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Evaluating Mediators of the Impact of the Linking the Interests of Families and Teachers (LIFT) Multimodal Preventive Intervention on Substance Use Initiation and Growth across Adolescence

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Abstract

Substance use outcomes were examined for 351 youth participating in a randomized controlled trial designed to assess the efficacy of a school-based multimodal universal preventive intervention, Linking the Interests of Families and Teachers (LIFT). Frequency of any use of tobacco, alcohol, and other drugs was assessed via self-report from grades 5 through 12. Latent variable growth models specified average levels, linear, and accelerated growth. The LIFT intervention had a significant effect on reducing the rate of growth in use of tobacco and illicit drugs, particularly for girls, and had an overall impact on average levels of use of tobacco, alcohol, and illicit drugs. Average tobacco use reductions were mediated by increases in family problem solving. The intervention obtained significant indirect effects on growth in substance use through intervention effects on reduced playground aggression and increased family problem solving. The intervention was also associated with roughly a 10% reduced risk in initiating tobacco and alcohol use. Implications for future studies of multimodal preventive interventions are discussed.

Keywords

substance use; adolescence; multimodal universal prevention; growth modeling; survival analyses; mediational analyses

Important components of most life course developmental models of youth problem behaviors are the social interactions between youth and their parent(s) and between youth and their peers (e.g., Hawkins & Weis, 1985; Kellam & Rebok, 1992; Coie & Jacobs, 1993; Reid & Eddy, 1997). Preventive interventions grounded in life course models are usually multimodal in nature, and delivered as early as possible in the course of problem development, which in most cases is during elementary and/or early middle school. Common intervention components include education and skills training for parents and social skills and problem solving training for youth. In studies of these interventions, youth outcomes of interest tend to be antisocial behaviors that impact both social relations and school success, such as verbal and physical aggression, noncompliance, lying, cheating, as well as strong correlates, such as spending time with a deviant peer group, early substance use and early sexual behavior. The prevention of the development of youth problem behaviors is hypothesized to decrease the likelihood of a variety of poor outcomes during adulthood, most notably the co-morbid problems of criminal behavior and substance abuse.

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Reports on the long term impacts of multimodal preventive interventions are few, but one outcome that several groups have examined is youth substance use. For example, participants in the Seattle Social Development Project who had received the complete intervention, which was delivered at various points throughout elementary school, reported less “heavy” drinking than participants who received either no intervention or intervention only at the end of elementary school (Hawkins, Catalano, Kosterman, Abbott, & Hill, 1999). No effects, however, were found on frequent cigarette or marijuana use. Similarly, the Raising Healthy Children Project, whose intervention also was delivered during elementary school, did not have an impact on the initiation of youth substance use during the period from the sixth to the tenth grades, but did reduce growth in the use of alcohol and marijuana (Brown, Catalano, Fleming, Haggerty, & Abbott, 2005). No impact was found on growth in cigarette use. Intervention participants in the Montreal Prevention Experiment, in which intervention occurred during middle elementary school, were less likely to report being drunk or using drugs by mid-adolescence than control participants (Tremblay, Mâsse, Pagani, & Vitaro, 1996). No data on tobacco use were reported. Thus, while some effect on substance use has been consistently found, exactly which effect this is varies.

While these findings are encouraging, understanding of what factors lead to which effects is extremely limited. Only a few studies have been published that examined hypothesized “mediational” processes through which these or other types of preventive interventions impact youth problem behaviors. One of the only studies to examine mediation of adolescent substance use effects related to a family and/or peer-based preventive intervention was conducted by Dishion, Nelson, and Kavanagh (2003). Within the context of a randomized study of their multimodal Adolescent Treatment Program (ATP), Dishion et al. (2003) found that positive effects related to the family-based component of their program were related to increases in a specific type of parental behavior that had been targeted by the intervention, namely monitoring of child whereabouts, activities, and associates.

In this paper, we first examine the long term impact on youth substance of a school based, multimodal, universal preventive intervention, the Linking the Interests of Families and Teachers program (LIFT; Reid, Eddy, Fetrow, & Stoolmiller, 1999; Eddy, Reid, & Fetrow, 2000). Second, we investigate whether any observed effects are related to hypothesized mediators that were both targeted by, as well as significantly influenced by, the intervention. The specific mediators of interest are indicators of the quality of social interactions between youth and parents and youth and peers.

The LIFT Program

The LIFT universal preventive intervention is based in a developmental model centered on moment-to-moment social interaction processes thought to be important in initiating and continuing youth problem behaviors (Reid & Eddy, 2002; Patterson, Reid, & Dishion, 1992; Patterson, 1982). Behaviors that are reinforced and punished during interactions are posited to be the primary shapers of youth outcomes. Youth who inadvertently receive high rates of reinforcement for coercive behaviors (i.e., the contingent use of aversive behaviors to stop the ongoing aversive behaviors of others) within their family during early childhood are hypothesized to be at risk for failure when they enter elementary school. Such youth not only become skilled at social aggression, they also become quite proficient at not complying with adult requests. Ultimately, youth who are consistently noncompliant and aggressive are often socially rejected by many of the adults and peers with whom they regularly interact, decreasing their access to normative social situations. As conventional social options become limited, youth may find acceptance within groups of peers with similar experiences and problems. Over time, the “deviant” peer group becomes a center for observing and learning not only about

typical antisocial behaviors such as stealing, intimidation, or violence, but also about substance use and abuse and high-risk sexual behavior.

The program was designed to prevent the developmental of youth antisocial behaviors by positively influencing interactions within highly influential social arenas, namely between youth and parent(s) in the home, between youth and peers in the classroom and on the playground, and between parents and teachers about youth (Eddy et al., 2000). Positive interactions in these areas were hypothesized to decrease the chance that youth would become engaged in antisocial social behavior, associate with a deviant peer group, and progress to more serious forms of problem behavior such as substance use. Several components comprise the program, which were delivered to all children and their parents within an elementary school grade. The parent management training component was designed to improve parent skills in consistent and effective positive reinforcement, discipline, and monitoring. The child social and problem solving skills training was designed to improve child skills in listening, emotion recognition and management, group cooperation, and problem solving. Linked to the child training was a school recess intervention, a version of the Good Behavior Game (Dolan et al., 1993), which was designed to encourage the “real life” use of social and problem solving skills. Parent and teacher communication was encouraged through a variety of media.

