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Adolescent Substance Use Outcomes in the Raising Healthy Children Project: A Two-Part Latent Growth Curve Analysis

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Work on this article was supported by National Institute on Drug Abuse Grant R01-DA08093. We gratefully acknowledge the assistance provided by Bengt Muthén and helpful comments by C. Hendricks Brown and members of the Prevention Science Methodology Group (Designs and Analyses for Mental Health Preventive Trials, R01-MH40859). Additionally, we thank the staff, families, and students of the participating schools in Edmonds School District #15 for their support and cooperation.

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Abstract

Raising Healthy Children (RHC) is a preventive intervention designed to promote positive youth development by targeting developmentally appropriate risk and protective factors. This study tested the efficacy of the RHC intervention on reducing adolescent alcohol, marijuana, and cigarette use. Ten public schools, comprising 959 1st- and 2nd-grade students (54% male, 18% minority, 28% low SES), were matched and assigned randomly to either intervention or control conditions. A two-part latent growth modeling strategy was employed to examine change in both use-vs.-nonuse and frequency-of-use outcomes while students were in 6th- through 10th-grades. Results indicated significant ($p < .05$) intervention effects in growth trajectories for frequency of alcohol and marijuana use but not for use vs. nonuse. These findings provide support for preventive interventions that take a social development perspective in targeting empirically supported risk and protective factors and demonstrate the utility of two-part models in adolescent substance use research.

Adolescent Substance Use Outcomes in the Raising Healthy Children Project: A Two-Part Latent Growth Analysis

Public health research suggests that reducing risks and enhancing promotive and protective factors are promising strategies for the prevention of substance abuse and other related problems (Coie et al., 1993; Mrazek & Haggerty, 1994; Stouthamer-Loeber, Loeber, Wei, Farrington, & Wikstroem, 2002). Risk factors are conditions in the individual or environment that predict greater likelihood of developing a problem such as substance abuse. Research has shown that multiple risk factors in the individual, family, and environment predict early adolescent substance use, which is itself a strong predictor of later substance abuse (Hawkins et al., 1997; Pedersen & Skrondal, 1998). Examples of risk factors for early substance use include: being male (Hops, Davis, & Lewin, 1999), antisocial behavior (Ellickson, Tucker, Klein, & McGuigan, 2001), low commitment to school (Williams, Ayers, Abbott, Hawkins, & Catalano, 1999), and associating with substance-using peers (Griffin, Botvin, Scheier, & Nichols, 2002), among others (for a review see Hawkins, Catalano, & Miller, 1992).

In addition to risk factors, researchers have identified promotive factors that counterbalance the effects of risk as well as protective factors that moderate the effects of risk (for the remainder of this article, we will include promotive factors as part of the term *protective factors*). Examples of protective factors include: affiliation with prosocial peers (Spoth, Redmond, Hockaday, & Yoo, 1996), parental supervision and support (Marshal & Chassin, 2000), and psychosocial composite indices of protection (Jessor, Van Den Bos, Vanderryn, Costa, & Turbin, 1995). Many risk and protective factors for early substance use also are factors for other problem behaviors including delinquency, school dropout, and teen pregnancy (Howell, Krisberg, Hawkins, & Wilson, 1995).

Only a few adolescent interventions that address multiple risk and protective factors at appropriate developmental periods have been tested. Most interventions have been brief (e.g., Kellam, Rebok, Ialongo, & Mayer, 1994; Spoth, Redmond, & Shin, 2001), have addressed a narrow range of risk and protective factors (e.g., Botvin & Griffin, 2002; Eddy, Reid, & Fetrow, 2000), or have focused on a single social domain (e.g., Ellickson, Bell, & Harrison, 1993). Two projects, the Fast Track project (Conduct Problems Prevention Research Group, 1992) and the Seattle Social Development Project (SSDP; Hawkins, Catalano, Kosterman, Abbott, & Hill, 1999) addressed a broad range of developmentally salient risk and protective factors in school, family, peer, and individual domains. These interventions targeted risk and protective factors in early childhood in order to prevent initiation and escalation of problem behaviors in adolescence. To date, these *social development* interventions have demonstrated positive effects in reducing substance use, violent behavior, conduct problems, and risky sexual behavior, as well as improving academic performance, commitment to school, and social cognitive skills (Catalano et al., 2003; Conduct Problems Prevention Research Group, 2002; Lonczak, Abbott, Hawkins, Kosterman, & Catalano, 2002).

This study examines the efficacy of the Raising Healthy Children (RHC) project. Modeled after SSDP, RHC is a comprehensive, multicomponent preventive intervention designed to promote positive youth development by targeting developmentally appropriate risk and protective factors. However, unlike SSDP, the intervention extended beyond the elementary-school period to include universal and selective components in middle and high school years. As a theory-based intervention, RHC is guided by the social development model (SDM; Catalano & Hawkins, 1996; Hawkins & Weis, 1985), which integrates empirically supported aspects of social control (Hirschi, 1969), social learning (Bandura, 1973), and differential association theories (Matsueda, 1988) into a framework for strengthening prosocial bonds and beliefs. Within this framework, the SDM emphasizes that prevention should (a) begin before the formation of antisocial beliefs and behaviors; (b) recognize the importance of individual and family characteristics as well as larger social contexts of community, school, and peer influences; and (c) identify and address the changing needs of its target population with regard to risk and protective factors that change in influence during the course of development. Specifically, the SDM organizes risk and protective factors into a causal model that explicates the mechanisms leading toward antisocial behavior. These mechanisms are specified as a sequence of mediated effects influenced by both prosocial and antisocial processes.

Following the SDM, four distinct points of intervention were targeted by RHC: (a) opportunities for involvement with prosocial others (e.g., family, teachers, and nonsubstance-using peers); (b) students' academic, cognitive, and social skills; (c) positive reinforcements and rewards for prosocial involvement; and (d) healthy beliefs and clear standards regarding substance use avoidance. According to theory underlying the intervention, increased opportunities for prosocial involvement, coupled with both positive reinforcements for that involvement and better skills on the part of the student, are theorized to lead to stronger bonds to prosocial others. Once strong bonds are established, individuals will tend to behave in a manner consistent with the norms and values of the individuals and groups with whom they associate. In turn, stronger prosocial bonds support positive belief formation against antisocial behaviors (e.g., adolescent substance use).

As the primary domains of social influence during elementary school years are theorized within the SDM to be the family and school, RHC intervention components during this period focused on these domains. Evaluation of early intervention effects found that teachers reported less disruptive and aggressive behavior and stronger effort on school work for intervention students compared to controls (Catalano et al., 2003). As students approach adolescence, peer influences become more important and bonds to family and school may become strained (Hawkins, Guo, Hill, Battin-Pearson, & Abbott, 2001). Preventive interventions that target norms and teach skills for resisting negative social influences during this period have been shown to be effective in reducing substance use (e.g., Griffin et al., 2002; Hansen & Graham, 1991). Thus, the constellation of intervention components within RHC gradually shifted from early risk and protective factors in the social domains of school and family (e.g., academic performance, bonding, and parental monitoring) toward individual- and peer-related risk and protective factors (e.g., refusal skills, healthy beliefs, and associations with substance-using peers).

