Multilevel Contextual Influences and Nonuse of Alcohol, Tobacco, and Other Drugs: A Latent Class Analysis of Substance Free Youth

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Abstract

Currently very few studies have examined the co-existence of ecological health-negating and health-promoting influencing factors for nonuse, experimentation, and regular use of alcohol, tobacco, and other drugs (ATOD) among adolescents. Understanding which factors are most strongly related to hidden subgroups (latent classes) in the adolescent population, as well as which factors characterize the most homogeneous latent classes can point interventionists to tailoring variables and target subgroups, increasing the effectiveness of health promotion and substance use prevention programs.

This descriptive probabilistic study used archival data from the National Longitudinal Study of Adolescent Health (Add Health), waves 1-4, to identify latent classes of youth according to their patterns of ecological influencing factors. The latent class structure among nonusers, experimenters, and regular/risky ATOD users was tested. The probability of nonuse, moderate use, or regular/risky use during adulthood given latent class membership during adolescence was ascertained. Covariates included age, gender, race/ethnicity, family socioeconomic status (SES), residential location, and neighborhood SES. Latent Class Analysis (LCA) with covariates and LCA with a distal outcome were conducted using SAS.

For the overall sample (*N*=4,198), a 3-class model fit the data the best. Self-regulation, peer substance use, and school connectedness had the strongest associations with the latent variable. Age, family SES, and neighborhood SES were significant covariates. Since measurement invariance did not hold across subpopulations of nonusers, experimenters, and regular/risky ATOD users, the model was fit separately for

each group. Each subpopulation fit a 2-class model the best, and the proportion of females within each class was significantly different when comparing the two classes of regular/risky users. Finally, relative to the overall population prevalence, regular/risky substance use during adulthood had the greatest probability (0.90) given membership in the "low self-regulators with mixed influences" class, and adult substance nonuse had the greatest probability (0.29) given membership in the "health-promoting influences" class. The results suggest that interactions among health-negating and health-promoting factors across youths' ecology do account for important subgroups in the population. The strongest latent class indicators, *i.e.,* self-regulation, peer substance use, and school connectedness, could be useful for tailoring interventions, while the latent classes can guide interventionists towards target subpopulations. More research is needed to understand the transitions in latent class membership occurring over time, and to identify other strong predictors of substance nonuse extending through adolescence and into adulthood.

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Dedication

This work is dedicated to my husband, Ed, and my children, Eleanor and Lewis, and my extended family that have provided unforgettable support and encouragement. It is also dedicated to all the youth and young adults I have encountered and will encounter in the coming years – this study is for you. A special thank you to Mary, Marti, Donna and many others who held me in their prayers as I worked toward the goal of completing this dissertation.

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I wish to extend deep gratitude to my dissertation committee chair and advisor, Dr. Pamela Kulbok, and committee members, Dr. Pam DeGuzman, Dr. Ishan Williams, and Dr. Karen Schmidt for their support, guidance, and constructive critique of this research and dissertation product. You are each an inspiration to me and have taught me so much.

CHAPTER 1: Introduction

The use of alcohol, tobacco, and other illicit substances (ATOD) is a major area of health concern for youth because of its linkages to injury and social and physical addiction (National Institute on Drug Abuse [NIDA], 2010). Although the incidence and prevalence of alcohol, tobacco, and other drug use among youth has been declining since the 1990s, recent statistics indicate the decline is slowing or has stalled (Centers for Disease Control and Prevention [CDC], 2011; National Center for Chronic Disease Prevention and Health Promotion, 2010). Prevention programs have been developed for school, family, and community settings to try to support non-use of ATOD in adolescents through the reduction of risk factors and enhancement of protective factors (Carson et al., 2011; Faggiano et al., 2005; Foxcroft & Tsertsvadze, 2011). Reviews indicate the general effectiveness of these programs, yet some programs have exhibited iatrogenic effects on substance use. For example, a recent RCT of a multi-component, school-based intervention that focused on demonstrating the personal, social, and legal risks of drug use and taught life skills resulted in increased alcohol and tobacco use in baseline non-users in the intervention group (Sloboda et al., 2009). A follow-up study could not identify the source of these effects (Teasdale, Stephens, Sloboda, Grey, & Stephens, 2009). Negative program effects on nonusers point to the need for further research regarding the etiology of youth substance nonuse. From their holistic health promotion standpoint, nurses are in a position to identify the tailoring variables and target subgroups that youth health promotion interventions might focus upon for increased effectiveness.

Most interventions have been developed to address risk and protective factors that were identified through variable-oriented studies (*i.e.,* regression and correlation) of

adolescent behavior in which adolescents were grouped into a dichotomized category of substance use (non-user vs. user), and in which non-users were treated as homogeneous (Johnson et al., 2006). These studies have not examined the ways in which risk and protective factors may co-exist in different patterns among youth, nor have they emphasized understanding the influencing factors among substance-free youth (Syvertsen, Cleveland, Gayles, Tibbits, & Faulk, 2010). The patterns of ecological influencing factors are important to identify because they provide a basis for tailoring health promotion interventions and targeting subgroups resulting in better program outcomes. The long-term goal of this program of research is to further the evidence-base of targetable patterns of risk and protective ecological influencing factors for substance non-use and to support the ongoing development of health promotion programs for United Statues (U.S.) adolescents. The major goal of the proposed study was to identify distinguishable subgroups of youth based on their self-reported ecological influencing factors for substance use and nonuse and to determine the predictive utility of these patterns for long-term substance nonuse. The specific aims were to:

1. Identify latent classes (homogeneous subgroups) of youth according to their patterns of self-regulation, exposure to ATOD use by friends and family, relationship to and authority of parents, school connectedness, exposure to community violence, and neighborhood connectedness.
2. Identify differences in these subgroups among adolescents who abstain from substance use as compared to youth who experiment with ATOD (*i.e.,* use but are not regular users) and youth who are regular users of ATOD.

3. Determine the predictive strength of the latent classes for substance non-use in young adulthood.

The aims of this descriptive, probabilistic study were met through secondary analysis of public-use data collected during the in-home survey interview of the National Longitudinal Study for Adolescent Health (Add Health), Waves 1-4 (n = 4,198; data collected 1994-2008) (Harris & Udry, 2013). Selected items from Wave 1 and 2 and substance use behavior at Wave 4 were used to construct variables used in the analysis. The influencing factors included measures of self-regulation, peer substance use, parental smoking, availability of tobacco in the home, closeness with parents, authority of parents, school connectedness, exposure to violence, and neighborhood connectedness.

This dissertation is divided into chapters including the dissertation proposal that provides an exemplar of a traditional grant proposal including details of background, significance, aims, and methods. In addition, a methods chapter describes the data preparation and analysis in greater detail than allowed in the proposal. Three publishable manuscripts represent the dissertation results. The first manuscript is a systematic review of the literature on substance free youth. The second manuscript presents the results of the latent class analysis and the effects of covariates and a grouping variable. The third manuscript, in research brief format, presents the results pertaining to the probability of adult substance nonuse given latent class membership during adolescence. The final concluding chapter summarizes the findings, addresses the relevance of this study to nursing and adolescent health behavior and health promotion research, and suggests directions for future research.

CHAPTER 2: PHS 398 Form

Project Summary:

Health promotion and disease prevention programs for youth continue to target alcohol, tobacco, and other drug (ATOD) use, a health behavior linked to significant injury and chronic addiction within this age group. Most programs, however, have short-lasting effects and many have very little effect. Recently the CDC has identified that the historical decline in rates of ATOD use among youth has begun to stall out or stop. Further research is needed to identify the processes by which youth remain substance-free in the presence of both health-promoting and health-negating factors, creating a clearer framework for developing programs that can work to enhance these processes. Since most studies of substance use etiology have emphasized predicting a dichotomous outcome (use vs. nonuse), research is also needed to enhance the understanding of youth who experiment with ATOD. The long-term objective of the proposed study is to further the evidence-base of targetable patterns of risk and protective ecological influencing factors for substance nonuse, to support the ongoing development of nurse-led health promotion programs for U.S. adolescents. The major aim of the proposed study is to identify distinguishable subgroups of youth based on their self-reported ecological influencing factors for substance use/non-use and to determine the predictive utility of these patterns for long-term substance non-use. The specific aims are to: 1.) Identify latent classes (homogeneous subgroups) of youth according to their patterns of self-regulation, exposure to ATOD use by friends and family, relationship to and authority of parents, school connectedness, exposure to community violence, and neighborhood connectedness. 2.) Identify differences and similarities in these subgroups among

adolescents who abstain from substance use as compared to youth who experiment with ATOD (*i.e.*, use but are not regular users) and to youth who are regular or risky (*i.e.,* multiple substances) users of ATOD. 3.) Determine the predictive strength of the latent classes for substance non-use in adulthood. The descriptive, correlational design will employ the use of Latent Class Analysis with a distal outcome to analyze archival public-use data from the National Longitudinal Study of Adolescent Health.

Relevance:

The outcomes of this research study will provide information to understand the most common patterns of multilevel influences for substance non-use among youth, to identify tailoring variables for individualizing programs, and to prioritize and develop targeted youth health promotion programs that support the non-use of alcohol, tobacco, and other drugs.

Specific Aims

The use of alcohol, tobacco, and other illicit substances (ATOD) is a major area of health concern for youth because of its linkages to injury and social and physical addiction (National Institute on Drug Abuse [NIDA], 2010). Although the incidence and prevalence of alcohol, tobacco, and other drug use among youth has been declining since the 1990s, recent statistics indicate the decline is slowing or has stalled (Centers for Disease Control and Prevention, 2011; National Center for Chronic Disease Prevention and Health Promotion, 2010). Prevention programs have been developed for school, family, and community settings to try to support non-use of ATOD in adolescents through the reduction of risk factors and enhancement of protective factors (Carson et al., 2011; Faggiano et al., 2005; Foxcroft & Tsertsvadze, 2011). Reviews indicate the general effectiveness of these programs, yet some programs have exhibited iatrogenic effects on substance use. For example, a recent RCT of a multi-component, school-based intervention that focused on demonstrating the personal, social, and legal risks of drug use and taught life skills resulted in increased alcohol and tobacco use in baseline non-users in the intervention group (Sloboda et al., 2009). A follow-up study could not identify the source of these effects (Teasdale et al., 2009).

Most interventions have been developed to target risk and protective factors that were identified through variable-oriented studies (*i.e.,* regression and correlation) of adolescent behavior in which adolescents were grouped into a dichotomized category of substance use (non-user vs. user), and in which non-users were treated as homogeneous (Johnson et al., 2006). These studies have not examined the ways in which risk and protective factors may co-exist in different, yet common, patterns among youth, nor have

they emphasized understanding the influencing factors among substance-free youth (Syvertsen et al., 2010). The patterns of ecological influencing factors are important to identify because they provide a basis for targeting and prioritizing health promotion interventions, resulting in better program outcomes. The co-existence of risk and protective factors (or health-negating and health-promoting factors) may also help to define the background for processes of resilience, or how youth develop healthy behaviors (*e.g.,* remain non-users) despite the presence of risk. The **long-term goal** of this program of research is to further the evidence-base for targetable patterns of health-promoting/negating influencing factors for substance non-use to support the ongoing development of health promotion programs for U.S. adolescents. The **major aim** of the proposed study was to identify distinguishable subgroups of youth based on their self-reported ecological influencing factors for substance use/non-use and to determine the predictive utility of these patterns for long-term substance non-use. The specific aims were to:

1. Identify latent classes (homogeneous subgroups) of youth according to their patterns of self-regulation, exposure to ATOD use by friends and family, relationship to and authority of parents, school connectedness, exposure to community violence, and neighborhood connectedness.
2. Identify differences and similarities in these subgroups among adolescents who abstain from substance use as compared to youth who experiment with ATOD (*i.e.,* use but are not regular users) and youth who are regular or risky (*i.e.,* multiple substances) users of ATOD.

3. Determine the predictive strength of the latent classes for substance non-use in young adulthood.

The aims of this descriptive, correlational study were met through secondary analysis of public-use data collected during the in-home survey interview of the National Longitudinal Study for Adolescent Health (Add Health), Waves 1-4 (n = 4,198) (Harris & Udry, 2013). Selected influencing factors and substance use categories from Wave 2 and substance use behavior at Wave 4 were used in the analysis.

Research Strategy

Significance

Despite efforts in schools, families, and communities to curtail the initiation of substance use, youth in the United States continue to use alcohol, tobacco, and other illicit drugs (ATOD) at problematic rates (NIDA, 2011). ATOD use during adolescence is a primary source of injury and addiction, and it impairs the processes of healthy development that are key to becoming productive and competent adults. Currently there are over 150 evidence-based programs for the prevention of substance use among youth cited in the National Registry for Evidence-based Programs and Practices (Substance Abuse and Mental Health Services Administration [SAMHSA], 2013). Some target multiple substances, while others target only one. Some prevention programs are for implementation in schools, while others are for families or communities. The most effective programs focus on teaching life skills including effective communication skills, assertiveness, drug resistance, coping with anxiety, decision-making, and understanding the consequences of drug use (Mihalic, Fagan, & Argamaso, 2008). The programs also

tend to focus on reducing risk factors and increasing protective factors for substance use (Scheier, 2010).

Recent prevalence rates reveal that the historical decline in substance use among youth since the 1990s has slowed or stalled. Meta-analyses of prevention programs indicate that the effectiveness of programs is usually short-lived, and many have only moderate effects (see *e.g.*, Faggiano et al., 2005; Foxcroft & Tsertsvadze, 2011). Despite this somewhat negative outlook, one must note that a small majority of 12th graders (51%) have remained substance-free during the past 30 days (Child Trends, 2012). Furthermore, the Positive Youth Development perspective encourages a paradigm shift towards viewing adolescence as a time when youth assets can be best enhanced by aligning them with appropriate contextual resources (Atkiss, Moyer, Desai, & Roland, 2011), and models of resilience are beginning to identify the processes by which youth develop into healthy adults despite the presence of risk (Fergus & Zimmerman, 2005).

Despite these shifts, there is a need for more research related to the co-existence of risk and protection and resilience. Most prevention programs are still primarily based on risk reduction and increasing protection and may be missing the key processes of resilience that prevent or stop substance abuse (Bandy & Moore, 2008). Furthermore, few studies exist that test and examine the interactions of health-promoting and health-negating factors in adolescents' lives (Syvertsen et al., 2010). The majority of studies continue to use models that test prediction of substance use vs. nonuse and that label a factor as 'protective' or 'risk' by virtue of the direction of the odds ratio for predicting substance use. In other words, if a factor predicts decreased use or the absence of use, it is "protective", while the opposite is a "risk" factor. Very few studies have identified

protective factors and the mediating and moderating effects of factors occurring at multiple levels of the ecological context for adolescent development (Stone, Becker, Huber, & Catalano, 2012a). Overall, there is still an approach to preventing substance use in adolescents that focuses on reducing risks, rather than on identifying and promoting the processes by which youth are resilient to risk (Bandura, 2005).

Another concern is that most of the supporting research for interventions has categorized youth as either non-users or users and has not acknowledged the spectrum of substance use occurring during adolescence. Some studies have identified that differentiation between non-users and experimenters and regular or problem users is a helpful distinction for understanding the precursors to substance-use initiation (Crano, Siegel, Alvaro, Lac, & Hemovich, 2008; McCusker, Roberts, Douthwaite, & Williams, 1995; McMillan, Sherlock, & Conner, 2003). For example, Crano et al. (2008) found that a group of vulnerable nonusers, defined as those who did not have clear intentions to not use marijuana in the future, were more likely to experiment with marijuana than resolute nonusers. McCusker et al. (1995) found that *repeated* illicit substance users had a greater number of friends who used substances and overall used more types of substances than *experimenters.* While there is evidence that expanding the user-nonuser dichotomy is useful, studies have not assessed the complex interactions of risk and protective factors for these groups, nor have they linked the interactions and the degrees of substance nonuse or use to adult substance use and nonuse behaviors.

The proposed study draws on Bronfenbrenner's (2000) bioecological theory of human development to identify the possible patterns of risk and protective factors that contribute to long-term non-use of substances. The bioecological model emphasizes that

the interactions between people and multiple levels of their context (*i.e.* intraindividual, interpersonal, institutional, community) are the basis for human development and behavior change over time. The constructs included in the study reflect one of each of these levels of context and are mathematically modeled together as patterns. The Positive Youth Development framework (Lerner, Lerner, von Eye, Bowers, & Lewin-Bizan, 2011), and the challenge model of resiliency (Fergus & Zimmerman, 2005) have also philosophically influenced the design, aims, and methods of the study. The research conceptual model (see Figure 1) proposes that influencing factors for substance non-use occur at multiple levels of the ecological system (intrapersonal, interpersonal, institutional, and neighborhood), and that there are important and distinguishable combinations of influencing factors (both risk and protective) that differentiate subgroups of youth from each other. In other words, there are subgroups of youth who have very similar within-group patterns of influencing factors, but these patterns when compared to another subgroup (*i.e.,* between group) are distinctly different (see *e.g.*, Johnson et al., 2006; Ludden & Eccles, 2007; Syvertsen et al., 2010). These subgroups highlight the heterogeneity of youth as well as the co-existence and interactions of risk and protective factors.

The model also proposes that when these subgroups are identified in youth who do not use substances and compared to subgroups identified in experimenters and regular substance-users, important differences and similarities in patterns of ecological influencing factors for substance use/non-use will be revealed. Modeling an expanded distinction of substance-use type (*i.e.*, nonusers, experimenters, and regular users of ATOD) in this way treats substance-nonuse as a moderator of all of the interactions

among risk and protective factors, rather than as an outcome (Collins & Lanza, 2010). Although not directly tested in the proposed model, identifying subgroups of youth based on patterns of co-existing risk and protective factors follows the challenge model of resilience where the presence of some risk may actually be beneficial in promoting coping skills and healthy outcomes in youth (Fergus & Zimmerman, 2005). These subgroups provide evidence for health promotion and substance-use prevention programs to consider more carefully which influencing factors they target and in whom (Collins, Murphy, & Bierman, 2004). Finally, the model suggests that the identified subgroups can also be useful for predicting long-term healthy outcomes such as non-smoking, no illicit substance use, and appropriate alcohol use in adulthood. Knowledge of the subgroups within adolescents that are most predictive of healthy outcomes in adulthood will enhance the understanding of sustainable healthy behavior development.

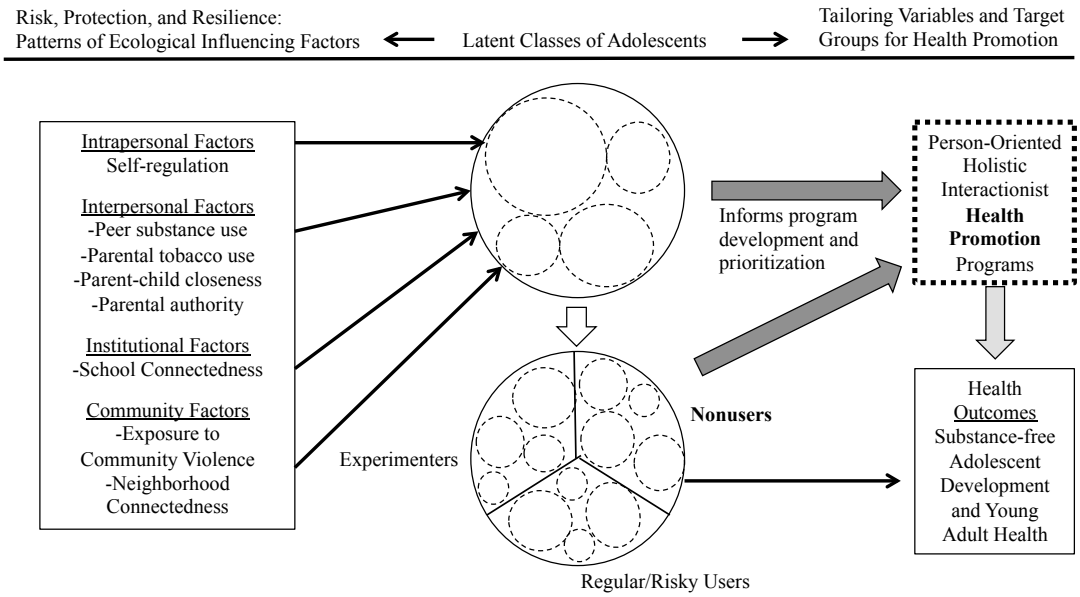

Figure 1. Research conceptual model. This figure illustrates the constructs and relationships being studied as well as the link to health promotion programs.