Mediators of LIFT Impacts on Adolescent Substance Use

During the first year of the intervention, LIFT led to significant reductions in youth aggression with peers on the playground (Reid et al., 1999), a target of the recess child social and problem solving skills and the Good Behavior Game intervention components, as well as significant improvements in parent-youth interaction (Reid et al., 1999) and family problem solving (DeGarmo & Forgatch, 2004), targets of the parent management training component. Within our developmental model, negative social interactions with peers and problematic family interaction are hypothesized to be key predictors of concurrent problem behaviors (Reid & Eddy, 2002), and the intervention was found to decrease the likelihood of problems with peers during the following grade (Reid et al., 1999), as well as decrease the likelihood of patterned alcohol use and contact with police during early adolescence (Eddy, Reid, Stoolmiller, & Fetrow, 2003). Prevention of deviance and problem behaviors as early as possible in development is hypothesized to be associated with reduced trajectories of deviance later in development (Reid & Eddy, 2002). Thus positive changes in the peer and family domains are hypothesized to be putative mediating mechanisms of any long-term benefits of the program, including impacts of substance initiation and growth.

There is some practical support relevant to our predictions about these mediators. In terms of peer interaction, in their initial Baltimore prevention studies, Kellam et al. (2008) found that during the emerging adulthood period, relative to controls, first and second grade youth assigned to a classroom-based Good Behavior Game intervention reported reduced rates of drug and alcohol abuse and less regular smoking. These results were replicated in a second cohort, and findings were more pronounced for men versus women (Kellam et al., 2008). In terms of family interaction, two year clinical treatment follow up data has demonstrated that effective parent-child problem solving is a cornerstone of the parent management training approaches for preventing trajectories of child deviance (Dishion & Kavanagh, 2003; Kazdin, 1996; Patterson, 2005). Patterson and Forgatch (1995) found that effective parent-child problem solving taught in parent training predicted two year follow up reductions in child arrests and out of home placements. Thus, for both theoretical and evidence-based reasons, we focus on indicators of youth interactions with peers and with parents as key mediators of long term outcomes.

Analytic Strategy

Controlling for two important covariates of youth substance use, parental substance use (and specifically, alcohol use; Duncan, Duncan, & Hops, 1998; Hops, Duncan, Duncan, & Stoolmiller, 1996) and deviant peer affiliation (Dishion, Nelson, Winter, & Bullock, 2004; Li, Duncan, & Hops, 2001), we will test intent to treat (ITT) effects of the LIFT program on adolescent substance use from grades 5 through grade 12. We expect that random assignment to the LIFT school based intervention will be associated with reductions in both substance use initiation and growth over time. For significant intervention effects, we will then conduct tests of mediation for prevention analyses (MacKinnon & Dwyer, 1993; Judd, Kenny, & McClelland, 2001). Requirements for mediation include a direct effect of the intervention on the putative mediators and a direct effect of the intervention on the distal child outcomes; this later effect is then rendered nonsignificant upon entering the mediators into the model. For the repeated measures continuous level substance use outcomes, we will conduct analyses using approaches for mediation using latent variable structural equation (LGM) growth models (Cheong, MacKinnon, & Khoo, 2003). As an additional requirement we will test significance of indirect effects using bootstrapped standard errors for the SEM path models (Preacher & Hayes, 2004; Shrout & Bolger, 2002). Hypotheses for time until substance use initiation will be specified with Cox survival models. Mediation analyses for survival models require the same steps above and are conceptually the same; however, Sobel tests for estimates of the indirect effects will be adjusted for binary outcomes (MacKinnon & Dwyer, 1993). Tein and MacKinnon (2003) have shown that the ratio of the indirect beta path product to its standard error is a comparable test for OLS regression estimates, a censored log-survival model, and a censored Cox proportional hazard model estimated here.

Methods

Design and Sample

During the late 1980's, police contacts due to juvenile delinquency were mapped in a moderate-sized metropolitan area in the U.S. Pacific Northwest. Neighborhoods with higher than the local median for police contacts were identified, and from 1991 to 1993, 12 randomly chosen public elementary schools within those neighborhoods were invited to participate. Schools were randomly assigned to either a "services as usual" control condition or the LIFT preventive intervention condition, and randomly assigned to either have the entire first grade (which included some combined first and second grade classes) or the entire fifth grade class (which included some combined fourth and fifth grade classes) be invited to participate. Of the 762 families with youth enrolled in the 12 study schools, 12% declined to participate, resulting in a sample of 671 families. Of those, 51% were female, and for 3%, only school data were collected. Eighty-five percent of the students were European American, 4% Asian American, 4% Latino American, 3% Native American, 1% African American, 2% other, and 1% did not report race or ethnicity. At the initial assessment, approximately 25% of the families were receiving some type of government financial assistance; 57% of youth were from two-biological-parent families, 22% were from single-parent families, and 20% from stepfamilies. Children and families were assessed three times during the intervention year, and then once per year in follow-up years. Assessment staff members were excluded from any discussions of the intervention, had offices separate from the interventionists, and were kept blind to the condition that specific participants were assigned. To date, no adverse events have occurred due to the intervention. Because of the developmental differences in substance use for several years following the intervention period in the first grade (i.e., almost no use by any youth during the initial follow-up period) and the fifth grade (i.e., initiation and growth in substance use by a significant number of youth during the initial follow-up period), this report focuses on outcomes for the fifth grade sample only ($N = 361$). Further, because of the variables of interest,

only those fifth graders who (a) participated fully in the baseline assessment (i.e., child, parents, and teachers participated) (n = 348) or (b) joined the study fully within the first two years of follow-up (n = 3), were included in the analyses. Additional details on the design and the sample are provided elsewhere (Reid et al., 1999; Eddy et al., 2003).

Intervention Conditions

LIFT—As noted above, the LIFT preventive intervention included multiple components, including parent management training, child social and problem solving skills training, the recess Good Behavior Game, as well as parent-teacher communication aids such as a weekly newsletter for parents and the “LIFT Line”, which was a dedicated phone line and answering machine within each intervention classroom. All youth and all families within the targeted grade were offered the intervention, and thus, the intervention was considered “universal” in nature (Mrazek & Haggerty, 1994). Over 90% of the content within each intervention component was delivered as planned. Participation in each intervention component was high, with the average youth attending 90% of social and problem solving skills sessions and associated recesses, and 93% of families receiving all parent training intervention content in some manner. While only 28% of parents attended all six group sessions, 51% received all six sessions in person (i.e., group and/or individual sessions). The primary source of parenting information (i.e., four or more sessions via the same source) was 58% group, 15% mail, 9% none, and 6% individual. In between sessions, families received an average of seven phone calls from their parent interventionist. Parents were compensated \$100 for the participation time for assessments in the first year of the study, and \$75 for each follow-up assessment. Teachers were compensated \$100 and provided a half-day substitute teacher during the first year of the study, and \$10 per participant for follow-up assessments. Intervention schools received no additional reimbursement above the services and resources provided through LIFT.

Control—Control participants received no preventive intervention from the research staff but had access to all regular school-based preventive and intervention services (e.g., counseling and special education). Control participants were compensated at the same rate as intervention families for their time to complete assessments. Control schools were also compensated \$2,000 in unrestricted funds during the first year of the study (i.e., the year the intervention took place).

