topic Meeting: "Construction of the 'Other': Development, Consequences, and Applied Implications of Prejudice and Discrimination", San Juan, PR.
3. Onovbiona, H., Halliday-Boykins, C., **Banks, D. E.**, Adams, Z., Joseph, J., McTeague, L., Calhoun, C., Hajcak, G., & Danielson, C. K. (accepted). Youth perceived racial discrimination and depression: moderating effects of positive parenting and parental involvement. Society for Research in Child Development Special Topic Meeting: "Construction of the 'Other': Development, Consequences, and Applied Implications of Prejudice and Discrimination", San Juan, PR.
4. **Banks, D. E.,** & Zapolski, T. C. B. (2020, June). Feasibility and acceptability of texting adolescents to assess daily alcohol and other substance use: A community-based example comparing Black and White youth. Research Society on Alcoholism, New Orleans, LA. (Conference canceled)
5. **Banks, D. E.**, Clifton, R. L., Wheeler, P. B., & Zapolski, T. C. B. (2020, April). Culturally relevant correlates of polysubstance use among Black young adults. Collaborative Perspectives on Addiction Conference, San Diego, CA. (Conference canceled)
6. Rowe, A. T., Zapolski, T. C. B., **Banks, D. E.**, & Faidley, M. T. (2019, June). Perceived discrimination and substance use among adolescents: Examining the moderating effect of distress tolerance and negative urgency. College on Problems of Drug Dependence, San Antonio, TX.
7. Crichlow, Q., **Banks, D. E.**, & Zapolski, T. C. B. (2018, November) The indirect effect of personal and collective self-esteem on racial discrimination and substance use among African American youth. Indiana Psychological Association, Indianapolis, IN.

8. **Banks, D. E.**, & Zapolski, T. C. B. (2018, June). Differential associations of marijuana typologies with psychological problems and substance abuse among juvenile detainees. College on Problems of Drug Dependence, San Diego, CA.
9. Zapolski, T. C. B., Yu, T., Brody, G., **Banks, D. E.**, & Barton, A. (2018, June). Why now? Examining antecedents for substance use initiation among African American adolescents. College on Problems of Drug Dependence, San Diego, CA.
10. Pemberton, T. A., **Banks, D. E.**, & Zapolski, T. C. B. (2017, November). The moderating effect of relationship status on hazardous alcohol use and risky sexual behavior among college students. Indiana Psychological Association, Indianapolis, IN.
11. Clifton, R. L., Carson, I., **Banks, D. E.,** Hershberger, A., Aalsma, M. C., & Zapolski, T. C. B. (2017, November). Family and peer influence on substance use among juvenile justice involved youth. Indiana Psychological Association, Indianapolis, IN.
12. **Banks, D. E.**, Rowe, A. T., Mpofu, P., & Zapolski, T. C. B. (2017, June). Typologies of alcohol, marijuana, and cigarette use among US adolescents: Variations by gender and race/ethnicity. Research Society on Alcoholism, Denver, CO.
13. **Banks, D. E.**, & Zapolski, T. C. B. (2016, June). Positive alcohol expectancies predict alcohol use among European American but not African American adolescents. Research Society on Alcoholism, New Orleans, LA.
14. **Banks, D. E.**, & Zapolski, T. C. B. (2016, June). Select dimensions of impulsivity and problem drinking among college students: The mediating role of sex-related alcohol expectancies and drinking before sex. Society for Prevention Research, San Francisco, CA.
15. **Banks, D. E.**, Zapolski, T. C. B., Dir, A. L., McIntyre, E., & Hulvershorn, L. A. (2015, May). Negative urgency and emotion regulation predict positive smoking expectancies in youth. Society for Prevention Research, Washington D.C.

INVITED PRESENTATIONS

1. **Banks, D. E.** (2020, March). Addressing health disparities in substance use and other risk behavior: Cultural and methodological considerations. Invited presentation delivered to the Department of Psychology, University of Kentucky.
2. **Banks, D. E.** (2019, November). Substance use health disparities: Cultural and

methodological considerations for improving risk/resilience models. Invited presentation delivered to the Department of Psychology, University of Missouri—St. Louis.

UNIVERSITY TEACHING

Courses Taught

2017-2018 Health Psychology, Department of Psychology, IUPUI
Average evaluation: 5.62/6.00

Courses Assisted

2017 Statistics, Department of Psychology, IUPUI

2017 Life Span Development, Department of Psychology, IUPUI

2016 Abnormal Psychology, Department of Psychology, IUPUI

2016 Introduction to Psychology, Department of Psychology, IUPUI

Mentorship

2018 Co-Mentor, Queenisha Crichlow, Post-Baccalaureate Research Education Program, IUPUI

PROFESSIONAL SERVICE

National

2019 Session Chair, College on Problems of Drug Dependence

2017–Present Ad Hoc Reviewer

Annals of Epidemiology, Drug and Alcohol Dependence, Journal of Ethnicity in Substance Abuse, Journal of Health Communication, Psychology of Addictive Behaviors, Personality and Individual Differences, Substance Use and Misuse, Women's Health Issues

2015 Abstract Review Committee, Society for Prevention Research

Campus

2018–2019 Student Liaison with Clinical Faculty, Department of Psychology, IUPUI

2018 Member, Student Selection Committee**,** Department of Psychology, IUPUI

2018 Member, Search Committee, Clinical Study Technician, Department of Psychology, IUPUI

2018 Peer Mentor, Department of Psychology, IUPUI

Community

2015–2016 Respite Volunteer, Easter Seals Crossroads Disability Services, Indianapolis, IN

CAMPUS & COMMUNITY PRESENTATIONS

1. Patel, J. S., & **Banks, D. E.** (2019, March). Burnout & self-care. Invited presentation delivered to the Department of Psychology, IUPUI.
2. **Banks, D. E.** (2017, November). Conscious vs. subconscious identity. Invited presentation delivered to high school students at Psychology Day, IUPUI
3. **Banks, D. E.** (2017, October). Graduate School Admissions "Prep." Invited presentation delivered to Psi Chi & Psychology Club, IUPUI.
4. Patel, J. S., **Banks, D. E.**, Miller, M. M., & Yu, Y. (2017, April). Health psychology perspectives. Invited presentation delivered during Mental Health Awareness Week, Department of Psychology, IUPUI.
5. Patel, J. S., **Banks, D. E.**, & Chinh, K. (2017, March). Health psychology meets neuroscience: The mind-body connection. Invited panelist at Brain Awareness Week, Department of Psychology, IUPUI

PROFESSIONAL MEMBERSHIPS

College on Problems of Drug Dependence

Research Society on Alcoholism

Society for a Science of Clinical Psychology

Society of Addiction Psychology (APA Div. 50)

Society for Research in Child Development