Assessing a Public Health Approach to Delay Onset and Progression of Adolescent Substance Use: Latent Transition and Log-Linear Analyses of Longitudinal Family Preventive Intervention Outcomes

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This study examined the effects of the Iowa Strengthening Families Program (ISFP) and the Preparing for the Drug-Free Years program (PDFY) on young adolescent transitions from nonuse of substances to initiation and progression of substance use. Analyses incorporated 3 waves of data collected over a 2.5-year period from 329 rural young adolescents. Outcomes were analyzed by using log-linear models that incorporated substance use status frequencies derived from latent transition analyses. Effects on delayed substance use initiation were shown for both the ISFP and the PDFY at a 2-year follow-up. Also at this follow-up, the PDFY showed effects on delayed progression of use among those previously reporting initiation.

Literature on the epidemiology of adolescent substance use has documented the extent of the problem and its deleterious consequences (e.g., Carnegie Council on Adolescent Development, 1995; Center for Substance Abuse Prevention, 1997; Dryfoos, 1997; Johnston, Bachman, & O'Malley, 1997; Murray & Perry, 1985). The literature also recommends a public health approach to prevalent adolescent problem behaviors such as substance abuse (Albee & Gullotta, 1997; Carnegie Council on Adolescent Development, 1995; Center for Substance Abuse Prevention, 1997; Dryfoos, 1997). This public health approach includes preventive interventions directed toward general populations that aim to delay early initiation of substance use or to prevent progression to more problematic use once initiation has occurred.

Empirically supported preventive interventions for general populations are clearly needed. In addition to the prevalence of adolescent substance abuse problems, another indication of the need is research demonstrating that early onset of substance use (e.g., prior to age 15) predicts substance-related problems in adolescence and adulthood (Fleming, Kellam, & Brown, 1982; Grant & Dawson, 1997; Hawkins, Catalano, & Miller, 1992; Kandel & Yamaguchi, 1993; Robins & Pryzbeck, 1985). Although a large number of preventive interventions for general populations—also known as universal interventions—have been developed, they are rarely evaluated (e.g., Center for Substance Abuse Prevention, 1997; Mrazek & Haggerty, 1994; Sploth, 1997, 1999; Sploth, Redmond, & Shin, 1998). Thus, it is critically important to evaluate the effectiveness of universal interventions designed to delay the onset and progression of substance use.

The purpose of this article is to address the gap in the research base on general-population interventions designed to delay substance initiation and progression through the examination of two universal, family-focused preventive interventions: the five-session Preparing for the Drug-Free Years program (PDFY) and the seven-session Iowa Strengthening Families Program (ISFP).

Prior PDFY and ISFP outcome evaluations have focused on short-term parenting or parent–child interactional outcomes (Kosterman, Hawkins, Sploth, Haggerty, & Zhu, 1997; Sploth, Redmond, Haggerty, & Ward, 1995; Sploth et al., 1998) or on mediational models of short-term family processes influencing short-term young adolescent outcomes, including alcohol refusal skills (e.g., Sploth, Yoo, Kahn, & Redmond, 1996). This article expands on previous short-term outcome modeling evaluations by examining direct intervention effects on longer term initiation and progression of young adolescent substance use. A recent report evaluated longer term intervention effects but addressed only ISFP intervention–control differences on alcohol initiation outcomes on the basis of observed frequencies (Sploth, Redmond, & Lepper, 1999). The present article extends this work by using a latent status approach to examine intervention versus control transition probabilities concerning progression (a) from nonuse of substances to initial use of alcohol or tobacco and (b) from initial use to more advanced use over the course of a 2-year follow-up period.

Although both of the tested interventions are of modest intensity, they have several features consistent with the expectation that they would be effective in delaying the onset and progression of young adolescent substance use (see Hawkins et al., 1992; National Institute on Drug Abuse [NIDA], 1997). The PDFY and the ISFP interventions are both theory based, designed to address risk...
and protective factors predicting young adolescent and adolescent substance use (see Catalano & Hawkins, 1996, and Catalano, Kosterman, Hawkins, Newcomb, & Abbott, 1996, for the theoretical and empirical bases of the PDFFY and DeMarsh & Kumpfer, 1986, and Kumpfer, Molgaard, & Spoth, 1996, for the same regarding the ISFP). For example, both are designed to enhance the protective factor of parent–child affective quality. Prior mediational model tests have shown that the affective quality of the parent–child relationship positively influences young adolescent inclination to use substances (Redmond, Spoth, & Shin, 1998; Spoth, Redmond, Hockaday, & Yoo, 1996). In addition, both interventions train participants in skills that positively affect risk and protective factors, using research-based interactive skills training techniques (e.g., modeling, rehearsal, feedback, and home practice). For example, these interventions engage parents or guardians and children in interactive peer referral training. Third, a number of methods were used to ensure high-fidelity implementation of the interventions’ protection enhancement and risk-reduction components, balanced with sensitivity to participant preferences. For instance, the programs were manualized, with essential content on videotapes. Also, a number of consumer-research studies on family engagement factors were conducted to guide refinement of implementation strategies (e.g., preferred scheduling options; see Spoth & Redmond, 1993a, 1993b).

Perhaps the most important reason for the expectation that the interventions could delay onset and progression of substance use is the timing of the delivery of the interventions at a critical period of developmental transition (see Cicchetti & Toth, 1996; Conduct Disorder Prevention Research Group, 1992; Hawkins et al., 1992; NIDA, 1997). The intent of the interventions was to address young adolescent risk and protective factors originating in the family—particularly those concerning parenting competencies, parent–child interactions, and youth social–interactional competencies—during the critical transitional stage of young adolescence (see Spoth et al., 1995, 1998, for reports supporting significant intervention effects on parenting competencies). It was expected that addressing these risk and protective factors, and thereby equipping parents and adolescents with important skills, would enable the targeted youth to meet normative demands and challenges in a more adaptive fashion. To maximize their impact, we offered the interventions at a point (first semester, sixth grade) when youth in the sample were beginning to experiment with substance use but before they progressed to more frequent and more varied substance use (Iowa Department of Education, 1997). The expectation was that this timing would positively alter the youths’ developmental trajectories of substance use by increasing their ability to meet challenges in the transition to adolescence, particularly increased substance use opportunities and peer encouragement of use.

In conclusion, the first hypothesis examined in this study concerns the primary prevention goal of the interventions examined (see Graham, Collins, Wugalter, Chung, & Hansen, 1991). That is, it was hypothesized that adolescents in the family interventions would show delayed initiation of the substance use process relative to adolescents in the control group. The second hypothesis concerned a secondary prevention goal (see Graham et al., 1991). It was hypothesized that adolescents in the family interventions would demonstrate delayed progression to more advanced substance use following initiation relative to adolescents in the control group. Latent transition analysis (LTA) can be used to examine both primary and secondary prevention effects across data-collection points, as described in the following paragraphs.

