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Reciprocal links between marijuana use and school adjustment in Black and White rural adolescents

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Abstract

Although research has established that school adjustment is associated with marijuana use (MU) in adolescence, few studies have tested these associations bidirectionally. Using random intercepts cross-lagged panel modeling, this study examined reciprocal associations between MU and school adjustment across 8th to 10th grade, including the transition to high school. Participants included 5470 rural adolescents (59% White, 41% Black) aged 12–17 years in 2002–2005. School adjustment factors predicted subsequent MU (i.e., higher self-reported grades were protective for Black and White youth; valuing education was protective for Black youth; school behavior problems predicted increased MU across the transition to high school for White youth). MU had several adverse effects on school adjustment, particularly during the transition to high school.

Adolescence is often marked by school adjustment difficulties, including decreases in school engagement and academic achievement (Witherspoon & Ennett, 2011). For some youth, adolescence is also a time of initiating the use of marijuana and other substances. Using marijuana and disengaging from school are co-occurring risk factors for a number of concerning and costly outcomes in late adolescence and young adulthood, including school dropout, delinquent behavior, and other substance use (Wang & Fredricks, 2014). A wealth of literature shows that school adjustment factors such as school engagement and grades are linked with marijuana use (MU; Bryant Ludden & Eccles, 2007; Ellickson et al., 2004). However, only a handful of studies have tested reciprocal associations between school adjustment factors and MU or other substance use in adolescence, including one study with urban African American youth (Zimmerman & Schmeelk-Cone, 2003), one study with primarily White rural youth (Henry, 2010), and two studies with diverse samples (Meisel & Colder, 2017; Wang & Fredricks, 2014). These few studies have tended to rely on cross-lagged panel models, which have received criticism for failing to disaggregate within- and between-person effects, which can bias estimates (Hamaker et al., 2015). Given

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

the methodological limitations of existing literature, the extent to which school adjustment factors precede and predict MU, and vice versa, is not well understood.

In the interest of promoting educational outcomes and preventing MU, a better understanding is needed of how they are associated. In the current study, we leveraged advances in developmental methods to test within-person reciprocal associations between MU and multiple school adjustment factors (i.e., grades, school behavior problems, school belonging, and valuing education) from 8th to 10th grade, across the transition to high school. The focus of this study is on Black and White rural youth, who are at unique risk for experiencing harmful consequences of substance use and who have lower educational persistence relative to their urban and suburban counterparts on average (Byun et al., 2012; Lambert et al., 2008). Diverse rural youth are also underrepresented in research, despite the fact that nearly one in five U.S. public school students attends a rural school (Irvin et al., 2012; Showalter et al., 2019).

Developmental sequencing of school adjustment and MU in adolescence

Theoretical and conceptual frameworks

School adjustment is conceptualized in this study as having aspects of school engagement and achievement. School engagement is a multidimensional construct consisting of behavioral, emotional, and cognitive components (Fredricks et al., 2004). Behavioral engagement includes compliance with school rules and participation in school tasks. Emotional engagement comprises school belonging (i.e., attachment to school) and valuing education (i.e., appreciation of academic tasks or educational attainment; Fredricks et al., 2004). Cognitive engagement is often conceptualized as self-regulated learning strategies and effort directed toward learning (Fredricks et al., 2004). We focused on behavioral and emotional engagement factors, which may have stronger associations with MU than cognitive engagement (Bryant Ludden & Eccles, 2007; Wang & Fredricks, 2014). Specifically, we examined school behavior problems (an indicator of low behavioral engagement), school belonging, and valuing education (components of emotional engagement). We also examined grades, an indicator of achievement that closely reflects engagement, and which serve as a source of feedback for youth about their academic achievement (Fredricks et al., 2004; Skinner & Pitzer, 2012).

The associations between school adjustment factors and MU may stem from processes that begin before adolescence (Bachman et al., 2012). Once youth reach adolescence, however, the question arises of the degree to which MU impacts school adjustment and vice versa (Bachman et al., 2012; Zimmerman & Schmeelk-Cone, 2003). The self-system model, based in self-determination theory (Deci & Ryan, 1985), is a motivational theory that has been applied to the study of school engagement and disengagement processes. The self-system model asserts that school engagement not only reflects motivation, but also plays a key part in the motivational system (Skinner et al., 2009). The extent to which youth are behaviorally and emotionally engaged promotes learning and achievement, as well as intrapersonal resources (e.g., competence, autonomy, relatedness) and interpersonal resources (e.g., supportive interactions with teachers and peers) that facilitate further school engagement (Skinner & Pitzer, 2012). High levels of engagement and achievement then

create a motivational context in which youth develop the capacity to cope with challenges and bounce back from setbacks (Skinner & Pitzer, 2012). In contrast, difficulties engaging in school may lead youth to turn to problem behaviors, which in turn can increase alienation from school, resulting in further disengagement (Skinner & Pitzer, 2012; Skinner et al., 2009). The processes of school engagement and disengagement therefore create motivational feedback loops that are self-amplifying (Skinner & Pitzer, 2012), suggesting that the associations among school adjustment and MU are reciprocal.

The effects of school adjustment and MU on one another may not be uniform over time. Based on a life course perspective, development can be understood in terms of "multiple, interlocking trajectories" across different domains (Elder, 1998, p. 19). Transitions in these interlocking domains can shape developmental pathways (Graber & Brooks-Gunn, 1996). One such transition is the transition from middle school to high school. Transitioning to high school is a normative experience for adolescents in the U.S. public school system, but adolescents may experience difficulty if their developmental needs are mismatched to the opportunities and obstacles presented by the social environment (Eccles et al., 1993). Although much of the research on the transition from middle school to high school has focused on youth in urban areas, rural youth likely face many of the same challenges during this transition, including increased academic demands, the introduction of academic tracking, opportunities for peer groups to reorganize, and increased availability of substances (Benner & Graham, 2009; Warren et al., 2015). The structural and social changes that youth experience during the transition to high school may accentuate the links between MU and school adjustment. To explore this possibility, we tested whether associations varied across 8th to 10th grade, including the transition to high school.

School adjustment and MU among Black and White youth

Youth's experience of school and schooling transitions are shaped by fit with environment and by social position variables like race (Eccles et al., 1993). Black youth are disproportionately represented in school disciplinary actions, are significantly more likely to perceive unfair treatment by teachers than White youth, and may be subject to race-based harassment by peers (Ruck & Wortley, 2002; U.S. Department of Education Office for Civil Rights, 2018). Research shows that experiences of racial discrimination and school racial unfairness are linked with more school disciplinary outcomes and lower grades for Black youth (Griffin et al., 2020; Neblett, 2006). Black youth's school adjustment may be more influenced by these contextual school-based factors and therefore may be less predictive of MU compared to White youth. Although few studies have examined the links between school adjustment and MU by race, one study indeed showed that school belonging was a stronger predictor of MU for White youth than Black youth in middle school and high school in rural areas (Shears et al., 2006). Further, Wallace and Muroff (2002) found that indicators of behavioral and emotional school engagement were more strongly correlated with substance use cross-sectionally (particularly cigarette and alcohol use, as well as MU) for White youth than Black youth.