A social development perspective to intervention also suggests that the goals of the intervention need to be flexible, as well. Whereas preventive interventions for early-adolescent substance use often center around abstinence themes, once adolescents begin to use substances, messages related to the prevention of escalating or problematic substance use become increasingly important. Furthermore, recent data have shown that some degree of experimentation with substances is normative (e.g., Johnston, O'Malley, & Bachman, 2003). Noting this, an increasing number of researchers have suggested that a concomitant goal of prevention should be the reduction in the amount of use (quantity or frequency) among users (e.g., Maggs & Schulenberg, 1998; McBride, Midford, Farringdon, & Phillips, 2000). As the prevalence of substance use increases typically during adolescence, a corresponding increase in the frequency of use is likely. Thus, social development approaches to the prevention of substance use address risk and protective factors not only for initial and experimental use, but for heavy or problematic use as well.

The purpose of this study was to test the efficacy of the RHC intervention on rates of substance use during early to middle adolescence. As a social development intervention, RHC was designed to be flexible in addressing both the developmental needs and the particular goals of its target population of students and their families. Whereas a primary aim of RHC was to deter students from using illicit substances in earlier developmental periods, increasing emphasis also was placed on avoiding escalation of use. In light of this, this study addressed two related questions: First, has the intervention been efficacious in reducing students' likelihood to use alcohol, marijuana, or cigarettes? And second, has the intervention been efficacious in altering the frequency at which students use alcohol, marijuana, or cigarettes?

Method

Participants

Participants consisted of a longitudinal panel of 1st- and 2nd-grade students originally enrolled in 1 of 10 public elementary schools in a suburban school district north of Seattle, Washington (substance use outcomes were assessed when these students were in 6th through 10th grades). The school district consisted of five different municipalities and surrounding areas with fairly high standards of living and others that were primarily working class, and ranks as the third largest in the State. Of the 25 elementary schools in the district, the 10 schools that ranked the highest on aggregate measures of risk (e.g., low income status, low standardized achievement test scores, high absenteeism, high mobility) were selected into the study. Schools were matched on these risk factors and one school from each matched pair was assigned randomly to either an intervention (n = 5) or control (n = 5) condition. Families of 1st- and 2nd-grade students from within these schools were recruited into the longitudinal study. To be included in the RHC sample, students had to remain in their school throughout the entire first year of their participation in the study and have a parent who spoke English, Spanish, Korean, or Vietnamese. In Year 1, 938 parents of 1,239 eligible students provided written consent to participate in the study. In Year 2, the sample was augmented with an additional 102 students from a second eligible pool of 131 students who newly entered 1 of the 10 schools during 2nd grade, thus yielding a total sample of 1,040 students. For the analysis sample, 77 students were excluded due to having missing data for all substance use outcome measures during Grades 6 through 10. Inspection of casewise patterns of self-reported substance use indicated questionable validity for an additional four students who reported maximal levels of substance use for almost all types of substances during all measurement occasions, prompting their exclusion from the analysis. Due to the small percentage (5%) of siblings in the sample, siblings were not excluded from the analysis. These criteria resulted in a final sample of 959 students (92% of the total sample) for analysis. Fifty-four percent of the analysis sample was male, 82% was European American, 7% was Asian/Pacific Islander, 4% was African American, 4% was Hispanic, and 3% was Native American. Mean age of students at the beginning of the study was 7.7 years (*SD* = 0.6), selected from both 1st- (52%) and 2nd-grade (48%) classrooms. Twenty-eight percent of the sample was from low-income households, defined as having received AFDC, TANF, food stamps, or free/reduced lunch programs during the first two years of the project.

Intervention Implementation, Fidelity, and Exposure

RHC consisted of prevention strategies that addressed risk and protective factors in four key domains (see Catalano et al., 2003; and Haggerty, Catalano, Harachi, & Abbott, 1998 for details). *School intervention strategies* consisted of a series of teacher and staff development workshops that included proactive classroom management techniques, cooperative learning methods, and strategies to promote student motivation, participation, reading, and interpersonal and problem-solving skills. Workshops were conducted with teachers in intervention schools while students were in elementary grades and in the first year of middle school. Additionally, one-on-one classroom-based coaching sessions with teachers were conducted monthly throughout the school year to monitor and enhance fidelity of school intervention strategies. After the first year of the project, teachers participated in monthly "booster" sessions to further reinforce RHC school intervention strategies. Teachers also were provided a substitute teacher for a half-day so they could observe other project teachers using RHC teaching strategies in their classrooms. School intervention strategies were designed to enhance students' learning, interpersonal, and problem-solving skills, and increase their academic performance and bonding to school.

Individual *student intervention strategies* consisted of volunteer student participation in after-school tutoring sessions and study clubs during Grades 4 to 6 and individualized booster sessions and group-based workshops during middle and high school years. These strategies were designed to (a) improve academic achievement, (b) increase students' bonding to school, (c) teach refusal skills, and (d) develop prosocial beliefs regarding healthy behaviors. Additionally, through classroom instruction and annual summer camps during elementary school, and social skills booster retreats in middle school, RHC provided universal *peer intervention strategies* for students to learn and practice social, emotional, and problem-solving skills in the classroom and other social situations.

Family intervention strategies consisted of multiple-session parenting workshops (e.g., "Raising Healthy Children," "How to Help Your Child Succeed in School," and "Preparing for the Drug Free Years") and in-home services for selected families. Family intervention strategies were delivered to families in group and individual sessions during Grades 1 through 8. Parents of intervention students were invited and encouraged to attend the school-wide workshops offered at the school. During high school, booster sessions were delivered through in-home visits where both parents and students completed assessments covering specific developmental risk areas (e.g., transition to high school, peer influences, family expectations, family conflict). These sessions were individualized to target the specific skills identified through the assessment process. Families who had moved outside the local geographic area had all intervention materials mailed to them with assessments completed through phone consultation. Family intervention strategies were designed to (a) enhance parents' skills in child rearing and educational support, (b) decrease family management problems and conflict, (c) identify and clarify family standards and rules regarding student behaviors (e.g., substance use, dating, and sex), and (d) practice peer resistance skills. All individualized intervention strategies included specified protocols for both assessment and intervention goals. Through the combined use of school, student, peer, and family intervention strategies, RHC sought to reduce risk factors of poor family management, family conflict, early antisocial behavior, academic failure, low commitment to school, associations with substance using peers, and favorable attitudes toward drug use; and enhance protective factors of bonding to family and school, setting healthy beliefs and expectations, and teaching social and emotional skills**.** Whereas all four intervention strategies were designed to deter substance use in earlier developmental periods, family and student booster sessions in middle and high school additionally targeted problematic use in later adolescence.

Implementation of the intervention in was coordinated by RHC-employed school-home coordinators (SHCs) who were former elementary school teachers or education specialists with experience in providing services to parents and families. The SHCs were responsible for all aspects of coordinating and implementing the intervention, including hiring, supporting, and training teachers and parents to administer school and family intervention strategies; coordinating parent and student workshops; soliciting feedback from students and parents for intervention refinement; and conducting periodic one-on-one follow-up visits with intervention students and their families. SHCs met weekly with the Project Director to review progress with individual cases. All intervention curricula were manualized with intervention training sessions monitored by the Project Director to ensure fidelity to curricula materials.

The RHC study design called for teachers in Grades 1 through 7 to receive at least six staff development workshop sessions and to begin the workshops during the year prior to receiving the students in the study. Workshops were delivered by a Staff Development Coordinator who was an experienced educational trainer with a Ph.D. in curriculum and instruction. Each year, teachers were observed repeatedly in the classroom (three times in the fall and three times in the spring) by independent raters to insure fidelity to school intervention strategies. Over 94% (N = 140) of eligible teachers and staff in intervention schools attended development workshops with a mean attendance of 5.7 sessions (SD = 3.1, range = 0 to 15). While intervention students were in elementary school, more than 1,700 classroom coaching visits were made, resulting in more than 684 reinforcement notes to teachers, 41 videotapes, 1,225 conferences with teachers, and 210 modeling sessions.