Graham et al. (1991) noted that, as a stage-sequential process, the onset and progression of substance use is best analyzed in terms of intraindividual changes rather than in terms of interindividual comparisons. In other words, assessing the onset and progression of substance use requires tracking individuals as they progress through different developmental stages (intraindividual) rather than comparing groups of individuals at different developmental stages (interindividual). Graham et al. described the related advantages of LTA, including (a) mathematically modeling changes over time in a stage-sequential process and (b) determining whether these changes are systematically influenced by certain factors (e.g., participation in an intervention designed to delay substance use onset and progression). In LTA, a stage-sequential process is modeled as a dynamic latent variable with discrete manifest indicators (e.g., “yes” or “no” responses to questions like “Have you ever smoked a cigarette?”). A thorough analysis of methodologies applicable to stage-sequential development lies beyond the scope of this article but is readily accessible (e.g., Collins, 1991; Collins & Horn, 1992; Collins & Wugalter, 1992; Hays, Widaman, DiMatteo, & Stacy, 1987; Kandel, Margulies, & Davies, 1978; Kessler, Paton, & Kandel, 1976).

Stage-sequential models of adolescent substance use typically posit a general sequence with the following statuses: (a) nonuse, (b) use of substances that are legal for adults (cigarettes or alcohol), and (c) use of illicit substances (e.g., Hays et al., 1987; Kandel & Faust, 1975; Maddahian, Newcomb, & Bentler, 1985; Martin, Velicer, & Fava, 1996; Single, Kandel, & Faust, 1974). Existing models of substance use initiation and involvement, however, vary somewhat in the specific statuses included in the sequence as well as in the range of substances considered (e.g., Graham et al., 1991; Kandel & Yamaguchi, 1985; Kandel, Yamaguchi, & Chen, 1992).

Graham et al. (1991) compared two stage-sequential models for purposes of assessing intervention outcomes. The first model was suggested by the common observation that at any given point in time, adolescents’ use of alcohol is more prevalent than their use of tobacco products and that the prevalence of their tobacco use is higher than the prevalence of more serious use of legal substances (e.g., occasions of drunkenness) or the use of illegal substances (e.g., marijuana). Thus, the first model tested by Graham et al. had adolescents trying alcohol first, cigarettes next, then becoming drunk for the first time, and finally progressing to higher levels of cigarette and/or alcohol use and/or initiating marijuana use. The second model was based on conclusions from the research of Kandel and colleagues (e.g., Kandel & Yamaguchi, 1985, 1993; 1

1 Analyzing intraindividual changes also has been the focus of growth modeling (e.g., Francis, Fletcher, Ste ubing, Davidson, & Thompson, 1991; Willett, Ayoub, & Robinson, 1991). With growth modeling, however, intraindividual changes are typically modeled in terms of continuous development in contrast with stage-sequential or qualitative development in LTA. Hierarchical data structures can also be incorporated in some growth modeling procedures evaluating discrete outcomes (e.g., hierarchical generalized linear models; Bryk, Raudenbush, & Congdon, 1996). However, in the present study, the small number of students per school, in conjunction with low-frequency behaviors, would not yield reliable estimates of school-level effects.
Kandel et al., 1992) indicating that alcohol use is not necessarily the first step in substance use. Instead, the second model allowed for adolescents starting with cigarette use and moving on to alcohol use or, alternatively, starting with alcohol use and moving on to cigarette use. The fit with the data was significantly better for the second, two-path model. It is noteworthy, however, that the participants were younger (7th grade at pretesting and 8th grade at posttesting) than those in the earlier studies by Kandel and colleagues (Kandel & Yamaguchi, 1993; Kandel et al., 1992). In the earlier studies, participants ranged from 12th graders to adults, up to age 35. A model with both alcohol and tobacco paths to more advanced-use statuses, similar to the better fitting model in the Graham et al. study, was used to examine intervention outcomes in the present article. Analysis of this model provided estimated frequencies of positive and negative outcomes associated with primary and secondary prevention goals across experimental groups. These frequencies were used to fit a log-linear model, and the probabilities of positive outcomes for intervention- and control-group adolescents were compared.

Method

Participants

Participants in the study were 329 sixth graders enrolled in 33 rural schools in 19 contiguous counties in a Midwestern state who completed pretest, 1-year follow-up, and 2-year follow-up assessment interviews. Schools included in the study were selected on the basis of school lunch program eligibility (15% or more of district families eligible for free or reduced cost lunches) and community size (populations of 8,500 or fewer). These schools were randomly assigned to one of three experimental conditions: the seven-session ISFP, the five-session PDFY, or a minimal-contact control condition. Schools were first blocked on enrollment and the proportion of students who resided in lower income households, then randomly assigned to the three experimental conditions. All families of sixth graders in participating schools were recruited for participation. At the time of pretesting, participating families did not know the experimental condition to which their child’s school had been assigned, although they had been informed that the project included an intervention component in some schools.

Of the 1,309 students and their families recruited for this study, 667 (51%) completed pretesting, including 221 PDFY-condition families, 238 ISFP-condition families, and 208 control-condition families. Recruitment rates were very similar across the three conditions, ranging from 50.6% for the PDFY condition to 51.4% for the ISFP condition. Evaluation of data on sociodemographic characteristics (parent education, household income, target child gender, parent marital status, and number of children) from a prospective survey of eligible families indicated that the families participating in the present study were generally representative of those in the sampling frame (see Spoth, Redmond, & Lepper, 1999). The most noteworthy difference was that the mean levels of education differed by 0.7 years between trial participants and nonparticipants, with participants showing the higher level.

Five hundred fifty-one (83%) of the 667 pretested sixth-grade students and their families completed the posttest. The 1-year follow-up assessment was completed by 472 students and their families (155 in the PDFY condition, 161 in the ISFP condition, and 156 in the control condition). The 2-year follow-up assessment was completed by 438 students and their families (144 in the PDFY condition, 153 in the ISFP condition, and 151 in the control condition). Retention rates for the three conditions from pretesting to the 2-year follow-up assessments were similar across the three conditions (65% for PDFY-condition families, 64% for ISFP-condition families, and 68% for control-condition families). Recent attrition analyses on family sociodemosographics and alcohol and tobacco initiation measures at all postintervention data-collection points for PDFY-control and ISFP-control comparisons failed to show any evidence of differential attrition. In addition, discrete-time survival analyses of six family social-emotional and socioeconomic risk factors found only parent education to be predictive of ongoing study participation across conditions (higher parent educational attainment was associated with lower study attrition through the 2-year follow-up assessment; Spoth, Goldberg, & Redmond, 1999).

Recruitment for the two interventions was conducted following the family pretest assessments. All families of sixth graders in intervention-condition schools were allowed to enroll in the interventions. However, only intervention-group families that completed the pretest assessment were actively recruited for the two programs. Of the 221 pretested PDFY-condition sixth graders and their families, 124 participated in the intervention; of the 238 pretested ISFP-condition sixth graders and their families, 117 participated in the intervention. The treatments were also attended by 25 PDFY and 44 ISFP school families that did not participate in the assessments and that did not provide data for analysis.