In addition to differences in schooling experiences, the consequences of MU may also vary for Black and White youth. Rates of MU are similar among Black and White youth in

early- to mid-adolescence (Evans-Polce et al., 2015), but Black youth are at greater risk of experiencing disciplinary and legal involvement as a result of MU. A Black person is nearly four times as likely to be arrested for marijuana possession than a White person, and this disparity extends across urban and rural areas (Bunting et al., 2013). Black youth may also perceive greater consequences of MU in the school setting. Compared to their White counterparts, Black adolescents report that the consequences at school would be more severe if a student were caught smoking (Wallace & Muroff, 2002). Black adolescents also report greater perceived peer disapproval of MU than White adolescents (Lee et al., 2021). If Black youth experience greater social consequences of MU in the school setting (e.g., greater teacher or peer disapproval), MU could have more deleterious effects on school adjustment for Black youth, but the existing research on these associations are limited. We conducted multiple group analyses to test whether the links between school adjustment factors and MU differed for Black and White youth.

Links between school adjustment and MU: A review of the literature

Based on Fredricks et al.'s (2004) conceptualization of school engagement, the current study examined associations between MU and multiple school adjustment factors: grades, school behavior problems, school belonging, and valuing education. A multidimensional conceptualization of school adjustment is ideal for the purposes of this study, as each dimension has varying patterns of associations with MU for White and Black youth in previous research.

Grades

Studies have shown that higher grades are associated with less MU in nationally representative samples (Bachman et al., 2012; Bryant et al., 2003) and in White rural youth (Henry et al., 2006). Longitudinal evidence of the reverse effect (i.e., MU predicting grades) in adolescence is more limited, but studies with predominantly White samples of youth show that earlier initiation of MU (Ellickson et al., 2004) and MU occurring alongside other behavior problems (Ansary & Luthar, 2009) predict lower grades. Longitudinal evidence for Black youth is limited and inconclusive. Estell et al. (2007) found that rural Black youth with profiles characterized by high grades in middle school generally had lower likelihood of substance use in 9th grade. Conversely, a study of predominantly Black urban youth found that grades were not associated with growth in MU from 10th to 12th grade (Bryant & Zimmerman, 2002). These discrepant findings for Black youth could be due to differences across the transition to high school (Estell et al., 2007) versus later in high school (Bryant & Zimmerman, 2002), emphasizing the importance of considering the role of the transition.

School behavior problems

Consistent with models of externalizing behavior, MU and other problem behaviors are often closely tied (Bachman et al., 2012). Evidence suggests that school behavior problems predict MU, with less longitudinal evidence for the reverse effect. In national samples, more school behavior problems in 8th grade predict increasing MU throughout adolescence (Bryant et al., 2003), and being suspended or expelled by 8th grade also predicts greater MU (Bachman et al., 2012). One study provides very limited support for this link in Black rural

youth: aggression in 8th grade predicted higher likelihood of substance use in 9th grade only for the small group of youth whose grades and popularity increased in middle school (Estell et al., 2007).

School belonging

Literature on school belonging and MU has focused on predominantly White samples of youth, showing that greater school belonging is linked with lower likelihood of MU (Bond et al., 2007; Shears et al., 2006) and less substance use longitudinally (Meisel & Colder, 2017). One exception is Bryant et al. (2003), who found that school bonding in 8th grade was not associated with change in MU during adolescence in a national sample. Research on school belonging and MU is limited for Black youth, but one cross-sectional study showed that school belonging was a stronger predictor of MU in White rural youth than Black rural youth (Shears et al., 2006).

Valuing education

Empirical findings on valuing education and MU are inconsistent, potentially due to differences in the conceptualization of valuing education and differences in samples. Some studies have conceptualized valuing education as youth's valuing of schoolwork and school tasks. Other studies have conceptualized valuing education as the extent to which youth consider education personally important for future success, which is a construct related to educational aspirations and expectations (Witherspoon & Ennett, 2011). For urban Black youth, greater valuing of schoolwork predicted less MU, but MU did not predict valuing schoolwork (which the authors labeled "school motivation"; Zimmerman & Schmeelk-Cone, 2003). National U.S. studies found that MU had no association with educational expectations (Bryant et al., 2003; Messersmith & Schulenberg, 2008), but one study showed that early initiation of MU predicted lower educational expectations in a sample of mostly White youth (Ellickson et al., 2004).

Schooling experiences and MU among rural youth

While there is considerable variability in rural youth's experiences, many rural youth face challenges associated with poverty (Irvin et al., 2012). Many of the challenges faced by residents of economically strained urban areas (i.e. lack of access to resources, limited educational and occupational opportunities) are equally relevant in rural areas (Witherspoon & Ennett, 2011). Rural youth may have more limited educational opportunities and curricula than their non-rural counterparts, as rural schools are less likely to offer advanced placement courses and may have difficulty retaining qualified teachers (Irvin et al., 2012). Ultimately, rural students are less likely to enroll in postsecondary education and less likely to attain a bachelor's degree than their urban and suburban counterparts (Byun et al., 2012). On the other hand, a potential strength of rural schools, for some students, is that smaller school sizes may foster a sense of belonging and greater chance to participate in activities (Byun et al., 2012; Witherspoon & Ennett, 2011).

Although the prevalence of adolescent MU is similar across rural and urban settings (Lambert et al., 2008), rural adolescents are at unique risk for harmful consequences of

substance use. Rural adolescents are more likely than their urban counterparts to engage in high-risk behaviors such as driving under the influence of substances (Lambert et al., 2008). Rural youth are also more likely to have unmet healthcare needs than urban youth (DeVoe et al., 2009). More than half of rural adolescents who felt they needed substance use treatment in the past year did not receive it (Elliott & Larson, 2004). Despite these unmet needs, diverse rural youth are underrepresented in research (Witherspoon & Ennett, 2011). The current study aims to advance knowledge about school adjustment and MU for Black and White youth in living in rural areas.

Current study

A vast body of literature shows that positive school adjustment has protective effects against MU (Bachman et al., 2012; Bryant et al., 2003; Zimmerman & Schmeelk-Cone, 2003), while a slightly smaller but still sizeable pool of studies shows that MU has adverse effects on school adjustment in adolescence (Ansary & Luthar, 2009; Bachman et al., 2012). However, the developmental sequencing of school adjustment and MU in adolescence is unclear, in large part due to methodological limitations of existing literature. Notably, the few studies that have tested reciprocal associations among school adjustment factors and MU (or any substance use) have primarily relied on cross-lagged panel models, which have received criticisms for the implicit assumption that all individuals vary over time around the same mean (Hamaker et al., 2015).

To test reciprocal associations among school adjustment and MU, we used the random intercepts cross-lagged panel model (RI-CLPM), which accounts for state- or trait-like stability of constructs, thereby disaggregating within- and between-person variance components (Hamaker et al., 2015). Within- and between-person associations carry different interpretations, as illustrated with this example by Dietvorst and colleagues (2018): adolescents who keep more secrets report *more* privacy invasion by their parents (i.e., a between-person association), but during periods where adolescents keep more secrets, they perceive their parents as *less* privacy invasive (i.e., a within-person association). Although not all cases are in such opposition, disaggregating within- and between-person effects is necessary to yield parameter estimates that are interpretable and unbiased (Hamaker et al., 2015). Developmental theories are fundamentally concerned with intraindividual or within-person variability—stability and change, continuity and discontinuity—but there has been a mismatch between developmental theories and the statistical models used to test them (Berry & Willoughby, 2017). Due to the methodological shortcomings of the existing literature, the developmental sequencing of school adjustment and MU is unclear.