Innovation

A significant way in which this study challenges current research in the etiology of substance use and healthy youth development is its theoretical and methodological approach. No studies have attempted to model latent classes of youth according to patterns of influencing factors at multiple levels of the ecological framework for development. No studies have used substance-user type (*i.e.,* nonuser, experimenter, and regular user) as a moderator, and no studies have attempted to link the identified subgroups to distal (adult) outcomes. This approach is largely made possible by advancements in statistical processing software and computer power for handling large amounts of data, as well as by methodological advancements in identifying and measuring categorical latent variables and other person-oriented methods (Collins & Lanza, 2010; Magnusson, 2003; Vermunt & Magidson, 2002). More studies using these methods are needed in order to refine the methods and to identify the implications of the findings. Comparing the findings from the person-oriented methods used in the proposed study to the findings of other studies using variable-oriented methods acknowledges the complementary nature of these two approaches (Magnusson, 2003), and reveals highly nuanced and rich information about the influencing factors for healthy youth development in relation to substance use. Finally, the use of data from the National Longitudinal Study of Adolescent Health (Add Health), a nationally representative, longitudinal data set, provides a unique opportunity to address study aims for which data collection and analysis would otherwise be very expensive and logistically difficult. The Add Health study data is particularly useful in that it reflects information about the same people as they have developed from adolescents into adults over time and includes

measures that assess the ecological levels or systems of influence, as well as important health behaviors.

Approach

Design and data. The proposed descriptive, correlational study employed a person-oriented methodological approach Latent Class Analysis (LCA) (including multiple-group LCA, LCA with covariates, and LCA with a distal outcome) in the secondary analysis of archival data to address the specific aims. The proposed study used data from the National Longitudinal Study for Adolescent Health (Add Health) (UNC Carolina Population Center, n.d.). Add Health has particular strengths not available in other data sets of adolescents: 1) It is longitudinal and has collected data from the same people (a nationally representative sample) over four waves covering early adolescence into adulthood; 2) Its variables include measures of health, health care, risk and protective factors, relationships with friends, parents, and schools, as well as other contextual variables; 3) The public-use data set is easily accessible and free. A possible weakness of the data is that the first several waves of data collection occurred in the mid-1990s. It may be that the context for adolescents today is enough different from adolescents in the 1990s that some of the research questions about influencing factors for adolescent health behavior cannot be reliably answered. However, the chosen influencing factors for substance-nonuse likely remain relevant and consistent across time, and the relationships between them have not changed (Brown, Schulenberg, Bachman, O'Malley, & Johnston, 2001). Furthermore, examining the predictive utility of influencing factors during adolescence for long-term (*i.e.,* adult) outcomes such as substance non-use capitalizes on the longitudinal nature of the data and the fact that the

same people were surveyed at each wave of data collection. Wave 1 data were collected in 1994-1995 when most participants were in middle and high school, Wave 2 data in 1996, Wave 3 data in 2001-2002, and Wave 4 in 2008-2009.

Sample/Sampling Plan. The Add Health study used a clustered, stratified sampling plan and is described in detail at www.cpc.unc.edu/projects/addhealth/design. The sample consisted of 80 high schools and 52 middle schools across the United States and selected with unequal probability of selection. However, the use of systematic, implicit stratification ensured that the sample is representative of U.S. schools in relation to region of country, urbanicity, school size, school type, and ethnicity (Harris et al., 2009). Eligible high schools were those that had an 11th grade and enrolled more than 30 students. More than 70% of sampled high schools participated, and for each school that declined participation, a replacement school within the same stratum was selected. The clustered sampling design was school-based because the researchers wanted to ensure access to most of the participants' peers. All students at each school were eligible to participate. Parents were informed in advance of the date of the questionnaire and could direct their children not to participate.

The public-use, Wave 1, In-Home Interview Questionnaire, Add Health data set contains 6,504 participants; Wave 2 contains 4,834 of the original Wave 1 participants; Wave 3 contains 4,882 of the original Wave 1 participants; and Wave 4 contains 5,114 of the original Wave 1 participants (UNC Carolina Popuation Center, n.d.). The response rate for Wave 1 was 79%, which is comparable to other response rates of 75-80% in substance-use surveys such as Monitoring the Future (Bachman, Johnston, & O'Malley, 2011). Lack of response was most likely due to absence from school on the day of the

survey, which could introduce some bias into the sample; however, the otherwise large sample size renders this bias extremely minimal. The proposed study included data pertaining to participants from Wave 1 through Wave 4 who meet the following inclusion criteria:

1. Age 12-19 at time of Wave 2 interview
2. In-school or on academic break at time of Wave 2 interview
3. Completed both the in-school and in-home questionnaires of Wave 1 and the in-home questionnaire of Wave 2.

These criteria ensured an increased likelihood of complete data on each participant for each of the independent variables of interest. No exclusion criteria were used.

A missing values analysis was conducted to identify any significant differences in participants who were missing responses as compared to those who were not missing responses, as well as to consider whether data appeared to be missing completely at random (MCAR), at random (MAR), or non-ignorable, not at random (MNAR) (Little & Rubin, 2002). The results supported that variables missing greater than 5% were related to other variables included in the analysis and were therefore treated as MAR. In the case of latent class analysis modeling, if data are considered missing at random, full information maximum likelihood estimation can be used to account for missing values for the indicators (Collins & Lanza, 2010). In contrast, cases missing data on the grouping variable (*i.e.,* substance use category), covariates, and the distal outcome are excluded from the analysis. In the current study, the 5.3% excluded due to missing the substance use indicator (nonuser, experimenter, regular/risky user) were more likely to be high self-regulators, report that no friends use substances, and be African American. No

other covariates were missing greater than 5% indicating a very small degree of bias introduced by cases excluded from analysis.

Social desirability bias. To reduce the degree with which respondents might alter their responses in a socially desirable direction (*e.g.,* report non-use of substances even when this is not the truth), the sensitive items of the Add Health In-Home Questionnaire were delivered to participants using computer and audio-assisted self-interview (CASI) (Harris et al., 2009). In addition, participants were reminded that their responses would not be linked to them directly, and they were provided with a certificate of confidentiality. Despite these efforts to reduce bias, it is likely that there still exists self-report bias within this survey (Paulhus, 2002). No specific efforts were made to control for this bias in the current study due to the already complex nature of the statistical model. Considering that at least one other study using Add Health data found no effect of response bias on the relationship between religiosity and responses to sensitive items (Regnerus & Uecker, 2007), it seemed prudent to move forward with the analysis without controlling for social desirability.

Measures. The study used items and subscales from the Wave 1 Parent Questionnaire and the Wave 1-4 Add Health In-home Interview Questionnaires (Mullan Harris & Udry, 2008) to operationalize the major constructs of interest, the various influencing factors at each level of the ecological model of health behavior (Bronfenbrenner, 2005; McLeroy, Bibeau, Steckler, & Glanz, 1988). The theoretical definitions, reliability, validity, and operationalization of each construct are described below.

Self-regulation. Self-regulation is defined as an individual's ability to "control or regulate one's emotions, cognitions and behavior" in order to attain socially acceptable goals or to demonstrate "competent functioning" (Belsky & Beaver, 2011). The construct captures the development of executive functioning that is rapidly expanding during adolescence, especially as the adolescent is experiencing more and more autonomy in the movement toward adulthood. Low levels of self-regulation have been associated with substance use initiation and problem use, while high levels are considered protective (Hustad, Carey, Carey, & Maisto, 2009; Lerner, Lerner, Bowers, et al., 2011; Wills, Sandy, & Yaeger, 2002).

The current study used an operationalization of self-regulation previously identified in the Add Health survey and used by Beaver, Ferguson, and Lynn-Whaley (2010) in their study of associations between parenting and adolescent levels of self-regulation. The measure consisted of the sum of 20 items asked in the Wave 2 Adolescent In-Home Interview. The items tapped self-regulation experiences such as whether they have trouble keeping their mind focused, whether they like to take risks, and whether they are sensitive to other people's feelings. Beaver et al. (2010) reported that "psychometric analyses revealed that the 20 items could be accounted for by a single factor, and additional analyses revealed that removing any of the items from the scale would not significantly increase the internal reliability of the scale" (p. 1052); their Cronbach's alpha was 0.72. Mimicking their procedure, the composite measure of self-regulation for the proposed study was the sum of all items. Before summing, some items were reverse coded so that a higher numbered response indicated a higher level of self-

regulation. The Cronbach's alpha generated for the current study sample was 0.73, demonstrating adequate internal consistency (Nunnally & Bernstein, 1994).

Exposure to ATOD by peers and family. Research has identified that a strong predictor of substance use in adolescents is the substance-use behavior of peers and family, including the availability of substances in the home (Hawkins, Catalano, & Miller, 1992). Studies have also identified that processes of resilience can be reflected in the number of youth who specifically do not use substances in the presence of relatively frequent exposure to ATOD use (Crano, Siegel, et al., 2008; Kulbok et al., 2010; Spijkerma & Engels, 2007). The current study uses the sum of responses to three Likert-type items (response options: 0, 1, 2, or 3) assessing the respondent's perception of friends' smoking behavior, alcohol use, and marijuana use (*e.g.*, Of your 3 best friends, how many smoke at least 1 cigarette a day?) to reflect perceived peer substance use behavior. Two dichotomous items assessing father and/or mother cigarette smoking in the past year and a single item assessing the availability of tobacco in the home (*e.g.*, Are cigarettes easily available to you in your home? 0 = no, 1 = yes) were summed to reflect exposure to tobacco by parents. Scores could range from 0 to 2. Higher scores for each scale indicated higher exposure to ATOD by peers and family. No reliability information had been previously generated in the literature. The Cronbach's alpha for peer substance use was 0.74, and the KR-20 for the parent tobacco use and home-availability of tobacco was 0.71. Stevens-Watkins and Rostosky (2010) recently found a significant association between perceptions of close friends' substance use and binge-drinking behaviors in African American males using the Add Health data set, indicating some predictive

validity of the peer substance use measure. No previous studies using the Add Health items regarding home availability of substances could be identified in the literature.

Relationship to parents (closeness and authority). Adolescents' relationships with their parents are another important source of influence for substance use behavior. Experiencing a close, warm relationship with parents and having parents who regularly monitor adolescent behavior and set household rules have been associated with positive outcomes in adolescent development (Guo, Reeder, McGee, & Darling, 2011; Peterson, Buser, & Westburg, 2010; Ryan, Jorm, & Lubman, 2010a). As a proxy for parent-child attachment, a recent study by Gault-Sherman (2012), used the average of ten Likert-type Add Health items (five pertaining to the mother, and five pertaining to the father; response options: strongly agree to strongly disagree) to assess perceived closeness with and care from parents, reporting an alpha of 0.86. If only one parent was in the home (*i.e.,* single-parent family), the score reflected the closeness with only the resident parent.

The Gault-Sherman (2012) study also used the sum of seven dichotomous Add Health items assessing the respondents' perceptions of how much the parent(s) allow him/her to make independent decisions about daily activities (*e.g.*, what to eat, when to go to bed, etc.), with alphas ranging from 0.61-0.65. This second composite measure was used as a proxy for rule-setting and parental monitoring. The current study used both subscales. The first reflected parent-child closeness (Cronbach's alpha = 0.86) and the second reflected parental authority (KR-20 = 0.63). This approach suggested that there might be different patterns where some youth are distinguished by having close relationships with their parents and low parental authority, while others have low parental authority and poor relationships or high authority and close relationships with their

parents. Although the reliability of the parental authority measure was low, a better proxy for parental authority could not be identified in the data set.

School Connectedness. School connectedness is theoretically defined as a "broad promotive influence….including positive peer relationships, perceptions of safety, feelings of belongingness, and teacher support" occurring in the school setting (Furlong, O'brennan, & You, 2011). A classic study by Resnick et al. (1997) was one of the first studies to use the Add Health School Connectedness subscale and to identify the predictive validity of school connectedness for health outcomes. More recently, Furlong and colleagues (2011) conducted a psychometric evaluation of the 5-item subscale by testing it across 18 sociocultural groups. In a sample of 500,800 junior and senior high school students in California, they identified that this unidimensional measure has acceptable reliability (alpha = .82 to .88) and concurrent validity with the *School Support Scale* from the Resilience Youth Development Module (r = .44 to .55) across the 18 sociocultural groups. Using confirmatory factor analysis methods, they also found that the subscale had a one-factor structure that satisfactorily fit in all 18 groups and with significant standardized factor loadings for each of the 5 items (*i.e.,* configural invariance). The model fit was satisfactory when loadings were constrained to be equal across all 18 groups (*i.e.,* metric invariance). In addition, the model fit was satisfactory when intercepts were also constrained across all 18 groups (*i.e*., scalar invariance) (Furlong et al., 2011).

Although there still remains some ambiguity concerning the conceptual definition of the underlying latent construct (Libbey, 2004), the face validity of the items indicate measurement of a sense of closeness to people at school, happiness about being at the

school, feeling a part of the school, that teachers treat students fairly, and feeling safe at school. Participants rate each statement using a 5-point Likert scale, where 1 = strongly disagree and 5 = strongly agree, and the sum of the responses is the School Connectedness score, ranging from 5 to 25. Higher values indicate stronger connection to school. The current study used the same procedures to generate a *school connectedness* score for each case, and alpha reliability was 0.78.

Exposure to Community Violence. Tests of the relationships between exposure to community violence and health or developmental outcomes have had mixed results. For example, while McDonald, Deatrick, Kassam-Adams, and Richmond (2011) found that community violence exposure had no significant effect on a measure of positive youth development, Taylor and Kliewer (2006) found that it predicted alcohol use at time-2 in a study of young adolescents. Because the neighborhood connectedness measure (see next section) in the current study did not include specifics about violence, it was important to tap this component of community life experience using a specific measure of community violence.

Exposure to community violence was measured using the sum of five items (Hagan & Foster, 2001; Thaweekoon, 2006). The items inquired as to how frequently the participant had experienced the following events during the past 12 months: "You saw someone shoot or stab another person; Someone pulled a gun on you; Someone pulled a knife on you; Someone shot you; Someone stabbed you." Adolescents could respond with *never* (1), *once* (2), or *more than once* (3). Higher scores indicated a higher exposure to interpersonal community violence. Hagan and Foster (2001) reported an alpha of 0.69. The alpha for the current study sample was slightly lower at 0.67.

Although this reliability is barely acceptable according to psychometric theory (Nunnally & Bernstein, 1994), an exploration of other items did not reveal more reliable items for measuring this construct using the Add Health public use data set. Furthermore, it is highly likely that the Cronbach's alpha measure of reliability underestimates the true internal consistency of this scale due to the ordinal nature of the included items (Gadermann, Guhn, & Zumbo, 2012). A polychoric ordinal reliability alpha generated using R resulted in an ordinal alpha of 0.90, indicating very good internal consistency reliability.

Neighborhood Connectedness. Neighborhood factors such as socioeconomic status, sense of cohesion, and safety have previously been linked to delinquent behaviors, binge drinking, marijuana use, and early sex initiation in youth (Choi, Harachi, & Catalano, 2006; Mahatmya & Lohman, 2012; Roche et al., 2005; Tucker, Pollard, de la Haye, Kennedy, & Green Jr., 2013). The current study focused on the youth's perception of their own neighborhood cohesion and sense of safety, as well as their sense of connection to neighbors, to understand possible neighborhood factors that are associated with resilience in youth. The Add Health in-home questionnaire contains four dichotomous and two likert-type items that were summed to reflect the level of neighborhood connectedness perceived by the youth: "You know most of the people in your neighborhood"; "In the past month, you have stopped on the street to talk with someone who lives in your neighborhood"; "People in this neighborhood look out for each other"; "Do you usually feel safe in your neighborhood?"; "On the whole, how happy are you living in your neighborhood?"; and, "If for any reason, you had to move from here to some other neighborhood, how happy or unhappy would you be?" No

previous reliability information could be identified in the literature, and the Cronbach's alpha using standardized items for the current study was 0.64. Other items were explored to attempt to increase the internal consistency, but no improvement could be made.

In support of some predictive validity of these items, Tucker and colleagues (2013) used two of the items to assess associations of neighborhood cohesion (*i.e.*, people look out for each other) and perceived safety with marijuana use and binge drinking. They found that binge drinking initiation during the one-year period between Add Health Wave 1 and Wave 2 was significantly associated with perceived greater safety in the neighborhood (OR 1.52, 95% CI 1.02-2.27, $p<.05$). They did not, however, detect any associations between the neighborhood cohesion measure and the marijuana and binge drinking measures. It was expected in the current study that using additional items that assess the youth's sense of connection or familiarity with neighbors would tap more variation in neighborhood connectedness.

Covariates. Covariates included age, gender, race/ethnicity (Caucasian, African American, Other Minority), family socioeconomic status, and residential location (urban, suburban, rural). These variables are typically used in studies of adolescent health behaviors and development because they are generally non-modifiable, and, by including them in the model, the generalizability of the findings increases. Furthermore, there is evidence that increasing age is associated with increased likelihood of trying substances (*i.e.*, youth will have inherently had more opportunities to try ATOD) (Scheier, 2010), gender differences interact differentially with a variety of factors (Chen & Jacobson, 2012; Mason et al., 2009), race/ethnicity also interacts with influencing factors (García-Rodríguez, Suárez-Vázquez, Secades-Villa, & Fernández-Hermida, 2010; Lac et al.,

2011; Thai, Connell, & Tebes, 2010), family poverty and affluence differentially affect health behaviors of youth (Humensky, 2010; Richter et al., 2009) and research is revealing that the youth's residential location may explain important differences in the circumstances and influencing factors for substance non-use, experimentation, and use (Clark, Nguyen, & Belgrave, 2011; Hanson et al., 2009; Kulbok et al., 2010; Lambert, Gale, & Hartley, 2008). Because the purpose of the current study was to identify the patterns of co-existing influencing factors at multiple ecological levels of the youths' developmental system, and to relate these patterns to as many youth across the U.S. as possible, it was important to investigate the relationship of these variables to the latent class structure and latent class membership.

Grouping variable: Substance-use categories. To address the second study aim, the participants who are nonusers, experimenters, and regular/risky users at Wave 2 were identified and categorized. The *a priori* substance-use group classification (*i.e.* non-users, experimenters, and regular/risky users) was operationalized based on responses to items concerning ever-use and past-30 day use of alcohol, tobacco, and other drugs, as well as items assessing heavy use, binge-drinking, and regular use of substances at Wave 2 (see Appendix, Table 1). The operationalization of each of these three classifications draws on previous studies that have examined the expansion of the nonuser-user dichotomy (Crano, Siegel, et al., 2008; McCusker et al., 1995; McMillan et al., 2003) and studies that have used latent class analysis and latent trajectory analysis to identify subgroups of ATOD use (Cleveland, Collins, Lanza, Greenberg, & Feinberg, 2010; Ludden & Eccles, 2007; McCoy et al., 2010).