Measures

Substance Use Outcomes

Participating youth completed a substance use questionnaire from grades 5 through grade 12 (or in the years when a youth would have been in these grades if he or she had dropped out of school). The outcome measures included a simple frequency count of any tobacco use (either through smoking or chewing), any alcohol use (e.g., beer, wine, liquor), and any illicit drug use (e.g., marijuana, amphetamines, heroine, cocaine). Use of each substance was rated in response to “How many times have you used in the last six months?” The following scale was used: “1” (once or twice), “2” (once every 2 to 3 months), “3” (once a month), “4” (every 2 to 3 weeks), “5” (once a week), “6” (2 to 3 times a week), “7” (once a day), and “8” (2 to 3 times a day or more).

Proximal Variables Targeted in the Intervention

Physical aggression on the playground was measured at baseline with repeated live observations conducted on the playground by professional observers (see Stoolmiller, Eddy, & Reid, 2000). Each youth participant was observed during the regularly scheduled recess period for 10 minutes on three separate days over a period of about three weeks. The Interpersonal Process Code (IPC; Rusby, Estes, & Dishion, 1991) was used to code physical aggression including hitting with hand, hitting with an object, pinching, ear flicking, kicking,

grabbing, restraining, spitting, or shoving. Observations were randomly selected (10%) for interobserver reliability. Percent agreement ranged from 77 to 81% and Cohen's kappa ranged from 0.65 to 0.70.

Family problem-solving outcomes were assessed through direct observation of parent-child interactions in our laboratory. Parents and children were asked to choose topics from an issues checklist of common parent-child conflicts, and were asked to attempt to resolve the "hottest" rated issues. The problem solving measure was developed to evaluate overall quality of the outcomes of the discussions. Two interactions were videotaped at two time points (in fall before the intervention and in spring following intervention): a 10-minute interaction between mother and the youth, and a 10-minute interaction between one or both parents and the youth. Family problem solving scores were globally rated domains of family interaction scored by trained observers *after* scoring family interaction tasks for the presence of discrete behaviors and affect. Observational coder training required from 16 to 20 weeks at 20 hours per week. The reliability criterion at the conclusion of training required scoring two tapes in a row with 75% event-by-event agreement and a Cohen's kappa of at least 0.65. Once considered "reliable", coders participated in weekly retraining meetings to maintain reliability and to prevent coder drift. The tape coding procedure required coders to view an interaction from beginning to end and to familiarize themselves with the interactants, topics under discussion, and general behaviors displayed. Difficult sections of the tapes were viewed up to three times to aid coders in scoring. Approximately 15% of the interactions were randomly selected for blind reliability checks. The problem solving outcome score was based on nine Likert-type items scored from "1" to "4" by observers rating various aspects of the outcome of each discussion (e.g., solution quality, extent of resolution, likelihood of follow through, apparent satisfaction, presence of a clear plan). Cronbach's α was 0.85 and 0.89 at pre and post intervention.

Control Variables

Group assignment was coded "1" for control group and "2" for intervention. *Sex* of the child was coded "1" for male and "2" for female. For the survival analyses, *parental drinking* was the mean score of mother and father drinking frequency from a parent questionnaire administered at baseline. Parents reported frequency of alcohol use on a scale of "1" (not at all) to "6" (at least once daily). For all of the longitudinal models, *deviant peer association* was entered in the models as a time-varying covariate of substance use. Deviant peer association was a composite score of several Likert-type items aggregated across mother, father, and teacher reports. We excluded child reports so that there would be no method overlap with the child reported substance use outcome. Teachers rated four items, "associates with kids who misbehave", "associates with kids who steal/vandalize", "associates with kids who get into fights", and "hangs out with kids who get into trouble." Parents rated four items, "how often child plays with kids who get into trouble", "how often child hangs out with kids who get into trouble", "how often child hangs out with kids who steal", "how often child hangs out with kids who set fires". All items were rescaled to range from 0 to 1 and averaged to form a composite score. Principal components factor analyses produced a one-factor solution for each year of the study. Cronbach's alphas ranged from .62 to .79, with the lowest alphas for scores in the fifth grade year.

Results

Student Clustering

The sample included 351 students nested within 17 different classrooms within 6 randomized schools. Prior analyses of LIFT data from fifth through eighth grade found nonsignificant intraclass correlations (ICCs) for change in outcomes of teacher rated peer-preferred behaviors, mother aversive behaviors observed in the laboratory, and fall to spring physical aggression

on the playground (see Reid et al., 1999; Eddy et al., 2003). For substance use growth slopes, we computed ICCs using 3 level hierarchical linear growth procedures in HLM6 (Raudenbush, Bryk, Cheong, & Congdon, 2004). The first model nested time within students and students within classrooms. The second model nested time within students and students within schools. The ICC or proportion of variance accounted for at classrooms is expressed as $\rho = [(\tau_{000})/(\tau_{000} + \tau_{00} + \sigma^2)]$. Where τ_{000} denotes the mean variance across 17 classrooms and τ_{00} represents student variation, and σ^2 denotes total predicted and error variance for Level 1 repeated measures. ICCs were negligible, coefficients for between schools ($n = 6$) ranged from .00 to .01 for average levels, linear and accelerated growth, from .00 to .01 for classrooms ($n = 17$). Based on these findings, we tested hypotheses using latent growth curve (LGC) analysis, which enabled us to more readily evaluate mediation hypotheses using path modeling.

Missing data

Across the observation period, 70% of all families participated in all waves of assessment (baseline to 12th grade), an additional 10% missed only one assessment, and 7% missed only two. For follow-up years, missing data averaged 13.5% and ranged from 3% to 18% in any given year (see Table 1). In a typical case, a participant missed one or more assessments and then returned to be interviewed at a later point. We evaluated missingness using an EM algorithm to compare estimated means and variances of partial and complete data cases. Missing at random (MAR) allows the probabilities of missingness to depend on observed data but not on missing data. A special case of MAR, called missing completely at random (MCAR) occurs when the missing data distribution does not depend on the observed data as well and therefore no bias is introduced due to missing data (Schafer & Graham, 2002). The overall covariance matrix was not MCAR due to increasing missingness over time for reported substance use [MCAR $\chi^2 = 483.37_{(406)}$, $p = .01$]. However, the longitudinal predictors were [MCAR $\chi^2 = 139.34_{(123)}$, $p = .15$]. We therefore estimated growth models using full information maximum likelihood (FIML) focusing on all available data (Arbuckle, 1997). FIML estimation is optimal even when data are not MAR producing less bias than listwise or pairwise deletion (Muthen, Kaplan, & Hollis, 1987).