Participation in the study posttest and follow-up assessments was not contingent on intervention participation; all pretested families were recruited for the posttest, regardless of whether or not they participated in an intervention. Our prior outcome research has included intervention-control group comparisons in which intervention-group membership was based on both those randomly assigned to the intervention group and those actually attending the intervention (e.g., Spoth, Redmond, & Lepper, 1999). Because of space constraints and the present emphasis on the evaluation of primary and secondary preventive intervention outcomes, the analyses conducted for this study included sixth graders from (a) control-group families and (b) intervention-group families that actually attended an intervention and that had provided data on all pertinent questions across all waves of data collection. Prior analyses of family risk factor influences on intervention participation (family attendance at one or more intervention sessions) failed to show a significant risk factor-participation relationship (Spoth, Redmond, & Lepper, 1999).

The analyzed sample consisted of 101 PDFY students (82% of those pretested and participating in the PDFY intervention), 91 ISFP students (78% of those pretested and participating in the ISFP intervention), and 137 control-group students (66% of those pretested), for a total sample of 329. At pretest, the average number of sixth graders per school in the analyzed sample was 10 (SD = 8). Among families in the analyzed sample, there was an average of 3 children. In just over half of these families (54%), the target student was a girl. As is common among families of sixth graders in the study region, most children (85%) had two parents living with them. Of these dual-parent families, 86% included both the target student's biological parents. The mean ages of mothers and fathers were 37.0 and 39.5, respectively. The large majority of both mothers and fathers (98% and 96%, respectively) completed high school. In addition, 5% of mothers and 58% of fathers reported some post-high school education. The median

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2 The adaptation of the Graham et al. (1991) model for the present study entailed collapsing the final two substance use statuses in the Graham et al. model (alcohol and tobacco with drunkenness and advanced use) into a single advanced status, also characterized as “advanced use.” Thus, the collapsed model had five statuses (no use, alcohol onset, tobacco onset, onset of both alcohol and tobacco, and more advanced use). This adaptation was deemed necessary because of the low rates of use reported for most substances other than alcohol and tobacco in the present study. The use of substances such as marijuana among adolescents in the study (in the eighth grade at the time of the 2-year follow-up assessment) and heavier use of alcohol and tobacco was not pronounced enough to afford reliable estimates of a six-status LTA model. Given the low substance use rates, a four-status model also was evaluated but ruled out because the measurement properties of the five-status model were considered to be stronger.
annual household income in the sample was $33,350. Virtually all participants were Caucasian (99%).

Procedures

Assessment. This study is part of a large-scale research project that involves comprehensive longitudinal assessments of a wide range of family-related variables. Families indicating a willingness to participate in the pretest were contacted by a project staff member to schedule the in-home assessment visit at a convenient time for the family. An informational packet was sent that included questionnaires to be completed individually by the parent(s) and the target child before the in-home visit. During the initial portion of the in-home visit, a household composition interview was conducted, followed by administration of written questionnaires to the participating family members, who completed them independently. Approximately 60 to 80 min were required to complete the questionnaires. During and after the administration of the questionnaires, the interviewer videotaped the family members as they engaged in structured interaction tasks. The complete visit averaged about 2.5 hr. Each family member was compensated approximately $10 per hour for time devoted to the assessments. The same procedures were followed at each subsequent data-collection point (posttest, 1-year follow-up, and 2-year follow-up).

Experimental conditions. The two interventions were both offered during weekday evenings, typically at local schools.

The PDFY is a family competency training program based on the Social Development Model (Catalano & Hawkins, 1996; Catalano et al., 1996). Its primary objectives are to enhance protective parent-child interactions and to reduce children's risk for early substance use initiation. For a more detailed description of the PDFY, see Table 1 and the article by Kosterman et al. (1997); for more information on implementation procedures, see the article by Spath et al. (1998).

The ISFP is based on the Biopsychosocial Model (DeMarsh & Kumpfer, 1986) and other empirically based family risk and protective factor models (Kumpfer et al., 1996); it targets the enhancement of family protective and resiliency processes, along with family risk reduction (Kumpfer et al., 1996). Further detail on the ISFP and implementation procedures can be found in the articles by Kumpfer et al. (1996) and Spath et al. (1998).

Table 1

<table>
<thead>
<tr>
<th>Feature</th>
<th>Preparing for the Drug-Free Years program (PDFY)</th>
<th>Iowa Strengthening Families Program (ISFP)</th>
</tr>
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<tbody>
<tr>
<td>Theoretical basis Objectives</td>
<td>Social Development Model (Catalano &amp; Hawkins, 1996; Catalano et al., 1996)</td>
<td>Biopsychosocial Model (DeMarsh &amp; Kumpfer, 1986; Kumpfer et al., 1996)</td>
</tr>
<tr>
<td></td>
<td>To enhance protective parent-child interactions and to reduce family-based risk factors for early substance use initiation</td>
<td>To enhance family protective and resiliency processes and to reduce family-based risk factors associated with child behavior problems</td>
</tr>
<tr>
<td>Program length</td>
<td>5 sessions conducted once per week for 5 weeks, with an average session length of 2 hr</td>
<td>7 sessions conducted once per week for 7 weeks; the first 6 sessions include 1 hr of separate parent and child training and 1 family hr; the 7th session includes only 1 family hr</td>
</tr>
<tr>
<td>Child involvement Program content</td>
<td>1 session requires child attendance; parents attend all sessions</td>
<td>Parents are taught to clarify expectations (based on developmental norms), use appropriate disciplinary practices, manage strong emotions regarding their child, and effectively communicate with their child; children’s session content parallels relevant parents’ session content but also includes peer resistance and peer relationship skills training; during family sessions, members practice conflict resolution and communication skills and engage in activities designed to increase family cohesiveness and positive involvement of the child in the family</td>
</tr>
<tr>
<td>Videotape use Group size</td>
<td>Videotapes to standardize delivery of content 15 two-person teams conducted 19 groups in 11 schools assigned to PDFY; groups averaged 10 families</td>
<td>Videotapes to standardize delivery of content 21 three-person teams conducted 24 groups in 11 schools assigned to ISFP; groups averaged 8 families</td>
</tr>
<tr>
<td>Attendance rates</td>
<td>94% of attending families were represented by a family member in 3 or more sessions, 93% attended 4 or 5 sessions, and 61% attended all 5 sessions</td>
<td>94% of attending families were represented by a family member in 5 or more sessions, 88% attended 6 or 7 sessions, and 62% completed all 7 sessions</td>
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</tbody>
</table>