First, non-users were defined as those who had reported never-use of alcohol, tobacco, and other illicit substances at Wave 1 and Wave 2. Then, if adolescents reported having tried or used alcohol, tobacco, marijuana, chewing tobacco, cocaine, inhalants, and other drugs during Wave 1 or Wave 2, but reported (a) *no use* during the past 30 days during Wave 2, (b) *no regular smoking* at Wave 2 (defined as smoking "at least one cigarette every day for 30 days"), and (c) *alcohol use no more than once a month* at Wave 2, they were coded as "experimenters." This category may have included those who were regular or risky users during Wave 1, but who had quit this type of use within 30 days before the Wave 2 interview. Finally, adolescent participants were coded as "regular/risky users" if they responded positively at Wave 2 to any substance-use items reporting use during the past 30 days (for marijuana, cocaine, inhalants, chewing tobacco, and other drugs), or if they indicated they smoked regularly, or that they used alcohol more than once a month. Although it is certainly possible that this category includes some participants who had just begun to experiment with an illicit substance during the past 30 days, a visual scan of the data revealed that many of those who had used a substance during the past 30 days, had used more than one substance during that time frame. According to the gateway theory, using multiple substances is an indicator that one is moving along the path of substance use initiation, from less to more (Degenhardt et al., 2010), and in the current study serves to designate a 'riskier' level of substance use than experimentation.

Distal Outcome Variable. To address the third study aim that tested the overall model latent classes' relationship to substance use at Wave 4, a similar operationalization of a tripartite classification of ATOD use was used: nonusers, moderate users, and

regular/risky users. *Nonusers* (unweighted *n* = 638, 17.8%) were again coded based on responding positively to Wave 4 items assessing *never* use of tobacco, alcohol, marijuana, and other illicit drugs. Because Wave 4 participants were of the legal alcohol drinking age, *moderate users* included participants who reported legal, non-binge and non-heavy use of alcohol during Wave 4. Heavy use was defined according to the Centers for Disease Control: for men, consuming an average of more than 2 drinks per day, and for women, consuming an average of more than 1 drink per day (Centers for Disease Control, 2012). *Moderate* users also included participants who may have tried tobacco and other illicit substances in the past (and none during the past 30 days), but who reported never being a regular smoker (unweighted *n* = 445, 12.4%). The third category, named *regular/risky users*, included responders who were ever regular smokers, those who had smoked or used illicit substances during the past 30 days, and those who had engaged in heavy or binge alcohol use during the past year (unweighted *n* =2,511, 69.9%). Although the proportions were somewhat unbalanced (18% vs. 12% vs. 70%), this classification schema was the clearest for differentiating abstainers from those who were using alcohol appropriately or who had tried various substances, and from those who have engaged in regular and/or recent risky substance use during their adulthood.

Statistical procedures. Latent Class Analysis was used to address the first study aim. Latent Class Analysis is a type of latent variable mixture model that can identify "a set of underlying subgroups of individuals based on the intersection of multiple observed characteristics" (Lanza & Rhoades, 2011). Latent variables are postulated, error-free variables, that are indirectly measured by two or more observed variables (Collins &

Lanza, 2010). The theoretical source of the observed variables is the latent construct and the measurement error. In Latent Class Analysis (LCA), the latent variable is categorical, rather than continuous, and an underlying assumption is that there exist "qualitative differences between the categories rather than quantitative differences along a continua" (Ruscio & Ruscio, 2008). LCA fits under an umbrella term, the "person approach," for analytic methods that consider "the main properties of the dynamic, complex character of the developmental processes of the individual as an integrated psychological, biological, and social being" (Magnusson, 2003). The major assumption of using this technique to study adolescents and the influencing factors of adolescent health behavior is that there exist homogeneous subgroups or categories of youth according to their patterns of influencing factors, therefore influencing factors should be modeled that way (Collins & Lanza, 2009). Already some evidence of the categorical nature of youth and their influencing factors exists (see *e.g.*, Johnson et al., 2006; Ludden & Eccles, 2007; Syvertsen, Cleveland, Gayles, Tibbits, & Faulk, 2010). Collins and Lanza (2009) suggest that another major reason to choose LCA is to "identify an organizing principle for a complex array of empirical categorical data" (p. 9). Many of the measures of influencing factors in Add Health are categorical or ordinal in nature, or must be treated as categorical or ordinal due to significantly non-normal distributions. Furthermore, latent class analysis can only be used if the indicator items are categorical or ordinal.

For the purposes of this study, and in a similar fashion to Syvertsen et al. (2010), each of the influencing factor measures were dichotomized at a meaningful cutpoint differentiating health-negating levels of a factor (*i.e.,* risk) from health-promoting levels of a factor (*i.e.,* protection). Health-negating is defined as a reported level of a factor

which likely contributes to poor health outcomes, and health-promoting is defined as a reported level of a factor which likely contributes to positive health outcomes (Brink, 2012; Løhre, Lydersen, & Vatten, 2010; Ramage-Morin, Shields, & Martel, 2010). For example, self-regulation was dichotomized at the 25th percentile, where at or below the 25th percentile (*i.e.,* low levels of self-regulation in relationship to the rest of the sample) was considered health-negating, and above the 25th percentile was considered a health-promoting level of self-regulation. Friends' substance use was dichotomized into "no friends use ATOD" vs. "at least 1 friend uses ATOD." Where original scales had a normal or moderately skewed distribution, the cut-point was set at the 25th percentile, while scales that were ordinal in nature or highly skewed were dichotomized at the breaking point between "none" or "zero" and "at least some/one/once."

Collins and Lanza (2009) at the Penn State Methodology Center have developed a SAS procedure for conducting Latent Class Analysis while including sampling weights to address the sampling design of large, nationally representative data sets (Collins & Lanza, 2010). The procedure uses an iterative, probabilistic process to compare Maximum Likelihood solutions among models with varying numbers of latent classes (*i.e.*, subgroups). The model solutions estimate two types of parameters: latent class prevalence (*i.e.*, the size of classes), and item-response probabilities (*i.e.*, the probability of response-type, conditioned on latent class membership, for each item entered as a factor into the model). Model fit was evaluated using several criteria including model fit statistics, percent of random sets of starting values (*i.e.,* seeds) associated with the best model, parsimony, and interpretability. The assumption of local independence was

implicitly tested by virtue of using the aforementioned model fit criteria for selecting the best model (J.J. Dziak, personal communication, November 18, 2013).

Once the model with the best fit was identified, the LCA with covariates procedure was used to include covariates in a multinomial logistic regression model with the latent variable as the outcome variable (Collins & Lanza, 2010). Continuous covariates were first standardized (*e.g.,* age) or dummy or vector coded (*i.e.,* gender, race, family SES, residential location, neighborhood SES) before being entered in a block fashion. More proximal and non-modifiable variables were entered before more distal and modifiable covariates. This modeling was conducted all within the LCA with covariates SAS procedure, thus controlling for classification inaccuracy when estimating the significance of the covariates (Lanza, Dziak, Huang, Xu, & Collins, 2013).

To address the second study aim, a multiple-group comparison of the latent class model was used to test whether the latent classes identified in the entire sample hold across different groups (*i.e.,* subpopulations) of adolescents defined *a priori* by their non-use, experimentation, or regular use of alcohol, tobacco, and other substances over time. This was a way to include substance-use behavior as a moderator of all the influencing factors, rather than as an outcome of influencing factors. Because measurement invariance (*i.e.,* the same latent structure) did not hold across the subpopulations, the structure of the latent classes was modeled and interpreted separately in each subpopulation (Collins & Lanza, 2010).

After identifying the models with the best fit, an LCA with covariates was attempted for each subpopulation. The models broke down and would not converge, however, with the inclusion of more than one block of covariates, likely due to data

sparseness (Collins & Lanza, 2010). An alternative classify-analyze approach was then used. The PROC LCA macro procedure calculates for each case the likelihood (the posterior probability) of being in each latent class. Nagin's (2009) classification accuracy criteria were used to evaluate classification accuracy before assigning individual cases to a class using the maximum posterior probability assignment rule. Thereafter, the frequency and percent of demographic characteristics across classes was explored using weighted cross-tabulations in SAS (PROC SURVEY FREQ).

The third study aim was addressed using a SAS macro for Latent Class Analysis and distal outcomes, also from the Methodology Center at Penn State (Yang, Tan, Lanza, & Wagner, 2012). This program estimates the conditional distribution of a categorical distal outcome, given a latent class variable (Lanza, Tan, & Bray, 2011). In other words, it tests the strength with which the probability of membership in a latent class predicts a distal outcome. This model-based technique has been shown to consistently produce less biased estimates of the effect compared to two other classify-analyze techniques, maximum-probability assignment and multiple pseudo-class draws (Lanza, Tan, & Bray, 2011). For this step of the analysis, the latent class model generated for the first specific aim (*i.e.,* the overall model, not accounting for substance use at Wave 2) was tested for its prediction of substance-use category (*i.e.*, nonuser, experimenter, and regular user) at Wave 4. The estimates of this model are conditional probabilities for the distal outcome.

Potential limitations and strategies. There are several potential limitations to the proposed study. The first major limitation is that the Add Health in-home interview questionnaire and study implementation may have sacrificed a degree of reliability and validity in its survey design in order to address as many factors/constructs as possible.

For example, it is not always clear from where the subscales and items came, and establishing previously tested reliability and validity of the subscales is somewhat difficult to identify in the literature. To overcome this limitation, the creation of composite items mimicked previous studies whenever possible, and Cronbach's alpha reliability measure (or other appropriate internal consistency measure) was generated for all of the indicators.

The second limitation is that personal interviews were used to collect data and may have introduced interviewer biases and interviewer-respondent perceptions (Brener, Billy, & Grady, 2003), as well as socially desirable responses (Paulhus, 2002). Several strategies used by the Add Health team attempted to minimize this bias (Harris et al., 2009). For example, none of the survey questions were open-ended and each participant had to provide a response according to the response-options provided. Interviewers always had the option to enter a "refused" or "I don't know" response or a "legitimate skip" response for the participant. These alternate answers were analyzed as missing values. Interviewers were all trained professionals who in advance were made aware of their potential to introduce bias into the study results.

Questions pertaining to sensitive items such as sexual behavior, sexually transmitted disease, substance use, and delinquent behavior were self-administered by the participants using audio and computer assisted self-interview. This procedure theoretically increased the likelihood of honest self-disclosure, however, socially desirable responses are still a probable bias in this survey (Paulhus, 2002). Participants were reminded during the consent and administration of the survey that all information was confidential and could not be tied to their name. Additionally, the large number of

participants reduced the likelihood that participants could later be identified by their responses. Future analyses should attempt to assess the degree to which social desirability mediates the relationship of substance nonuse, experimentation, and regular use with the latent classes identified in the current study (Regnerus & Uecker, 2007).

A third limitation is that the main waves of data collection during adolescence occurred during the mid-1990s. The time-lapse and interaction of history and society over time mean that the results may not be directly generalizable to present-day experiences of adolescents (Burns & Grove, 1995). There is, however, some evidence that the most important influencing factors for substance use/non-use among adolescents and the relationships between these factors remain stable over time (Brown et al., 2001), indicating applicability to today's youth. Furthermore, in the current study an attempt was made to identify linkages between influencing factors during adolescence and young adult substance use/nonuse. A unique aspect of the proposed study is that it tested whether the latent classes of the adolescent participants, who were adolescents during Wave 2, are associated with a distal outcome occurring in 2008 when the participants were young adults. This step was important in establishing the utility of identifying latent classes among youth at any time in history.

Finally, the statistical analysis proposed in the study was relatively complex, creating an opportunity for potential errors if used or interpreted inappropriately. The primary investigator worked closely with an experienced statistician, as well as kept in close contact with personnel at the Penn State Methodology Center while preparing, analyzing, and interpreting the data and results (Creswell, 2008). The primary investigator had already been working with the Add Health data for approximately two

years, becoming very familiar with the codebooks and variables as well as conducting some preliminary analyses using the tri-partite classification of nonuser, experimenters, and regular users of ATOD and various influencing factors. A preliminary 2-step cluster analysis (*i.e.*, a non-model based clustering method) in SPSS identified three distinguishable clusters of adolescents at Wave 2.

Human Subjects Protection. Add Health data collection procedures followed a specific, IRB-approved protocol for surveying the participants and protecting their identities over the four waves of data collection (Harris et al., 2009). IRB study approval was obtained from the University of Virginia before study procedures began. Measures to prevent the possibility of deductive disclosure of participant identities were carefully followed. For example, data were not aggregated in such a way that only one or two persons exist in a cell identified by personal information such as age, gender, ethnicity, and location. The current study did not propose testing variation by specific regions or states in the U.S., also mitigating the possibility of deductive disclosure. The investigator did not inadvertently become aware of a participant's identity. The public-use data sets were held on a password protected personal computer and were not shared with others. The Add Health Study data are available to others from the Inter-university Consortium for Political and Social Research (ICPSR).

Summary and Implications

The purpose of this study was to identify the underlying patterns of multilevel, ecological influencing factors for substance non-use, experimentation, and regular or risky use among youth. The findings of the study may help those who are planning health promotion programs for youth to identify which influences are most strongly

associated with important subpopulations, and therefore might be used as tailoring variables or to identify target subgroups among youth (Collins, Murphy, & Bierman, 2004; Lanza & Rhoades, 2011). For example, for indicators that are strongly related to differentiating the latent classes, a health-promotion program could be structured around assessing this factor among youth and prescribing a low or high dose of intervention (*e.g.,* social competence skills training, family counseling, or peer resistance training) specific to the individual's assessment results. Or, programs could be developed with a target subgroup in mind, such as those youth who are non-users and have many health-promoting influences in their lives but need challenges or leadership training, or youth who have mostly health-promoting influences but many friends who are experimenting with or using ATOD. Future research can build upon the findings to test the transitions among latent class membership over time (*i.e.,* latent transition analysis), and to refine which indicators are most strongly related to the latent variable by testing other indicators and covariates.

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Protection of Human Subjects

The proposed research will use data that was collected during the National Longitudinal Study of Adolescent Health (Add Health), Wave I-IV, which is available through the Inter-University Consortium for Political and Social Research. The data collection has been completed. IRB approval for conducting the proposed secondary analysis was gained through the University of Virginia SBS-IRB.

A. Risks to Human Subjects

1. Human subjects involvement and characteristics, design
    - The proposed research uses archival data, so there is no planned involvement of human subjects to accomplish the work in the Research Strategy Section.
    - The intent of the proposed research is to clarify subgroups (latent clusters) of adolescents who do *not use* ATOD, to compare with those who experiment with and regularly use ATOD, according to influencing factors of the Ecological Model of Health Behavior. The original data collection was for a study of adolescent health, with a focus on the influencing factors of adolescents' health and risk behaviors, including personal traits, families, friendships, romantic relationships, peer groups, schools, neighborhoods, and communities. The study database currently contains four waves of data collection with the same participants, the last wave having occurred in 2008. The proposed research will utilize data from the In-Home Questionnaire from Wave 1 and Wave 2, completed in 1995 and 1996 respectively, since these waves contain the most adolescents, and also Wave 4 (completed in 2008), when participants had become young adults. The data set is a nationally representative sample of adolescents, and selected oversamples were conducted in order to meet this qualification. The proposed study will use participants who were 12-19 years old at wave 2, who were in school or on academic break from school, and who completed both in-school and in-home questionnaires. Appropriate sample and cluster weights will be applied during the analysis to reflect the stratified sampling design.
    - No special vulnerable populations are involved. Although it is possible that adolescents who were pregnant or who had disabilities or chronic illness were included in the study, this information is not the focus of the proposed research and will not be included in the analysis.
    - The proposed research does not involve study groups or intervention.
    - There were 80 collaborating schools in the original data collection and none of these sites are involved in the proposed research

2. Sources of Materials

- No specimens were collected from participants in the original research. Data collection consisted of survey interviews.
- The Add Health researchers gathered basic demographic information, measures of family income, residential location, mental health and well-being, and some sensitive topics such as sexual behavior, substance use behavior, and delinquency. Data from the original survey that will be used will be gender, age, substance use behavior, and measures of self-regulation, peer substance-use behavior, parent-child attachment, school connectedness, residential location (urban vs. rural), and neighborhood trust.
- Although no identifiable, private information is available in the data set, the possibility of deductive disclosure of participants is a remote possibility. The data used in the proposed research will be accessible to the PI; the project adviser, Dr. Pamela Kulbok; the University of Virginia School of Nursing faculty data manger, Dr. Ivora Hinton; and a University of Virginia Quantitative Psychology faculty and statistician, Dr. Karen Schmidt.
- Only the public use data will be used for the current study, and data will only be stored on the PI's personal secure laptop computer or on the PI's encrypted personal home drive at the University of Virginia.

3. Potential Risks

- The data is archival; therefore the risks to human subjects from the proposed research are related to the potential of identification of the individual participants, particularly through deductive disclosure. There are questions in the data set about illegal behaviors including drug use and delinquency. Likelihood of identification is very low. The data will be stored only on the PI's password protected computer or encrypted and password protected UVA home drive. Considering the data to be analyzed is 17 years old, it would be difficult to identify participants. In the unlikely instance that the investigator learns the identity of participants, this information will be kept confidential.
- There are no alternative treatments and procedures being undertaken in the proposed research.

B. Adequacy of Protection Against Risk

1. Recruitment and Informed consent

- Because the data are archival, no additional recruitment of subjects will be undertaken. The original study procedures are documented in Harris, K.M., C.T. Halpern, E. Whitsel, J. Hussey, J. Tabor, P. Entzel, and J.R. Udry. 2009. The National Longitudinal Study of Adolescent Health: Research Design [WWW document]. URL: http://www.cpc.unc.edu/projects/addhealth/design. This

document describes the sampling design and the procedure for obtaining parental consent and participant/adolescent assent. Respondents were fully informed verbally and in writing about the purpose of the project and the topics of study and were notified that they were free to end participation at any point in the study and that all responses were kept strictly confidential.

- The information above describes how the original researchers obtained informed consent.

2. Protection against risk

- Reports of the results of this study will never include descriptions of the regions of the United States involved in the study nor the specifics of urban or rural locations.
- The data is archival; therefore the risks to human subjects from the proposed research are related to the potential of identification of the individual participants, particularly through deductive disclosure. There are questions in the data set about illegal behaviors including drug use and delinquency. Likelihood of identification is very low. Considering the data set to be analyzed is 17 years old, it would be difficult to identify participants. The data will be stored only on the PI's password protected computer or encrypted and password protected UVA home drive.

C. Potential Benefit to Subjects and Others

- There are no potential benefits to the participants of this study from the proposed research. The risks are minimal, and are related to confidentiality of the data. The data is already collected. While there are no benefits to the participants, the potential benefit of the study results contributing to the development of new knowledge of adolescent health behavior outweigh the minimal benefits to the participants.

D. Importance of Knowledge to be gained

- The proposed research study will provide new insight into the patterns of influencing factors and substance-use and *non-use* behavior in adolescents in the United States. It will help health practitioners understand the adolescent population and its health promotion needs, as well as represent an innovative statistical approach to interpreting patterns and predictors of human behavior. A better understanding of the adolescents who never use alcohol, tobacco, and other drugs may reveal important information for preventing addiction and dangerous substance-use.

E. Inclusion of Women

- Female adolescents of reproductive age will be included in this study.

F. Inclusion of Minorities

- See enrollment table below. The sample is a nationally representative sample of adolescents living in the United States in 1995. Minorities were deliberately included in the sample.

G. Inclusion of Children

- All of the participants to be included in the proposed study are children ages 12-19. See enrollment table below.