In addition to questions about the directionality of effects, the limitations of existing literature give rise to questions about the timing of effects between MU and school adjustment. In particular, the transition from middle school to high school presents a host of stressors and opportunities that may serve to magnify the effects among school adjustment and MU. We explored whether associations between MU and school adjustment factors varied over time from 8th to 10th grade, including the transition to high school, in Black and White rural youth. Because the educational experiences of Black and White youth may differ, and because the consequences of MU may also differ by race, we conducted multiple

group analyses to examine whether the links between school adjustment and MU differed for Black and White youth.

Based on theoretical considerations and existing literature, we hypothesized that school adjustment and MU would be inversely and reciprocally associated over time. Specifically, we hypothesized that higher grades, more school belonging, and higher valuing education would each predict lower MU and vice versa, while more school behavior problems would predict more MU and vice versa. We hypothesized stronger associations around the transition to high school than at other times. Based on previous research showing that school adjustment factors had stronger links with substance use for White youth than Black youth (Shears et al., 2006; Wallace & Muroff, 2002), we expected stronger associations for White youth. However, given that consequences of MU could be greater for Black youth, we considered that the within-person paths from MU to school adjustment factors could be stronger for Black youth.

METHOD

Study overview and procedures

Data were drawn from the Context of Adolescent Substance Use study, a study of adolescent development and risk behavior (Ennett et al., 2008). The study included youth enrolled in public school systems in three predominantly rural counties in North Carolina. These counties had higher rates of high school dropout and a higher proportion of African American population than the U.S. overall. The largest towns or cities in these counties had populations ranging from approximately 8700 to 16,000 residents. All schools in these counties with grades 6–12 were included, which included a total of eight middle schools, two K-8 schools, six high schools, and three alternative schools. An accelerated longitudinal design was utilized, with a total of seven waves of data collection occurring each semester across three and a half years. Three cohorts of youth entered the study in spring 2002 when they were in 6th, 7th, or 8th grade and completed the study in fall 2005 when they were in 10th, 11th, or 12th grade respectively. The current study utilized adolescent survey data spanning fall of 8th grade to fall of 10th grade, which includes the transition to high school (beginning in 9th grade in the current study counties).

Data were collected with self-administered questionnaires at school in classrooms or group settings (e.g., cafeteria). Data collection occurred on at least two occasions for each wave at each school to limit the effect of absenteeism on response rates. Adolescents completed the questionnaires in approximately 1 h and returned them to trained data collectors in envelopes. At each assessment, all students enrolled in the target grade levels were eligible to participate, except for those in self-contained classrooms for exceptional children and those with insufficient English language proficiency to complete the questionnaire. As all eligible students were invited to participate, new participants were enrolled in the study at each wave. Of eligible students, 88% participated at Wave 1 (N = 5220), 81% at Wave 2 (N = 5060), 81% at Wave 3 (N = 5059), 79.1% at Wave 4 (N = 5017), 76% at Wave 5 (N = 4676), 69% at Wave 6 (N = 2775), and 65% at Wave 7 (N = 2406). Protocols were approved by the institutional review board of the University of North Carolina at Chapel Hill. The board approved a waiver of written parental consent. Parents were informed about the study

with a letter that was mailed as well as sent home with the adolescent. Parents could refuse their child's participation by returning a postage-paid form or by calling a toll-free number. Trained data collectors obtained written adolescent assent at the time of data collection.

Analytic sample

Of the total number of unique cases (N = 7174), selection of the current study sample began with the youth who participated between the fall 8th grade and the fall of 10th grade (N = 6449, 89.9%). Youth were included if they identified as White (N = 3244) or Black/African American (N = 2274), as youth of other racial/ethnic groups were too few for the current analyses (Latinx: N = 237; other race or ethnicity: N = 419). The majority of youth who repeated 8th, 9th, or 10th grade (n = 363, 6.6%) were included. However, because grade level determined the passage of time in the current analyses, a small subset of youth were excluded (n = 48, 0.9%) because it could not be determined which grade they repeated due to missing data.

The final sample included N = 5470 youth (59.1% White, 40.9% Black). Participant demographic information appears in Table 1. Half the sample identified as female (50.3%). The average age at fall of 8th grade was 13.66 years (SD = .65). The median level of parents' highest education was some postsecondary education. Parents' education was higher for White youth than Black youth on average ($\chi^2[1] = 144.67$, $p < .001$), with 26.1% of Black youth and 41.6% of White youth having a parent whose highest education was at least a college degree. A greater proportion of White youth (77.7%) lived in a two-parent household than Black youth (49.8%; $\chi^2[1] = 446.84$, $p < .001$). By 8th grade, a greater proportion of Black youth (27.6%) reported ever having repeated a grade than White youth (12.6%; $\chi^2[1] = 183.03$, $p < .001$). Youth in the current analytic sample participated at five waves (n = 522, 9.5%), four waves (n = 1845, 33.7%), three waves (n = 1037, 19%), two waves (n = 1354, 24.8%), or one wave (n = 712, 13%). Compared to youth who participated at all five waves, youth who participated in fewer waves were older ($t[5356] = -4.16$, $p < .001$), more likely to be Black ($\chi^2[1] = 7.34$, $p < .01$), more likely to be male ($\chi^2[1] = 6.84$, $p < .01$), and more likely to report having repeated a grade by the time they reached 8th grade ($\chi^2[1] = 6.37$, $p < .05$).

Measures

Marijuana use—Marijuana use was assessed with the item, "During the past 3 months, about how many times have you used marijuana?" rated on a five-point scale (0 = none, 1 = 1–2 times, 2 = 3–5 times, 3 = 6–9 times, 4 = 10 times or more). Frequency is a commonly assessed dimension of MU and has shown longitudinal associations with school adjustment factors (Bryant et al., 2003). Previous research suggests that adolescents are more forthcoming about substance use information in self-administered questionnaires compared to interviewer-administered questionnaires, and in school-based questionnaires compared to home-based questionnaires, likely to due to reduced concerns about privacy and confidentiality (Brener et al., 2003).

Grades—Youth reported their grades in math, English/language arts, science, and history/social studies for the most recent marking period (0 = D or lower, 1 = C, 2 = B, 3 = A).

Youth could respond that they had not taken the subject, which was considered missing. Grades were averaged across subjects. The internal consistency of self-reported grades items was good, with Cronbach's alpha ranging from .76 to .88 across measurement occasions. Previous research suggests that the correlations between self-reported grades and actual grades are relatively high, particularly for the core subjects assessed in this study, and self-reported grades generally predict academic outcomes as well as actual grades (Kuncel et al., 2005).

School behavior problems—Five items from the Problem Behavior Frequency Scale (Farrell et al., 2000) were averaged to assess school behavior problems in the past 3 months, consistent with previous research (Witherspoon & Ennett, 2011). Youth were presented with the prompt, "During the past 3 months, about how many times have you …" followed by items such as "cheated on a test," "skipped school," and "threatened to hurt a teacher." Youth rated items on a five-point scale ranging from "none" to "10 times or more." Internal consistency of school behavior problems items was good, with Cronbach's alpha ranging from .75 to .83. Previous research has shown high test—retest reliability of adolescents' self-reported behavior problems (Brener et al., 2002).

School belonging—School belonging was assessed with three items from a scale measuring students' sense of school as a community (Battistich & Hom, 1997), consistent with previous research (Witherspoon & Ennett, 2011). Youth rated statements such as "My school is like a family" on a five-point scale ranging from "strongly disagree" to "strongly agree." Items were averaged, with higher values indicating higher school belonging. Internal consistency of school belonging items was good, with Cronbach's alpha ranging from .83 to .87 across measurement occasions. The scale has shown negative correlations with substance use, victimization at school, and behavior problems in previous research (Battistich & Hom, 1997).