Measures

Similar to the study by Graham et al. (1991), measures of lifetime and past-month use of substances were used in the analyses. The measures were lifetime cigarette use ("Have you ever smoked cigarettes?"), lifetime alcohol use ("Have you ever drunk beer, wine, wine coolers, whiskey, gin, or other liquor?"), and "advanced substance use" (e.g., regular past-month use of cigarettes and alcohol, lifetime drunkenness, and lifetime use of illicit substances). Also similar to the Graham et al. study, items used to measure advanced substance use had relatively low base rates and likely would have shown considerable instability in models in which these items were considered separately. Thus, as was done by Graham et al., we combined the advanced-use items into a single measure. That is, the measurement of advanced use was coded "1" if the respondent indicated one or more of the following: four or more alcoholic drinks in the past month, one or more cigarettes a day on average for the past month, lifetime drunkenness, lifetime marijuana use, lifetime use of illicit drugs other than marijuana, and lifetime use of inhalants. The measure was coded "0" if the respondent did not endorse any of the above items. The selected cutoff points for past-month alcohol use and past-month cigarette use were based on Iowa Department of Education (1997) survey results suggesting that...
these use levels would be considered normatively "heavy" (i.e., drinking every week and smoking daily).

Several studies have supported the validity of young adolescent self-reports of substance use (e.g., Elliott, Ageton, Huizinga, Knowles, & Canter, 1983; Smith, McCarthy, & Goldman, 1995; Williams et al., 1995). Although the possibility of self-report biases in responses to written questionnaires exists, it is important to note that it is likely that students in all experimental conditions would recognize socially desirable responses to questions concerning their use of substances in similar ways at data-collection points over 1 and 2 years beyond intervention completion.

**Analyses**

Data analyses entailed three phases: (a) analyses of a stage-sequential model of substance use using LTA, (b) log-linear modeling to assess experimental-condition effects on the onset and progression of substance use, and (c) ISFP–control and PDFY–control comparisons concerning the onset and progression of substance use.

The first data-analysis phase involved fitting a two-path stage-sequential model in which initiation to substance use is either through alcohol or through tobacco. Prior to model fitting, pretest equivalence across experimental conditions on the substance use outcome variables was confirmed (see Table A1). As shown in Figure 1, substance use progresses through one of two paths (no use → alcohol use only → alcohol and tobacco use → advanced use or no use → tobacco use only → alcohol and tobacco use → advanced use). A two-path model was chosen instead of a one-path model because it was the model that best fit the data in past study (Graham et al., 1991; see Footnote 2). The two-path model was fit to the data across two transition periods (i.e., from pretest to the 1-year follow-up assessment and from the 1-year follow-up assessment to the 2-year follow-up assessment). Using LTA, we estimated the number of participants remaining in each status or advancing to another status for each transition period, adjusting for measurement error. We computed these frequencies separately for the ISFP, PDFY, and control groups for the two transition periods. Thus, for example, we estimated how many of the ISFP participants who had not initiated substance use at pretest continued to refrain from substance use at the 1-year follow-up; we also estimated the corresponding number of PDFY and control-group participants.

In the second data-analysis phase, we used LTA-derived frequencies to fit three-dimensional log-linear models for the two transition periods. Dimensions in this model were (a) initial status (no use vs. non-advanced use, with non-advanced use defined as alcohol only, tobacco only, or alcohol and tobacco), (b) group (ISFP, PDFY, or control), and (c) outcome (positive, defined as remaining at the initial status, vs. negative, defined as progressing to any more advanced status—based on transitions observed in the five-status LTA model).\(^3\) The model included two- and three-way interactions. Separate log-linear models were fit for the two transition periods, from the pretest to the 1-year follow-up and from the 1-year follow-up to the 2-year follow-up.

The application of log-linear analysis to LTA-produced outcome frequencies provided a convenient way to assess the significance of interaction effects associated with substance use status, experimental group, and transition outcomes using data adjusted for measurement error within the context of a theory-based dynamic process model. Although similar effects could be assessed through systematic assessments of LTA model constraints, such an investigation would require a series of model tests involving numerous model constraints and would likely yield less readily interpretable results.

In the third data-analysis phase, we conducted 2 tests to test both primary and secondary prevention hypotheses. To test the primary prevention

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\(^3\) The log-linear models are $2 \times 3 \times 2$, rather than $5 \times 3 \times 2$, for two reasons. First, outcomes are not meaningful for the fifth advanced-use status—there are no transition outcomes to be evaluated for participants beginning any transition period in this status. Second, the alcohol-only, tobacco-only, and alcohol-plus-tobacco statuses were combined to test the secondary prevention hypothesis. Although we collapsed the alcohol-only, tobacco-only, and alcohol-plus-tobacco statuses into a single non-advanced-use status, the outcomes for participants classified into that status were based on the hypothesized five-status model. For example, a student beginning a transition period in the alcohol-only status and ending the transition period in either the alcohol-plus-tobacco or the advanced-use status would be assigned a negative outcome, whereas someone both beginning and ending the transition period in the alcohol-only status would be assigned a positive outcome. Similarly, a student beginning a transition period in the tobacco-only status and ending the transition period in either the alcohol-plus-tobacco or the advanced-use status would be assigned a negative outcome, whereas someone both beginning and ending the transition period in the tobacco-only status would be assigned a positive outcome.
hypothesis, we compared the ISFP and PDFY groups with the control
group with respect to the proportion of participants who remained in the
no-use status (i.e., the proportion of positive outcomes for the no-use
status). To test the secondary prevention hypothesis, we compared the ISFP
and PDFY groups with the control group with respect to the combined
proportion of positive outcomes for the alcohol-only; tobacco-only, and
alcohol-plus-tobacco statuses. In testing both the primary and secondary
prevention hypotheses, we made ISFP-control and PDFY-control com-
parisons for both the transition from the pretest to the 1-year follow-up and
for the transition from the 1-year follow-up to the 2-year follow-up.

Results

Goodness of Fit of the Two-Path Stage-Sequential Model

As mentioned in the previous section, we modeled the onset and
progression of substance use using two possible paths of substance
initiation (see Figure 1). The overall goodness of fit of this model
appeared to be adequate, as assessed by the likelihood ratio chi-
square statistic, \( G^2 (df = 1463) = 328.3 \).\(^4\)

Table 2 shows the probabilities of responding “yes” to the
alcohol, tobacco, and advanced-use items, given membership
in each of the different states. (These probabilities are described as
measurement parameter estimates in LTA.) Overall, these proba-
bilities indicate that the items generally defined the latent statuses
well. Item-response probabilities for “yes” were high for latent
statuses in which “yes” was the expected response and were low
for latent statuses in which “no” was the expected response. For
example, given membership in the no-use status, low probabilities
of responding “yes” to all three items were observed. For the status
of alcohol onset, a high probability of responding “yes” to the
alcohol item and low probabilities of responding “yes” to the other
items were observed, and so on.\(^6\)

The Number of Participants Remaining at Their Current
Statuses or Progressing to More Advanced Statuses

As previously mentioned, LTA yielded frequencies of partici-
pants remaining in a status (positive outcome) or advancing to
another status (negative outcome) during each transition period.