Substance Use Initiation Model

For the first step of the mediational hypotheses we tested for direct effects of the intervention on substance use initiation using a set of hierarchical Cox survival models. We entered group assignment and the baseline covariates followed by change in the hypothesized mediators entered as auto-regressive parameters. Deviant peer association was modeled as a time-varying covariate. Results are shown in Table 2. Controlling for parental drinking and deviant peer association, the intervention was associated with reduced risk in initiation of tobacco use ($\beta = -.10$, $p < .01$) and alcohol use ($\beta = -.07$, $p < .05$) and had a marginal effect on initiation of illicit drug use ($\beta = -.09$, $p < .10$). These effects also translated to odds ratios of a 10%, 7%, and 9% reduction in risk respectively for tobacco use, alcohol use and illicit drug use for the LIFT intervention youth relative to the controls. Upon entering the hypothesized mediators, increases in problem solving were associated with less likelihood of starting to use tobacco and illicit drugs but there was no evidence of full mediation effects. Deviant peer association was the strongest predictor of initiation risk contributing roughly 3 times the likelihood of starting to use tobacco and starting to use illicit drugs.

Given no evidence of full mediation for tobacco, alcohol, or illicit drug use initiation, we next tested for significant indirect effects of the LIFT intervention on initiation of tobacco use because it was the outcome that had a significant effect from one of the hypothesized mediators, change in problem solving from fall to spring. A Sobel test on the Cox parameters of the indirect pathway was conducted adjusting for the dependent variable. Specifically, parameter estimates from the change in problem solving mediator to the outcome was multiplied by the standard

deviation of the mediator and dividing by the standard deviation of the outcome (MacKinnon & Dwyer, 1993). The indirect effect of the LIFT intervention predicting time until use of tobacco through change in problem solving obtained a critical ratio of -2.29 , which is statistically significant ($p = .02$).

Predicting Growth in Substance Use

We next focused on frequency or rate of growth over time by estimating an unconditional model of factor variance and means, controlling for deviant peer association as a time-varying covariate. The means and standard deviations for the observed substance use measures and the estimated latent variable growth means and variances are presented in Table 3. Inspection of the means indicated each outcome showed a rapid increase in growth from grades 5 through grade 12 for the whole sample.

For estimating growth, latent factors were specified as average levels, linear, and accelerated growth (i.e., quadratic) using fixed factor loading for time weighting, also known as chronometric time weighting (for a discussion of factor time weights, see Biesanz, Deeb-Sossa, Papadakis, Bollen, & Curran, 2004). A simple 3-wave parameterization would be 1, 1, 1 for average intercept; $-1, 0, 1$ for linear slope; and $1, -2, 1$ for quadratic slope. For the present analyses, the 6-wave orthogonal polynomial time weights for average level intercepts, linear and quadratic slopes were obtained from a repeated measures polynomial transformation of time specified as grades 5, 6, 7, 8, 10, and 12.

Examining the factor variances, the results in Table 3 indicated that each growth factor for the respective substance use outcomes had significant variance, meaning there was significant individual variation in average levels over time and individual differences in the rates of linear increases and accelerated growth. The factor means also indicated that the entire sample exhibited significant mean increases in tobacco, alcohol, and illicit drug use from middle school entry through high school. In addition, tobacco and illicit drug use exhibited significant accelerated growth. Of the three outcomes, alcohol use was the most common over time and demonstrated the highest level of increase.

Extending the unconditional model, we next tested the mediational prevention hypothesis by estimating the ITT main effect for group assignment, sex of the child and the interaction term for intervention by sex of child using effects coding. Because there was individual variation in growth patterns, we specified linear and accelerated growth as dependent outcomes. We also controlled for the contribution of parents' drinking at baseline. Results are presented in Figure 1 in the form of standardized beta paths with deviant peer association entered as a time varying covariate. Only significant prediction paths are shown for clarity. The fixed factor time loadings are represented as the block arrows from the growth factors to the repeated measures.

The intervention had a significant beneficial impact on overall average use for each substance use outcome over time ($\beta = -.10, -.15, \text{ and } -.12$, respectively for tobacco, alcohol, and illicit drug use). Left to right on each path, tobacco use estimates are shown first, with alcohol use estimates in parentheses, and illicit drug use estimates enclosed in square brackets. Girls exhibited higher rates of tobacco and illicit drug use relative to boys in the sample. At the same time, the LIFT program was also associated with greater benefits for girls in terms of their growth rates in tobacco use ($\beta = -.14, p < .001$) and illicit drug use ($\beta = -.14, p < .05$). The same intervention by gender pattern was obtained for accelerated growth in tobacco use and drug use ($\beta = -.13 \text{ and } -.11$, respectively, $p < .05$). Parents' drinking was a significant risk factor for average levels over time for each outcome and parental drinking predicted linear growth in tobacco use and drug use rates. Effect sizes were estimated with partial η^2 using repeated measures multivariate analysis of variance. The average level effects and the group \times time \times

sex effects on growth in Figure 1 produced η^2 values of .02. Cohen (1988) characterizes η^2 of .01 as a small effect and .06 as a medium effect.

In the next step, mediation effects for each outcome were evaluated. Playground aggression and problem solving factors were entered as auto-regressive change because prior effects were obtained across the first two time points only. Because these models had substantially greater complexity, only significant paths are displayed, and redundant information on the deviant peer association covariates is not displayed.

Results are shown in Figures 2 through 4 starting with tobacco use over time (Figure 2). Results for tobacco use indicated that the group by gender effect on growth rates was not mediated by intervention components; however, the intervention impact on average levels of tobacco use was mediated by increases in effective problem solving. The LIFT program was associated with reductions in playground aggression at the spring follow up ($\beta = -.21, p < .05$) and the intervention was associated with increases in effective family problem solving ($\beta = .12, p < .05$). In turn, increases in playground aggression predicted linear ($\beta = .25, p < .05$) and accelerated growth ($\beta = .30, p < .01$) in tobacco use. Accounting for the intervention path to average levels of tobacco use, increases in effective problem solving predicted reductions in average tobacco use as well as linear growth in use.

Results for alcohol use are shown in Figure 3. The direct intervention path to average levels remained significant in the model. There was an indirect path of the intervention through increases in problem solving to growth in alcohol use. That is, increases in effective problem solving were associated with reductions in alcohol use growth ($\beta = -.14, p < .01$). Intervention impact on playground aggression was not associated with alcohol use growth. As shown in Figure 4, change in aggression was associated with accelerated growth in illicit drugs ($\beta = .33, p < .01$). However, problem solving effectiveness was not associated with illicit drug use.

Finally, we conducted a test of the indirect effects of the intervention on the substance use outcomes by using bootstrap sampling (Preacher & Hayes, 2004) to estimate standard errors for the indirect effects and their bias-corrected confidence intervals. In order, the LIFT intervention had significant indirect effect on reductions in growth in tobacco use ($p < .01$) and accelerated tobacco use ($p < .05$); a marginal indirect effect on growth in alcohol use ($p < .06$), and a significant indirect effect on accelerated illicit drug use ($p < .03$).