Valuing education—Youth's valuing of education was assessed with two items about how personally important or unimportant "finishing high school" and "going to college" were for the youth. Items were rated on a four-point Likert scale ranging from "not at all important" to "very important." Items were averaged, with higher values indicating greater valuing of education, consistent with previous research (Witherspoon & Ennett, 2011). Pearson's r for the two valuing education items ranged from .56 to .65 across measurement occasions.

Covariates—Youth reported their sex assigned at birth (0 = female, 1 = male); their birthdate, which was used to calculate age; their household structure (1 = two-parent household, 0 = other structure); and the highest level of education attained by parents (0 = less than high school, 1 = high school, 2 = some postsecondary education, 3 = college degree, 4 = graduate school). Youth reported alcohol use in the past 3 months on a six-point frequency scale ranging from "0 days" to "20 days or more." Youth reported whether they had ever repeated a grade by 8th grade (0 = no, 1 = yes). Study cohort was also included as a covariate.

Data analysis

Data from three study cohorts were merged by semester and grade in school, resulting in five discrete time points at 6-month intervals (fall 8th grade, spring 8th grade, fall 9th grade, spring 9th grade, and fall 10th grade). For youth who repeated 8th grade, the current analysis began with the second 8th grade year, followed by the subsequent time points. For youth who repeated 9th grade, the analysis incorporated the fall of their second 9th grade year immediately following the spring of their first 9th grade year (i.e., where fall of 10th grade would otherwise be). For youth who repeated 10th grade, the second 10th grade year was not included because it was outside the two-year span of the current analysis. Analyses were conducted in Mplus version 8 (Muthén & Muthén, 2012). Nonnormality of univariate distributions were handled using maximum likelihood estimation with robust Hubert-White standard errors, which are robust against heteroskedasticity and violations of distributional assumptions (Yuan & Bentler, 2002). Missing data were handled using full information maximum likelihood, which is recommend for handling wave nonresponse in longitudinal studies (Schafer & Graham, 2002). Approximately 13% of data were planned missing due to the cohort sequential design (as shown in the surveying schedule in Table S3). The total proportion of missing data was 36.36%.

Model building and evaluation—Hypotheses were tested using multiple group RI-CLPM (Hamaker et al., 2015), using an iterative approach and selecting the most parsimonious model at each step. Figures S1–S3 depict the model building process at each step. Univariate models were first estimated for each construct in the entire sample, with indicators at each measurement occasion regressed onto a random slope with loadings set to 1 (as in Figure S1). The autoregressive paths ($t_{n-1} \rightarrow t_n$) were tested for equality across time (Hamaker et al., 2015). If allowing autoregressive paths to vary did not improve model fit, they were constrained across time in subsequent models. After establishing the univariate models, a panel model was estimated in the entire sample, with random intercepts of all constructs allowed to covary (as in Figure S2). Covariances among time-specific residuals for each pair of constructs were tested for equality over time and were constrained if allowing them to vary did not improve model fit. Cross-lagged paths were then added to the model, including paths from each construct to all other constructs at the following time (as in Figure S3). To test the exploratory hypothesis that associations may vary during the transition to high school, cross-lagged paths were tested for equality, starting with the paths from each school adjustment indicator to subsequent MU, then the paths from MU to subsequent school adjustment indicators, and finally the paths from school adjustment indicators to subsequent school adjustment indicators. If parameters did not vary across time in the configural models (i.e., in the entire sample), then they were constrained across time in the subsequent multiple group models.

After determining whether parameters varied over time in the configural models, a parallel series of multiple group models evaluated whether parameters varied for White youth and Black youth. In the univariate models, autoregressive paths were tested for equality by race and were constrained across groups in subsequent models if allowing them to vary did not improve fit. In the panel model with all constructs, covariances among the time-specific residuals were tested for equality and constrained across groups if allowing them to vary did

not improve fit. To evaluate whether prospective associations varied by race, cross-lagged paths were then tested for equality across groups in the same order that they were tested for equality across time. Covariances among the random intercepts were also tested for equality across groups. In the final multiple group RI-CLPM, covariates were included as predictors of the random intercepts. Because MU and all school adjustment factors were incorporated in the same model, analyses also controlled for the time-varying effects of school adjustment factors.

Likelihood ratio tests were used to evaluate nested models at each step. A scaled chi-square difference test was used to determine improvement in fit (Yuan & Bentler, 2002). When testing for equality of parameters over time, an alpha of $p<.10$ was selected as the indicator of significantly improved fit because each likelihood ratio test assessed differences across five measurement occasions (i.e., four parameters). A smaller alpha would have increased the likelihood of constraining multiple parameters to be equal even if one varied from the others. When testing for equality of parameters between Black youth and White youth, an alpha of $p<.05$ was selected as the indicator of significantly improved fit, as multiple group model tests were utilized to test moderation hypotheses, in which we compared the magnitude of either a single estimate (i.e., when a set of parameters were held equal over time) or four estimates (i.e., when a set of parameters was allowed to vary over time) between groups. Model fit was evaluated using comparative fit index (CFI) and root mean square error of approximation (RMSEA), with values of CFI > .95 and RMSEA <.06 indicating good fit (Hu & Bentler, 1999). Unstandardized estimates were reported because standardized estimates for parameters with equality constraints are not computed as a single value.

Interpretation of RI-CLPM—RI-CLPM accounts for trait-like stability of constructs by including a random intercept factor for each construct (Hamaker et al., 2015), which parses between-person and within-person variance components. In the RI-CLPM, the variances and covariances of the random intercepts represent the between-person level. Hypothetically, a negative covariance of the random intercept of MU with the random intercept of grades would be interpreted that youth with higher MU (relative to their peers) also have lower grades (relative to their peers). At the within-person level, the structured residuals represent an individual's time-specific deviation from their expected score (Hamaker et al., 2015). The autoregressive effects ($t_{n-1} \rightarrow t_n$) can therefore be interpreted as the amount of within-person carry over from one time to the next (Hamaker et al., 2015). A hypothetical cross-lagged path from MU to grades can be interpreted as the extent to which a deviation from one's own expected MU score predicts a subsequent deviation from one's expected grades score, controlling for the preceding deviations of the expected scores.

RESULTS

Descriptive statistics

Table 2 displays measure descriptive statistics at each wave, including ranges, means and standard deviations, and mean differences by race. Examination of mean differences shows that average MU was lower among White youth at earlier times but did not differ from Black

youth's MU at later time points. Average grades were higher for White youth at all time points. School behavior problems did not differ at most times, but Black youth had lower average school behavior problems in fall of 10th grade. School belonging was higher among White youth at all times on average. Valuing education was higher among Black youth at most times on average. Bivariate correlations are available for the entire sample in Table S1 and by race in Table S2.

Univariate random intercept models

The estimates for the multiple group univariate models are shown in Table 3.

Marijuana use—The overall fit of the MU model was good (RMSEA = .02, CFI = .99). The autoregressive paths varied across time and by race, such that the autoregressive paths were stronger at later time points for White youth than for Black youth.

Grades—The grades model had good fit to the data (RMSEA <.01, CFI = 1.00). The autoregressive paths varied over time, such that all paths were significant except during the transition to high school, from spring of 8th grade to fall of 9th grade. Autoregressive paths did not vary between Black and White youth.

School behavior problems—The school behavior problems model had good overall fit (RMSEA = .01, CFI = .98). The autoregressive paths did not vary over time or by race.