Table 2

<table>
<thead>
<tr>
<th>Substance use status</th>
<th>Alcohol item</th>
<th>Tobacco item</th>
<th>Advanced-use item</th>
</tr>
</thead>
<tbody>
<tr>
<td>No use</td>
<td>.053</td>
<td>.016</td>
<td>.009</td>
</tr>
<tr>
<td>Alcohol only</td>
<td>.865</td>
<td>.016</td>
<td>.009</td>
</tr>
<tr>
<td>Tobacco only</td>
<td>.053</td>
<td>.700</td>
<td>.009</td>
</tr>
<tr>
<td>Alcohol plus tobacco</td>
<td>.865</td>
<td>.700</td>
<td>.766</td>
</tr>
</tbody>
</table>

Note. Probability estimates were constrained to be equal across the ISFP,
PDFY, and control groups. In addition, probabilities for each of the three
response items were constrained so that the probability of responding “yes”
to a given item could have only one of two values: one value for latent
statuses in which “yes” was the expected response, and another value for
latent statuses in which “no” was the expected response. LTA = latent
transition analysis; ISFP = Iowa Strengthening Families Program;
PDFY = Preparing for the Drug-Free Years program.

These frequencies were adjusted for measurement error; they were
computed separately for the ISFP, PDFY, and control groups for
the two transition periods.

Tables 3–5 show the probabilities on which these frequencies
were based. Table 3 provides the probabilities of belonging to each
substance use status for the ISFP, PDFY, and control-group par-
ticipants at pretest, 1-year follow-up, and 2-year follow-up. Most
participants had not initiated substance use at the pretest, as sug-
gested by the large probabilities of being in the no-use status as
compared with the probabilities of being in the other statuses.
Probabilities of being in the no-use status, however, decreased
across time; these decreases were necessarily accompanied by
increases in probabilities of being in the other, more advanced
statuses.

Table 4 reports the probabilities of remaining in a status or
advancing to another status during the transition from pretest to the
1-year follow-up for the ISFP, PDFY, and control-group partici-
pants. Table 5 is similar to Table 4, except that the probabilities are
for the transition from the 1-year follow-up to the 2-year follow-
up. In general, participants tended to remain in their initial statuses
(as suggested by high probabilities on the diagonal entries), al-
though there were a number of participants in different statuses
who progressed to a more advanced status (off-diagonal entries).
The probability of a shift from the tobacco-only status at the
pretest in the ISFP group to the advanced-use status at the 1-year

\(^4\) As noted earlier, transition outcome “frequencies” produced using
LTA were used in subsequent log-linear models, with log-linear results
subsequently used to conduct \( z \) tests for differences in probabilities of
favorable outcomes. It is important to note that the LTA-produced transi-
ton outcome frequencies are not precisely equivalent to observed frequen-
cies; that is, they do not represent observed transitions of individual
respondents. Rather, they are expected frequencies based on transition
probability estimates consistent with model constraints (and adjusted for
measurement error) and sample sizes. As such, intraclass correlations
cannot be calculated to assess school-level effects on outcomes (see also
Footnote 1 concerning issues related to school-level effects).

\(^5\) Degrees of freedom are equal to the number of possible item-response
patterns minus the number of parameters estimated minus one. In this case,
the number of possible response patterns for each of the three groups was
512 (there were three items measured three times, and each item had two
response categories), making the total number of response patterns equal to
3 \times 2^3 = 1,536. The model included 12 parameters for Initial Status \times
Group Membership proportions, 6 measurement parameters (item-response
probabilities given group and status membership), and 54 transition prob-
abilities, yielding a total of 72 parameters estimated. Hence, degrees of
freedom for the tested LTA model were 1,536 − 72 − 1 = 1,463.

\(^6\) High probabilities are less than 1.0 and low probabilities are greater
than 0.0 because of a combination of model constraints and inconsistent
responses considered to be measurement errors. As an illustration, consider
the reported value of .865 for the probability of responding “yes” to the
alcohol item, given classification in the alcohol-only status. One reason this
probability is not 1.0 is that the probability of responding “yes,” given the
alcohol-only status, is constrained to equal the probability of responding
“yes,” given the alcohol-plus-tobacco status, and “yes,” given the
advanced-use status (a status generally, but not necessarily, implying
alcohol use). Further, measurement error is introduced in the case of a
respondent who reports having tried alcohol at the pretest but also reports
never having used alcohol at the 1-year follow-up (a logically inconsistent
response and inconsistent with model constraints not allowing transition from
the alcohol-only status to the no-use status).
follow-up (1.000, as reported in Table 4) is a noteworthy exception to the general tendency to remain in initial statuses. This result occurred because there was 1 (estimated) ISFP student (see Table 6, described below) in the tobacco-only status at pretest; that student classified as tobacco only at the pretest progressed to the advanced status at the 1-year follow-up. It should be noted that the probability of moving into the ISFP tobacco-only status at the 1-year follow-up was .066 for participants in the no-use status at pretest (see Table 4) and that those classified in the tobacco-only category at the 1-year follow-up were more likely to remain in the tobacco-only status at the 2-year follow-up (.791) than progress to the advanced-use status (.209, see Table 5).

The expected frequencies derived from the probabilities in Tables 3–5 are shown in Table 6. The frequencies reported are those of positive outcomes (remaining in a status) and of negative outcomes (progressing to a more advanced status). Frequencies are reported separately for each group and for both transitions. We subsequently used log-linear models to analyze these frequencies.

Log-Linear Models for Group, Stage, and Outcome

As previously mentioned, the second data-analysis phase involved determining how the likelihoods of positive and negative outcomes were associated with initial status (no use vs. nonadvanced use) and group (ISFP vs. PDFY vs. control). Separate models were fit for the transition from pretest to the 1-year follow-up and for the transition from the 1-year follow-up to the 2-year follow-up.

For the transition from pretest to the 1-year follow-up, only one interaction effect was significant, namely, the interaction of outcome and status, \( \chi^2(1, N = 317) = 9.55, p < .01. \) An examination of expected frequencies suggested that adolescents in the no-use status were more likely to remain in their current status (a positive outcome) than were adolescents in the other statuses (i.e., alcohol only, tobacco only, and alcohol plus tobacco).

For the transition from the 1-year follow-up to the 2-year follow-up, the interaction effect of group and outcome was significant, \( \chi^2(2, N = 288) = 16.05, p < .01. \) No other interaction effects were significant. Expected frequencies indicated that ISFP and PDFY adolescents were more likely than control-group adolescents to remain in their respective statuses instead of progressing to a more advanced status during the transition period.

Two-way interaction effects, when taken as a group, were significant for both transition periods, \( \chi^2(5, N = 317) = 19.00, p < .01, \) and \( \chi^2(5, N = 288) = 22.80, p < .01, \) for the pretest to the 1-year follow-up and the 1-year follow-up to the 2-year follow-up, respectively.