Inclusion Enrollment Report

Add Health Wave I In-home Interview

Study Title: Add Health

Total Enrollment: 20,745 **Protocol Number:**

Grant Number:

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race				
	Sex/Gender			
Ethnic Category	**Females**	**Males**	**Unknown or Not Reported**	**Total**
Hispanic or Latino	1751	1774		3525 **
Not Hispanic or Latino	8694	8464		17158
Unknown (individuals not reporting ethnicity)	35	25	2	62
Ethnic Category: Total of All Subjects*	10480	10263	2	20745 *
Racial Categories				
American Indian/Alaska Native *	124	116		240
Asian **	644	715		1359
Native Hawaiian or Other Pacific Islander ***				
Black or African American	2297	2107		4404
White	6015	5939		11954

More Than One Race	548	490		1038
Unknown or Not Reported ****	852	896	2	1750
Racial Categories: Total of All Subjects*	10480	10263	2	20745 *

PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)

Racial Categories	Females	Males	Unknown or Not Reported	Total
American Indian or Alaska Native *	75	50		125
Asian **	26	19		45
Native Hawaiian or Other Pacific Islander ***				
Black or African American	43	41		84
White	743	756		1499
More Than One Race	120	115		235
Unknown or Not Reported ****	744	793		1537
Racial Categories: Total of Hispanics or Latinos**	1751	1774		3525 **

* These totals must agree.
** These totals must agree.

Vertebrate Animals: No vertebrate animals were or will be included in this study.
Select Agent Research: This study does not involve the use or study of select agents.
Multiple PD/PI Leadership Plan: Not applicable
Consortium/contractual arrangements: Not applicable
Letters of support (*e.g.*, Consultants): Not applicable

Resource Sharing Plan

- Parts of the data set being used for this study are available for public use through the Inter-University Consortium for Political and Social Research. The restricted-use data set is also available through a contractual agreement with the ICPSR. The applicant will not disclose any portion of the data set with anyone outside of the already described research team.

- "Add Health adheres to the NIH policy on data sharing but due to the sensitive nature of Add Health data access is limited and governed by the Add Health data management security plan; therefore, authors are unable to provide Add Health data to journal editors. While authors may not provide Add Health data to the editors, they may provide the program code used to construct variables and analyze the data. Editors may obtain a copy of the data under the terms and conditions as described on the Add Health website at http://www.cpc.unc.edu/projects/addhealth/data." Retrieved April 12, 2012 from the Add Health website.

Appendix

Table 1. *ATOD items across Add Health Waves 1–4.* *Were used in the proposed study

	Wave 1	Wave 2	Wave 3	Wave 4
During the past 30 days, how often did you drive a car or other vehicle when you had been drinking alcohol?	H1GH43	H2TO37		
Since June 1995, have you driven while drunk?			H3TO49	
In the past year, have you attended a drug abuse or alcohol abuse treatment program?	H1HS5	H2HS7	H3HS23	
*Have you had a drink of beer, wine, or liquor-not just a sip or taste of someone else's drink-more than 2 or 3 times in your life?	H1TO12	H2TO15	H3TO37	H4TO33
Do you ever drink beer, wine, or liquor when you are not with your parents or other adults in your family?	H1TO13	H2TO16		
*During the past 12 months, on how many days did you drink alcohol?	H1TO15	H2TO19	H3TO38	H4TO35
*Think of all the time you have had a drink during the past 12 months. How many drinks did you usually have each time?	H1TO16	H2TO20	H3TO39	H4TO36
*Over the past 12 months, on how many days did you drink five or more drinks in a row?	H1TO17	H2TO21	H3TO40	H4TO37 {4 or more/5 or more}
*(Males) During the past two weeks, how many times did you have five or more drinks on a single occasion, for example, in the same evening?			H3TO41	
* (Females) During the past two weeks, how many times did you have four or more drinks on a single occasion, for example, in the same evening?			H3TO42	
Over the past 12 months, on	H1TO18	H2TO22	H3TO43	H4TO38

how many days have you gotten drunk or 'very, very high' on alcohol?				
Alcohol Use Severity index	H1TO19-28	H2TO25-29 (or 30-33)	H3TO45-47 (or 48A-E)	H4TO46-50 (and others)
Have you ever tried to quit or cut down on your drinking?				H4TO54
*During your life, how many times have you used marijuana?	H1TO31	H2TO44		
*Since June 1995, have you used marijuana?			H3TO108	
*In the past year, have you used marijuana?			H3TO109	
*Have you ever used any of the following drugs? Steroids, marijuana, cocaine, crystal meth, other (includes inhalants)				H4TO65A-D
*During the past 12 months, on how many days did you use marijuana?				H4TO71
*During the past 30 days, how many times did you use marijuana?	H1TO32	H2TO47	H3TO110	H4TO71
Have you ever tried to quit or cut down on your use of marijuana?				H4TO82
During your life, how many times have you used inhalants, such as glue or solvents?	H1TO38	H2TO54		
During the past 30 days, how many times did you use inhalants?	H1TO39	H2TO56		
*During your life, how many times have you used any other type of illegal drug? (LSD, PCP, ecstasy, etc.)	H1TO41	H2TO59	H3TO117	
*During the past 30 days, how many times did you use any of these types of illegal drugs?	H1TO42	H2TO60	H3TO119	
{Favorite drug} questions				H4TO93-99
*Have you ever tried smoking, even just 1 or 2 puffs?	H1TO1	H2TO1	H3TO1	
*Have you ever smoked an entire			H3TO2	H4TO1

cigarette?				
*Have you ever smoked cigarettes, regularly, that is, at least 1 cigarette every day for 30 days?	H1TO3	H2TO3	H3TO4	H4TO3
*During the past 30 days, on how many days did you smoke cigarettes?	H1TO5	H2TO5	H3TO7	H4TO5
….cigars?			H3TO8	
…beedies?			H3TO9	
Have you smoked a cigar or pipe at least 20 times in your entire life?				H4TO23
During the past 30 days, how many days did you smoke cigars or a pipe?				H4TO24
During the past 30 days, on the days you smoked, how many cigarettes did you smoke each day?	H1TO7	H2TO7	H3TO10	H4TO6
How many cigarettes a day do you smoke?			H3TO15	H4TO11
During the past 6 months, have you tried to quit smoking cigarettes?	H1TO8	H2TO9	H3TO11	
Have you ever tried to quit or cut down on smoking or using tobacco?				H4TO27
During the past 30 days, on how many days did you use chewing tobacco or snuff?	H1TO10	H2TO12	H3TO36	H4TO26

Chapter 3: Manuscript One

A Systematic Review of the Literature on Substance Free Youth

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(Prepared for submission to Journal of Addictions Nursing:
APA format, 250 word Abstract, 3,000-5,000 word body text)

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Abstract

Background. Research has identified many risk and protective factors for substance use. However, there is minimal research on adolescents who abstain from or experiment with substances. The purposes of this review are to summarize and analyze the extant research literature pertaining to substance free youth.

Methods. Search terms and their variants for *alcohol, tobacco, illicit drug, marijuana, nonuse,* and *abstain* were used to identify peer-reviewed research published from 2003 to 2013 in the PubMed, Medline OVID, PsycInfo, and CINAHL databases. Twenty-one articles were retained for detailed review.

Results. The studies varied widely in theoretical approach and methodology. Application of the levels of the ecological model of health behavior (psychological/cognitive influences, peer and family influences, school, and neighborhood influences) guided the synthesis and presentation of findings.

Implications. Future research should consider the ways in which the presence and absence of multilevel factors interplay to support substance-free lifestyles among youth.

Substance Free Youth: A Systematic Review of the Literature

Currently about 51% of 12th graders report that they have not used any alcohol, tobacco, or other illicit drugs (ATOD) in the past 30 days (Child Trends, 2012). Despite the prevalence of "substance-free" youth, these adolescents remain largely under-investigated and under-emphasized in health-promotion and disease prevention literature. Youths' participation in other health-enhancing behaviors such as regular exercise and good nutrition has received far more attention (Barnett et al., 2013; Berge, Wall, Larson, Loth, & Neumark-Sztainer, 2013; Craike et al., 2013; Leech, McNaughton, & Timperio, 2014; Rosenberg, Norman, Sallis, Calfas, & Patrick, 2007). The focus for adolescents has been on risk reduction and disease prevention and not on the features of youth who are engaging in a substance-free lifestyle (SFL) (Bandura, 2005; Lerner, Lerner, von Eye, et al., 2011).

Within the disease prevention paradigm, research has identified numerous risk and protective factors for substance use (Acosta, Fernandez, & Pillon, 2011; Bartlett, Holditch-Davis, Belyea, Halpern, & Beeber, 2006; Clark et al., 2011; Hawkins, Catalano, & Miller, 1992; Stone, Becker, Huber, & Catalano, 2012). Risk factors are those that directly predict a negative outcome for ATOD *use* among adolescents (Hawkins et al., 1992). Protective factors are those that indirectly predict an attenuated negative outcome (also called a "buffering" effect or "mediating" effect), or that directly predict a decreased likelihood of a negative outcome (Hawkins et al., 1992; Jessor, Turbin, & Costa, 1998; Stone, Becker, Huber, & Catalano, 2012). For example, risk factors for youth ATOD use include laws and norms favorable for use, economic deprivation, community or neighborhood disorganization, academic failure, low

commitment to school, and family history of substance use and abuse (Catalano, Hawkins, Berglund, Pollard, & Arthur, 2002). Protective factors include positive social orientation, high intelligence, social and emotional competencies such as refusal skills and decision-making skills, family monitoring, close child-parent relationships, and gender (Stone et al., 2012). These are not exhaustive lists of the identified risk and protective factors; however, other reviews (Stone et al., 2012) have revealed that fewer studies investigate protective factors than risk factors.

For adolescents, a group typically viewed as relatively healthy but at high risk for injury and addiction to ATOD (Edberg, 2007), substance-use prevention is a major focus in families, schools, and communities. Over 150 evidence-based programs for substance use prevention are endorsed by the Substance Abuse and Mental Health Services Administration (SAMHSA, 2013) National Registry of Evidence-based Programs and Practices. These programs work to reduce risk factors and enhance protective factors to prevent youth from using substances, and they have contributed to a steady decline in substance use initiation and regular use over the past thirty years (National Institute on Drug Abuse [NIDA], 2011). Some programs address the prevention of using *any* substance, while others target the specific substances such as tobacco or alcohol (SAMHSA, 2013). One of the most effective programs, *LifeSkills Training*, helps youth develop personal self-management skills, social skills, and drug resistance skills (Griffin & Botvin, 2010). These programs are evaluated by how well they prevent substance-use initiation and other problem behaviors, but not achievement of sustained SFL.

There is a need for additional research to evaluate youth both who are "substance-free," and those who progress to only appropriate alcohol use during adulthood.

Recently, the rates of ATOD initiation and regular use among adolescents have slowed their decline or 'stalled out' (NIDA, 2011). Adolescents who abstain from substances are choosing a lifestyle that is likely a pathway to long-term health and wellbeing (Tucker, Ellickson, Collins, & Klein, 2006). Additional research can aid those who plan, develop, and prioritize youth health promotion programs to develop tailored interventions for target subpopulations, particularly those who remain non-users (Collins, Murphy, & Bierman, 2004). Therefore, the purpose of this systematic literature review is to summarize and analyze studies from the past decade that focus upon youth who maintain or engage in a SFL. Specific aims of this review include 1.) identifying and describing the theoretical frameworks used to study substance-free youth, 2.) summarizing and analyzing research methods of the studies, and, 3.) synthesizing the results and implications of the studies. Understanding the specific attributes, characteristics, and influencing factors of non-users could provide more direction about how youth health-promotion programs affect sustainable SFL.

Methods

An electronic database search using Medline Ovid, PubMed, PsycInfo, and CINAHL was conducted. Search terms included *alcohol, tobacco, marijuana, illicit drug, nonuse,* and *abstain,* and variants and combinations of these terms. Limiters were set to adolescents and peer-reviewed research articles published from 2003 to 2013. Initial searches resulted in over 400 manuscripts. After abstracts were reviewed, studies were narrowed to those that identified unique predictors of substance non-use or unique features of non-users, leaving 21 studies to be analyzed in this review. Studies were reviewed and summarized, and a table was developed for comparing and contrasting

theoretical frameworks, aims, sample, design, methods, and results. Table 1 presents a summary of these elements specific to substance-free youth.

Results

Theoretical frameworks

Well-formulated research utilizes a testable theoretical framework. Often, in health behavior research, the theories are complex and include multiple constructs and interactions (Edberg, 2007). Not surprisingly, the theories in many of the selected studies were complicated, and in many cases, the studies could not encompass all of the concepts included in the theory. The theories reflected individual-level, cognition-oriented conceptualizations of adolescent behavior, for example the Theory of Reasoned Action, Transtheoretical Model of Behavior Change, and Cox and Klinger's motivational model of alcohol use; social learning and peer network explanations such as Social Learning Theory; and, ecological-systems-oriented frameworks such as Ecological Assets for Positive Youth Development.

A positive youth development or developmental assets approach was the most commonly cited theory for understanding youth who do not engage in substance use (Beebe et al., 2008; Dunn, Kitts, Lewis, Goodrow, & Scherzer, 2011; Oman et al., 2004; Syvertsen et al., 2010; Theokas & Lerner, 2006). These four studies tested whether specific youth "assets" were associated with substance nonuse. Examples of youth assets included non-parental adult role models and use of time for sports or religious activities (Beebe et al., 2008), peer role models and family communication (Oman et al., 2004), goal-setting and positive school orientation (Syvertsen, Cleveland, Gayles, Tibbits, & Faulk, 2010), and resources such as recreation areas near home (Theokas & Lerner,

2006). Dunn et al. (2011) assessed the association of developmental assets, as identified in the Search Institute's Developmental Assets Framework ("Developmental Assets Lists - Search Institute," n.d.), with alcohol, tobacco, and marijuana use. These studies oriented themselves toward identifying protective and promoting factors that directly predict positive developmental outcomes, including nonuse of ATOD.

Several studies focused upon a theory of expanding the nonuser-user dichotomy through differentiating the nonusers into two subgroups: vulnerable vs. resolute (Crano, Gilbert, Alvaro, & Siegel, 2008; Crano, Siegel, Alvaro, Lac, & Hemovich, 2008), vulnerable vs. resistant (McMillan, Sherlock, & Conner, 2003), or susceptible vs. resolute (Okoli, Richardson, Ratner, & Johnson, 2009; Seo, Torabi, & Weaver, 2008). Forrester, Biglan, Severson, and Smolkowski (2007) found supporting evidence that "susceptibility" to smoking was a predictable characteristic of some nonusers. These studies tested the theory that some cognitions such as openness to future smoking, perceived addiction to tobacco, intentions to not use, and future expectations for nonuse can differentiate nonusers who are at particularly high risk for the initiation of substance use. Each study identified contextual factors that are associated with each subtype of nonusers.

A third group of studies tested individual-level, or psychological, correlates of substance nonuse, but each with a different theoretical framework. For example, Frankenberger (2004) modeled egocentrism, sensation seeking, and risk perceptions, among never-triers, infrequent/experimental, and regular smokers to evaluate a theoretical framework of perceived invulnerability and personal fable. Anderson, Briggs, and White (2013) evaluated a motivational framework by testing the role of motives *not*

to drink on alcohol use and problems across adolescence into adulthood. Johnson and colleagues (2006) created profiles of four distinct clusters of non-users based on constructs of the Transtheoretical Model of Behavior Change, specifically decisional balance, temptation to use, intentions to use or stop using, and processes of prevention.

Kulbok et al. (2008 and 2010) conducted qualitative studies based on the National Institute of Mental Health Theorists' Workshop (Fishbein et al., 1991, as cited in Kulbok et al., 2008) on factors influencing health behavior and behavior change. They examined protective factors for non-smoking from the direct perspective of non-smoking youth and parents, identifying personal choice to be a non-smoker and open communication with parents to be important influences. These qualitative studies also identified external influences. For example, sources of approval for remaining a nonsmoker come from teachers and people at church (Kulbok et al., 2008).

Despite some differences, the theories tested in each of these studies shared important characteristics. First, the studies accounted for the underlying assumption that there are inherent strengths, resources, or assets within and around youth that directly relate to, or influence, the nonuse of ATOD, as well as other healthy behaviors. Each study attempted to contribute to a deeper understanding of substance-free youth and the correlates of a SFL. Second, they addressed the notion that youth who abstain from using substances may have distinguishable and targetable features, for example, future expectancies and intentions to "ever" use, along with contextual experiences that could be modified, enhanced, or supported through health promotion programming. Finally, each theoretical approach revealed the complexity of the influencing factors for how young people develop health-enhancing and health-negating behaviors. No theory

assumed that a single factor was most important in influencing youth to abstain from substance use.

Methods

Design. The predominant research design for this collection of studies was quantitative, cross-sectional, and correlational. Only two studies used a qualitative, focus group approach (Kulbok et al., 2008; Kulbok et al., 2010), and three studies used longitudinal, quantitative designs (Bernat, Erickson, Widome, Perry, & Forster, 2008; Crano, Siegel, et al., 2008; Pollard, Tucker, Green, Kennedy, & Go, 2010). Some designs used original survey data; many of them used secondary data (Crano, Gilbert, et al., 2008; Dunn et al., 2011; Ludden & Eccles, 2007; Okoli et al., 2009; Pollard, Tucker, Green, Kennedy, & Go, 2010; Syvertsen et al., 2010; Theokas & Lerner, 2006). Studies using secondary data had larger and more diverse samples and more sophisticated data analysis with a larger number of variables and estimates. Computer assisted audio self-interview survey methods were cited commonly as a technique to reduce social desirability of responses on items assessing sensitive topics such as illegal substance use (Beebe et al., 2008; Oman et al., 2004). Not surprisingly, most studies were cross-sectional and correlational in nature, since longitudinal designs can be cost-prohibitive or difficult due to challenges of obtaining and following a large group of young adolescents over a long time.

Samples. Race and ethnicity were identified in most studies, and were included as variables, primarily either to examine the influence of race/ethnicity or as covariate because of its known relationship to health behaviors (Dubay & Lebrun, 2012; Eaton et al., 2012). For example, Beebe et al. (2008) selected the 134 Native Americans from a

larger random selection of inner-city households in two Oklahoma cities (N=1,350) to assess influencing factors for drug non-use. Kulbok et al. (2010) sought mother-daughter pairs in rural, tobacco producing counties in Virginia, to identify specific factors that influence nonsmoking behavior of the adolescent girls. Most studies with large sample sizes used race or ethnicity as a predictor variable or covariate in the study (Beebe et al., 2008; Bernat et al., 2008; Crano, Siegel, et al., 2008; Oman et al., 2004). Several studies did not include race/ethnicity as a variable, possibly because sample size limited the number of variables to be included in the analysis and retain adequate power (Dunn et al., 2011), or because race/ethnicity was not part of the theoretical framework (Forrester et al., 2007).

Most of the studies reviewed did not address socio-economic status (SES) in the sample description or covariates, despite that SES at either extreme – poverty or affluence – has been identified as a factor in predicting substance use behavior among youth and young adults (Goodman & Huang, 2002; Humensky, 2010). Of the few studies that included socioeconomic status, Oman and colleagues (2004) included parental income and parental education level as covariates in their model of relationships between youth assets and alcohol and drug nonuse. Pollard and colleagues (2010) used parental education as a proxy for socioeconomic status. While some studies did not report any information at all on the SES of the sample, others reported general information such as that the sample was from a predominantly middle class, medium-sized city (Frankenberger, 2004).

The residential location of youth influences their access to peers, mentors, community services, activities, and schools, as well as access and exposure to ATOD

(Martino, Ellickson, & McCaffrey, 2008). The nature of the environment and resources available in rural and urban locations affect possibilities for health promotion and substance use prevention programs, thus making this sample characteristic important to evaluate in current research studies. Consideration of the residential location of sample participants was present in most of the studies included in this review. Sometimes measures reflecting the residential location were used as covariates (see *e.g.*, Theokas & Lerner, 2006).