School belonging—The overall fit of the school belonging model was good (RMSEA = .02, CFI = .99). The autoregressive paths varied over time, such that all paths were significant except during the transition to high school, from spring of 8th grade to fall of 9th grade. Autoregressive paths did not vary by race.

Valuing education—The valuing education model had good fit (RMSEA = .02, CFI = .96). The autoregressive paths varied over time, such that the only significant path was following the transition to high school, from fall of 9th grade to spring of 9th grade. The autoregressive paths did not vary between Black and White youth.

Multiple group RI-CLPM results

Table 4 shows associations between MU and school adjustment factors from the final multiple group RI-CLPM, which had good overall fit (RMSEA = .01, CFI = .97). Results are displayed in Figure 1. Associations of covariates are shown in supplemental Table S4.

Grades and MU—The cross-lagged paths from grades to MU did not vary over time or by race. Higher grades predicted less MU the following semester ($B = -.08$, $SE = .03$, $p < .01$). The magnitude of this effect can be interpreted such that a one-point increase in grades was associated with a decrease of .08 in MU frequency. In the reverse direction, the effects of MU on grades varied over time (scaled $\chi^2[3] = 10.84$, $p < .05$) but not by race. More MU predicted lower grades during the transition to high school, from spring of 8th grade to fall of 9th grade ($B = -.09$, $SE = .03$, $p < .01$) and fall of 9th grade to spring of 9th grade ($B = -.06$, $SE = .02$, $p < .01$).

School behavior problems and MU—The paths from school behavior problems to MU varied over time (scaled $\chi^2[3] = 7.38$, $p < .10$) and by race (scaled $\chi^2[4] = 15.23$, $p < .01$). For White youth, more school behavior problems predicted more MU across the transition to high school from spring of 8th grade to fall of 9th grade ($B = .27$, $SE = .11$, $p < .01$), such that a one-point increase in the school behavior problems frequency scale was associated with an increase of .27 in MU frequency. School behavior problems did not predict MU for Black youth. Regarding the effects of MU on school behavior problems, the paths varied over time (scaled $\chi^2[3] = 7.74$, $p < .10$) but not by race. More MU was associated with more school behavior problems following the transition to high school, from fall of 9th grade to spring of 9th grade ($B = .16$, $SE = .03$, $p < .001$), but not at other times.

School belonging and MU—The cross-lagged paths from school belonging to MU did not vary over time or by race, and school belonging did not predict subsequent MU. In the reverse direction, the effects of MU on school belonging did not vary over time or by race. MU predicted lower school belonging at each measurement occasion ($B = -.04$, $SE = .02$, $p < .05$).

Valuing education and MU—The paths from valuing education to MU did not vary over time but did vary by race (scaled $\chi^2[1] = 1069.15$, $p < .001$). Valuing education predicted less MU at all subsequent times for Black youth ($B = -.35$, $SE = .12$, $p < .01$) but not for White youth. The cross-lagged paths from MU to valuing education varied over time (scaled $\chi^2[3] = 11.47$, $p < .01$) but not by race. Valuing education predicted less MU following the transition to high school, from fall of 9th grade to spring of 9th grade ($B = -.09$, $SE = .03$, $p < .001$), but not at other times.

DISCUSSION

The current study elucidates the links between school adjustment and MU for Black and White rural youth across 8th to 10th grade, including the transition to high school. This is one of only a handful of studies investigating reciprocal associations between school adjustment and MU (or any substance use) in adolescence and is the first study to do so using developmental methods to examine within-person associations. Results showed that school adjustment factors were predictive of MU: grades were protective against MU for Black and White youth across time; valuing education was protective against MU for Black youth across time; and school behavior problems predicted increased MU across the transition to high school for White youth. MU also had several harmful effects on school adjustment: MU predicted decreased grades during and after the transition to high school, increased school behavior problems following the transition, decreased valuing education following the transition, and decreased school belonging across time for Black and White youth.

Study findings generally support the self-system model, which posits that school engagement is a reciprocal process, such that high engagement and achievement can create a motivational context which promotes resilience and protects against problem behaviors (Skinner & Pitzer, 2012). Conversely, disengagement from school can place youth at further risk for alienation from school, affiliation with disengaged peers, and involvement in risky

behaviors. Although some of the associations between school adjustment factors and MU spanned across 8th to 10th grade, some of the associations were limited to the transition from middle school to high school. These transition effects can be understood in terms of a life course perspective (Elder, 1998), which suggests that important life transitions can impact "interlocking trajectories," across developmental domains.

Nearly all the effects of MU on school adjustment factors were concentrated around the transition to high school. These findings pinpoint the transition to high school as a turning point, during which youth may be more susceptible to the harmful effects of MU for a variety of reasons. When youth engage in more frequent MU before the transition to high school, they may be placed in lower academic tracks or may be less prepared to navigate the novel demands of high school, which could contribute to lower emotional and behavioral engagement. Also, as entry to high school presents opportunity for reorganization of peer groups (Benner & Graham, 2007), youth who engage in MU before and during the transition may select more deviant peer groups whose interests are less conducive to school engagement and achievement.

Based on previous research showing stronger associations between school adjustment factors and MU for White youth than Black youth, we conducted multiple group analyses by race. Two differences emerged in the prediction of MU. School behavior problems predicted increased MU across the transition to high school for White youth but not Black youth, whereas valuing education was protective against MU for Black youth but not White youth. The effects of MU on school adjustment did not vary by race. Overall, results show that the links between school adjustment and MU are more similar for Black and White rural youth than they are different, with each school adjustment factor showing a unique pattern of associations with MU.

Grades and MU

Results showed that higher grades had small but persistent effects on reduced MU for Black and White youth, which is consistent with hypotheses and previous research with national samples (Bachman et al., 2012; Bryant et al., 2003). Achievement serves as feedback about academic functioning, so high grades may be protective against MU for Black youth and White youth alike by bolstering academic self-efficacy and academic identity, as well as by reinforcing youth's investment of time and energy in school. Regarding the effects of MU on grades, MU predicted decreased grades for Black and White youth, but only around the transition to high school (i.e., spring of 8th grade to fall of 9th grade and fall of 9th grade to spring of 9th grade). These findings advance the limited literature on the effects of MU on grades by identifying the transition to high school as a period in which grades are more subject to detrimental effects of MU. When youth use marijuana before and during the transition, they may find themselves less prepared to meet increased academic demands, resulting in lower grades.

School behavior problems and MU

Findings showed that school behavior problems and MU were not closely tied, except during the transition to high school. School behavior problems predicted increased MU

only across the transition to high school and only for White youth. Entering high school likely presents greater availability of marijuana (Warren et al., 2015), so White youth with behavior problems at the end of middle school may be more inclined to experiment with MU in high school if the opportunity becomes available. A previous study of diverse youth (53% White, 37% Black) showed that behavior problems were associated with substance use via higher social status and social integration in early adolescence (Hussong et al., 2020). School behavior problems in 8th grade may therefore create more opportunities for White youth to use marijuana upon entering high school.

The fact that school behavior problems did not predict MU for Black youth suggests that these social processes may operate differently for Black and White youth. Peers have been shown to play a larger role in White youth's substance use than Black youth's (Rowan, 2016), so school behavior problems in early adolescence may not be as likely to lead to MU via peer affiliations for Black youth. Moreover, school behavior problems can be precipitated by factors such as harsh discipline and perceptions of unfair treatment, which Black youth are more likely to experience (Gregory & Weinstein, 2008). If Black youth exhibit behavior problems at school, the behaviors may be in response to these school-based stressors and more specific to the school setting, meaning they may be less indicative of a pattern of general behavior problems and less likely to lead to MU.