Discussion

While there are increasing numbers of longitudinal randomized prevention trials demonstrating the efficacy of prevention programs within various populations, there continues to be a critical need to understand how programs work, and most notably which potential mediating mechanisms explain long-term effects (DeGarmo, Patterson, & Forgatch, 2004; Tein, Sandler, MacKinnon, & Wolchik, 2004). In this report, we examined theoretically specified mediators of the LIFT intervention on youth substance use initiation and growth across adolescence. The goal was to test aspects of a developmental model hypothesizing short-term mechanisms accounting for growth in long-term substance use. Hypothesized mediators were two social interaction outcomes that had been significantly impacted by the intervention early in the randomized trial (Reid et al., 1999): youth behavior with peers (i.e., observed playground aggressive behavior) and parent-youth interaction (i.e., observed problem solving outcomes).

Controlling for deviant peer association, the present analyses indicated that the LIFT intervention had a significant effect on reducing the rate of growth in use of tobacco and illicit drugs, particularly for girls, and had an overall impact on overall average levels of use for tobacco, alcohol, and illicit drugs for all youth in the LIFT program. The intervention was also associated with a 10% reduced risk in starting to smoke or chew tobacco and a 9% reduced

risk in starting to drink alcohol. Across the board, deviant peer association was the strongest risk factor for substance use initiation. Taken together, the LIFT prevention program did help reduce the risk of starting substance use but primarily slowed down the rate at which use increased across adolescence. Further, the intervention had beneficial impact on reduced levels of use through increased effective family problem solving and with reductions in playground aggression during the fifth grade year.

In the present study girls compared to boys were at greater risk for increases in linear growth and accelerated growth in tobacco use and illicit drug use over time but not drinking frequency. We also examined main effects of the intent to treat intervention and also tested the effectiveness for the intervention on boy versus girl contrasts because there is evidence to suggest that girls and boys differ in substance use across adolescence. Our findings indicate that the LIFT intervention operated in a preventive fashion to reduce the growth rates for girls compared to their control group counterparts. However, the variables considered in the present tests of mediation did not account for the beneficial preventive effect for girls.

Contrary to findings in one of the Baltimore prevention trials (Kellam et al., 2008), effects of the intervention or playground aggression effects were not more pronounced for boys compared to girls. A possible explanation may be a function of growth rates for girls peaking sooner than boys during adolescence. The present LIFT data was up to grade 12, typically 17 to 18 years of age. The Baltimore trial outcomes were for young adults aged 19 to 21. Similarly, national data reported by Romer and Hennessy (2007) showed that girls peaked sooner than boys in areas of sensation seeking and peer reinforcement for risky behaviors which predicted growth in tobacco, marijuana, and alcohol between the ages of 14 and 22 years. National data show that in the last decade, gender differences in the initiation and frequency of alcohol, tobacco, and marijuana use are converging between girls and boys (Wallace et al., 2003). However, most studies continue to report higher levels of substance use for boys across adolescence (Romer & Hennessy, 2007). Longer term follow up is needed to examine whether gender differences continue across young adulthood.

The LIFT gender effect has important implications. As has been found elsewhere, there is an indication in these data that family predictors, home environment, and early child behavior are even more important in the prevention of substance use for girls than for boys (e.g., Hops, Davis, & Lewin, 1999). Females have greater health consequences associated with tobacco use, and in particular smoking, and have a harder time quitting compared to males (Fiore et al., 2000). In 2001, the Youth Risk Behavior Survey by the CDC indicated that about 11% of eighth graders and 30% of eleventh graders in the U.S. smoked tobacco (Oregon Department of Human Services [ODHS], 2003). Currently, smoking prevalence is in essence largely a function of both *increases in smoking initiation* among young adults and a concomitant *failure to quit* and maintain abstinence among established smokers (Niaura & Abrams, 2002). The economic and health consequences for such use are severe. In the state of Oregon, and within Lane County where this study was conducted, tobacco was responsible for one out of four deaths in 2001 (ODHS, 2003). The estimated economic costs in direct health care and lost productivity due to disability and premature death in that year was estimated at \$1,800,000,000 for the state and \$147,800,000 for Lane County (ODHS, 2003). The importance of preventing initiation is further underscored by the odds of lifetime dependence decreasing by 14% with each additional year of delayed initiation (Trudeau, Spoth, Goldberg-Lillehoj, Redmond, & Wickrama, 2003). Clearly, primary prevention of tobacco use is extremely important.

In terms of specific intervention targets, our data support the association between family centered risk factors and deviant peer association as predictors of substance use growth. Parental behaviors, family contexts, and peer contexts are all implicated as worthy targets for specific intervention (Andrews, Hops, & Duncan, 1997; Dishion, Kavanagh, Schneiger,

Nelson, & Kaufman, 2002). Accumulating evidence suggests that multimodal efforts that include families, schools, agencies, and peers are more promising than single component efforts (Dishion et al., 2002; Dishion & Kavanagh, 2003; Spoth, Redmond, & Shin, 2001). Evidence is also building suggesting that early primary prevention efforts are important in terms of reducing impact of deviant peers. However, compared to studies reporting effects of deviant peers, there are relatively few prevention studies that examine intervention on deviant peer affiliation (Lacourse, Nagin, Tremblay, Vitaro, & Claes, 2003).

Parent's drinking was an important predictor. Parent influence on youth substance use goes beyond modeling and can resemble deviant peer influence. A recent study by the Substance Abuse and Mental Health Services Administration found that 650,000 underage drinkers in the past month were given alcohol by their parents or guardians and 40% of the nation's 10.8 million underage drinkers were provided free alcohol by adults age 21 or older (Pemberton, Colliver, Robbins, & Gfroerer, 2008).

Children with extreme behavior problems tend to live in a social world that provides a rich array of reinforcement for antisocial behaviors and little reinforcement for positive behaviors. In targeting an entire school and entire classrooms within schools, rather than targeting individual children, the density of reinforcement that an individual child received for positive behaviors had the potential to increase to a much greater degree. We hypothesize that interventions designed to increase positive reinforcement, such as the Good Behavior Game or child problem-solving and social skills training, probably have their most powerful effects by changing a given social milieu, which over time effects change on individuals, rather than vice versa (Eddy et al., 2000).