Table 3
Substance Use Status Membership Probabilities by Experimental Group at Pretest, 1-Year Follow-Up, and 2-Year Follow-Up

<table>
<thead>
<tr>
<th>Substance use status</th>
<th>Pretest</th>
<th>1-year follow-up</th>
<th>2-year follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ISFP group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>.911</td>
<td>.775</td>
<td>.656</td>
</tr>
<tr>
<td>Alcohol only</td>
<td>.047</td>
<td>.091</td>
<td>.135</td>
</tr>
<tr>
<td>Tobacco only</td>
<td>.010</td>
<td>.060</td>
<td>.048</td>
</tr>
<tr>
<td>Alcohol plus tobacco</td>
<td>.015</td>
<td>.025</td>
<td>.044</td>
</tr>
<tr>
<td>Advanced use</td>
<td>.017</td>
<td>.048</td>
<td>.118</td>
</tr>
<tr>
<td></td>
<td>PDFY group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>.773</td>
<td>.595</td>
<td>.500</td>
</tr>
<tr>
<td>Alcohol only</td>
<td>.069</td>
<td>.076</td>
<td>.089</td>
</tr>
<tr>
<td>Tobacco only</td>
<td>.071</td>
<td>.052</td>
<td>.067</td>
</tr>
<tr>
<td>Alcohol plus tobacco</td>
<td>.016</td>
<td>.128</td>
<td>.128</td>
</tr>
<tr>
<td>Advanced use</td>
<td>.070</td>
<td>.149</td>
<td>.216</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>.837</td>
<td>.648</td>
<td>.473</td>
</tr>
<tr>
<td>Alcohol only</td>
<td>.078</td>
<td>.132</td>
<td>.114</td>
</tr>
<tr>
<td>Tobacco only</td>
<td>.036</td>
<td>.042</td>
<td>.022</td>
</tr>
<tr>
<td>Alcohol plus tobacco</td>
<td>.027</td>
<td>.018</td>
<td>.095</td>
</tr>
<tr>
<td>Advanced use</td>
<td>.022</td>
<td>.160</td>
<td>.297</td>
</tr>
</tbody>
</table>

Note. ISFP = Iowa Strengthening Families Program; PDFY = Preparing for the Drug-Free Years program.

Table 4
Probabilities of Remaining in a Status or Advancing to Another Status During the Transition From Pretest to the 1-Year Follow-Up by Experimental Group

<table>
<thead>
<tr>
<th>Pretest substance use status</th>
<th>1-year follow-up substance use status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>ISFP group</td>
<td></td>
</tr>
<tr>
<td>1. No use</td>
<td>.851</td>
</tr>
<tr>
<td>2. Alcohol only</td>
<td>X</td>
</tr>
<tr>
<td>3. Tobacco only</td>
<td>X</td>
</tr>
<tr>
<td>4. Alcohol plus tobacco</td>
<td>X</td>
</tr>
<tr>
<td>5. Advanced use</td>
<td>X</td>
</tr>
<tr>
<td>PDFY group</td>
<td></td>
</tr>
<tr>
<td>1. No use</td>
<td>.770</td>
</tr>
<tr>
<td>2. Alcohol only</td>
<td>X</td>
</tr>
<tr>
<td>3. Tobacco only</td>
<td>X</td>
</tr>
<tr>
<td>4. Alcohol plus tobacco</td>
<td>X</td>
</tr>
<tr>
<td>5. Advanced use</td>
<td>X</td>
</tr>
<tr>
<td>Control group</td>
<td></td>
</tr>
<tr>
<td>1. No use</td>
<td>.774</td>
</tr>
<tr>
<td>2. Alcohol only</td>
<td>X</td>
</tr>
<tr>
<td>3. Tobacco only</td>
<td>X</td>
</tr>
<tr>
<td>4. Alcohol plus tobacco</td>
<td>X</td>
</tr>
<tr>
<td>5. Advanced use</td>
<td>X</td>
</tr>
</tbody>
</table>

Note. "X" indicates probability estimates that were constrained to the value zero (e.g., the probability of moving from the alcohol-only status to the no-use status was constrained to be zero). Caution should be used when interpreting estimates associated with statuses exhibiting low base-rate probabilities of membership (see Table 3 for status membership probabilities). ISFP = Iowa Strengthening Families Program; PDFY = Preparing for the Drug-Free Years program.

As an illustration of how the frequencies in Table 6 were obtained from the probabilities in Tables 3–5, consider the estimated 60.12 PDFY participants in the no-use status at pretest who did not advance in their status of use at the 1-year follow-up (positive outcome). This frequency was obtained through the following multiplication: the total number of PDFY participants \( \times \) the probability of being in the no-use status for PDFY at pretest (see Table 3) \( \times \) the probability of remaining in the no-use status for PDFY during the transition from pretest to 1-year follow-up (see Table 4). Thus, \( 101 \times .773 \times .770 = 60.12. \)
Table 5
Probabilities of Remaining in a Status or Advancing to Another Status During the Transition From the 1-Year Follow-Up to the 2-Year Follow-Up by Experimental Group

<table>
<thead>
<tr>
<th>1-year follow-up substance use status</th>
<th>2-year follow-up substance use status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISFP group</td>
<td></td>
</tr>
<tr>
<td>1. No use</td>
<td>0.847</td>
</tr>
<tr>
<td>2. Alcohol only</td>
<td>0.926</td>
</tr>
<tr>
<td>3. Tobacco only</td>
<td>0.791</td>
</tr>
<tr>
<td>4. Alcohol plus tobacco</td>
<td>0.000</td>
</tr>
<tr>
<td>5. Advanced use</td>
<td>0.000</td>
</tr>
</tbody>
</table>

| PDFY group                           |                                     |
| 1. No use                            | 0.840                               |
| 2. Alcohol only                      | 0.715                               |
| 3. Tobacco only                      | 0.763                               |
| 4. Alcohol plus tobacco              | 0.000                               |
| 5. Advanced use                      | 1.000                               |

| Control group                        |                                     |
| 1. No use                            | 0.730                               |
| 2. Alcohol only                      | 0.319                               |
| 3. Tobacco only                      | 0.512                               |
| 4. Alcohol plus tobacco              | 0.621                               |
| 5. Advanced use                      | 1.000                               |

Note. "X" indicates probability estimates that were constrained to the value zero (e.g., the probability of moving from the alcohol-only status to the no-use status was constrained to be zero). Caution should be used when interpreting estimates associated with statuses exhibiting low base-rate probabilities of membership (see Table 3 for status membership probabilities). ISFP = Iowa Strengthening Families Program; PDFY = Preparing for the Drug-Free Years program.