The number of intervention contacts (lasting 30 minutes or more for students or 60 minutes or more for families) received by students and families were recorded to monitor intervention exposure. For student and peer intervention strategies, 27% of intervention students attended at least one study club (offered twice a week during Grades 4 to 6), 40% attended at least one of the middle school retreats or workshops (out of five that were offered during Grades 7 and 8), and 51% attended at least one summer camp (out of the four that were offered during Grades 2 to 5). Typically, three family intervention workshop series were offered per year. Over half (51%) of intervention students' families voluntarily attended at least one group workshop, 35% received individual contacts including home-based services, and 77% received at least one middle or high school period booster workshop. All intervention students and their families received at least one intervention component with overall means of 28.3 contacts (*SD* = 44.5) received by students and 12.6 contacts (*SD* = 12.3) received by their families.

Procedure

Student data collection in Years 6 through 8 (i.e., Grades 6 through 9) consisted of both group and one-on-one survey administration in students' schools during regular school hours. Trained interviewers read aloud survey questions to students who were instructed to confidentially record their responses on a response sheet and return it to the interviewer at the end of the interview. Students who were not at school at time of data collection (e.g., were absent, home-schooled, or had dropped out of school) were contacted at home and individually administered an in-person, telephone, or mail-in survey. In Year 9, (i.e., Grades 9 and 10), a one-on-one, computer-assisted personal interviewing (CAPI) mode of data collection was used in which interviewers read survey questions aloud to students and recorded their verbal responses directly into a data collection program on a laptop computer. Retention rates for student surveys during project Years 6 through 10 were all greater than 88%. In order to maintain confidentiality, students' parents, teachers, and other school personnel were not present and did not participate in any student data collection activities. All students were informed that their responses would not be shared with their parents or other school personnel. A small yearly gift (e.g., disposable camera, clock radio) or monetary compensation (e.g., $10 gift certificate) was given to students for their participation in each wave of the study.

Measures

Substance use outcomes. Annual substance use measures were constructed from student self-reports of frequency of alcohol, marijuana, and cigarette use during both previous year and previous month time periods. Consistent with previous adolescent alcohol use research (e.g., Bryant, Schulenberg, O'Malley, Bachman, & Johnston, 2003), a six-point scale was created for alcohol and marijuana use where 0 = *no use in the previous year*, 1 = *some use within the past year*, 2 = *once or twice within the past month*, 3 = *three to five times within the past month*, 4 = *6 to 19 times within the past month*, and 5 = *20 or more times within the past month*. The cigarette use measure was constructed using the following categorization: 0 = *no use in the previous year*, 1 = *less than one cigarette per day*, 2 = *one to five cigarettes per day*, 3 = *6 to 10 cigarettes per day*, 4 = *11 to 20 cigarettes per day*, 5 = *21 to 40 cigarettes per day*, and 5 = *more than 40 cigarettes per day*.

Intervention status and background variables. As an intent-to-treat analysis, intervention status was assigned using students' original school assignment; that is, students from the five program schools were coded 1 and students from the five control schools were coded 0. Background variables consisted of: students' grade-cohort status (coded 0 for students from the 1st-grade cohort with substance use data from Grades 6 through 9 and 1 for students from the 2nd-grade cohort with data from Grades 7 through 10) and gender (coded 0 for females and 1 for males). Although it was not possible to test for equivalency in pre-intervention rates of substance use (i.e., the intervention began before initiation of substance use for both intervention and control groups), it was possible for the groups to be different in their latent propensity to use substances. Therefore, two additional measures theorized to be related to adolescent substance use were included as covariates. First, a measure of classroom antisocial behavior was constructed consisting of the average of 10 items taken from either the Teacher Report Form/4-18 (TRF; Achenbach, 1991) Aggressive syndrome behavior scale or the Teacher Observation of Classroom Adaptation-Revised (TOCA-R; Werthamer-Larsson, Kellam, & Wheeler, 1991), completed by teachers at baseline (i.e., students' first year of entry into the study). Response options for the items consisted of 1 = *rarely or never true*, 2 = *sometimes true*, and 3 = *often true*. Alpha reliability coefficient for the Year 1 antisocial behavior measure scale was .91 (M = 1.24, SD = .38). Second, a baseline measure of low income status was constructed to identify families that received AFDC, TANF, food stamps, or free-lunch school programs (coded 1 for receipt of service and 0 otherwise). Intervention status and all background variables were mean centered for analysis.

Data Analysis

Two-part latent growth model (LGM). To address the research questions posed in this study, we employed a two-part latent growth modeling strategy (Muthén, 2001; Olsen & Schafer, 2001). As a longitudinal adaptation to two-part (or two-equation) multiple regression models (e.g., Ellickson et al., 2001; Manning, 1997), this strategy decomposed the original distribution of substance use outcomes into two parts, each modeled by separate, but correlated, growth functions (see Figure 1). In Part 1 of the model, nonuse was separated from the rest of the distribution by creation of binary indicator variables distinguishing any positive level of use within the previous year (coded 1) from nonuse (coded 0). Use-versus-nonuse outcome variables for each substance were analyzed as a random-effects logistic growth model with the log-odds of use regressed on growth factors. Intervention status and background variables were included as covariates for examination of inter-individual differences in growth trajectories. Detailed specifications for this part of the model are described in Muthén (2001) and Muthén and Asparouhov (2002).

Part 2 of the model consisted of continuous indicator variables representing the frequency of substance use, given that some use had taken place. Here, each frequency-of-use outcome was modeled as a LGM with growth factors of nonzero substance use regressed on intervention status and background variables following traditional latent growth modeling techniques for normally distributed substance use measures (e.g., Curran, 2000; Duncan & Duncan, 1996; Taylor, Graham, Cumsille, & Hansen, 2000). However, in this part of the model, substance nonuse within each time period was treated as missing data for frequency of use, following standard assumptions of data missing at random (MAR; Little & Rubin, 1987). Thus, students who reported nonuse of a particular substance throughout the study contributed little information to growth parameter estimates (i.e., means, variances, and covariances) of frequency-of-use trajectories; however, any and all information related to positive substance use was incorporated in the derivation of growth parameters.

The procedure for constructing the two-part LGMs consisted of first identifying the unconditional (i.e., without intervention status or background variables) functional form of each part of the model separately. Change in use-versus-nonuse and frequency-of-use outcomes was modeled as linear, quadratic, or piecewise growth. Loadings for linear and quadratic growth factors were specified as orthogonal polynomial contrasts with intercepts centered at the middle of the time points (Raudenbush & Xiao, 2001). Loadings for piecewise growth functions were specified as segmented linear growth functions (Raudenbush & Bryk, 2002), again with intercepts centered at the midpoint. These different parameterizations were selected in order to model change in substance use as a constant process (i.e., using linear growth); with gradual acceleration or deceleration in use (i.e., using quadratic growth); or as a discontinuous process (i.e., using piecewise growth) typically characterized by a transitional event, for example, entry into high school. An additional rationale for examining segmented piecewise growth was to account for potentially differential impact of covariates on growth between middle and high school periods (Li, Duncan, & Hops, 2001). As model Parts 1 and 2 were free to follow different functional forms, it also was possible for intervention status and background variables to have differential effects on growth factors between each model part. To represent the potential conditionality of the frequency-of-use outcome on the initial decision whether or not to engage in substance use, growth factors between model Parts 1 and 2 were allowed to be correlated. All models were analyzed using Mplus 3.0 (Muthén & Muthén, 2004), which provided maximum-likelihood parameter estimates with robust standard errors under MAR via numerical integration.[1]

Model fit for each part of the two-part LGMs was assessed using chi-square difference tests based on model log-likelihood values and by plotting observed rates against model-predicted values and visually inspecting for misfit. Additionally, standardized residuals (i.e., observed minus model-predicted values) were plotted for each time point and assessed for potential outliers. For frequency-of-use outcomes, model fit also was assessed using the comparative fit index (CFI; Bentler, 1990), Tucker-Lewis fit index (TLI; Tucker & Lewis, 1973), and root mean square error of approximation (RMSEA; Browne & Cudeck, 1993; Steiger & Lind, 1980). These indices were not available to evaluate fit in Part 1 of the models.