Specific to rural areas, Kulbok et al. (2010) conducted a qualitative study of adolescent girls and their mothers who lived in rural tobacco-producing counties, assessing the factors that supported non-smoking behavior in the girls. In contrast, Ludden and Eccles (2007) used data from the Maryland Adolescent Development Context Study, representing youth living in urban settings. Samples from nationally representative surveys included Monitoring the Future data (Syvertsen et al., 2010), the National Longitudinal Study of Adolescent Health (Pollard et al., 2010), the National Survey of Parents and Youth (Crano, Siegel, et al., 2008), and the 4-H Study of Positive Youth Development (Theokas & Lerner, 2006).

Age or grade-level was also identified in most of the studies, due to its influence on adolescent health behavior. The temporal associations with SFLs among youth are intuitive: younger adolescents are more likely to be substance-free than older adolescents by virtue of having had fewer opportunities to engage in substance use or experimentation. Developmental science also supports the temporal changes in levels of autonomy, self-regulation skills, and influences of peers, family, and other adults, such as teachers and mentors, as young adolescents mature (Berk, 2006). The cross-sectional

studies using diversely aged participants, usually ages 13-19, appropriately included age as a covariate in their models (Beebe et al., 2008). Some studies specifically addressed young adolescents, for example 6th and 7th graders, because they are more likely to be substance free (Crano, Gilbert, et al., 2008). Longitudinal trajectory analyses naturally incorporated the temporal aspects of youth developmental processes in relation to substance non-use (Pollard et al., 2010). Anderson et al. (2013) identified differences in mediation effects of motives not to drink for three different age cohorts over time.

Measures. A challenge for research in health promotion and health behavior among adolescents is determining and selecting reliable and valid measures of the behaviors of interest, as well as measures of the psychological and ecological factors that influence behavior. The adolescent age group adds an added level of complexity because they are a vulnerable population. Consideration of their privacy and the legal ramifications of revealing information about illegal or delinquent behavior increase the difficulty of surveying and/or interviewing youth about themselves. The selected studies exhibited the challenges of identifying, selecting, and implementing reliable and valid measures in this population.

The spectrum of use and types of substances. The included studies are diverse in their measures of substance nonuse and substance types. Five studies focused on general substance non-use by including measures of multiple substances including alcohol, tobacco, marijuana, and other drugs (Beebe et al., 2008; Dunn et al., 2011; Johnson et al., 2006; Ludden & Eccles, 2007; Sloboda et al., 2009). Other studies focused specifically on tobacco or nonsmoking behavior (Bernat et al., 2008; Forrester et al., 2007; Frankenberger, 2004; Kulbok et al., 2008; Kulbok et al., 2010; Okoli et al., 2009; Pollard

et al., 2010; Seo et al., 2008; Velicer, Redding, Anatchkova, Fava, & Prochaska, 2007). Within this group of studies, two focused on susceptibility to smoking as measured by future intentions to smoke (Forrester et al., 2007) and openness to future smoking (Seo et al., 2008). A unique study by (Okoli et al., 2009) examined nonsmokers who "puffed," *i.e.,* didn't inhale, cigarettes and their perceived addiction to tobacco, comparing them with nonsmokers who completely abstained from smoking. While some studies focused upon nonsmokers by comparing them to participants who reported other degrees of smoking such as "triers" and "regular" smokers (Frankenberger, 2004), others only included nonsmokers or former experimenters in their sample (Kulbok et al., 2008; Kulbok et al., 2010; Velicer et al., 2007). The remaining studies focused upon specific substances such as marijuana (Crano, Siegel, et al., 2008; Tucker et al., 2006), inhalants (*e.g.,* solvents, glue) (Crano, Gilbert, et al., 2008), ecstasy (McMillan et al., 2003), alcohol alone (Anderson et al., 2013), and alcohol and other drugs (Oman et al., 2004). The use of alcohol and other drugs among adolescents has previously been identified as a separate dimension of health behavior from tobacco use (Kulbok & Cox, 2002), and the immediate psychological effects of these substances might add to both qualitative and quantitative differences in the predictors of non-use of such substances.

Among all of the studies that included specific measures of substance use, there was usually an attempt to capture the frequency, or spectrum, of substance use behavior, rather than reducing the variable to a dichotomous nonuser-user measure. Combinations of ever-use, past year use, and past 30-day use survey items were included to reflect the spectrum of use. All of the studies were clear on how they operationalized this spectrum, yet none of them was exactly alike, making comparisons challenging. Bernat et al.

(2008) and Pollard et al. (2010) did, however, identify very similar trajectories of smoking behavior through the use of multiple time points, frequency measures, and latent trajectory analysis. Bernat and colleagues (2008) identified "never use, triers, less than monthly, experimenter, regular, [and] established smoker" trajectories, while Pollard and colleagues (2010) identified "never use, steady low, delayed increaser, early increaser, decreaser, [and] steady high" trajectories.

Psychological and ecological constructs. The studies used measures spanning individual-level constructs, *i.e.,* intrapersonal, psychological constructs, such as attitudes, beliefs, aspirations for the future, egocentrism, and subjective norms; social-level constructs, such as perceived peer substance use behavior, parental monitoring, parent-child relationships, and peer networks; and environmental constructs, such as community involvement, school activities, and neighborhood resources. Only the studies by (Beebe et al., 2008; Oman et al., 2004; Theokas & Lerner, 2006) included measures that reflected the entire spectrum of the ecological model of health behavior. Several focused only on intra-individual factors (Frankenberger, 2004; Johnson et al., 2006), while the rest included measures of personal factors along with peer and parental factors. Some studies provided clear information about the internal reliability of the measures (Ludden & Eccles, 2007; Theokas & Lerner, 2006; Velicer et al., 2007), and others provided no information on reliability in the manuscript (Seo et al., 2008). A common challenge for the researchers was addressing skewed variables. Typically this was addressed through categorizing or dichotomizing variables (Seo et al., 2008). Information on construct validity was also largely under-reported, except in instances where establishing internal and external validity was specified as an aim of the study (Velicer et al., 2007).

Data Analysis. A detailed discussion of the data analysis methods used in the studies is beyond the scope of this review, however, a summary of the analytic techniques revealed the complexities of addressing research questions pertaining to adolescent health behavior and the developmental processes occurring during this life stage. Data analysis procedures ranged from bivariate associations, ANOVA, and logistic regression (Beebe et al., 2008; Crano, Gilbert, et al., 2008; Dunn et al., 2011), to multivariate methods including MANOVA (Crano, Gilbert, et al., 2008; Frankenberger, 2004; McMillan et al., 2003) and hierarchical multiple logistic regression (Oman et al., 2004; Theokas & Lerner, 2006).

While the aforementioned studies focused upon relationships among variables, several of the studies adopted a person- or case- oriented analytic method such as Ward's clustering algorithm (Johnson et al., 2006), K-means cluster analysis (Ludden & Eccles, 2007), latent class growth analysis (Bernat et al., 2008; Pollard et al., 2010), and latent class analysis (Syvertsen et al., 2010). Simply stated, these studies estimated the number and types of clusters of cases characterized by shared patterns of responses at one time point, as in cluster or class analysis, or over time, as in growth or trajectory analysis, revealing otherwise hidden or unknown subgroups in the sample. The advantages of using a latent class analysis technique over a K-means clustering or Ward's clustering method is that a latent class model uses less arbitrary clustering criterion, and it is a model-based, maximum likelihood method that includes rigorous statistical tests to determine the best model fit (Magidson & Vermunt, 2002). These techniques help describe the heterogeneity among substance-free youth, and point to ways in which health promotion and substance use prevention programs might be tailored or adapted to

target various subgroups of adolescents (Caldwell, Bradley, & Coffman, 2009; Collins et al., 2004).

Findings

A critical analysis of the findings of each of the studies included in this review revealed that an array of factors are associated with youth not using alcohol, tobacco, or other drugs. Using an ecological framework (Bronfenbrenner, 2000) to synthesize the study findings, there is evidence that these factors exist at multiple levels of influence or systems within youths' lives. For example, at the intra-individual level, boys' future aspirations significantly predicted past-30 day nonuse of alcohol (Dunn et al., 2011) and a high rating on making responsible choices was associated with nonuse of alcohol ever (Oman et al., 2004). In contrast, making responsible choices was not a significant predictor of non-use in Beebe et al.'s (2008) study. Crano, Siegel, et al. (2008) identified that "resolute nonusers" were significantly stronger in refusal strength, lower on sensation seeking, and less likely to approve of others' drug use when compared to "vulnerable nonusers" and "users" of marijuana. Forrester et al. (2007) found that deviant behavior, low grade point average, and easy access to tobacco predicted "susceptibility" to smoking among nonsmoking youth. These studies point to the benefits of ongoing inclusion of psychological factors, attitudes, beliefs, decision-making, and refusal skills in health promotion programs for youth.

Within the inter-individual or peer/other interaction and family relationships systems, several studies identified significant associations between relational ties and substance non-use among youth. Having non-parental adult role models was a strong predictor of alcohol, tobacco, and other-drug nonuse in Beebe and colleagues' (2008)

study of Native American youth. This study also identified family communication as significantly associated with illicit drug non-use. Interestingly, peer role models were *not* significant predictors of non-use in their study, and they attributed this to the strong family role-importance in Native American culture. Crano, Siegel, et al. (2008) identified that higher parental monitoring and warmth was characteristic of "resolute" marijuana nonusers, and Forrester et al. (2007) found that parental monitoring decreased "susceptibility" to smoking. Furthermore, parent expectations and positive peer influences predicted past 30-day alcohol nonuse among boys and girls in Dunn and colleagues' (2011) study, while parent expectations differentially predicted boys' nonsmoking and parent support differentially predicted girls' nonsmoking during the past 30 days. These study findings remind us that different genders and cultural/ethnic groups might have different needs in relation to the influences of family and peer relationships on health promotion and the prevention of substance use. Theokas and Lerner (2006) found that family collective activity was strongly associated with substance nonuse among adolescents. It is clear that interaction with family and parents influences adolescents' lifestyle choices.

Relatively few studies examined the association of institutional systems, such as schools, with substance nonuse behavior among youth. Theokas and Lerner (2006) conducted a hierarchical regression to determine the unique associations of various ecological factors with a composite measure of positive youth development features, including competence, confidence, character, caring, and connection. Their study identified that beyond the 14% explained variance of family physical resources and collective activity, school physical and accessibility resources explained an additional 2%

of the variance. School accessibility was also a strong and significant independent predictor of substance nonuse among youth in their study (Theokas & Lerner, 2006).

From a different angle, a person-oriented cluster analysis by Ludden and Eccles (2007) revealed that youths' "low school importance" attitudes and their "social reasons for enjoying school" were distinguishing features of two of the five clusters of youth who abstained from substance use. While the study that identified school accessibility as a predictor of substance nonuse implies the importance of schools in supporting SFLs, Ludden and Eccles' (2007) findings reveal that some youth who don't use substances might not value school. These adolescents might need support in increasing their perceptions of the value of school.

Besides schools, several other institutional and societal factors were included in some of the selected studies. Bernat et al. (2008) found that difficulty finding places to smoke, and negative perceptions of the tobacco industry were associated with being in a nonsmoker trajectory. While exposure to anti-tobacco messages was a predictor of decreased susceptibility to smoking in Forrester and colleagues' (2007) study of 7th grade nonsmokers, Seo et al. (2008) found that pro-tobacco messages had a stronger effect than anti-tobacco messages on openness to future smoking. Spending time in religious activities, for example church youth group attendance, predicted nonuse of alcohol and drugs (Oman et al., 2004).

Only one study addressed the possible relationships between neighborhood characteristics and adolescent SFLs. Theokas and Lerner (2006) found that neighborhood human resources (assessed through measuring the education level of neighborhood residents, employment, and presence of adult mentors) significantly

predicted an additional 2% variance of a composite positive youth development measure, after controlling for other ecological influencing factors.

Directions for Future Research

One of the challenges of synthesizing the included studies stemmed from the different approaches taken for data analysis. As referenced earlier, several studies employed person-oriented methods for data analysis, including latent trajectory analysis, K-means cluster analysis, Ward's clustering analysis, and latent class analysis. Most of the other studies used more traditional, variable-centered methods such as logistic regression, hierarchical modeling, and MANOVA. While these different methods may be viewed as complimentary rather than contradictory (Magnusson, 2003), their findings support different theoretical approaches to understanding health behavior and health promotion (Sterba & Bauer, 2010). Overall, the person-oriented methods were better at identifying characteristics and patterns of influencing factors specific to substance-free youth. For example, the person-oriented studies recognized and identified that youth who do not use alcohol, tobacco, and other drugs are not all alike and are not simply the opposite of youth who engage in substance use (Ludden & Eccles, 2007). Future research should build upon these findings by identifying patterns or the most common combinations of both health-promoting and health-negating influences in adolescents' lives and the relationship between these patterns and health behavior outcomes.

A direct precursor to the differences in methodology was the differences in theory: ecology vs. positive youth development vs. individual-level risk and protective factors. While all are likely valid representations of components affecting adolescent development and behavior, the positive youth development (PYD) framework was

clearest at its intent to identify features of adolescents and their lives that are directly associated with abstinence from alcohol, tobacco, and other drug use. A limitation of the PYD studies is that they did not examine possible interactions between youth assets and risk factors, leaving a gap with regard to the possibility of resilience, defined as the strength of assets in predicting positive health behavior despite the presence of risk factors (Ahern, 2006). Approaches to understanding substance non-use should be careful to include the possibility that there are youth who remain substance-free despite the lack of multiple "assets" or "protective factors" in their lives (Bandura, 2005). Furthermore, none of the studies accounted for the possibility that each influencing factor exists on its own valence of health-promoting vs. health-negating effects. In other words, it was impossible to ascertain whether the absence of a so-called "protective factor" or "asset" was equivalent to the presence of a so-called "risk factor," and vice versa. Research would benefit from examining the interplay of the presence and absence of multilevel influencing factors in youths' lives.

Finally, the various operationalizations of substance use and nonuse emphasized the ways in which expanding the typically dichotomous outcome might greatly add to our understanding of both substance nonuse and use. While many of the studies conceptualized substance use in a dichotomous fashion (use vs. nonuse), several of the studies highlighted and tested an expanded view of substance use. Bernat et al. (2008) identified five mutually exclusive trajectories of tobacco use, and that nonsmokers and triers shared some characteristics, while multilevel factors predicted membership in different user trajectories. Pollard et al. (2010) identified six trajectories of smokers; then, they examined how friendship network positions (member, liaison, or isolate)

related to trajectory membership. Among smokers of any trajectory, network position was associated in different ways with membership in a trajectory, while the members, isolates, and liaisons to nonsmoking groups remained nonsmokers. Future research should build upon these expanded views of substance use and nonuse to identify the ways in which experimenters, for example, return to a SFL, and the factors that influence abstainers to remain substance-free long-term.

While it is possible that this systematic review did not capture all of the current literature containing substantive information about adolescents who do not use ATOD, the review provides support for the general sense that there remains much to know and understand about them. The review summarized theoretical approaches, methods, and findings, and delineated conclusions and recommendations for further study. Healthcare providers, teachers, social workers, and public health workers who are planning and revising current programs to promote SFLs among youth can use this information to consider which variables might be most important to their target population. Finally, researchers can address the knowledge gaps identified herein.

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Table 1

Characteristics of the articles (ordered chronologically by publication date) included in the review

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
McMillan, Sherlock, & Conner (2003)	Features of resistant and vulnerable ecstasy nonusers, multiple subtypes of ecstasy users Theory of Planned Behavior; Expanding the user/non-user dichotomy	*n* = 1,048; 16-25 year olds; United Kingdom	Cross-sectional, correlational Survey	Chi-square, ANOVA, MANOVA, Multinomial Logistic Regression Measures: Gender, age, urban/rural Drug use behavior Intentions to use Normative influence Beliefs about drug use	-Resistant ecstasy non-user: young, female, low levels of other drug use -Vulnerable ecstasy non-user: more frequent other drug use than the resistant non-users -Having ecstasy-using friends increased odd of being a vulnerable non-user or user -Non-users and users significantly differed on beliefs, behavior, and intentions
Frankenberger (2004)	Adolescent egocentrism, risk-perceptions, sensation-seeking characteristics in relation to non-smoking and smoking Developmental theories of invulnerability, sensation seeking, personal fable	*n* = 215; High school students; convenience sample from middle class, medium-sized city, Pacific NW	Cross-sectional, correlational Survey	MANOVA stratified by nonsmoker, trier, regular level of smoking and by sex Measures: Egocentrism Risk perceptions Sensation Seeking	-Lower sensation-seeking associated with nonsmoking -Egocentrism unrelated -Nonsmokers who had higher levels of personal fable, imaginary audience, and experience-seeking perceived greater number of peers who smoke -Differentiated committed nonsmokers from triers/experimenters
Oman et al. (2004)	9 youth assets and their relationship with alcohol and drug nonuse Positive Youth Development	*n* = 1,350 adolescents and parents; 2 Midwestern large cities	Cross-sectional, correlational Survey	Chi-square; Multiple Logistic Regression Covariates: Age, gender, race/ethnicity; parental income, parental education, family structure Measures: Alcohol (past 30 day) and drug (ever) nonuse	-After controlling for demographics and all other assets, **Alcohol nonuse** associated with use of time (religion), peer role models, family communication, and responsible choices -Girls: use of time (religion), responsible choices -Single-parent: Community involvement -Youth who had all 4 of the significant assets were more than 4 times more likely to report nonuse of alcohol cf. those who reported 3 or

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
				Nonparental Adult Role Models Peer Role Models Family Communication Use of time (Groups/sport) Use of time (Religion) Community Involvement Aspirations for the Future Responsible Choices Good Health Practices	fewer -After controlling for demographics and all other assets, **drug nonuse** associated with peer role models, use of time (religion), and responsible choices -Youth who had all 3 were more than 5 times more likely to report nonuse of drugs cf. those who had 3 or fewer
Johnson et al. (2006)	Clusters of non-users characterized by shared constructs of the Transtheoretical Model of Behavior Change Stages of Change (TTM)	*n* = 1,240; elementary, middle, and HS students from US, England, Israel	Cross-sectional, correlational Survey	Ward's cluster analysis, ANOVA (for region and school level effects) Measures: Demographics Decisional Balance Temptation to Use Substance Use Intention to use Intention to stop using Processes of Prevention	-4 distinct profiles of non-users: Most protected, Least positive, Most negative, Most tempted -Clusters replicated across multiple settings and age groups -Constructs were associated with multiple substance non-use and use, not just single substances
Theokas & Lerner (2006)	Ecological assets and their associations with adolescent problems (depression, delinquency, substance use) Positive Youth Development, Social Ecological Model for Human Development	*n* = 646 5th graders; 4-H study of Positive Youth Development	Secondary data analysis; Cross-sectional, correlational Survey	Correlations; Hierarchical Multiple Regression Covariates: Sex, race, residential locale Measures: PYD composite (competence, confidence, character, caring, connection) Contribution (ideology & behavioral) Depression	After controlling for effects of covariates and all other predictors, Significant and positive predictors of PYD: -Family physical resources -Family collective activity -School physical resources -School accessibility -Neighborhood human resources Significant and positive predictors of less risk behavior (includes substance use): -Family collective activity -School accessibility