1-year follow-up and for the 1-year follow-up to the 2-year follow-up transitions, respectively. However, three-way interactions were not significant for either of the transition periods, \( \chi^2(2, N = 317) = 2.40, ns \), and \( \chi^2(2, N = 288) = 4.20, ns \), for the pretest to 1-year follow-up and for the 1-year follow-up to the 2-year follow-up periods, respectively. The overall fits of the log-linear models, excluding the three-way interaction terms, were adequate for both transition periods, \( \chi^2(2, N = 317) = 2.48, ns \), and \( \chi^2(2, N = 288) = 4.48, ns \), for the earlier and later transition periods, respectively. Consequently, positive outcome probabilities were based on expected cell frequencies from log-linear models that excluded three-way interaction terms. Table 7 shows probabilities of positive outcomes for each group for the two transition periods.

Intervention–Control Group Comparisons

We used \( z \) tests to compare the positive outcome probabilities (the probability of not progressing in use status) for the intervention groups with those of the control group (see Table 7). For each of the two intervention–control group comparisons, we conducted two one-tailed \( z \) tests for each of the two transition periods, corresponding to the primary and secondary prevention hypotheses: (a) a comparison of the probabilities of a positive outcome, given membership in the no-use status at the beginning of the transition period, and (b) a comparison of the probabilities of a positive outcome, given membership in any one of the three non-advanced-use statuses (alcohol only, tobacco only, and alcohol plus tobacco).

The \( z \) test results for effects associated with the individual interventions were consistent with the log-linear modeling results. For the earlier transition period (from pretest to the 1-year follow-up assessment), there were no statistically significant intervention–control group differences in positive outcome probabilities associated with either intervention. Although the estimated probability of a positive outcome at the 1-year follow-up was higher for intervention-group adolescents in all instances, these differences were not statistically significant at the .05 level. These findings are consistent with the absence of a significant Experimental Group \( \times \) Outcome interaction effect in the log-linear analysis, \( \chi^2(2, N = 317) = 2.51, ns \).

Table 6
Expected Frequencies of Positive and Negative Outcomes for the Transition From Pretest to the 1-Year Follow-Up and for the Transition From the 1-Year Follow-Up to the 2-Year Follow-Up by Group and Substance Use Status

<table>
<thead>
<tr>
<th>Substance use status at beginning of transition period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>ISFP</td>
</tr>
<tr>
<td>PDFY</td>
</tr>
<tr>
<td>Control</td>
</tr>
</tbody>
</table>

Note. ISFP = Iowa Strengthening Families Program; PDFY = Preparing for the Drug-Free Years program.

* For those classified in the advanced use status at the beginning of a transition position, there is no relevant outcome to be considered.
### Table 7

<table>
<thead>
<tr>
<th>Substance use status</th>
<th>ISFP group</th>
<th>PDFY group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition from pretest to 1-year follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>.84</td>
<td>.80</td>
<td>.76</td>
</tr>
<tr>
<td>Non-advanced use</td>
<td>.63</td>
<td>.55</td>
<td>.49</td>
</tr>
<tr>
<td>Transition from 1-year follow-up to 2-year follow-up</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No use</td>
<td>.85</td>
<td>.88</td>
<td>.70</td>
</tr>
<tr>
<td>Non-advanced use</td>
<td>.72</td>
<td>.77</td>
<td>.50</td>
</tr>
</tbody>
</table>

Note. Probabilities for the ISFP and PDFY groups that are in bold were significantly different from the corresponding probabilities for the control group. Post hoc analyses indicated PDFY and ISFP probabilities were not significantly different from one another. Non-advanced use refers to students reporting use (alcohol only, tobacco only, alcohol plus tobacco) but not advanced use. ISFP = Iowa Strengthening Families Program; PDFY = Preparing for the Drug-Free Years program.

In contrast to the earlier transition period, the Experimental Group × Outcome interaction effect for the second transition period (from the 1-year follow-up assessment to the 2-year follow-up assessment) was significant. This finding was reflected in the z tests comparing intervention- and control-group positive outcome probabilities for this transition period; three of the four z tests for this period were statistically significant.

In the PDFY–control group analysis, both z tests were significant, indicating that (a) adolescents in the PDFY group who had not initiated substance use at the time of the 1-year follow-up were more likely to have remained in the no-use group through the 2-year follow-up assessment than were control-group adolescents (z = 2.65, p < .01) and (b) adolescents in the PDFY group who had initiated substance use at the time of the 1-year follow-up were more likely to have remained in their 1-year follow-up substance use status through the 2-year follow-up assessment than were control-group adolescents (z = 1.99, p < .05).

ISFP–control group comparisons also indicated a primary prevention effect for the second transition period: ISFP adolescents in the no-use status at the 1-year follow-up were more likely to remain in that status at the 2-year follow-up than were control-group adolescents (z = 2.33, p < .01). Although the estimated probability of a positive outcome at the 2-year follow-up for adolescents who had already initiated substance use at the 1-year follow-up was also higher for ISFP adolescents than for control-group adolescents (.72 vs. .50), the z test for this difference only achieved significance at the .10 level. Post hoc comparisons of ISFP and PDFY positive outcome probabilities were not significant in all instances, as suggested by the similarity of the probabilities reported in Table 7.

**Discussion**

With respect to the public health goals of delayed substance use initiation and progression, results showed positive intervention effects for both the ISFP and PDFY interventions. Although substance use rates increased among all groups over the course of the study, the likelihood of substance use initiation at the 2-year follow-up was significantly lower among intervention-group adolescents. Both PDFY and ISFP intervention groups showed significantly lower probabilities of transitions from the no-use status to a use status for the 1-year follow-up to 2-year follow-up period. This finding indicates a primary prevention effect among the targeted young adolescents detectable 2 years after their families participated in the intervention, at a point when those young adolescents were entering higher risk years for substance initiation. The positive primary prevention effects from these modest intensity interventions are consistent with the rationale for the expected effects presented in the introduction, particularly with the developmental timing of the interventions. They are also consistent with prior findings of positive effects on parenting outcomes that have been associated with delayed substance use onset among young adolescents (Redmond, Spoth, Chin, & Lepper, in press; Spoth et al., 1998). The positive long-term effects from this study are particularly important in light of epidemiological and etiological literature indicating the benefits of delayed onset among young adolescents. For example, Grant and Dawson (1997) reported results from the National Longitudinal Epidemiologic Survey (N = 27,616) indicating that (a) the lifetime alcohol dependence rates of those who initiate alcohol use by age 14 are four times as high as those who start at age 20 or older and (b) the odds of lifetime dependence decreased by 14% with each additional year of delayed initiation, after adjusting for potentially confounding variables.

The primary prevention effect was not significant for either intervention group during the pretest to the 1-year follow-up period. However, estimated probabilities of positive outcomes were higher among PDFY and ISFP adolescents than among the control-group adolescents for the earlier transition period, suggesting that intervention effects were beginning to emerge. The generally low rates of substance use still manifest at the 1-year follow-up may have reduced power to detect such effects at that time. In other words, the relatively low rates of substance use at the 1-year follow-up (second semester, seventh grade), as compared with higher 2-year rates, may have reduced the likelihood of detecting differences in the measured substance use outcomes at the 1-year time point.