We note several limitations. The effect sizes were small, and the specific mediating mechanisms examined only account for a portion of the variation in outcomes. It is possible that given the size of the effects, the study was underpowered to detect the impact of the short term mediators in this sample of fifth graders. Although the sample was representative of at-risk schools and neighborhoods in the community within which it was conducted, the data is limited in generalizability to more diverse racial and ethnic populations. The scope of the data could not address how interventions might inform key areas in many adolescent substance use prevention programs, such as cognitive processes regarding abstinence and intention to use, and behavioral processes and mechanisms underlying peer refusal skills (Orlando, Ellickson, McCaffrey, & Longshore, 2005; Spoth, Redmond, Trudeau, & Shin, 1999; Trudeau et al., 2003). The role of deviant peer association trajectories is no doubt a more complicated and mutually influential process. Data were not available for parental substance use as a time-varying component, nor were there data available on types of parental substance use. There are indications that this might be important, with several studies finding that time varying parental type of use predicts matched type of use for adolescents (Andrews et al., 1997; Hops et al., 1996). Despite these limitations, a relatively low cost intervention that lasted for only a few months during late elementary school led to significant direct and indirect effects not only on targeted mediators, but on levels of youth substance use and growth in youth substance use across adolescence. Given the high individual, family, and societal costs related to not preventing substance use, these findings are significant, and suggest the importance of additional long term investigations not only of outcomes due to multi-modal preventive interventions, but also the short and long-term mediators of those outcomes.

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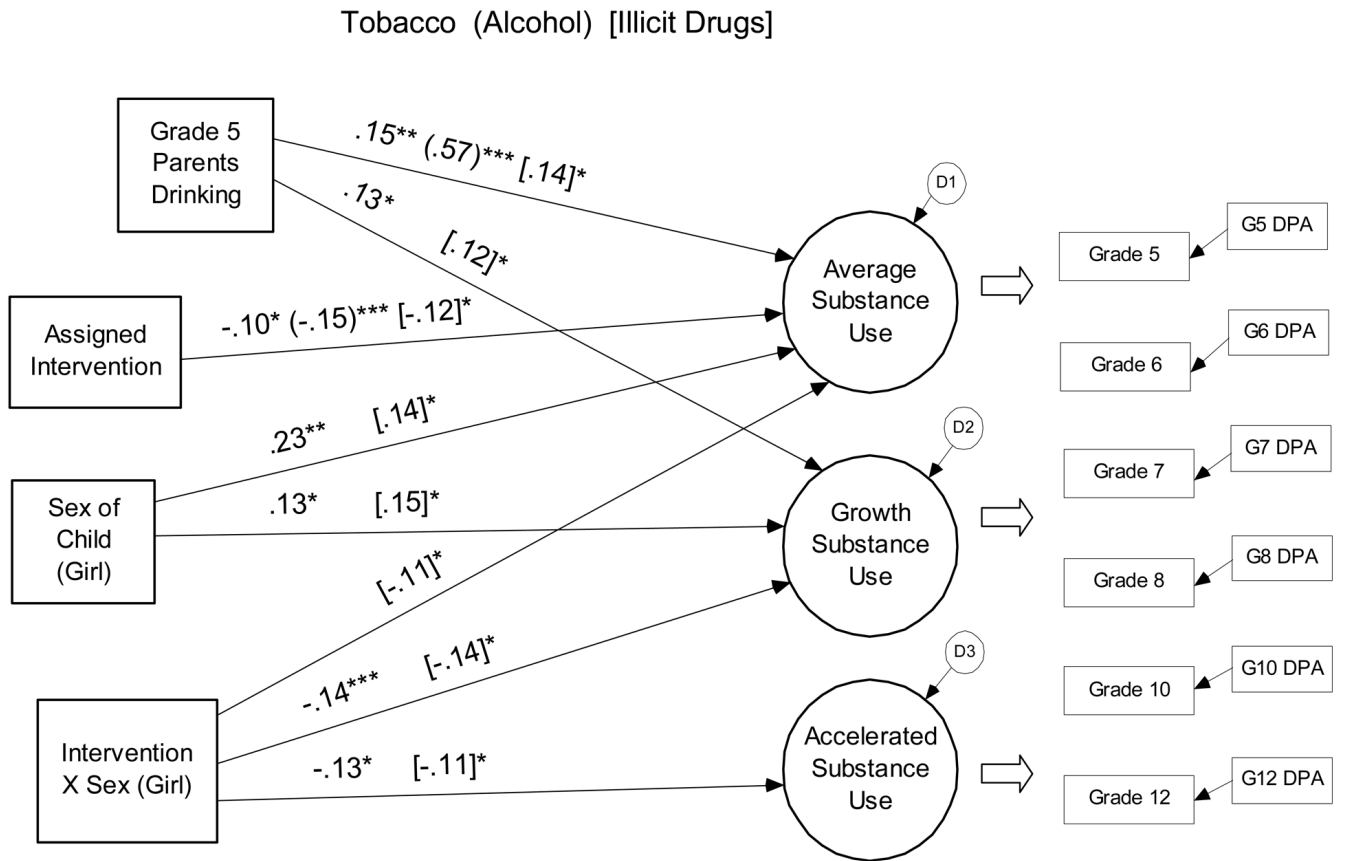


Figure 1. LIFT Preventive Intervention Effects on Average Levels, Linear Growth, and Accelerated Growth in Substance Use from grades 5 through 12. Paths are standardized coefficients for Tobacco, (Alcohol), and [Illicit Drugs]. DPA = Deviant Peer Association.