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
				Risk Behaviors (delinquency & alcohol, cigarette use) Family resources School resources Neighborhood resources	
Tucker, Ellickson, Collins, & Klein (2006)	Social functioning of marijuana abstainers, experimenters, and frequent users during adolescence and adulthood Shedler & Block's (1990) abstainers are psychological maladjusted	*n* = 2,255; 7th graders; Project ALERT sample	Longitudinal, Correlational Survey Classified participants as abstainer, experimenter, frequent user based on 12th grade report of past use	Covariates: Gender, race/ethnicity, parental education Grade 12 functioning: Time use Social competence with opposite gender Loneliness Peer support Parental support General mental health Deviant behavior Self-reported poor grades Young adult functioning: College degree Deviant behavior Mental health Satisfaction with friends and family Extent that emotional problems interfere with daily life	Compared to experimenters and frequent users, Abstainers had: -higher parental support (gr. 12) -greater satisfaction with family and friends (age 23) -stronger orientation to school (age 23) -less involvement in deviant behavior (age 23) -overall were equal to or better off than experimenters (age 23) -stringent abstainers had higher college graduation rates and less delinquent behavior than experimenters
Forrester, Biglan, Severson, & Smolkowski (2007)	Predictors of smoking "susceptibility" and smoking initiation Social and marketing influences, Academic	*n* = 3,641 nonsmokers; 7th and 9th graders; rural Oregon	Cross-sectional, Correlational Survey	Hierarchical Logistic Regression Measures: Parental, sibling, and friends' smoking	3 predictors of decreased susceptibility to smoking: -Male gender -Exposure to anti-tobacco messages -Parental Monitoring

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
	and Problem Behaviors, Susceptibility of Nonusers			Low School Achievement Deviant Behavior Alcohol use Susceptibility to Smoking Smokeless Tobacco Use Parental Monitoring Perceived Smoking Norms Parent Attitudes Access to Tobacco Exposure to Anti-tobacco Messages Extracurricular Activities	3 predictors of increased susceptibility: -deviant behavior -Low GPA -Easy access to tobacco
Ludden & Eccles (2007)	Cluster classification and cluster membership of adolescent substance non-users and users over time Holistic interactionism in human development	*n* = 733; at 8th grade and 11th grade; Maryland Adolescent Development in Context Study	Longitudinal, Correlational Survey	Logistic Regression; K-means cluster analysis Measures: Tobacco, Alcohol, Marijuana use/non-use Academic Achievement School Misbehavior Depressive Symptoms Self-esteem Positive self-regard Academic Motivation Perceptions of teachers, parents, friends	-Nonusers overall characterized by high academic achievement in the presence of having fun at school, high task value, and low SES, and overall less "risky" profiles compared to substance users -Moderate substance users were not substantially different from nonusers for the included predictors -Nonusers were unlikely to engage in school misbehavior and have friends who do poorly in school -5 clusters of nonusers: Low Grades/Low Risk, Depressed, Low Grades/Low School Importance, High Grades/High Social, High Grades/Low Social -Three of these clusters were also evident among the 5 clusters of substance users: Low Grades/Low Risk, Depressed, High Grades/High Social
Velicer, Redding, Anatchkova, Fava, & Prochaska	Typology of "Acquisition Precontemplation" subgroup of adolescent nonsmokers	*n* = 1542 nonsmokers; 9th grade students; Rhode Island	Secondary data analysis; Longitudinal, correlational;	Ward's minimum variance clustering algorithm in 3 random subsamples; proportion of each cluster remaining in acquisition	Four clusters replicated across subsamples: protected, risk denial, ambivalent, high risk. -External validity: protected group had higher family support, fewer smoking friends

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
(2007)	Stages of Smoking Acquisition; Transtheoretical Model of Behavior		Survey	precontemplation (aPC) at 12 mos, 24 mos, 36 mos Measures: Stages of change Decisional balance Situational temptations to smoke Family support for nonsmoking Peer influences	-Predictive validity: protected had highest proportion remaining in the aPC stage; effect size largest at 12 mos. -Risk denial cluster least likely to remain in the aPC stage
(Beebe et al., 2008)	Nine youth assets and tobacco, alcohol, and other drug non-use among American Indian adolescents Positive Youth Development	*n* = 134; ages 13-19 years	Cross-sectional, Correlation Interviews and CASI	Bivariate associations; Logistic Regression Covariates: Age, gender, parent income and education, family structure, city Measures: Non-parent adult role models; peer role models; family communication; groups/sports; religion; good health practices; community involvement; aspirations for future, responsible choices	No alcohol use: 79% No tobacco use: 71% No other drug use: 87% Non-parental adult role models, use of time (religion) predicted alcohol nonuse; Non-parental adult role models predicted tobacco non-use; In one-parent households, good health practices predicted tobacco non-use; Non-parental adult role models and family communication predicted other drug non-use
Bernat, Erickson, Widome, Perry, & Forster (2008)	Smoking trajectories and factors associated with trajectory membership Developmental Smoking Trajectories; Social Development	*n* = 3,637; ages 12-16 years at baseline	Longitudinal, cohort sequential (over 3 yrs) Survey	Latent Trajectory Analysis Covariates: Cohort (age), region, race, family structure Measures: Tobacco Use	Six trajectories: *nonsmokers*, triers, occasional users, early established, late established, and decliners 54% were nonsmokers Nonsmokers and triers shared same negative attitudes toward tobacco industry and low functional meaning of smoking. Nonsmokers more likely to live in suburban

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
	Model;			Gender Parents' Smoking Friends' Smoking Attitudes & Beliefs Home Smoking Policy	areas cf. occasional users and late onset smokers. White race, two-parent family structure, nonsmoking policies in the home, and perceived difficulty finding a place to smoke were associated with nonsmoking.
Crano, Siegel, Alvaro, Lac, & Hemovich (2008)	Predictive validity of dividing marijuana nonusers into vulnerable and resolute categories; Identify variables that change prior to, during, and after marijuana uptake Model to differentiate within-group differences among marijuana nonusers	*n* = 2,111 age 12-16 at baseline; National Survey of Parents and Youth	Secondary analysis of 4-round Longitudinal, Panel; Computer Assisted Personal Interview; Paper/pencil Survey	Discriminant Function Analysis Measures: Future expectations of use Parental monitoring Parental warmth Adult supervision Refusal strength Sensation seeking Approval of others' use ATOD use Academic Performance	*a priori* categorized nonusers as "resolute" nonusers if reported no future expectations for marijuana use; as "vulnerable" nonusers if indicated some possible expectation for future marijuana use -cf. "Resolute" nonusers, "Vulnerable" nonusers 5.63 times greater likelihood of marijuana use at round 2 -Increased classification accuracy when nonusers are categorized as "resolute" vs. "vulnerable" -Resolute nonusers: higher parental monitoring, warmth, adult supervision, greater refusal strength, lower sensation seeking and less likely to approve of others' drug use than vulnerable nonusers -Academic performance better for both types of nonusers than for users
Crano, Gilbert, Alvaro, & Siegel (2008)	Adolescents' vulnerability to inhalant use; Assigning risk to nonusers Theory of Reasoned Action, acculturation and parenting characteristics	*n* = 596, 6th and 7th graders; 5 school districts in southern Arizona	Secondary analysis; Cross-sectional, Correlational Survey	Binary logistic regression (Phase 1), MANOVA, ANOVA (Phase 2) Measures: Attitudes Subjective Norms Intentions to Use Inhalants Prior Inhalant Use Prior Marijuana Use Acculturation	-"Resolute" inhalant non-users, even when *at risk* based on other factors, were less likely to use marijuana or inhalants than "vulnerable" non-users -"Resolute" non-users more likely to be monitored more closely by parents and less likely to be rebellious than "vulnerable" nonusers;

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
				Rebelliousness Familism Parental Monitoring	
Kulbok et al. (2008)	Modifiable protective attitudes, beliefs, norms for deciding not to smoke IMH Theorists' Workshop on Factors Influencing Behavior and Behavior Change	*n* = 39; adolescents from urban city, central Virginia, African American and Caucasian	Qualitative, Content Analysis Focus Groups, Validation Interview	Identifying, coding, and categorizing by emic names; ranking categories from most important to least important	-Facilitators of nonsmoking: health risks, self-confidence, appearance, self-image -Advantages to nonsmoking: longevity, no addiction, feel healthier, smell better, save money, free from being caught -Disadvantages to nonsmoking: being looked down upon, no respect, not much bad about non-smoking -Sources of approval: own beliefs, parents, friends, people at church, teachers, people who do not smoke -Perceived characteristics of nonsmokers: smoking is a personal choice, self-control, self-confident, make good choices
Seo, Torabi, & Weaver (2008)	Openness to future smoking among non-smoking adolescents and environmental risk and protective factors Susceptibility to Smoking, Media, Second-hand smoke exposure, and Social Norms	Stage 1: *n* = 1,416 high school students, 1,516 middle school students Stage 2: *n*=3,433 high school students, 1,990 middle school students; Indiana Youth Tobacco Survey	2-stage clustered sampling; Longitudinal, correlational Survey	Logistic Regression with survey weights Covariates: Gender, grade, race/ethnicity Measures: Openness to future smoking Exposure to pro-tobacco and anti-tobacco messages Health consequences Second-hand smoke Perceived benefits of smoking Peer acceptance of smoking Smoking behavior	-Exposure to second-hand smoke in homes or cars positively associated with openness to future smoking -Pro-tobacco messages had a greater effect on openness than anti-tobacco messages -Proportion of youth who reported *not* being open to future smoking increased between 2000 and 2004 from 74% to 77%

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
Okoli, Richardson, Ratner, & Johnson (2009)	Smoking susceptibility and perceived tobacco addition among adolescents who "puff" cigarettes and non-smokers Susceptibility to smoking and Perceived addiction as risk factors for smoking	*n* = 5,278; British Columbia Youth Survey on Smoking	Cross-sectional, correlational Survey	Univariate associations; Multivariate Logistic Regression Measures: Gender, age, school grade Non-smoker vs. "puffer" Substance Use Exposure to Smoking at home Family smoking Peer smoking Depression Perceived mental addiction to tobacco Perceived physical addiction to tobacco Susceptibility to smoking	-Non-smokers could be differentiated based on their total abstinence or "puffer" status and their susceptibility to smoking -Susceptibility to smoking was associated with female gender, younger age, ever puffed a cigarette, used alcohol or marijuana, family members or peers who smoke, higher depression scores, and higher perceived physical and mental addiction to tobacco. -Female gender, Older grade, Peers smoking, Ever use of alcohol and ever puff of cigarettes, Perceived mental addiction, and higher depression scores remained significant predictors of susceptibility after controlling for all other factors
Kulbok et al., (2010)	Protective factors for nonsmoking among adolescents living in rural tobacco-producing counties in Virginia Health behavior and communications theory	*n* = 18 adolescent female non-smokers; *n* = 10 mothers of the non-smokers	Qualitative, Content Analysis Semi-structured group interview (adolescents focused on attitudes, beliefs, and norms; mothers focused on communication patterns)	Codes, categories, and themes identified in transcribed interviews	Protective factors identified by both youth and parent groups: -open communication with parents; receiving clear, direct messages about dangers of smoking; social norms for deciding not to smoke; encouragement to set high goals; underlying goal for leading healthy, happy, and productive lives -mothers' expressed pride in daughters' decisions not to smoke; girls acknowledged mothers' pride

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
Pollard, Tucker, Green, Kennedy, & Go (2010)	Peer network position and smoking trajectories during adolescence Social Learning Theory; Peer Group Structure: Member, Isolate, Liaison	*n* =; National Longitudinal Study of Adolescent Health (Add Health)	Secondary Analysis; Longitudinal, Correlational Survey	Latent Class Growth Analysis and Friendship Network Analysis (social network program NEGOPY); included survey weights Covariates: Gender, race/ethnicity, depressed affect, coping, self-esteem, parental education, and resident parent who smokes Measures: Smoking history Network position Number of (perceived) friends who smoke	-6 developmental trajectories of smokers: never smokers, steady lows, delayed increasers, early increasers, decreasers, steady highs -Members of nonsmoking groups did not significantly differ in trajectory group membership from isolates or liaisons to nonsmoking groups only, whereas network positions in relation to smoking groups were associated in varying degrees with membership in a smoking trajectory.
				Positive School orientation Parents' monitoring Parent-child communication Friends' ATOD use Non-Parental Adult communication	
Dunn, Kitts, Lewis, Goodrow, & Scherzer (2011)	Youth assets and alcohol, cigarette, marijuana use, sexual behavior, in rural-dwelling adolescents Search Institute's Developmental Assets Framework	*n* = 834; 41% age 14, 31% age 15; convenience sample from two public schools in rural Tennessee	Secondary data analysis; Cross-sectional, Correlational Survey	Logistic Regression Covariates: Gender Measures: Alcohol, tobacco, marijuana use Sexual activity Future Aspirations Internal Control	-Presence of assets more significantly associated with past 30-day nonuse than ever use -Peer help associated with alcohol abstinence (ever use) -Future aspirations associated with alcohol 30-day nonuse -Peer help associated with non-smoking ever -Parent expectation (boys), positive peer influence (boys), parent support (girls)

Study	Focus & Framework	Sample	Design	Analysis & Measures	Substance-Free Youth Findings
				Empathy Parental Expectation Parental Support Self-confidence Positive Peer Influence Peer Help	associated with non-smoking 30-day -Future aspirations (boys), parent support (girls) associated with 30-day nonuse of marijuana -Parent support (girls), positive peer influence (girls) associated with past year sexual activity -Evidence of gender differences in asset effects
Anderson, Briggs, & White (2013)	Personality & motivations for alcohol consumption and problems across adolescence and young adulthood Cox & Klinger's (1988) Motivational Model of Alcohol Use	*n* = 1,380 (49% women) Rutgers Health and Human Development Project (1979-1994)	Prospective, Longitudinal Cohort (baseline age 12-, 15-, 18-yrs old) Self-report questionnaires, interviews	Path Analysis Measures: Alcohol Use Problems r/t alcohol use Motives to Drink Motives to Abstain Personality: Harm avoidant and impulsivity	For youngest cohort, adverse consequences and convictions mediated personality effects for drinking frequency. For older cohorts, fear of loss of control was the only significant mediator.

Chapter 4: METHODS

Preparing large-questionnaire survey data for secondary analysis requires careful considerations of the items and subscales within the survey and their psychometric properties before including them in an analysis or statistical model (Garmon Bibb, 2007; Rew, Koniak-Griffin, Lewis, Miles, & O'sullivan, 2000). The National Longitudinal Study of Adolescent Health (Add Health) researchers developed the Add Health In-Home Questionnaire, the primary instrument used in the present study, by drawing together items from numerous surveys and questionnaires assessing various sociological, psychological, physical, and environmental features; however, no original subscales exist in their entirety within the questionnaire (Harris et al., 2009). Therefore, the Add Health survey developers recommend that all researchers using the data conduct their own analyses for considering the reliability and construct validity of the included items and scales.

In preparation for the current study, a literature review resulted in the identification of other studies that had used Add Health data to study similar constructs of interest. Whenever possible, scales were selected in a fashion that would allow for replication of previously identified reliable and valid constructs within the Add Health data set (Garmon Bibb, 2007). For example, the self-regulation measure used in the current study was an exact replica of the self-regulation measure used by (Beaver, Ferguson, Lynn-Whaley, 2010) in their study on adolescent self-regulation, cumulative-genetic plasticity, and parenting. If an exactly replicated scale in the current study had a lower Cronbach's alpha reliability than what was reported in the literature, consideration was given to eliminating or altering the included items to improve the internal

consistency of the scale. In some instances, single items were chosen to represent constructs of interest; for example, family socioeconomic status and neighborhood socioeconomic status. Since the Latent Class Analysis procedure cannot include cases with missing values on covariates or grouping variables (Collins & Lanza, 2010), large proportions of missing values sometimes dictated the use of single items that had more complete data.

A detailed decision-making process for item and scale selection and data preparation is described in the following discourse on data preparation for Latent Class Analysis using data from Add Health. First is a short discussion on attrition, missing values, and sampling weights and their effects on the generalizability of findings. Thereafter follows the conceptual description of indicator items and their operationalization using Add Health survey items.

Attrition/Recruitment Bias

Sample attrition is a threat to internal validity that is not unusual in studies of individuals spanning long time-periods (Polit & Beck, 2011). The current secondary analysis used data from the Add Health public use data set Waves 1 through 4, and set specific inclusion criteria for which cases would remain in the analytic sample. One rationale for setting the inclusion criteria was to reduce the number of indicators with missing values; however, sample attrition still affected the cases that could have been included in the analysis.

Previous research has revealed factors influencing attrition in longitudinal surveys. (Kalsbeek, Yang, & Agans, 2002) identified several significant predictors for four types of attrition (*i.e.,* not solicited, solicited but unable, solicited but unwilling, and

other nonrespondents) in Wave 2 of the Add Health Adolescent In-Home Survey. Neighborhood security, household being above poverty level, and current smoking status as of Wave 1 data collection had a positive effect on *being solicited* to participate in Wave 2. *Unwillingness* to participate was predicted by White race/ethnicity, *not* having smoked in the past 30 days during Wave 1, having parents who did not volunteer to do fundraising for the parent-teacher organization (PTO), and parents whose highest educational level was high school or less. Living in a rural area and having smoked in the last 30 days predicted *inability to participate*. And, finally, *participation* was more likely in nonwhites and in children of parents who had attended college or had volunteered to raise funds for the school PTO.

The predictors of non-participation for Wave 2 highlight the possibility that the study sample may under-represent adolescents who are from disadvantaged neighborhoods, who are White, smokers, and children of parents who were less involved in PTO activities and less well-educated. While attrition exists in the Add Health survey, the sampling bias introduced by attrition can be attenuated through the use of sampling weights associated with the most recent wave of data collection being used in the analysis (Chantala, 2006). Cluster and sample weights were included in the current study's statistical analyses whenever possible to adjust for attrition bias.

Missing Values Analysis

Beyond the attrition due to non-participation at subsequent waves of data collection, the inclusion criteria set for the current study resulted in the following steps in loss of sample size:

1. Merged public use Waves 1 through 4: N = 6,504 cases

2. Limit to those who were ages 12-19 at Wave 2: N = 4,792
3. Limit to those who were in school during Wave 2: N = 4,431
4. Limit to those who had Substance Use (ATOD) responses at Wave 1 and Wave 2: N = 4,198

A portion of those lost between step 1 and 2 were lost due to non-response at Wave 2 as well as being outside the age range. Those lost between step 2 and 3 were strictly due to responding that they were not currently in school or on academic break from school. These participants were not included since they would also be missing responses on the school connectedness indicator due to the 'legitimate skip' algorithm of the survey design. The 5.3% sample size reduction between step 3 and 4 was due only to the requirements of multiple-group Latent Class Analysis that there be no missing on the grouping variable (*i.e.,* ATOD-use status), and the recommendation of (Collins & Lanza, 2010) to conduct baseline model assessment using the same sample that will be used in the multiple-group analysis.

To follow-up on any key differences between those excluded due to missing on ATOD-use (5.3%) as well as any other variables missing >5%, a missing values analysis was conducted using SPSS v. 21 (IBM Corporation, 2012). A first step in missing values analysis is to try to determine whether data are randomly missing. Little and Rubin (2002) define three types or patterns of missing data: missing completely at random (MCAR), missing at random (MAR), and non-ignorable missingness. MCAR is a missing value pattern in which the cause of missing data is completely random and unrelated to other items and the missing item itself. Missing at random occurs when the missing values are related to one or more other variables included in the analysis, and

theoretically unrelated to the value that would have been observed. Non-ignorable missing values are related to the values that would have been observed (Little & Rubin, 2002).

Those who were missing the Substance Use (ATOD) responses had some significant differences on key measures compared to those who were not missing. The unadjusted average Parent-child closeness score was higher among those missing ATOD-status at 4.42 cf. 4.27 (t = -4.1, df = 243.7, p<0.001; Cohen's d = -0.53). Average parental authority scores were also higher (2.01 cf. 1.65) among those missing ATOD-use information (t = -3.2, df = 247.2, p=0.002; Cohen's d = -0.41). Self-regulation scores were somewhat higher (64.58 cf. 63.07; t = -2.8, df = 244.2, p = 0.005; Cohen's d = -0.36). These mean differences are small and have low to moderate effect sizes, may have been impacted by skewed distributions, are unadjusted for sampling design, and may not be meaningful differences. However, they point to the assumption that the data are missing at random (Little & Rubin, 2002).