Analysis of intervention effects and background variables in conditional models were conducted using two-tailed tests of significance with $p < .05$ as the criterion for statistical significance. All analyses were conducted at the individual (i.e., student) level with standard errors for intervention effects multiplied by outcome-specific design effects (Dielman, 1994) to account for potential clustering of students from their original school assignments.

Missing data. To determine whether there was differential attrition among students excluded from the analysis because of missing outcome data ($n = 81$), proportions of missingness were examined for intervention status and background variables. Results indicated no significant difference in the proportion of students with missing outcome data for intervention versus control groups, 1st- versus 2nd-grade cohorts, low income status, or by level of student antisocial behavior. However, a significantly greater proportion of females had missing outcome data (9.8%) than males (6.0%), χ^2 (1, N = 1,040) = 5.03, $p < .05$; therefore, a follow-up logistic regression was conducted to examine the difference in proportions of missingness between intervention and control groups by gender. Results indicated no significant Intervention Status × Gender interaction, Wald χ^2 (1, N = 1,040) = 1.05, $p > .05$. Given these results and the small degree of missing outcome data, we relied on full information maximum likelihood estimation under the assumption of data MAR.

Results

Prevalence and Frequency of Substance Use

Prevalence rates for alcohol, marijuana, and cigarette use for the measured time periods are presented in Table 1. For marijuana and cigarette use, extremely low prevalence rates in 6th grade precluded the use of this time point in the analysis and are not shown in the table. Prevalence rates for all three substances increased generally during Grades 6 to 10. For example, 29% of all students in 6th grade had used alcohol at least once in the previous 12 months. By Grade 10, the percentage of students who had tried alcohol in the previous 12 months had increased to 51%. The percentage of students who used marijuana increased from 8% in 7th grade to 31% in 10th grade. Additionally, prevalence of cigarette use doubled from 9% in 7th grade to 18% in 10th grade. Rates of substance use in the RHC sample during Grade 10 were similar to population-based rates for students in the State of Washington (Washington State Department of Health, 2003). As shown in Table 1, apparent differences in rates of alcohol and marijuana use between male and female students are notable. Females engaged in lower rates of 6th-grade alcohol and 7th-grade marijuana use (24% and 5%, respectively) than males (34% and 11%, respectively). However, by 9th grade, rates of alcohol and marijuana use by females (50% and 27%, respectively) had reached or surpassed rates of use by males (44% and 27%, respectively). Descriptive statistics for frequency of alcohol, marijuana, and cigarette use, for those having positive use within a grade (independent of use in other grades), are presented in Table 2. Longitudinal patterns of growth in frequency of alcohol and marijuana use were different from patterns of growth in prevalence rates for these two substances. Whereas the prevalence of alcohol and marijuana use increased each year during Grades 6 through 10, mean frequency of alcohol and marijuana use peaked at 8th grade and declined thereafter. However, mean frequency of cigarette use increased throughout Grades 7 to 10.

Two-part Latent Growth Model of Alcohol Use

Unconditional model. As the first step in modeling alcohol use, we examined the functional form of growth for each part of the two-part LGM separately, excluding intervention status and background variables (recall that the Part 1 of the model refers to growth in substance use vs. nonuse and Part 2 refers to the frequency of use, given that some use had taken place). Comparison of intercept-only, linear, quadratic, and piecewise growth functions for Part 2 of the alcohol use model indicated that frequency of alcohol use was best modeled as a two-segment piecewise model consisting of separate linear growth functions for Grades 6 to 8 and Grades 8 to

10, χ^2 (8, N = 628) = 13.52, p = .10, CFI = .944, TLI = .937, and RMSEA = .033.[2] In Part 1 of the model, a linear growth model demonstrated better fit to alcohol use (vs. nonuse) than an intercept-only model, $\Delta\chi^2$ (1, N = 959) = 89.66, $p < .01$. Inclusion of a quadratic growth factor did not improve model fit, $\Delta\chi^2$ (1, N = 959) = 0.28, $p > .05$. Because the segmented piecewise model allowed us to examine the same linear pattern of growth in the data as well as account for the possibility of differential covariate effects between middle and high school periods, we chose to model growth in this part of the model in a similar piecewise fashion.

Examination of growth factor variances and covariances indicated significant variation in intercept growth factors for both model Parts 1 and 2 (Variances = 5.105 and .341, *SE*s = .567 and .060, *p*s < .001, respectively), indicating significant individual heterogeneity around mean levels of alcohol use (vs. nonuse) and frequency of use at Grade 8. Intercept growth factors between model Parts 1 and 2 also exhibited significant positive covariation (r = .686, $p < .001$) suggesting that students with lower propensities to engage in alcohol use (at Grade 8) had correspondingly less frequent use. For both model parts, minimal heterogeneity in linear growth during Grades 6 to 8 resulted in nonsignificant slope variances; these variances were required to be fixed at zero for model convergence. Although variances for linear growth factors during Grades 8 to 10 also were nonsignificant (Variances = .576 and .048, *SE*s = .306 and .041, *p*s > .05, for model Parts 1 and 2, respectively), these parameters were estimable and retained for subsequent analysis of intervention status and background variables. All other covariances among growth parameters, both within and between model parts, were nonsignificant and subsequently fixed at zero.

Intervention status and background variables. Next, intervention status and background variables were added to both parts of the model and regressed on intercept and piecewise growth segments. Parameter coefficients (i.e., growth factor means) and standard errors for the final two-part LGM are shown in Table 3. Results of the alcohol use-versus-nonuse part of the model indicated a significant gender effect with females being more likely to use alcohol at Grade 8 and having a significantly greater rate of increase in their likelihood to use alcohol during Grades 6 through 8 relative to males. Higher baseline classroom antisocial behavior was associated with both a greater likelihood to use alcohol at Grade 8 and growth in the likelihood to use alcohol during Grades 8 to 10. Additionally, students from low socioeconomic status households were at greater likelihood of using alcohol at Grade 8 and had greater growth in use during Grades 6 to 8. No significant difference was found between students in the intervention group and controls for change in alcohol use versus nonuse.

Results of the frequency-of-alcohol use part of the model showed a significant intervention effect indicating a greater rate of linear decline in the frequency of alcohol use during Grades 8 to 10 for the intervention group relative to controls.[3] Model-implied mean trajectories for intervention and control groups (adjusted by covariates) are shown in Figure 2. Shaded regions in the figure denote 95% confidence bands around each group's mean trajectory (Curran, Bauer, & Willoughby, 2004). The standardized effect size for the difference in mean trajectories was $\delta = .91$.[4] In terms of an adjusted mean difference in frequency-of-use rates at Grade 10, the corresponding effect size was $d = .40$. Additionally, a significant grade-cohort effect was present for growth in frequency of alcohol use during Grades 8 through 10 with a greater decline for the 1st-grade cohort than the 2nd-grade cohort. To determine whether the intervention effect was consistent for both grade cohorts, an Intervention Status × Grade Cohort interaction term was added to the Grade-8-through-10 segment of the model. Results indicated that the interaction term had no significant effect on growth in frequency of alcohol use during this period (β = -.089, *SE* = .139, *p* > .05), indicating that grade-cohort status did not moderate the effects of the intervention on frequency of alcohol use.