In terms of the reverse association, MU in fall of 9th grade predicted increased school behavior problems in spring of 9th grade for Black and White youth alike, which adds to limited existing research on the role of MU in later school behavior problems. The effect of MU on increased school behavior problems following the transition to high school could reflect peer effects, as youth who use marijuana may befriend new peer groups in high school that influence increased involvement in school behavior problems. Additionally, this effect could be indicative of coping with a difficult transition to high school. If youth use marijuana to cope with adjustment challenges during fall of 9th grade, they may also exhibit low behavioral engagement or low-level behavior problems, which could escalate to more elevated school behavior problems later in the year.

School belonging and MU

School belonging did not predict MU at any time for Black or White youth, contrary to previous research (Bond et al., 2007; Shears et al., 2006). This discrepancy with previous findings may be because the current study utilized a method that accounted for trait-like stability in these constructs, whereas previous studies did not. Additionally, the links between school belonging and MU may be moderated by other factors, such as social integration. Low school belonging could reflect affiliation with marijuana-using peers, or alternatively, low school belonging could reflect low involvement with peers altogether (Bond et al., 2007).

In the other direction, MU was associated with small decreases in school belonging across 8th to 10th grade for Black and White youth. Previous qualitative research has revealed that youth often report feeling highly visible in rural communities, and that news or gossip about risky behavior would spreadly quickly because people know one another (Haugen & Villa, 2006). Given limited existing empirical work focusing on the role of MU in school

belonging, it is unclear the extent to which the rural context of the current sample plays a role in this finding, but it is possible that small school settings in rural areas may magnify the stigmatization and social consequences of MU, resulting in lower school belonging in the current study.

Valuing education and MU

Valuing education predicted less MU across time for Black youth but not White youth. These findings for Black youth are consistent with limited existing work showing that greater valuing of schoolwork predicted less MU for urban Black adolescents (Zimmerman & Schmeelk-Cone, 2003). In the present study, valuing education was conceptualized as viewing future educational attainment as personally important. Believing that education is a key to future success may help youth separate their current schooling experiences from their long-term educational goals, which could be especially important for Black youth given the potential for marginalization and discrimination within the school setting (Griffin et al., 2020; U.S. Department of Education Office for Civil Rights, 2018). A potentially invalidating schooling environment may make MU more desirable or rewarding for youth who have low valuing of education for longer-term goals. However, Black youth often value education intrinsically and for the opportunities it can provide (Witherspoon & Ennett, 2011), which can enhance motivation to refrain from behaviors that could compromise future success.

Results also showed that MU was linked with lower valuing education following the transition to high school for Black and White youth alike. This finding pinpoints the transition to high school as a sensitive period for the effect of MU on valuing education. The timing of this association may reflect peer effects, as valuing of education could decrease when youth are introduced to marijuana-using peers in high school. Previous research has shown that peers' valuing education predicted rural youth's valuing education over and above their own prior valuing education (Hamm et al., 2011). It is also possible that using more marijuana during fall of 9th grade may be indicative of experiencing a difficult transition to high school. If youth use marijuana as part of a pattern of avoidant coping during a challenging school transition, they may also lower their valuation of school or distance themselves from educational goals.

Limitations and future directions

Despite the strengths of the current study, it is not without limitations. Measures of grades and school behavior problems were self-reported by youth, as alternative sources of information (i.e., school reports) were not available. However, measures were obtained via self-administered questionnaires in the school, which are thought to mitigate social desirability biases (Brener et al., 2003). Another limitation is that school characteristics were not assessed. Future research should examine whether the associations found in the current study are impacted by school composition and teacher characteristics, as well as factors that may help mitigate challenges of the transition (e.g., positive school climate, school racial fairness, teacher support).

As with all studies, the external validity of the current study is limited. The extent to which these findings generalize to youth in urban areas is unclear. It is possible that the links of school adjustment with MU may be different in urban areas, where greater availability of marijuana (Warren et al., 2015) may make experimentation with MU more likely, even when youth have high school engagement and achievement. Schooling transitions may also operate differently based on rurality. On one hand, schooling transitions may be more challenging for some youth in urban areas, where school sizes tend to be larger, such that youth receive less individual support and attention. On the other hand, schooling transitions can help interrupt peer dynamics that are conducive to bullying (Farmer et al., 2011), so youth in urban areas may have more opportunities to find a niche peer group with similar prosocial interests, which could mitigate the harmful effects of MU during the transition to high school.

Findings may also differ based on youth's identification with rurality or with their rural community. Place and identity are often intertwined for rural residents (Hektner, 1995). Rural communities tend to have strong ties, with residents often expressing a desire or expectation to continue living in a rural area (Byun et al., 2012). Pursuing postsecondary education often requires leaving rural communities, and youth may feel conflicted about postsecondary education if they expect to remain close to their community. Hektner (1995) found that rural youth, compared to their urban and suburban counterparts, were more likely to have conflicting desires of remaining close to friends and family versus leaving the area after high school, which was associated with greater pessimism about the future. Future research should investigate whether school adjustment factors operate differently based on youth's ties to their rural community. Valuing education be less protective against MU if youth feel that educational pursuits are in opposition to their rural identity or their desire to remain close to family and friends.

Crucial directions for future research include testing the mechanisms implicated in the current findings, including peers and identity. Peers play an important role in adolescents' school adjustment and substance use (Hamm et al., 2011). Identity exploration is particularly salient in middle adolescence (French et al., 2006), which coincides with the transition to high school. Academic and ethnic-racial identity may be influenced by processes that take place across this transition, such as academic tracking (Legette, 2018) and selection of peer groups.

Implications and conclusions

The current study contributes to knowledge about the links between school adjustment and MU in adolescence. Because this study contributes new knowledge regarding the timing of effects, the findings must be replicated and underlying mechanisms investigated in future research. Nonetheless, the findings have implications for the timing of prevention efforts. Results showed that MU had greater impacts on school adjustment factors around the transition from middle school to high school than at other times, which suggests that middle school is a critical time to prevent the harmful effects of MU from spilling into academic domains. In further support of this timing, a meta-analysis found that school-based substance use prevention programs delivered during middle school years had

larger intervention effects than programs targeting elementary or high school age youth (Gottfredson & Wilson, 2003).

Additionally, the bidirectionality of effects among MU and school adjustment has implications for the types of interventions that may best address these interlocking domains. Social and emotional learning interventions aim to provide youth with intrapersonal and interpersonal skills (e.g., problem solving, emotion regulation and coping strategies) that can be applied specifically or toward a broad range of domains (Domitrovich et al., 2017). These social and emotional competencies can serve to protect against the development of MU and help youth overcome challenges in school and schooling transitions (Taylor et al., 2017).