After converting all the indicators to categorical variables (procedures described elsewhere in the chapter), those missing on ATOD use were again compared to non-missing using adjusted cross-tabulations accounting for the sampling clusters and weights. Point estimates (row percent) and 95% Confidence Intervals for missing ATOD-use status by all indicator items and covariates were calculated using SAS (v.9.3) PROC SURVEY FREQ. The proportion of those *missing* ATOD-use who reported that *no* close friends use substances (52.28%, 95%CI 44.45,60.10) was higher than those not missing (29.85%, 95%CI 27.33, 32.37), and the proportion missing ATOD-use who were African American, non-Hispanic (27.43%, 95%CI 18.92,35.94) was higher than the non-

missing (13.73%, 95%CI 9.75,17.72). Again, these findings point to the assumption that the portion of the sample with missing responses to the ATOD items is missing at random (Little & Rubin, 2002).

To summarize, when those missing on the ATOD grouping variable are eliminated from the analysis, the sample will somewhat under-represent adolescents who reported having no close friends who use alcohol, tobacco, or other drugs, and somewhat over-represent Caucasian, non-Hispanics. It may also under-represent youth who have a close relationship with their parents, parents who set more household rules, and who have higher self-regulation. These findings align with the possibility of social desirability bias: youth who have the aforementioned characteristics may be less willing to disclose a socially *un*desirable response such as substance use, and therefore declined to answer the questions. However, it's also possible that these youth considered substance-use questions inapplicable to them, and simply did not answer the questions (*i.e.,* nonresponse bias).

Social Desirability Bias

To reduce the degree with which respondents might alter their responses in a socially desirable direction (*e.g.,* report non-use of substances even when this is not the truth), the sensitive items of the Add Health In-Home Questionnaire were delivered to participants using computer and audio-assisted self-interview (CASI) (Harris et al., 2009). All sensitive items had response options for "refused" and "don't know," and a questionnaire algorithm reduced the number of questions needing an answer by following a "legitimate skip" plan. Participants were also reminded that their responses would not be linked to them directly, and they were provided with a certificate of confidentiality.

Despite these efforts to reduce bias, it is likely that self-report bias still exists within this survey (Paulhus, 2002). No specific efforts were made to control for this bias in the current study due to the already complex nature of the statistical model. At least one other study using Add Health data found no effect of response bias on the relationship between religiosity and responses to sensitive items (Regnerus & Uecker, 2007).

Sampling Weights

The Add Health survey was conducted using a sample selection method that incorporated schools as the primary sampling unit (Harris, 2011). A stratified sample of 80 high schools were selected with probability proportional to enrollment size, and stratified by region, urbanicity, school type, ethnic mix, and size (Harris, 2011, p. 3). Then a matching 'feeder' school sample (n = 52) was also selected with probability proportional to the number of students who graduated into the paired high school. 79% of the schools that were invited to participate agreed to do so. Within these 132 sample schools, all students in seventh through twelfth grade were asked to complete the In-School Questionnaire. Because of the stratified, unequal probability of school and student selection, school-level weights and student-level weights were calculated to incorporate into analyses. A detailed description of the calculation of school-level and student-level weights can be found in Tourangeau and Shin (1999).

Incorporating sampling weights and clustering variables into analyses provides a means to obtain unbiased estimates when analyzing non-random samples. Following the recommendations of Lanza et al. (2013), the current analyses used the CLUSTER2 variable, which is the school-level weight or clustering variable, and the Wave 2 grand

sample weight (GSWGT2) for the student-level sampling weight in the Latent Class Analysis model.

The SAS procedure for LCA incorporates the sampling weights into the estimation of the logistic regression parameters and item response parameters in the same way as a frequency weight (Lanza, Dziak, Huang, Xu, & Collins, 2013). That is, characteristics of classes are calculated as weighted averages by sampling weight and posterior probability, instead of weighting only by posterior probability. If the weights were not included in the model, each case/participant would be counted exactly equally in generating the estimates and would be biased in relation to the non-random sampling method. Furthermore, when incorporated into the latent class model, the sampling weights are taken into account when calculating standard errors using a "sandwich" or "robust" method (i.e., Taylor linearization) resulting in unbiased standard errors (Lanza et al., 2013). Incorporating the school-level and student-level sampling weights increases the generalizability of the estimates to a nationally representative population of students. Currently, there is no known better way to incorporate the sampling weights into a latent class analysis.

Indicator Variables

Self-regulation. Self-regulation has been conceptually defined as an individual's ability to "control or regulate one's emotions, cognitions and behavior" in order to attain socially acceptable goals or to demonstrate "competent functioning" (Vazsonyi & Huang, 2010, as cited in Belsky & Beaver, 2011). It captures the development of executive functioning that is rapidly expanding during adolescence, especially as the adolescent is experiencing more and more autonomy in the movement toward adulthood. Low levels

of self-regulation have been associated with substance use initiation and problem use, while high levels are considered protective (Hustad et al., 2009; Lerner, Lerner, Bowers, et al., 2011; Wills et al., 2002).

The current study uses an operationalization of self-regulation previously identified in the Add Health survey and used by Belsky and Beaver (2011) in their study of associations between parenting and adolescent levels of self-regulation. The measure consisted of the sum of 20 items asked in the Wave 2 Adolescent In-Home Interview. The items tapped self-regulation experiences such as whether they have trouble keeping their mind focused, whether they like to take risks, and whether they are sensitive to other people's feelings. In a previous study, (Beaver et al., 2010) reported "psychometric analyses revealed that the 20 items could be accounted for by a single factor, and additional analyses revealed that removing any of the items from the scale would not significantly increase the internal reliability of the scale" (p. 1052); their Cronbach's alpha was 0.72.

The same scale was computed for the current study using the following 20 items (Table 1) from the Add Health Adolescent In-Home Interview. Response options were on a 4-or 5-point likert-type scale where 0 = Never/rarely and 1, 2, and 3 reflected progressively higher frequency of the experience, or 1 = Strongly agree, and 5 = Strongly disagree. Before summing, some items were reverse coded so that a higher numbered response indicated a higher level of self-regulation. The Cronbach's alpha for this sample was 0.73, demonstrating adequate internal consistency (Nunnally & Bernstein, 1994).

Table 1.

Wave 2 Adolescent In-Home Interview Items: Self-regulation indicator

Item number	Stem
	How often was each of the following true during the past seven days?:
H2FS5r	You had trouble keeping your mind on what you were doing.
H2FS11	You were happy.
H2FS15	You enjoyed life.
H2FS16r	You felt sad.
	Since school started this year, how often have you had…
H2ED11r	Trouble getting along with your teachers?
H2ED12r	Trouble paying attending in school?
H2ED13r	Trouble getting your homework done?
H2ED14r	Trouble getting along with other students?
	How strongly do you agree/disagree with the following statements?
H2PF12r	When you get what you want, it's usually because you worked for it.
H2PF13	You usually go out of your way to avoid having to deal with problems in your life.
H2PF14	Difficult problems make you very upset.
H2PF15	When making decisions, you usually go with your gut feeling without thinking too much about the consequences of each alternative.
H2PF16r	After carrying out a solution to a problem, you usually try to think about what went right and what went wrong.
H2PF24r	You like yourself just the way you are.
H2PF25r	You feel like you are doing everything just about right.
H2PF26r	You feel socially accepted.
H2PF28	You like to take risks.
H2PF32r	You are sensitive to others feelings.
H2PF34r	You can pretty much determine what will happen in your life.
H2PF35	You live your life without much thought for the future.

r = Reverse Coded

Exposure to ATOD: Peers and Parents. Research has identified that a strong predictor of substance use in adolescents is the substance-use behavior of peers and family, including the availability of substances in the home (Hawkins et al., 1992). Studies have also identified that processes of resilience can be reflected in the number of youth who specifically do not use substances in the presence of relatively frequent exposure to ATOD use (Crano, Gilbert, et al., 2008; Kulbok et al., 2010; Spijkerman & Engels, 2007). To operationalize exposure to ATOD by peers, the current study uses the

sum of responses to three Likert-type items (response options: 0,1,2, or 3) assessing the respondent's perception of friends' smoking behavior, alcohol use, and marijuana use (*e.g.*, Of your 3 best friends, how many smoke at least 1 cigarette a day?) (Cronbach's alpha for the current study sample = 0.74).

Exposure to parental substance use and availability of substances in the home was challenging to construct using the Add Health items. No previous studies could be identified for replication. The items assessing alcohol and drug availability in the home were not correlated with the parental tobacco use item (which was the only measure of parents' substance use), thus, an indicator variable for parental tobacco use and availability of cigarettes in the home was created using two items. First, an item reflecting whether either resident parent had ever smoked since the Wave 1 interview was created using two separate items (*i.e.,* one that asked about the resident mother's smoking behavior, and one that asked about the resident father's smoking behavior) so that 1 = at least one resident parent smoked, and 0 = no resident parent smoked. This dichotomous item was summed with the response to another dichotomous (0 = no; 1 = yes) question "Are cigarettes easily available to you in your home?" The KR-20 for these two items for the current study was 0.71. Scores ranged in whole numbers from zero to 2.

Parent-child Relationship: Closeness and Authority. Adolescents' relationships with their parents are another important source of influence for substance use behavior. Experiencing a close, warm relationship with parents and having parents who regularly monitor adolescent behavior and set household rules, have been associated with positive outcomes in adolescent development (Guo, Reeder, McGee, & Darling, 2011; Peterson, Buser, & Westburg, 2010; Ryan, Jorm, & Lubman, 2010b). As a proxy

for parent-child attachment, a recent study by Gault-Sherman (2012) used the average of ten Likert-type Add Health items (five pertaining to the mother, and five pertaining to the father) that assessed perceived closeness with and care from parents, reporting an alpha of 0.86. Items were reverse-coded as needed so that higher scores reflected greater parent-child closeness.

The current study followed Gault-Sherman's (2012) procedures and first calculated a maternal closeness score using the items pertaining to the resident mother by summing and averaging the responses. Then, the sum and average of the paternal items created the father closeness score. Finally, if both averages were present, they were summed and averaged for a *parent-child* closeness score. For respondents for which only the mother or paternal average score was present, the *parent-child* closeness score took the value of the available parent (either mother or father) closeness score. This assured that no participant living in a single parent household was missing from the analysis. The alpha for the current study sample was 0.86, indicating reliable internal consistency (Nunnally & Bernstein, 1994). The items (Table 2) were used to construct the *parent-child closeness* score. Items were reverse coded if needed so that higher scores reflect higher parent-child closeness, and all items were measured on a 5-point likert-type scale.

Table 2.

Wave 2 Adolescent In-home Interview: Parent-Child Closeness Indicator

	Item	Response options
1.	How close do you feel to {MOM/DAD NAME}?	(1 = not at all; 5 = very much)
2.	Most of the time, {MOM/DAD NAME} is warm and loving toward you.	(1 = not at all; 5 = very much)
3.	Most of the time, {MOM/DAD NAME} is warm and loving toward you.	(1 = strongly agree; 5 = strongly disagree)
4.	When you do something wrong that is important, {MOM/DAD NAME} talks about it with you and helps you understand why it is wrong.	(1 = strongly agree; 5 = strongly disagree)
5.	You are satisfied with the way {MOM/DAD NAME} and you communicate with each other.	(1 = strongly agree; 5 = strongly disagree)

A computed subscale that also followed the procedures of Gault-Sherman (2012) operationalized the concept of *parental authority*. This indicator was created by summing seven dichotomous items from the Adolescent In-Home Interview pertaining to respondents' perceptions of how much the parents allow him/her to make independent decisions about daily activities. The KR-20 for the current study sample was 0.63. Although this indicates somewhat low internal consistency, a better proxy for parental authority could not be identified in the literature on Add Health nor by exploring the inclusion of other items or the effects of removing items from the scale. Items were reverse coded before summing so that higher scores indicated higher parental authority (*i.e.,* more rule-setting by parents). The specific items included are listed in Table 3.

Table 3.

Wave 2 Adolescent In-home Interview: Parental Authority Indicator

	Do your parents let you make your own decisions about… (0=no, 1=yes)
1.	The time you must be home on weekend nights?
2.	The people you hang around with?
3.	What you wear?
4.	How much television you watch?
5.	Which television programs you watch?
6.	What time you go to bed on weeknights?
7.	What you eat?

School Connectedness. School connectedness has been theoretically defined as a "broad promotive influence….including positive peer relationships, perceptions of safety, feelings of belongingness, and teacher support" occurring in the school setting (Furlong, O'brennan, & You, 2011). A classic study by Resnick et al. (1997) was one of the first studies to use the Add Health School Connectedness subscale and to identify the predictive validity of school connectedness for health outcomes. More recently, Furlong and colleagues (2011) conducted a psychometric evaluation of the 5-item subscale by testing it across 18 sociocultural groups. In a sample of 500,800 junior and senior high school students in California, they identified that this unidimensional measure has acceptable reliability (α = 0.82-0.88) and concurrent validity with the *School Support Scale* from the Resilience Youth Development Module (r = 0.44 to 0.55) across the 18 sociocultural groups. Using confirmatory factor analysis methods, they also found that the subscale had a one-factor structure that satisfactorily fit in all 18 groups and with significant standardized factor loadings for each of the 5 items (*i.e.,* configural invariance); the model fit was satisfactory when loadings were constrained to be equal across all 18 groups (*i.e.,* metric invariance); and, model fit was satisfactory when

intercepts were also constrained across all 18 groups (*i.e.*, scalar invariance) (Furlong et al., 2011).

Although there still remains some ambiguity concerning the conceptual definition of the underlying latent construct (Libbey, 2004), the face validity of the items indicate measurement of a sense of closeness to people at school, happiness about being at the school, feeling a part of the school, that teachers treat students fairly, and feeling safe at school. Participants rate each statement using a 5-point Likert scale, where 1 = strongly disagree and 5 = strongly agree, and the sum of the responses is the *school connectedness score*, ranging from 5 to 25. Higher values indicate stronger connection to school. The alpha reliability for the present study was 0.78.

Community Factors: Exposure to Community Violence. Tests of the relationships between exposure to community violence and health or developmental outcomes have had mixed results. For example, while McDonald, Deatrick, Kassam-Adams, and Richmond (2011) found that community violence exposure had no significant effect on a measure of positive youth development, Taylor and Kliewer (2006) found that it predicted alcohol use at time two in a study of young adolescents. Because the neighborhood connectedness measure (see next section) in the current study did not include specifics about violence, it was important to tap this component of community life experience using a specific measure of community violence.

The sum of five items indicated the construct of exposure to community violence (Hagan & Foster, 2001). The items inquired as to how frequently the participant had experienced or witnessed violent events (Table 4) during the past 12 months.

Table 4.

Wave 2 Adolescent In-home Interview: Exposure to Community Violence Indicator

	Item
1.	You saw someone shoot or stab another person.
2.	Someone pulled a gun on you.
3.	Someone pulled a knife on you.
4.	Someone shot you.
5.	Someone stabbed you.

Adolescents could respond with *never* (1), *once* (2), or *more than once* (3). Higher scores indicated a higher exposure to interpersonal violence. Hagan and Foster (2001) reported an alpha of 0.69. The alpha for the current study sample was slightly lower at 0.67. Although this reliability is barely acceptable according to psychometric theory (Nunnally & Bernstein, 1994), an exploration of other items did not reveal more reliable items for measuring this construct using the Add Health public use data set. Furthermore, it is highly likely that the Cronbach's alpha measure of reliability underestimates the true internal consistency of this scale due to the ordinal nature of the included items (Gadermann, Guhn, & Zumbo, 2012). A polychoric ordinal reliability alpha generated using R resulted in an ordinal alpha of 0.90, indicating good internal consistency.

Neighborhood Connectedness. Neighborhood factors such as socioeconomic status, sense of cohesion, and safety have previously been linked to delinquent behaviors, binge drinking, marijuana use, and early sex initiation in youth (Choi, Harachi, & Catalano, 2006; Mahatmya & Lohman, 2012; Roche et al., 2005; Tucker, Pollard, de la Haye, Kennedy, & Green Jr., 2013). The present study focused on youth's perception of their own sense of safety in the neighborhood, as well as their sense of connection to neighbors, to understand possible neighborhood factors that are associated with resilience in youth.

The Add Health In-home Interview contains nine items labeled as pertaining to *neighborhood.* Since only two studies in the literature could be identified as having used some of these particular items to indicate neighborhood connectedness and neither reported reliability information (Tucker et al., 2013; van den Bree & Pickworth, 2005), a decision was made, based on the face validity of items, to explore the relationships among seven of the nine items (Table 5). The two items labeled "neighborhood" in the codebook but not included in the analysis were: "Have you lived here since the previous interview?" And "How many months have you lived here?" (Mullan Harris & Udry, 2008, p. 1205).

Table 5.

Wave 2 Adolescent In-Home Interview: Neighborhood connectedness indicator

	Item	Response options
1.	You know most of the people in your neighborhood.	(1 = True; 2 = False)
2.	In the past month, you have stopped on the street to talk with someone who lives in your neighborhood.	(1 = True; 2 = False)
3.	People in this neighborhood look out for each other.	(1 = True; 2 = False)
4.	Do you use a physical fitness or recreation center in your neighborhood?	(0 = no; 1 = yes)
5.	Do you usually feel safe in your neighborhood?	(0 = no; 1 = yes)
6.	On the whole, how happy are you living in your neighborhood?	(1 = not at all; 5 = very much)
7.	If, for any reason, you had to move from here to some other neighborhood, how happy or unhappy would you be?	(1 = very unhappy; 5 = very happy)

Checking the relationships among the dichotomous items using cross-tabulations, revealed significant (p <0.01) chi-square associations between several of the measures (Table 6). Nonparametric correlations between the two items with likert-type response options (*i.e.,* how happy are you living in your neighborhood? and, how unhappy/happy would you be to move to some other neighborhood?) identified a significant, moderate relationship between the two items (Spearman's rho = 0.44, p <.001).

Table 6.

Inter-item correlations (Cramer's V) of Neighborhood Connectedness items

	Q1r	Q2r	Q3r	Q4	Q5
Q1r	1.00				
Q2r	.41*	1.00			
Q3r	.32*	.25*	1.00		
Q4	.03	.05*	.03	1.00	
Q5	.06*	.01	.24*	.01	1.00

*$p<0.01$; r = reverse coded

Next a Cronbach's alpha using standardized items was generated using all but the item assessing use of a recreation center, due to its very low correlations with other items. The Cronbach's alpha using standardized items was 0.64. For the purposes of this study, it was decided that the 6-item scale had adequate reliability to be used as a measure of neighborhood connectedness.

Categorizing the Indicator Variables

Since Latent Class Analysis is designed to detect patterns (homogeneous subgroups) of responses to categorical variables, each of the indicator variables that had a continuous distribution was categorized. Although some would argue that this results in a "loss of information," the purpose of the current study was to identify patterns of influencing factors that have been operationalized according to their discrete levels of presence in individuals (Collins & Lanza, 2010; Syvertsen, Cleveland, Gayles, Tibbits, & Faulk, 2010). Furthermore, because most of the items were significantly skewed (Appendix A, Figures 1-8), converting them to categorical variables provided a simplifying lens to more quickly understand a given individual's position (health-negating vs. health-promoting) on a measure reflecting his/her experience of an influencing factor and in relation to others' experiences of the same influencing factor.

Examination of the distribution of each variable and on frequencies of responses, as well as one other study that used a similar categorization (Syvertsen et al., 2010), provided the basis for categorizing the indicators. Although originally the plan was to use six tripartite indicators (low vs. medium vs. high) and two dichotomous indicators, the LCA model using these indicators was unstable and would not converge when covariates were included. It was decided then, to simplify the model by using all dichotomous indicators. The variables that approximated a normal distribution most closely or that had scale ranges greater than 7 were dichotomized at the 25th percentile (*i.e.,* health-negating vs. health-promoting): self-regulation, closeness to parents, school connectedness, and neighborhood connectedness. Frequency analyses confirmed that the cut-off values used to code the items according to the 25th percentile were as accurate as possible given the scores.