Two-part Latent Growth Model of Marijuana Use

Unconditional model. Given the apparent nonlinear growth in marijuana use during Grades 7 through 10, a curvilinear growth model for the Part 1 use-versus-nonuse outcome containing intercept, linear, and quadratic growth factors was compared to an intercept-and-linear-only growth model (because only 4 time points were available to model marijuana use, the two-segment piecewise model was not considered). Results indicated better fit for the curvilinear model than the linear model, $\Delta\chi^2$ (1, *N* = 959) = 5.40, *p* < .01. The unconditional curvilinear model for the Part 2 frequency of marijuana use exhibited marginal negative linear growth (β = -.047, *SE* = .030, *p* = .058) and nonsignificant quadratic growth (β = -.057, *SE* = .047, *p* > .05). However, fit of the intercept-only model was poor, χ^2 (8, *N* = 340) = 15.75, *p* = .046, CFI = .718, TLI = .789, and RMSEA = .053.[5] Inclusion of a linear growth factor substantially improved model fit, χ^2 (5, *N* = 340) = 8.46, *p* = .133, CFI = .890, TLI = .890, and RMSEA = .038; therefore, the linear growth term was retained in the final unconditional model for frequency of marijuana use.

Significant variation existed in intercept growth factors (i.e., Grade 8.5 status) for both model Parts 1 and 2 (Variances = 9.113 and .691, *SE*s = 1.251 and .154, *p*s < .001, respectively). Growth factor intercepts between outcomes were significantly correlated (*r* = .796, *p* < .001). In Part 1 of the model, variances for both linear and quadratic growth factors were nonsignificant and were required to be fixed at zero for model convergence. In Part 2 of the model, the variance for the linear growth factor also was nonsignificant (Variance = .024, *SE* = .017, *p* > .05) but was retained as a freely estimated parameter for analysis of intervention status and background variables. All other covariances among growth parameters, both within and between model parts, were nonsignificant and subsequently fixed at zero.

Intervention status and background variables. Results of the final two-part growth latent model for marijuana use, including intervention status and background variables, are shown in Table 4. Significant gender, grade cohort, baseline antisocial behavior, and income effects were found for the intercept growth factor in Part 1 of the model indicating that females, 2nd-grade-cohort students, students with high baseline antisocial behavior, and students from low socioeconomic status households had significantly higher rates of marijuana use (vs. nonuse) at Grade 8.5 than their respective counterparts. Additionally, females demonstrated a significantly greater increase in marijuana use during Grades 7 to 10 than males, with females reaching males' prevalence of marijuana use by 9th grade and declining thereafter. No significant differences were found in marijuana use growth rates between intervention students and controls. However, for frequency of marijuana use, results indicated a significant intervention effect with students in the intervention group exhibiting greater linear decline in the frequency of marijuana use than students in the control group (see Figure 3). Intervention effect sizes were $\delta = 1.44$ for the standardized difference in mean trajectories and $d = .57$ for the adjusted mean difference in frequency-of-use rates at Grade 10.

Two-part Latent Growth Model of Cigarette Use

Unconditional model. For the unconditional cigarette use-versus-nonuse outcome, results of the unconditional model indicated better fit with intercept, linear, and quadratic growth factors than the intercept-and-linear-only model, $\Delta\chi^2$ (1, $N = 959$) = 6.31, $p < .01$. For the frequency-of-use outcome, a quadratic growth model similarly provided optimal fit to the data, χ^2 (1, $N = 239$) = 6.93, $p = .33$, CFI = .953, TLI = .953, and RMSEA = .026.[6] Among all growth factors in both

Parts 1 and 2 of the model, significant variation existed only for intercept growth factors (i.e., Grade 8.5 status; Variances = 10.342 and .865, *SE*s = 1.531 and .190, *p*s < .001, respectively). Again, growth factor intercepts between model Parts 1 and 2 were highly correlated ($r = .856$, $p < .001$). All other variances and covariances in the model were fixed at zero.

Intervention status and background variables. Results of the final two-part LGM of cigarette use, including intervention status and background variables, are shown in Table 5.[6] Similar to marijuana use, significant effects for background variables indicated that females, 2nd-grade-cohort students, students with high baseline antisocial behavior, and students from low socioeconomic status households had higher rates of cigarette use (vs. nonuse) at Grade 8.5. The only significant effect for frequency of cigarette use was for baseline antisocial behavior with higher levels related significantly to more cigarette smoking at Grade 8.5. No other variables were associated with change in either cigarette use-versus-nonuse or frequency-of-use outcomes.

Discussion

This study examined the efficacy of the Raising Healthy Children (RHC) intervention on trajectories of alcohol, marijuana, and cigarette use during early to middle adolescence. Using the social development model as a theoretical framework for the intervention, RHC targeted a broad set of empirically supported risk and protective factors through the multiple contexts of school, family, peers, and the individual student. As the aims of the intervention were designed to be both developmentally appropriate and consistent with the goals of its participating families, we investigated students' substance use in terms of the likelihood to abstain from use as well as the frequency of use for those who did not abstain from use.

These related outcomes were analyzed using a two-part latent growth modeling (LGM) strategy. Similar to standard LGM techniques, this method allows for the examination of both intra- and inter-individual patterns of change in substance use trajectories. However, the two-part LGM decomposes the original semicontinuous outcome measures into dichotomous use-versus-nonuse and continuous frequency-of-use parts. In addition to providing a more detailed examination of the effects of the intervention, this approach substantially improved the normality of the frequency-of-use outcomes—a fundamental assumption underlying the appropriateness of LGMs in general. Consequently, we recommend this approach to other researchers faced with similarly distributed outcomes.

Results of this study provide evidence for the efficacy of the RHC intervention in reducing the frequency of alcohol and marijuana use. Between-group examination of alcohol and marijuana frequency-of-use trajectories shows greater decreases for intervention students relative to controls during middle to high school periods. Standardized effect sizes associated with mean trajectory differences are substantial (.91 and 1.44, respectively), representing almost a full standard deviation unit difference in mean alcohol frequency-of-use trajectories and almost a 1½ standard deviation unit difference in mean marijuana frequency-of-use trajectories between intervention students and controls. In terms of adjusted mean differences in frequency-of-use rates at Grade 10, corresponding effects sizes represent medium intervention effects (.40 and .57, respectively). Although these findings support the intervention's goal of reducing frequent use, the lack of significant intervention effects on students' decision to engage in alcohol or marijuana use demonstrates a lack of support for the intervention's abstinence-oriented goals regarding these two substances.

The differential impact of the RHC intervention on alcohol and marijuana use outcomes is noteworthy. From a social development perspective, intervention students' bonding with those with prosocial beliefs and standards is keeping them from more frequent alcohol and marijuana use, which would disappoint those they are bonded to and threaten their investment in school or family relations if they were to do otherwise. On the other hand, experimentation with alcohol and marijuana, perhaps because of low risk of detection or general acceptance as a rite of passage, may not pose as great a threat to bond disruption. Consequently, experimental use may not be as amenable to social development interventions. Findings by Ellickson et al. (2001) note the distinction between experimental and problematic use, suggesting that "prevention programs that target alcohol misuse may be more successful than those that advocate abstinence" (p. 773). In contrast, the addictive nature of cigarette smoking and increased public information campaigns regarding youth smoking may account for its nonsignificant relationships with the intervention. Experimental cigarette use appears to be less normative, as evidenced by its low prevalence in our sample compared to alcohol and marijuana use. Furthermore, the greater potential for cigarette addiction may make escalating (i.e., more frequent) use less susceptible to social development intervention. From a prevention perspective, more research is needed to disentangle the mediating processes leading toward adolescents' decisions to engage in experimental and escalating substance use.