Overall, findings underscore the importance of preventing MU, which could ameliorate adjustment difficulties, particularly as adolescents transition from middle school to high school. This may be particularly important in rural areas, as adolescents who could benefit from mental health or substance use treatment are less likely to receive these services in rural areas for a number of reasons, including stigma associated with seeking treatment and difficulty maintaining confidentiality in a small-town clinic (DeVoe et al., 2009; Elliott & Larson, 2004). Findings also emphasize the importance of promoting school engagement for diverse youth early and often. Fostering school engagement could deescalate the development of behavior problems, including MU, and promote educational persistence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

CFI	comparative fit index
MU	marijuana use
RI-CLPM	random intercepts cross-lagged panel model
RMSEA	root mean square error of approximation

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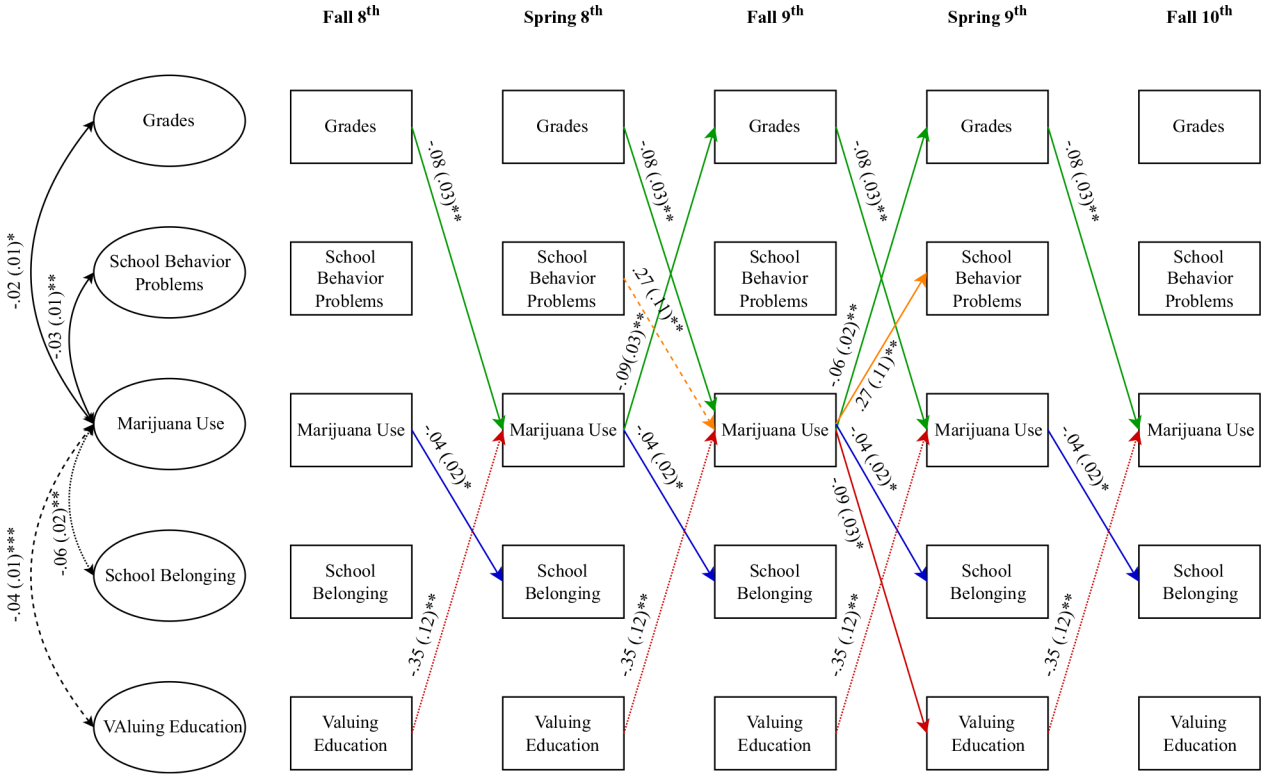

FIGURE 1.

Associations between marijuana use and school adjustment factors. *Note*: Solid lines represent associations in the entire sample; dotted lines represent associations for Black youth only; dashed lines represent associations for White youth only. Cross-lagged paths among school adjustment factors are not depicted. ***$p < .001$, **$p < .01$, *$p < .05$.

TABLE 1

Participant demographic information

	Black youth (*N* = 2274)	**White youth (*N* = 3244)**	
	M (SD)	***M (SD)***	**Wald χ^2**
Age in fall 8th grade	13.82 (.75)	13.55 (.53)	204.23***
	***n* (%)**	***n* (%)**	
Sex			1.75
Female	1129 (51.4%)	1575 (49.5%)	
Male	1066 (48.6%)	1605 (50.5%)	
Parents' highest education			144.67***
Less than high school	188 (9.7%)	237 (7.9%)	
High school degree or equivalent	629 (32.4%)	656 (21.7%)	
Some postsecondary education but less than 4-year college degree	616 (31.8%)	869 (28.8%)	
College degree	411 (21.2%)	857 (28.4%)	
Graduate school	95 (4.9%)	400 (13.2%)	
Household structure			446.84***
Two-parent household	1079 (49.8%)	2486 (77.7%)	
Other household structure	1087 (50.2%)	713 (22.3%)	
Repeated a grade by eighth grade			183.03***
Yes	474 (27.6%)	326 (12.6%)	
No	1243 (72.4%)	2252 (87.4%)	

*** $p < .001$.

TABLE 2

Measure descriptive statistics at each measurement occasion by race

Variable name and measurement occasion	Possible range	*M (SD)* Black youth (*N* = 2274)	*M (SD)* White youth (*N* = 3244)	Wald χ^2
Marijuana use	0–4			
Fall 8th		0.42 (1.00)	0.22 (0.63)	21 95***
Spring 8th		0.46 (1.04)	0.30 (0.79)	23.61***
Fall 9th		0.60 (1.21)	0.48 (1.15)	7.75**
Spring 9th		0.73 (1.29)	0.60 (1.25)	3.42
Fall 10th		0.66 (1.26)	0.62 (1.29)	0.49
Grades	0–3			
Fall 8th		1.63 (0.83)	2.05 (0.81)	139.98***
Spring 8th		1.56 (0.79)	2.04 (0.81)	346.74***
Fall 9th		1.48 (0.82)	1.94 (0.86)	232.82***
Spring 9th		1.54 (0.76)	1.99 (0.82)	115.00***
Fall 10th		1.56 (0.81)	1.96 (0.87)	139.13***
School behavior problems	0–4			
Fall 8th		0.32 (0.51)	0.22 (0.47)	3.50
Spring 8th		0.30 (0.55)	0.30 (0.53)	2.44
Fall 9th		0.36 (0.60)	0.35 (0.61)	0.18
Spring 9th		0.44 (0.65)	0.48 (0.76)	0.96
Fall 10th		0.37 (0.57)	0.43 (0.66)	5.03*
School belonging	0–4			
Fall 8th		1.23 (1.16)	1.42 (1.10)	11.71***
Spring 8th		1.21 (1.13)	1.35 (1.10)	14.13***
Fall 9th		1.24 (1.17)	1.35 (1.10)	7.75**
Spring 9th		1.17 (1.14)	1.31 (1.10)	4.13*

Variable name and measurement occasion	Possible range	*M (SD)* Black youth (N = 2274)	*M (SD)* White youth (N = 3244)	Wald χ^2
Fall 10th		1.19 (1.14)	1.30 (1.12)	5.05*
Valuing education	0–3			
Fall 8th		2.84 (0.42)	2.83 (0.46)	0.53
Spring 8th		2.84 (0.42)	2.80 (0.51)	4.086*
Fall 9th		2.82 (0.44)	2.78 (0.51)	4.083*
Spring 9th		2.80 (0.52)	2.72 (0.59)	5.89*
Fall 10th		2.84 (0.44)	2.77 (0.51)	5.57*