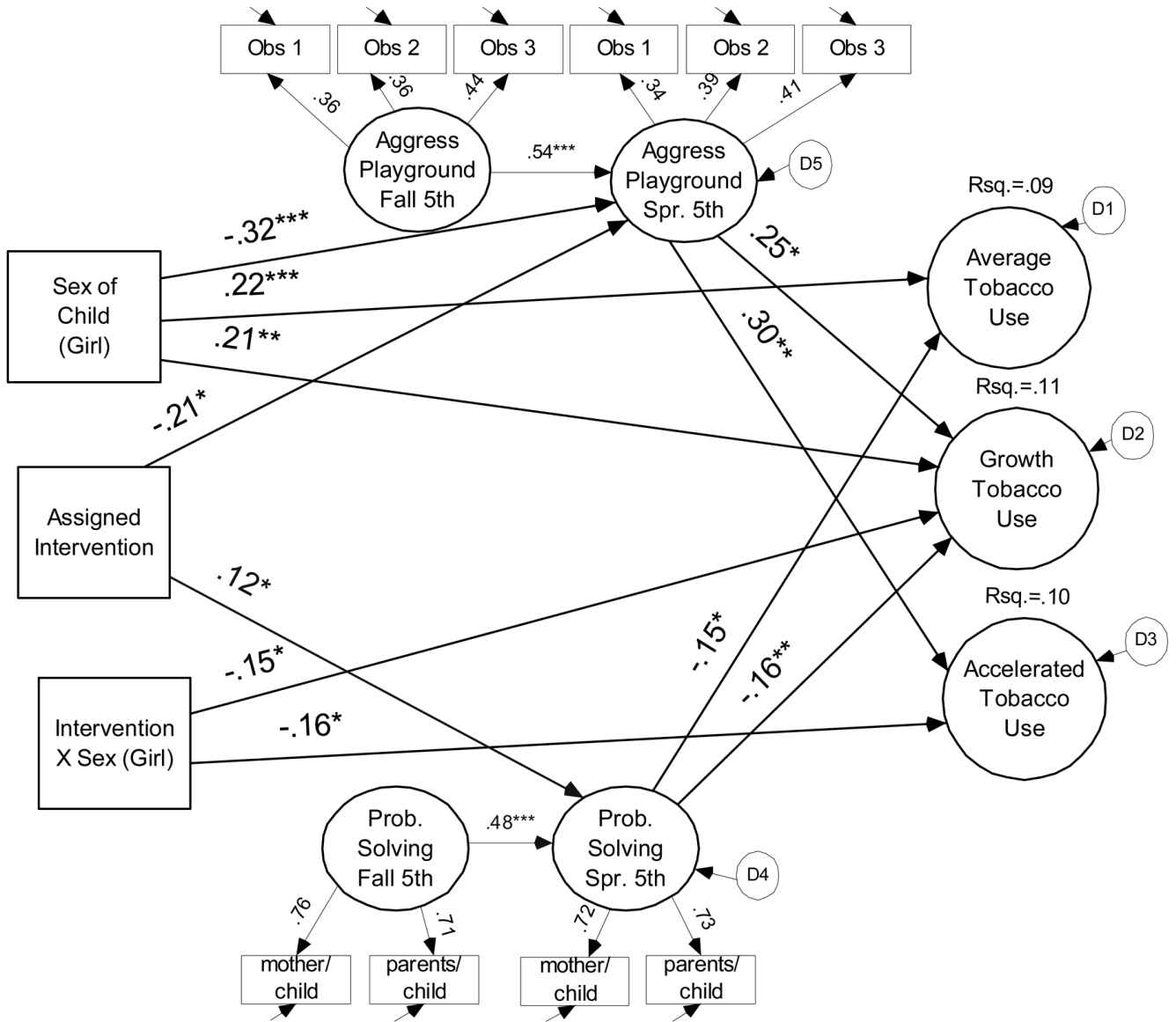


Figure 2. Test of Change in Playground Aggression and Family Problem Solving as Mediators of Intervention Effects on Growth in Tobacco Use. Paths are standardized coefficients. Spr. = spring; $\chi^2(248) = 618.14, p = .00, CFI = .80, \chi^2/df = 2.49, RMSEA = .06, *p < .05, **p < .01, ***p < .001.$

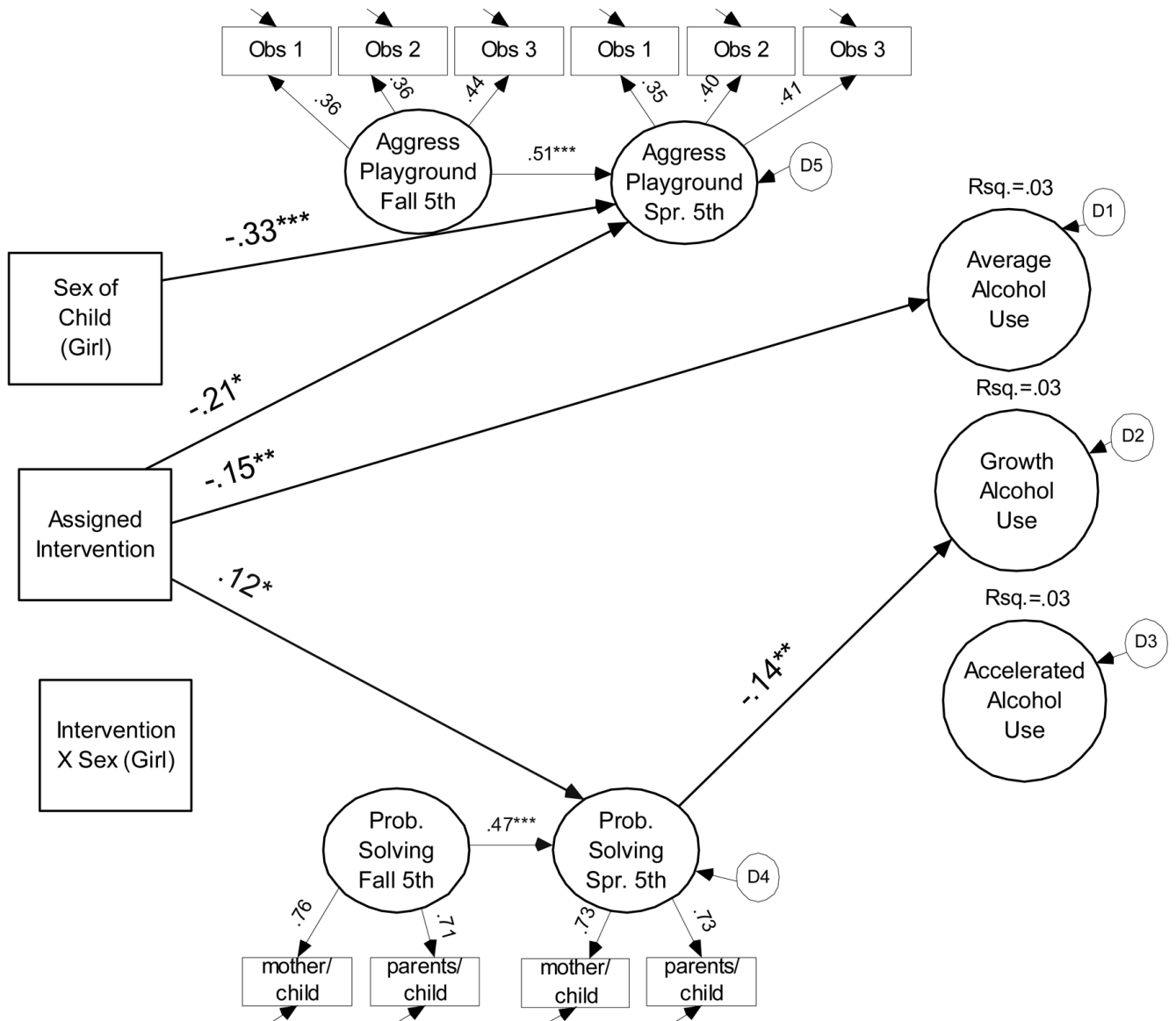


Figure 3. Test of Change in Playground Aggression and Family Problem Solving as Mediators of Intervention Effects on Growth in Alcohol Use. Paths are standardized coefficients. Spr. = spring; $\chi^2_{(248)} = 618.14$, $p = .00$, CFI = .80, $\chi^2/df = 2.49$, RMSEA = .06, $*p < .05$, $**p < .01$, $***p < .001$.