Differences in the longitudinal patterns of substance use between model Parts 1 and 2 (within each type of substance) are noteworthy, as well. Results of this study showed that, whereas prevalence rates for alcohol and marijuana use increased during the middle to early high school period, frequency-of-use patterns for these substances were either nonlinear (for alcohol) or remained relatively unchanged (for marijuana). Conversely, although the prevalence of cigarette use changed very little during Grades 8 to 10, frequency of cigarette use increased steadily during the same period. Although different longitudinal patterns are apparent between use-versus-nonuse and frequency-of-use outcomes within each substance, we note that growth processes between outcomes are related, nonetheless. The large correlation (r = .69) between intercept growth factors for alcohol use is consistent with findings from similar research using this methodology (Olsen & Schafer, 2001). This, and the large correlations between intercepts within marijuana- and cigarette-use models (*r*s = .80 and .86, respectively) can be interpreted as strong positive relationships between a student's latent propensity to engage in use and the ensuing conditional decision on how often to use. In other words, students who are less likely to use are less likely to use often if they do use. As failure to model this "could introduce substantial bias into the estimated coefficients" (p.738), we advise researchers using two-part models to consider such relationships in their analysis.

Results of this study also demonstrate that predictor variables can have differential effects on patterns of substance use depending on level of use. Gender, for example, was related to patterns of alcohol and marijuana use with female prevalence rates "catching up" to males' rates by 10th grade. This increase in prevalence rates of alcohol and marijuana use by gender is consistent with reported national trends (Johnston et al., 2003). However, in this study, gender was not associated with patterns of frequency of alcohol or marijuana use. These findings are consistent with results from other studies that have found differential effects of risk factors on level-dependent substance use outcomes (Colder & Chassin, 1999; Gutierres, Molof, & Ungerleider, 1994; Olsen & Schafer, 2001). The implication for substance abuse prevention programs is that they recognize students' developmentally related levels of substance use (e.g., experimental or heavy) and tailor their interventions to that level.

Although this study addresses several methodological deficits that often characterize prevention studies of adolescent substance use (e.g., nonexperimental design, lack of theoretical or empirical basis, no long-term follow-up, differential attrition), generalizability of results from this study are limited by relying solely on adolescent self-reported substance use, the predominantly European American composition of the sample (reflective of the suburban school district from which students were sampled), and the exclusion criteria incorporated into the study design (e.g., students who did not remain in their original schools throughout the first entire year of the study were excluded). Additionally, this study did not exhaustively examine other explanatory variables (i.e., risk and protective factors) with regard to their potential prediction of substance use. As the focus of the study was to test the efficacy of the RHC intervention, covariates were limited to those variables that had well established predictive relationships with substance use (e.g., antisocial behavior and low socioeconomic status) and could statistically control for pretest differences between intervention and control students.

As a comprehensive, longitudinal preventive intervention with universal and selective components, the Raising Healthy Children project incorporates principles of effective prevention programs (Nation et al., 2003) to address empirically identified and developmentally appropriate risk and protective factors for adolescent substance use. Although the effects of the intervention presented in this study are limited, they support the efficacy of the intervention in reducing the frequency of early alcohol and marijuana use, which are known risk factors for later substance abuse. It will be important to see if these effects demonstrated in middle and early high school are maintained and are associated with outcomes related to heavy or problematic use as students reach the ages of peak use.

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Footnotes

[1]Mplus scripts used in the analyses can be obtained from the Mplus website (www.statmodel.com).

[2]Fit indices based on $n = 628$ students with nonzero frequency of alcohol use.

[3]To determine whether intervention effects for frequency of alcohol use and marijuana use were caused by students in the control condition having earlier onset of use (and consequently having higher frequency of use in latter grades), we constructed a covariate that represented the grade at which students first used each respective substance. This covariate and its interaction with intervention status were included in the final conditional models as predictors of linear growth during Grades 8 through 10 (for frequency of alcohol use) and Grades 7 through 10 (for frequency of marijuana use). Results of these analyses indicated nonsignificant main effects and interaction terms (ps > .05) for both outcomes suggesting that the declines in these outcomes by intervention students were not associated with the timing of initial use.

[4]δ is defined as the group difference in a growth factor divided by the population standard deviation of that growth factor (see Raudenbush & Xiao, 2001, Equation 13).

[5]Fit indices based on $n = 340$ students with nonzero frequency of marijuana use.

[6]Fit indices based on $n = 239$ students with nonzero frequency of cigarette use.

[7]Given the high degree of skewness and kurtosis for Grade 7 frequency of cigarette use, parallel analyses were conducted with log transformed outcome data. Results indicated no substantive differences between analyses with log transformed and untransformed outcomes; therefore, for consistency, we report results from analysis of cigarette use in the original metric.

Table 1

Annual Substance Use Prevalence Rates by Intervention Status and Gender

Grade	Intervention	Controls	Females	Males	Total Sample
			Alcohol		
6[a]	.29	.30	.24	.34	.29
7	.33	.29	.29	.33	.31
8	.37	.40	.43	.34	.38
9	.46	.48	.50	.44	.47
10[b]	.52	.50	.52	.50	.51
			Marijuana		
7	.08	.09	.05	.11	.08
8	.16	.18	.16	.18	.17
9	.25	.28	.27	.27	.27
10[b]	.30	.31	.27	.33	.31
			Cigarettes		
7	.09	.08	.10	.08	.09
8	.14	.13	.17	.11	.14
9	.16	.17	.18	.15	.16
10[b]	.16	.20	.20	.16	.18

Note. Prevalence rates denote the proportion of students having used each substance within the previous 12 months.

[a]Represents 1st-grade cohort only. [b]Represents 2nd-grade cohort only.

Table 2

Descriptive Statistics for Frequency of Substance Use

Grade	*N*	Mean	Standard Deviation	Skewness	Kurtosis
			Alcohol		
6[a]	143	1.57	0.88	1.97	4.32
7	297	1.85	0.99	1.31	1.37
8	361	2.05	1.07	0.91	0.03
9	430	1.98	1.08	1.02	0.24
10[b]	227	1.81	1.06	1.34	1.04
			Marijuana		
7	79	2.41	1.33	0.60	-0.87
8	158	2.58	1.44	0.53	-1.10
9	245	2.29	1.31	0.72	-0.77
10[b]	136	2.21	1.39	0.77	-0.87
			Cigarettes		
7	82	1.68	0.95	1.99	3.45
8	128	2.02	1.29	1.32	1.30
9	149	2.03	1.16	1.25	1.49
10[b]	80	2.09	1.06	0.88	0.91

Note. Scale ranges from 1 (*some use within the past year*) to 5 (*20 or more times within the past month*).

[a]Represents 1st-grade cohort only. [b]Represents 2nd-grade cohort only.