In addition to the primary prevention effects at the 2-year follow-up, the PDFY also showed a secondary preventive effect at this time point. That is, adolescents in this intervention condition who had already initiated use at the 1-year follow-up were more likely to have the same substance use status at the 2-year follow-up than were corresponding control-group adolescents who had already initiated use. Given the importance of delaying both substance use onset and progression suggested by the epidemiological literature cited previously, this secondary prevention effect evident 2 years following the intervention is noteworthy. Although the ISFP failed to show significance in this delayed progression to more frequent or varied use, it did show a positive trend in that direction (significant at the .10 level); as noted in the Results section, post hoc comparisons of ISFP and PDFY positive outcome probabilities were not significant in any instance. Also, recent analyses of ISFP intervention–control group differences in observed frequencies of individual substance use initiation behaviors at the 2-year follow-up (lifetime alcohol use, alcohol use without...
parental permission, drunkenness, cigarette use, and marijuana use) showed significant results for all initiation behaviors; in addition, the ISFP showed a large effect size (see Cohen, 1988) on a composite measure of alcohol initiation at the 2-year follow-up (Spoth, 1998). Such effects are likely to strongly influence the progression of substance use.

The stage-sequential model studied specified a sequence of statuses in which the adolescent participants were initiated into substance use and progressed to more frequent or more varied substance use across 30 months of a longitudinal study. There are two important ways in which this model is similar to other stage-sequential models of substance initiation and involvement. First, as in other models (e.g., Kandel & Faust, 1975; Kandel et al., 1992; Maddahian et al., 1985), this model posited that adolescents are initiated into substance use through substances that are legal for adults but not for children rather than through illegal substances. Second, as in other models (e.g., Graham et al., 1991; Kandel & Yamaguchi, 1985; Kandel et al., 1992), this model specified two alternative paths (through alcohol or through tobacco) through which adolescents are initiated into substance use.

In at least one respect, however, this model is different from other stage-sequential models of substance initiation and involvement. Specifically, this model does not show clear delineations among more frequent and varied substance use. Although more specific and more varied items about advanced use—or the inclusion of additional substance use statuses in the model—may have resulted in more marked delineations of advanced use, the less delineated model of advanced statuses in the present study likely reflects characteristics of the young adolescent participants in this study that differ from those of the participants in prior studies. The participants in this study were younger, and they also had lower base rates of substance use than those in other studies (e.g., Kandel & Yamaguchi, 1985; Kandel et al., 1992; Maddahian et al., 1985). Related to this point, the length of time over which the participants were followed may have also contributed to less delineated statuses of advanced substance use. For instance, studies that followed adolescents through young adulthood have shown a clearer progression toward more frequent or more varied substance use (e.g., Kandel et al., 1992; Maddahian et al., 1985). Issues concerning the age of study participants and other factors that can influence the fit of stage-sequential models (e.g., current vs. cumulative use measures and the stability of use status) are discussed at length elsewhere (e.g., Graham et al., 1991; Hays et al., 1987; Maddahian et al., 1985).

As described earlier, the key advantage of LTA is its explicit modeling of dynamic latent variables. Such modeling is well suited to examining progressive outcomes such as substance use. Nonetheless, cautions concerning the use of LTA models in certain situations have been raised. Most common among these is LTA’s use with sparse data; related limitations are especially relevant to the interpretation of significance tests. In analyses involving several variables and/or several occasions of measurement, a great many response patterns are possible. Often many of these response patterns occur rarely or not at all in the data. The approximation of G² to a chi-square distribution in such cases is questionable (see, e.g., Collins & Wugalter, 1992). In the present study, three dichotomous variables were measured on each of three occasions (a total of nine items) for each of the three experimental conditions. There are 512 possible response patterns associated with nine dichotomous items. Clearly, even using a very modest number of items will result in sparse data for all but the largest sample sizes. Until this issue has been resolved, caution should be exercised when interpreting G² significance tests.

Another caution relevant to the interpretation of results presented here concerns the rural nature of the sample. As indicated above, the families included in this study were selected from rural Midwestern school districts. As is representative of families of young adolescents in the region, the vast majority were dual-parent families and virtually all participants were White. It is not clear to what extent the present findings would generalize to urban and/or more culturally diverse populations.

Another sample-related issue concerns the exclusion from the analyses of intervention-group families that did not participate at all in the intervention. As noted in the Method section, both space constraints and validity considerations led to the decision to analyze data from attending families. Our prior studies addressed concerns regarding potential self-selection biases. These studies have demonstrated intervention participant–nonparticipant equivalence on a variety of family sociodemographic, social–emotional, and problem behavior measures at the time of pretesting (Spoth, Redmond, Kahn, & Shin, 1997; Spoth et al., 1998). In addition, prior research conducted with families successfully and unsuccessfully recruited for the intervention evaluation project indicated that practical issues, such as time and scheduling factors, were the most common causes of family resistance to project activities rather than family member predispositions that might otherwise bias results (Spoth & Redmond, 1994, 1996; Spoth, Redmond, Hockaday, & Shin, 1996).

Although providing an initial insight into the role of universal preventive interventions in altering the progression of substance use behaviors among adolescents, future research extending and broadening this line of investigation is needed. One obvious extension would involve the inclusion of additional waves of data. As discussed earlier, the absence of a clear advanced-use status in the present study is suggestive of a substance use process that is not fully developed in the present sample. Additional waves of data collected as the sample of adolescents progresses through high school and beyond could provide a much more complete picture of substance use patterns. Another line of investigation will involve the detailed examination of intervention effects on specific substance-related problem behaviors. Such examinations will focus on drunkenness and driving while intoxicated, for example. Finally, future work will examine a model of the mediational role of intervention-induced improvements in parenting on adolescent substance outcomes, building on prior work that has evaluated mediational models of parenting effects on predictors of substance use, such as peer refusal skills.

References


### Appendix

**Pretest Equivalence Chi-Square Tests of Experimental Groups for the Observed Variables Used in the Analysis**

<table>
<thead>
<tr>
<th>Variable</th>
<th>% PDFY group</th>
<th>% ISFP group</th>
<th>% control group</th>
<th>$\chi^2(2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol only</td>
<td>16.74</td>
<td>13.03</td>
<td>18.84</td>
<td>2.889</td>
</tr>
<tr>
<td>Tobacco only</td>
<td>11.76</td>
<td>5.88</td>
<td>8.21</td>
<td>5.113</td>
</tr>
<tr>
<td>Advanced use</td>
<td>3.62</td>
<td>1.26</td>
<td>1.44</td>
<td>3.739</td>
</tr>
</tbody>
</table>

*Note.* PDFY = Preparing for the Drug-Free Years program; ISFP = Iowa Strengthening Families Program.

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