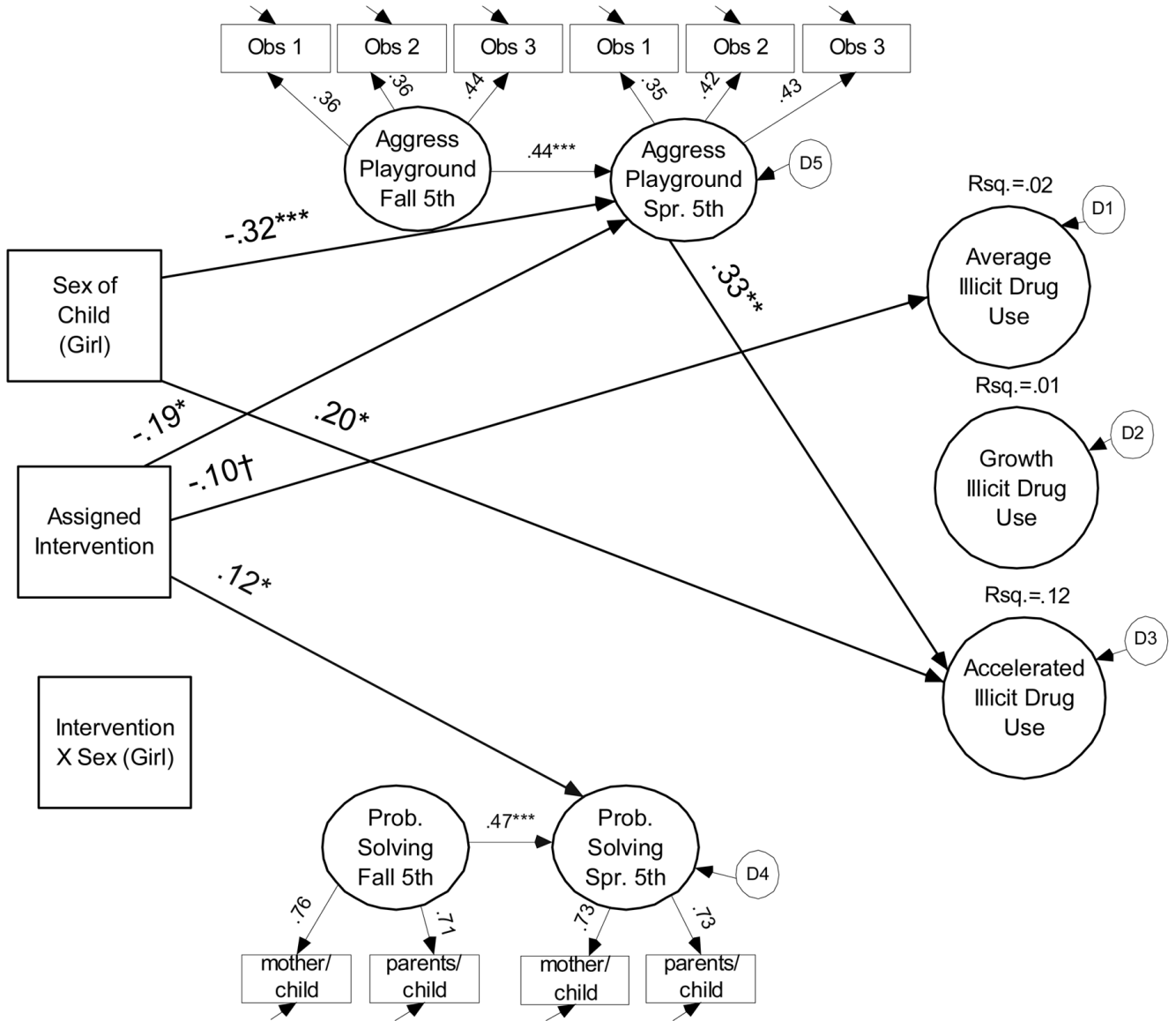


Figure 4. Test of Change in Playground Aggression and Family Problem Solving as Mediators of Intervention Effects on Growth in Illicit Drug Use. Paths are standardized coefficients. Spr. = spring; $\chi^2_{(248)} = 595.47, p = .00, CFI = .80, \chi^2/df = 2.40, RMSEA = .06, \dagger p < .10, *p < .05, **p < .01, ***p < .001.$

Table 1
Missing data over time for 361 LIFT Fifth Graders Randomized at Baseline

Grade	Baseline Pre-intervention					Post-intervention						
	5	6	7	8	10	12	5	6	7	8	10	12
Randomized Completed	361											
Interview Data	348	310	296	288	294	292	342	310	296	288	294	292
Missing	3	41	55	63	57	59	9	41	55	63	57	59

Table 2
Survival Analyses of Substance Use Initiation from Grade 5 to Grade 12 with Deviant Peer Association as a Time-varying Covariate

	Tobacco		Alcohol		Illicit Drugs	
	β	β	β	β	β	β
Assigned Intervention	-.10**	-.11*	-.07*	-.07*	-.09 [†]	-.09 [†]
Sex of Child	.01	-.01	-.04	-.05	-.11 [†]	-.14*
Intervention \times Sex	.03	.04	.03	.04	.03	.05
Parents' Drinking	.03	.04	.14***	.14***	.13	.12**
Deviant Peer Assoc.	2.89***	2.93***	1.29***	1.32***	2.96***	3.03***
School Aggression T1	-.04	-.03	-.01	-.01	.01	.02
Problem Solving T1	-.27***	-.21**	-.18**	-.17**	-.26**	-.21*
School Aggression T2		-.03		-.03		-.13
Problem Solving T2		-.19**		-.03		-.17*
$\Delta LR \chi^2$	180.79***	6.69*	89.24***	1.31	142.75***	8.78**

Δ = Change;

*** $p < .001$;

** $p < .01$;

* $p < .05$;

[†] $p < .10$

Table 3
Observed Means and Standard Deviations for Substance Use and Estimated Growth Factor Means and Variances Controlling for Time-varying Deviant Peer Association

Observed Scores	Tobacco		Alcohol		Illicit Drugs	
	M	SD	M	SD	M	SD
log Grade 5	.05	.18	.26	.39	.01	.09
log Grade 6	.10	.35	.33	.49	.03	.18
log Grade 7	.20	.48	.33	.50	.07	.26
log Grade 8	.35	.63	.46	.61	.17	.40
log Grade 10	.61	.83	.83	.74	.40	.62
log Grade 12	.68	.92	.87	.57	.63	.75
<u>Latent Growth Factors</u>	M	VAR	M	VAR	M	VAR
Average Growth	.19***	.51***	.90***	.73***	.14**	.48***
Linear Growth	.28***	.47***	.42***	.27***	.29***	.26***
Accelerated Growth	.09*	.17***	.00	.11***	.13***	.11***
<u>Latent Growth Model</u>						
X ² ₍₄₂₎		110.49		130.43		137.32
P		.00		.00		.00
CFI		.95		.93		.92
RMSEA		.06		.07		.07
χ ² Ratio (χ ² /df)		2.63		3.10		3.26

* Note: $p < .05$;

** $p < .01$;

*** $p < .001$