Table 3

Parameter Estimates and Standard Errors for Alcohol Use Growth Factors and Covariates

Variable	Grade 8 status		Linear growth Grades 6 to 8[a]		Linear growth Grades 8 to 10	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
			Part 1: Use versus nonuse			
Growth factor mean	.821***	.117	.440***	.106	.452***	.099
Intervention group	.013	.556	-.005	.198	.047	.190
Gender (male)	-.687**	.232	-.815***	.178	.092	.171
Grade cohort (older)	.398	.230	.274	.215	.069	.196
Antisocial behavior	.838**	.312	.191	.235	.567*	.264
Low income	.674**	.238	.495**	.179	-.131	.180
			Part 2: Frequency of use			
Growth factor mean	1.774***	.061	.297***	.050	-.207***	.046
Intervention group	-.031	.412	-.029	.095	-.199*	.096
Gender (male)	.076	.098	-.081	.071	-.045	.077
Grade cohort (older)	.054	.099	.075	.100	.242**	.093
Antisocial behavior	.287*	.123	.005	.078	-.056	.105
Low income	.056	.102	.028	.078	.072	.087

Note. Standard errors for intervention effects adjusted by corresponding design effects. [a]Growth factor variance and associated covariances set to zero in model Parts 1 and 2.

*p < .05. **p < .01. ***p < .001.

Table 4

Parameter Estimates and Standard Errors for Marijuana Use Growth Factors and Covariates

Variable	Grade 8.5 status		Linear growth		Quadratic growth[a]	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Part 1: Use versus nonuse						
Growth factor mean	3.233***	.212	.475***	.065	-.463***	.112
Intervention group	-.178	.498	.055	.104	-.008	.143
Gender (male)	.388	.274	-.170*	.088	.514***	.146
Grade cohort (older)	.888**	.311	.071	.120	.175	.217
Antisocial behavior	1.306***	.351	.203	.106	-.133	.214
Low income	.878*	.283	.030	.083	-.138	.149
Part 2: Frequency of use						
Growth factor mean	1.511***	.139	-.005	.037	na	na
Intervention group	.103	.132	-.223***	.052	na	na
Gender (male)	.100	.128	.088	.053	na	na
Grade cohort (older)	.160	.134	.001	.068	na	na
Antisocial behavior	.221	.148	.003	.082	na	na
Low income	.006	.121	.005	.053	na	na

Note. Standard errors for intervention effects adjusted by corresponding design effects.

na = not applicable (i.e., quadratic growth factor not included in Part 2 model).

[a]Quadratic growth factor variance and associated covariances in model Part 1 set to zero.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 5

Parameter Estimates and Standard Errors for Cigarette Use Growth Factors and Covariates

Variable	Grade 8.5 status		Linear growth[a]		Quadratic growth[a]	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Part 1: Use versus nonuse						
Growth factor mean	4.245***	.280	.146*	.074	-.395**	.133
Intervention group	.164	.741	-.153	.105	-.123	.155
Gender (male)	-.795**	.306	.051	.089	.149	.161
Grade cohort (older)	1.118**	.374	.183	.143	.249	.255
Antisocial behavior	1.030**	.374	-.105	.101	-.074	.206
Low income	.916**	.318	.094	.090	.029	.156
Part 2: Frequency of use						
Growth factor mean	.833***	.187	.133**	.044	-.048	.094
Intervention group	.017	.150	-.008	.042	-.033	.092
Gender (male)	-.112	.132	-.066	.048	-.055	.108
Grade cohort (older)	.022	.193	-.057	.086	-.271	.167
Antisocial behavior	.431*	.172	.000	.061	.205	.118
Low income	.108	.132	-.013	.040	-.010	.090

Note. Standard errors for intervention effects adjusted by corresponding design effects. [a]Growth factor variance and associated covariances set to zero in model Parts 1 and 2.

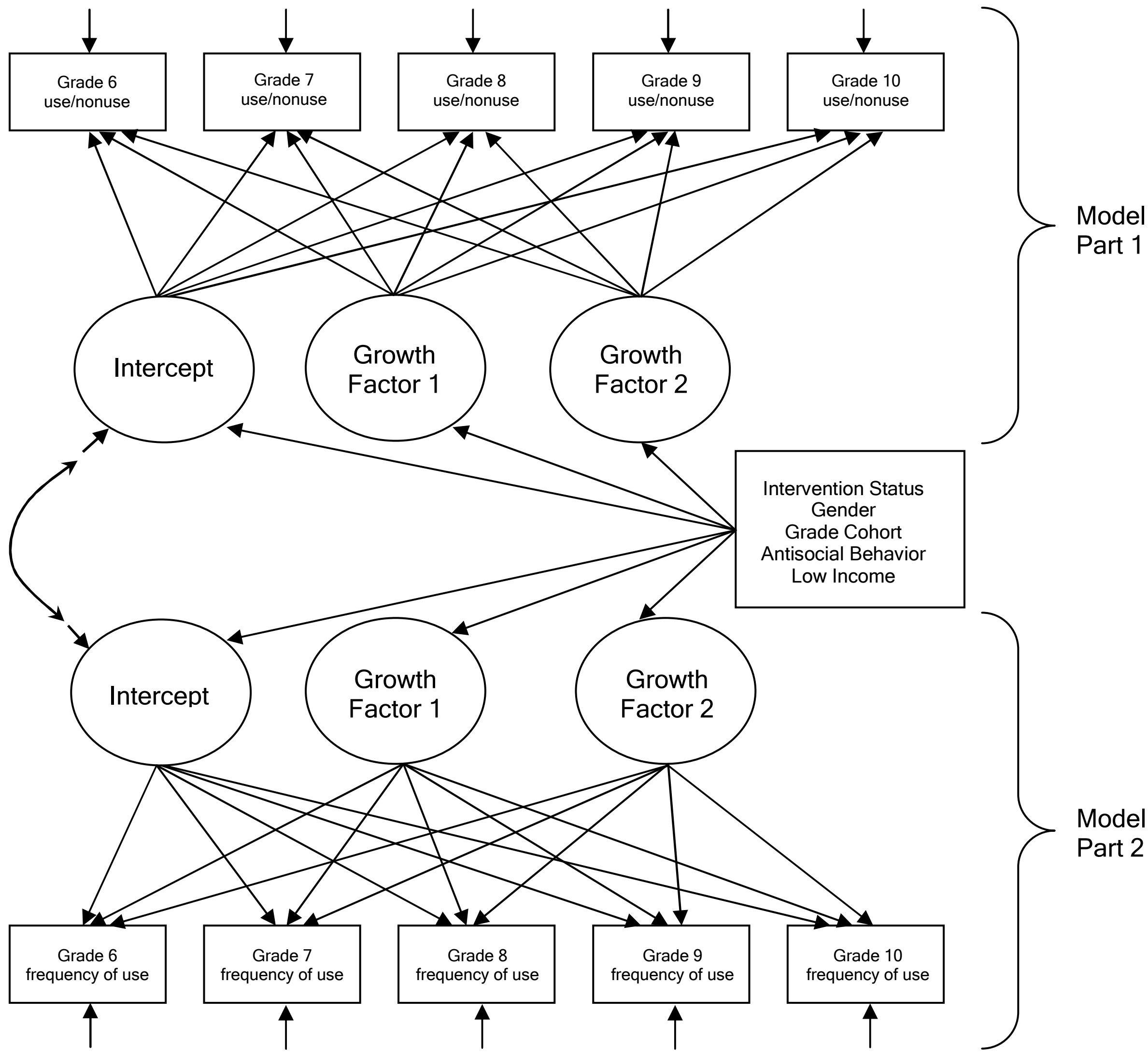
*p < .05. **p < .01. ***p < .001.