* $p < .05$

** $p < .01$

*** $p < .001$.

TABLE 3

Multiple group univariate random intercept models

	Model characteristic	**Marijuana use**	**Grades**	**School behavior problems**	**School belonging**	**Valuing education**
Group	**Model fit**	**RMSEA = .02, CFI = .99**	**RMSEA<.01, CFI =1.00**	**RMSEA = .01, CFI = .98**	**RMSEA = .02, CFI = .99**	**RMSEA = .02, CFI = .96**
Black youth	Intercept variance	*σ*	*σ*	*σ*	*σ*	*σ*
		.60***	.27***	.09***	.43***	.09***
	Autoregressive paths	*B (SE)*	*B (SE)*	*B (SE)*	*B (SE)*	*B (SE)*
	Fall 8th — Spring 8th	*.29 (.14)**	.32 (.03)***	.24 (.05)***	.21 (.03)***	.17 (.11)
	Spring 8th → Fall 9th	*.28 (.12)**	.08 (.04)	.24 (.05)***	.06 (.04)	.17 (.10)
	Fall 9th → Spring 9th	*.47 (.08)****	.12 (.04)***	.24 (.05)***	.17 (.04)***	.45 (.10)***
	Spring 9th → Fall 10th	*.34 (.07)****	.16 (.05)***	.24 (.05)***	.20 (.04)***	.13 (.06)*
White youth	Intercept variance	*σ*	*σ*	*σ*	*σ*	*σ*
		*.38****	*.38****	*.09****	*.57****	*.12****
	Autoregressive paths	*B (SE)*	*B (SE)*	*B (SE)*	*B (SE)*	*B (SE)*
	Fall 8th → Spring 8th	*.13 (.24)*	.32 (.03)***	.24 (.05)***	.21 (.03)***	.17 (.11)
	Spring 8th → Fall 9th	*.57 (.11)****	.08 (.04)	.24 (.05)***	.06 (.04)	.17 (.10)
	Fall 9th → Spring 9th	*.64 (.05)****	.12 (.04)***	.24 (.05)***	.17 (.04)***	.45 (.10)***
	Spring 9th → Fall 10th	*.52 (.05)****	.16 (.05)***	.24 (.05)***	.20 (.04)***	.13 (.06)*

Note: Italicized estimates were allowed to vary across groups. Non-italicized estimates were held equal across groups.

Abbreviations: CFI, comparative fit index; RMSEA, root mean square error of approximation.

* $p < .05$

*** $p < 001$.

TABLE 4

Multiple group random intercepts cross-lagged panel model results: associations between marijuana use (MU) and school adjustment factors (SCHOOL)

		Grades	School behavior problems	School belonging	Valuing education
Group	**Model parameter**	***B (SE)***	***B (SE)***	***B (SE)***	***B (SE)***
Black youth	Covariance of random intercepts				
	Intercept (MU) → Intercept (SCHOOL)	−.02 (.01)*	.03 (.01)*	*−.06 (.02)***	*.01 (.02)*
	Covariance of time-specific residuals				
	Spring 8th (MU) → Spring 8th (SCHOOL)	−.05 (.01)***	.11 (.02)***	−.05 (.01)***	−.05 (.01)***
	Fall 9th (MU) → Fall 9th (SCHOOL)	−.05 (.01)***	.19 (.02)***	−.05 (.01)***	−.06 (.02)***
	Spring 9th (MU) → Spring 9th (SCHOOL)	−.05 (.01)***	.26 (.03)***	−.05 (.01)***	−.11 (.02)***
	Fall 10th (MU → Fall 10th (SCHOOL)	−.05 (.01)***	.18 (.03)***	−.05 (.01)***	−.05 (.02)**
	Cross-lagged paths: SCHOOL → MU				
	Fall 8th (SCHOOL) → Spring 8th (MU)	−.08 (.03)**	*.10 (.16)*	−.01 (.02)	*−.35 (.12)***
	Spring 8th (SCHOOL) → Fall 9th (MU)	−.08 (.03)**	*−.04 (.11)*	−.01 (.02)	*−.35 (.12)***
	Fall 9th (SCHOOL) → Spring 9th (MU)	−.08 (.03)**	*.27 (.15)*	−.01 (.02)	*−.35 (.12)***
	Spring 9th (SCHOOL) → Fall 10th (MU)	−.08 (.03)**	*.18 (.13)*	−.01 (.02)	*−.35 (.12)***
	Cross-lagged paths: MU → SCHOOL				
	Fall 8th (MU) → Spring 8th (SCHOOL)	.02 (.04)	.05 (.04)	−.04 (.02)*	−.02 (.04)
	Spring 8th (MU) → Fall 9th (SCHOOL)	−.09 (.03)**	.07 (.04)	−.04 (.02)*	−.03 (.03)
	Fall 9th (MU) → Spring 9th (SCHOOL)	−.06 (.02)**	.16 (.03)***	−.04 (.02)*	−.09 (.03)***
	Spring 9th (MU) → Fall 10th (SCHOOL)	.01 (.02)	.05 (.03)	−.04 (.02)*	−.01 (.02)
White youth	Covariance of random intercepts				
	Intercept (MU) → Intercept (SCHOOL)	−.02 (.01)*	.03 (.01)*	*−.01 (.01)*	*−.04 (.01)****
	Covariance of time-specific residuals				
	Spring 8th (MU) → Spring 8th (SCHOOL)	−.05 (.01)***	.11 (.02)***	−.05 (.01)***	−.05 (.01)***
	Fall 9th (MU) → Fall 9th (SCHOOL)	−.05 (.01)***	.19 (.02)***	−.05 (.01)***	−.05 (.02)***
	Spring 9th (MU) → Spring 9th (SCHOOL)	−.05 (.01)***	.26 (.03)***	−.05 (.01)***	−.11 (.02)***

Group	Model parameter	Grades	School behavior problems	School belonging	Valuing education
		B (SE)	***B (SE)***	***B (SE)***	***B (SE)***
	Fall 10th (MU) → Fall 10th (SCHOOL)	−.05 (.01)***	.18 (.03)***	−.05 (.01)***	−.05 (.02)**
	Cross-lagged paths: SCHOOL → MU				
	Fall 8th (SCHOOL) → Spring 8th (MU)	−.08 (.03)**	*.17 (.15)*	−.01 (.02)	*.08 (.08)*
	Spring 8th (SCHOOL) → Fall 9th (MU)	−.08 (.03)**	*.27 (.11)***	−.01 (.02)	*.08 (.08)*
	Fall 9th (SCHOOL) → Spring 9th (MU)	−.08 (.03)**	*−.03 (.08)*	−.01 (.02)	*.08 (.08)*
	Spring 9th (SCHOOL) → Fall 10th (MU)	−.08 (.03)**	*−.20 (.11)*	−.01 (.02)	*.08 (.08)*
	Cross-lagged paths: MU → SCHOOL				
	Fall 8th (MU) → Spring 8th (SCHOOL)	.02 (.04)	.05 (.04)	−.04 (.02)*	−.02 (.04)
	Spring 8th (MU) → Fall 9th (SCHOOL)	−.09 (.03)**	.07 (.04)	−.04 (.02)*	−.03 (.03)
	Fall 9th (MU) → Spring 9th (SCHOOL)	−.06 (.02)**	.16 (.03)***	−.04 (.02)*	−.09 (.03)***
	Spring 9th (MU) → Fall 10th (SCHOOL)	.01 (.02)	.05 (.03)	−.04 (.02)*	−.01 (.02)

Note: Italicized estimates were allowed to vary across groups. Non-italicized estimates were held equal across groups.

* $p < .05$

** $p < .01$

*** $p < .001$.