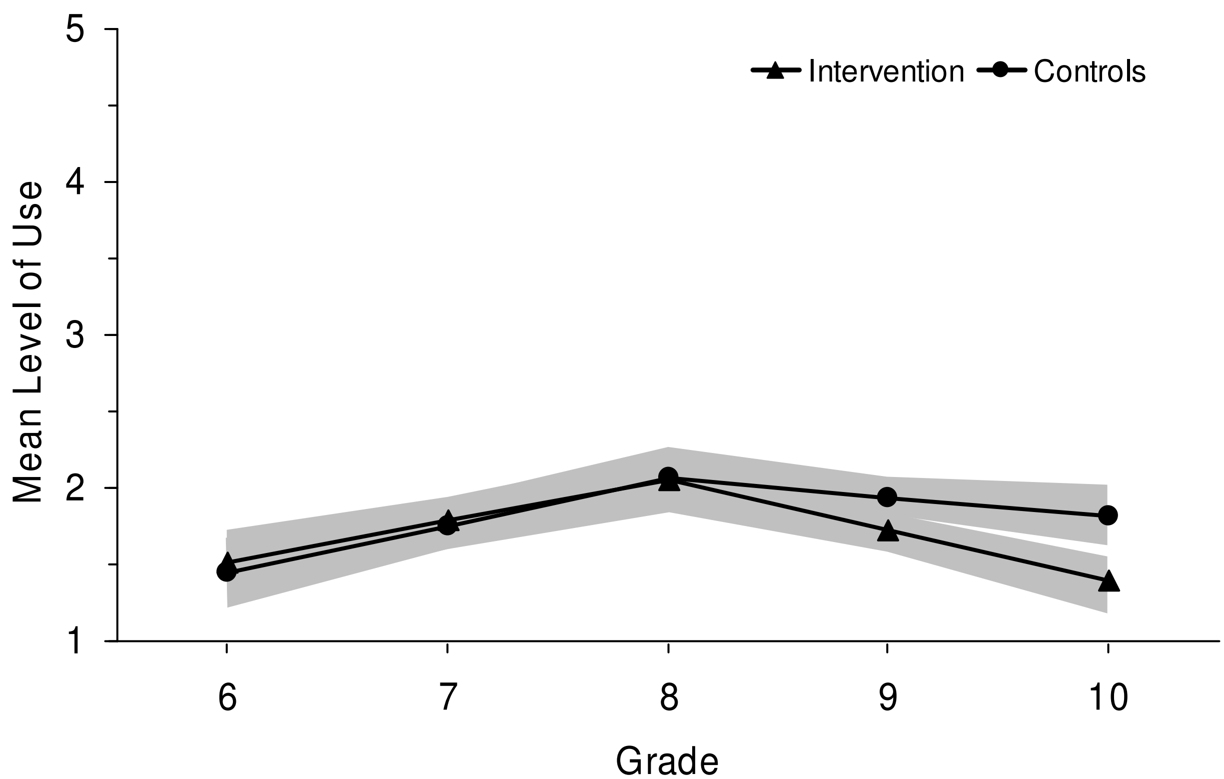
Figure Captions

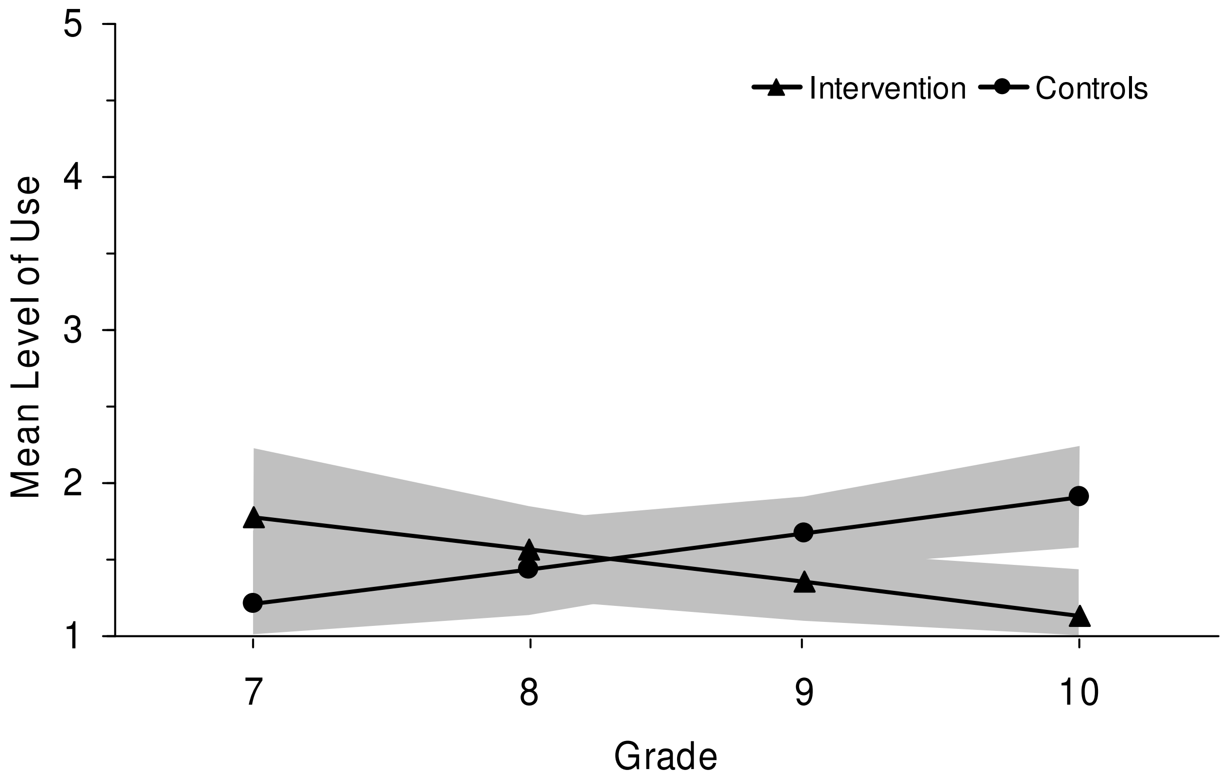
Figure 1. Path diagram for two-part latent growth model. Top portion of diagram depicts Part 1 of the model (i.e., substance use vs. nonuse); bottom portion depicts Part 2 of the model (i.e., frequency of substance use). Growth Factors 1 and 2 correspond to piecewise or linear and quadratic growth factors (correlations between growth factors within each model part omitted for clarity).

Figure 2. Adjusted mean trajectories for frequency of alcohol use (excluding nonuse) during Grades 6 through 10 by intervention status. Shaded regions represent 95% confidence bands for mean trajectories. Scale ranges from 1 (*some use within the past year*) to 5 (*20 or more times within the past month*).

Figure 3. Adjusted mean trajectories for frequency of marijuana use (excluding nonuse) during Grades 7 through 10 by intervention status. Shaded regions represent 95% confidence bands for mean trajectories. Scale ranges from 1 (*some use within the past year*) to 5 (*20 or more times within the past month*).


Grade 6
use/nonuse
Grade 7
use/nonuse
Grade 8
use/nonuse
Grade 9
use/nonuse
Grade 10
use/nonuse
Model
Part 1
Intercept
Growth
Factor 1
Growth
Factor 2
Intervention Status
Gender
Grade Cohort
Antisocial Behavior
Low Income
Intercept
Growth
Factor 1
Growth
Factor 2
Model
Part 2
Grade 6
frequency of use
Grade 7
frequency of use
Grade 8
frequency of use
Grade 9
frequency of use
Grade 10
frequency of use


Intervention
Controls
Mean Level of Use
5
4
3
2
1
6
7
8
9
10
Grade


5
4
3
2
1
Mean Level of Use
Intervention
Controls
7
8
9
10
Grade