Several items were highly skewed, and dichotomization was most logical at the difference between absence or presence of a factor: no close friends use ATOD vs. some friends use; neither parents smoke and no easy access to tobacco at home vs. at least one parent smokes and/or there is easy access to tobacco at home; parents allow youth to make all their own decisions vs. parents have at least some rules or input into decisions; never experienced community violence vs. experienced violence at least once. Appendix A gives the figural depiction of the distributions before dichotomizing each indicator. A comparison of the latent class item response probabilities (IRP) when using items all dichotomized at the 50th percentile revealed that the indicators had moderately stronger relationships to the latent variable (*i.e.,* IRPs varied across latent classes and were closer

to 0 and 1) when dichotomized at the 25th percentile (Collins & Lanza, 2010). Table 7 gives the distribution (frequency and percent) for each level of each indicator.

Table 7.

Distribution of Dichotomized Indicators (unweighted frequency, %)

	Frequency	Percent
Self-regulation		
Health-negating*	1134	25.6
Health-promoting*	3248	73.3
Missing	49	1.1
Close Friends' ATOD use		
Friends do not use	1357	30.6
Some friends use	2968	67.0
Missing	106	2.4
Parents' Tobacco Use & Home Availability		
Health-negating	2013	45.4
Neither parent smokes nor home availability	2320	52.4
Missing	98	2.2
Parent-Child Closeness		
Health-negating	980	22.1
Health-promoting	3232	72.9
Missing	219	4.9
Parental Authority		
Health-negating	1086	24.5
Health-promoting	3262	73.6
Missing	83	1.9
School Connectedness		
Health-negating	1118	25.2
Health-promoting	3300	74.5
Missing	13	0.3
Exposure to Community Violence		
None	3653	82.4
At least once	753	17.0
Missing	25	0.6
Neighborhood Connectedness		
Health-negating	813	18.3
Health-promoting	3544	80.0
Missing	74	1.7

*Health-negating defined as levels of the factor which likely contribute to poor health outcomes; Health-promoting defined as levels of the factor which likely contribute to positive health outcomes

The next step was to analyze the overall relationships among the indicator items to determine if there were highly related items that might be partially redundant indicators of the latent variable (Lanza, Collins, Lemmon, & Schafer, 2007). Cross-tabs and Cramer's V analysis revealed that although there were some significant bivariate associations among the indicator items (p<0.001), this was likely due to the very large sample size, and none of the Cramer's V values was greater than 0.30 (Table 8), indicating moderate associations at best. Some of the associations were quite low (0.001-0.23), pointing to the possibility that these factors may not be strong indicators of the latent class variable. These items were still retained due to their relevance to the research conceptual model. One of the dichotomized items, *exposure to interpersonal violence*, had such significant skew that only 17.1% fell into the 'experienced any violence' category, however, cross-tabs were still stable using this item due to the large sample size.

Table 8.

Inter-item correlations (Cramer's V) of Dichotomous Indicator Items

	SR	FU	PTH	PCC	PA	SC	EV	NC
Self-regulation	1.00							
Friends who use	.16**	1.00						
Parents' Tobacco & Home	.06**	.10**	1.00					
Parent-Child Closeness	.23**	.09**	.05*	1.00				
Parental Authority	.04*	.07**	.02	.001	1.00			
School Connect	.28**	.09**	.08**	.15**	.006	1.00		
Experienced violence	.15**	.15**	.10**	.05**	.001	.13**	1.00	
Neighborhood Connectedness	.15**	.03*	.02	.12**	.02	.21**	.05*	1.00

**p<0.001; *p<0.01

Covariates

Age. Age was a continuous variable measuring age in years and selected from the Wave 2 public use data set. Add Health flagged seventeen cases as having an incorrectly calculated age at Wave 2, and these were corrected using the date of birth and the interview date for Wave 2 data collection. Before inclusion in the LCA model with covariates, this variable was standardized (Lanza et al., 2013).

Gender. Gender was reflected in the BIO_SEX variable from Wave 1, and was dummy coded as male (0) or female (1).

Race/ethnicity. A race/ethnicity categorical variable was created by first following recommended coding schemata from the Add Health website (Table 9).

Table 9.

Distribution of Race/Ethnicity

Race/ethnicity	Unweighted Frequency	Percent
Hispanic, all races	500	11.3
African American, non-Hispanic	963	21.7
Asian, non-Hispanic	137	3.1
Native American, non-Hispanic	48	1.1
Other, non-Hispanic	37	.8
White, non-Hispanic	2731	61.6
Total	4416	99.7
System Missing	15	.3

Since some categories were quite small, a 3-category race/ethnicity variable was coded into White, non-Hispanic (1), African American, non-Hispanic (2), and Other Minority (3) (Table 10).

Table 10.

Distribution of Collapsed Race/Ethnicity

Race/ethnicity	Frequency	Percent
White	2731	61.6
African American	963	21.7
Other minority	722	16.3
Total	4416	99.7
System Missing	15	.3

Socioeconomic Status (SES).

Family. Although the Add Health public use data set contains a variable for parent-reported total annual household income (PA55), this variable had significant missing values (21%) and could not be considered a reliable indicator for family socioeconomic status. A missing values analysis revealed that missing household income was associated with other items reflecting low income, such as whether the parent received public assistance. Furthermore, parental education level also had significant missing values, both from parent report (11%) and adolescent report (mother: 93%, father: 85%).

Other proxy socioeconomic status variables were explored. Dichotomous items from the parent questionnaire assessed having enough money for bills, and receiving specific kinds of public assistance (SSI, AFDC, Food Stamps, Unemployment, Housing Subsidy, SS/RR). Missing values on these items ranged from 11% to 13.8%. The adolescent report of parent receiving public assistance was then explored. From the Adolescent In-Home Questionnaire, two items, one for each possible resident parent, ask "Does your {resident mother/father} receive public assistance?" (response options: yes/no). The item for resident mother had only 5.6% missing, many of which were missing due to the participant having no resident mother. By combining the items for

resident mother and resident father into one indicator of parent(s) receiving public assistance, missing values were reduced to 2.3% for this indicator of family socioeconomic status. This variable was moderately correlated with the non-missing parent-report of total annual household income (Spearman's rho = .32, p <.001). Since no other reliable measures of socioeconomic status of the family with fewer than 5% missing could be identified, it was decided to retain this single-item, dichotomous indicator ("yes, at least one parent receives public assistance" vs. "no, neither parent receives public assistance") as the primary measure of family SES.

Neighborhood Socioeconomic Status. Since only a single item indicator for family SES could be identified, the contextual, block-level variables were also explored for indicators of neighborhood socioeconomic status (Tucker et al., 2013). Add Health constructed these items using geocodes, or actual addresses, and the associated census data for the area surrounding the participants' residence (Harris, 2011). One item designates the proportion of the block group that is under poverty (low vs. medium vs. high), and another designates the unemployment rate of the block group (low vs. medium vs. high). These two items were moderately correlated (Spearman's rho = .53, p <0.001), and since the item assessing proportion below poverty was missing fewer than the unemployment rate (1.3% vs. 3.3%), the item assessing the block group proportion below poverty was retained as a single indicator of neighborhood socioeconomic status.

Residential location: Rural, Suburban, or Urban. A single-item from the Adolescent In-Home Questionnaire and recorded by the trained interviewer was used to operationalize the residential location of the participant. The item reflects the dominant land-use of the surrounding area of the participant's home (i.e., "How would you describe

the immediate area or street (one block, both sides) where the respondent lives?"). Response options include: rural, suburban, urban/residential only, 3 or more commercial properties/mostly retail, 3 or more commercial properties/mostly wholesale/industrial, other, refused, don't know. Refused and don't know were counted as missing (1.1%), and the 'other' and commercial property options were collapsed into the urban category so that this item indicates rural, suburban, or urban residential location. This item was selected for its specificity to each participant's home, rather than using the block-level data that refers more generally to the neighborhood and Census tract data.

Grouping Variable for Multiple Group LCA

Degree of Substance Nonuse/Use during Wave 1 and Wave 2. The groups reflecting three different degrees of substance nonuse or use (nonuser, experimenter, and regular/risky user) were created using items from the Adolescent In-Home Interview, computer-assisted self-interview (CASI) at Wave 1 and Wave 2. Using a tripartite classification more likely captures a valid classification of the spectrum of substance non-use and use in adolescents (McCusker, Robers, Douthwaite, & Williams, 1995; Nonnemaker, McNeely, & Blum, 2003).

Nonusers. If adolescents reported no use of alcohol, tobacco, marijuana, chewing tobacco, cocaine, inhalants, and other drugs at both Wave 1 and Wave 2, they were coded as nonusers (1). Example items from the Add Health survey include: "Have you tried cigarette smoking, even just one or two puffs?" and "Have you had a drink of beer, wine, or liquor (not just a sip or a taste of someone else's drink) more than two or three times?"

Experimenters. Participants were coded as experimenters (2) if they reported having tried or used alcohol, tobacco, marijuana, chewing tobacco, cocaine, inhalants,

and other drugs during Wave 1 or Wave 2, but reported (a) *no use* during the past 30 days during Wave 2, (b) *no regular smoking* at Wave 2 (defined as smoking "at least one cigarette every day for 30 days"), and (c) *alcohol use no more than once a month* at Wave 2. Example items used to assess this included "During the past 30 days, on how many days did you smoke cigarettes?" and "During the past 30 days, how many times have you used marijuana?" This category may have included those who were regular or risky users during Wave 1, but who had reportedly quit this type of use within 30 days before the Wave 2 interview.

Regular or Risky users. Adolescent participants were coded as regular or risky users (3) if they responded positively at Wave 2 to any substance-use items reporting use during the past 30 days (for marijuana, cocaine, inhalants, chewing tobacco, and other drugs), or if they indicated they smoked regularly, or that they used alcohol more than once a month. Although it is possible that this category included some participants who had just begun to experiment with an illicit substance during the past 30 days, a visual scan of the data revealed that many of those who had used a substance during the past 30 days, had used more than one substance during that time frame. According to the gateway theory, using multiple substances is an indicator that one is moving along the path of substance use initiation, from less to more (Degenhardt et al., 2010), and in the current study serves to designate a riskier level of substance use than experimentation.

It was not determined whether there were inconsistent responses or logically "invalid" responses to the substance-use questions as performed in some other analyses using Add Health data (Sieving et al., 2001). By using a combination of measures to designate the substance-using status of each participant, it was assumed that each

categorization would reliably reflect the best category for most participants. In addition, using data from both Wave 1 and Wave 2 to assign the category during adolescence, accuracy of group assignment was likely increased. The "regular or riskier use" category has the greatest chance of including "invalid" responses because some of the 30-day-past-use items had responses ranging from 1 through 555, where the highest numbers could have been considered invalid. Rather than excluding these outliers, they were assigned to the most closely related group matching their reported levels of substance use.

Distal Outcome: Substance Use Behavior in Adulthood. To address the third specific aim of the study, a categorical distal outcome variable was created in a similar fashion to the multiple-group substance use variable at Wave 2, but using data from Wave 4, when Add Health participants were young adults (ages 24-32). *Nonusers* (unweighted n = 638, 17.8%) were again coded based on responding positively to Wave 4 items assessing *never* use of tobacco, alcohol, marijuana, and other illicit drugs. The second category, called *moderate users*, included participants who may have tried tobacco and other illicit substances in the past (and none during the past 30 days), but who reported never being a regular smoker and reported non-heavy alcohol use (*i.e.,* females drinking no more than 2 drinks on average at one sitting, and males drinking no more than 3 drinks on average at one sitting) (unweighted n = 445, 12.4%). The third category, named *regular/risky users*, included responders who reported ever regularly smoking, those who had smoked or used illicit substances during the past 30 days, and those who had engaged in heavy or binge alcohol use during the past year (unweighted n =2,511, 69.9%). Sample size loss between the overall model sample (n=4,198) and the Wave 4 distal outcome sample (n=3,594) was 604 (14.39%). Since the overall latent

class structure and item response probabilities were consistent between both samples, no further analysis of attrition effects was conducted.

Power

The estimation of needed sample size to have adequate power to select the correct number of latent classes is a current area of research, and very little has been published about how to make this estimation (Dziak, Lanza, & Tan, in press; Tekle, Gudicha, & Vermunt, n.d.). Power in latent class analysis is related to effect size, sample size, and alpha, just as with other simple statistical tests, but is more complex in that it is also related to the number of indicator items included in the model, the number of rho parameters being estimated, the strength of the relationship between indicators and the latent variable, and the number of classes being compared (Dziak et al., in press; Tekle et al., n.d.). Because the strength of the relationship between indicators and the latent variable were largely unknown before conducting this LCA, and there is currently no regularly-used effect size parameter (although Dziak et al., and Tekle et al. make suggestions for effect size parameters), the current study was conducted with the assumption that adequate power (0.80) to detect the "true" number of classes would easily be obtained due to the very large sample size (n=4,198). The findings of Dziak et al. (in press) support the likelihood that even with a low to moderate strength of relationship between the indicators and the latent variable, the use of eight dichotomous indicators, and comparing models fit to 5, 4, 3, 2, and 1 classes with a sample greater than 1,500 would exceed a power of 0.80 to detect the best number of classes.

Data Analysis

Overall Model Specification and Identification. To address the first specific aim, a latent class analysis of the entire sample was performed in SAS v. 9.3 (SAS Institute, Cary NC) using PROC LCA, a macro developed and maintained by the Penn State Methodology Center (Lanza, Dziak, Huang, Xu, & Collins, 2013). PROC LCA uses the expectation-maximization (EM) algorithm to produce maximum-likelihood estimates of the prevalence of latent classes (gamma) and the item response probabilities (rho) of each of the latent classes. Complex data with sampling weights and clustering variables can be analyzed using PROC LCA by using the WEIGHTS and CLUSTERS statements. When clusters and weights are included in the model, PROC LCA uses the pseudo-maximum-likelihood approach (Skinner, 1989, as cited in Lanza et al., 2013, p.10), and calculates standard errors using a "robust" or "sandwich" style covariance estimate (Lanza et al., 2013).

The first steps in the procedures for LCA were to specify the model and then select the most optimal model (Collins & Lanza, 2010; Lanza, Collins, Lemmon, & Shafer, 2007). To identify the overall optimal model based on balancing model fit and parsimony, a series of latent class models with varying numbers of classes (*e.g.,* 1- through 5- classes) were compared according to absolute and relative model fit indices (Table 11). Model identification (*i.e.*, whether a meaningful maximum-likelihood solution can be found [Meyers, Gamst, & Guarino, 2012]) was assessed by checking the modal G^2 (likelihood ratio statistic) of models with different numbers of classes and generated from 100 different random starting values (Collins & Lanza, 2010). The use of multiple random sets of starting values is recommended because LCA models with

positive degrees of freedom can still be underidentified, or even unidentified, due to small absolute sample size, data sparseness (*i.e.,* a small ratio of the sample size N to the number of cells W in the contingency table), and/or a weak relationship between the observed variables and the latent variable (Collins & Lanza, 2010).

Table 11.

Summary of Fit Information for Selecting Number of Latent Classes

Number of Latent Classes	Number of Parameters Estimated	G^2*	*df*	AIC	BIC	Log-likelihood	Percentage of Seeds associated with best fitted model
1	8	1518.56	247	1534.56	1585.30	-18531.83	100%
2	17	445.31	238	479.31	587.13	-17995.20	99%
3	26	338.74	229	390.74	555.64	-17941.91	100%
4	35	297.75	220	367.75	589.73	-17921.42	53%
5	44	266.56	211	354.56	633.62	-17905.82	19%

**p*-values not reported due to large *df*
Note: Fit indices are based on the pseudo-likelihood incorporating weights.

In the current study, models with one-, two-, and three-classes had 99%-100% of the random seeds associated with the best-fitted model. A model with four classes was also fairly well-identified, having 53% of the random seeds associated with the best-fitted model. A model with 5-classes became poorly identified with only 19% of random seeds associated with the best-fitted model. Comparisons of the G^2 likelihood ratio test statistic, Akaike's Information Criterion (AIC; Akaike, 1974), the Bayesian Information Criterion (BIC; Schwarz, 1978), and interpretability of results between the different class solutions helped to determine that the three-class model was the most optimal and parsimonious solution.

Compared to models with one and two classes, the three-class model had the smallest G^2, and the smallest AIC and BIC. Although the item response probabilities (IRP) showed that the indicators have only a modest relationship to the latent variable (*i.e.*, the IRP are not widely distributed across the classes, nor do many of them fall close to 0 and 1), the homogeneity and separation of the latent classes was adequate for assigning meaningful descriptions to the latent classes based on the most probable response patterns for each class (Collins & Lanza, 2010). The three-class model was chosen over the four-class model, which was also adequately identified, because of the principle of parsimony, and because 100% of the random starting seeds were associated with the most optimal model while only 53% were associated with the optimal model in the 4-class solution. Furthermore, it was not clear that the additional fourth class was significantly different or separate from the 'health-promoting influences' class in the three-class model. Once the three-class model was chosen, the estimates of latent class prevalence (*gamma*) and the estimates of the item response probabilities (*rho*) were examined and used to describe the qualities of each class.

Multiple Group Latent Class Analysis. To address the second specific aim, the latent class structure was explored for three subpopulations in the data: the substance *nonusers*, the *experimenters*, and the *regular/riskier substance users*. Multiple-group latent class analysis and the statistical comparison of latent class prevalence across subpopulations require that measurement invariance across the subpopulations exists (Collins & Lanza, 2010). Measurement invariance means that the latent variable "has the same measurement characteristics in each group" (Collins & Lanza, 2010, p. 117).

Using the exact same model-identification procedures described for the overall model to examine the latent class structure in the nonuser, experimenter, and regular/risky user groups (including the sampling weight and clustering variables) revealed that measurement invariance across the groups could *not* be assumed. The prevalence of classes was different from the overall model (*i.e.,* each subpopulation fit a 2-class model better than a 3-class model), and although the subpopulations shared the same number of classes, the rho parameters were enough different across the classes that the meaning of at least one of the classes differed between each group (Table 12).

Table 12.

2-class Structure of Influencing Factors in Subpopulations of Adolescents

Nonusers (n=1,025)	Class 1	Class 2
Class Description	All Health-Promoting Influences	Mixed Influences with Health-negating School Connectedness
Class Prevalence	0.85	0.15
Self-regulation	**0.94**	**0.57**
Peers ATOD use (none)	**0.69**	**0.54**
Parent Smokes & Easy Home Access (neither)	**0.67**	**0.55**
Parent-child closeness	**0.89**	**0.67**
Parental Authority	**0.81**	**0.85**
School Connectedness	**0.94**	0.27
Exposure to Community Violence (none)	**0.94**	**0.87**
Neighborhood Connectedness	**0.90**	**0.57**
Experimenters (n=1,616)	Class 1	Class 2
Class Description	Health-promoting Influences with Friends who use ATOD	Low self-regulators, low school connectedness
Class Prevalence	0.66	0.34
Self-regulation	**0.92**	0.47
Peers ATOD use (none)	0.32	0.31
Parent Smokes & Easy Home Access (neither)	**0.58**	0.46
Parent-child closeness	**0.88**	**0.60**
Parental Authority	**0.74**	**0.81**
School Connectedness	**0.93**	0.47
Exposure to Community Violence (none)	**0.89**	**0.74**
Neighborhood Connectedness	**0.91**	**0.63**
Regular/Risky Users (n=1,557)	Class 1	Class 2
Class Description	Health-promoting influences with Friends Who Use ATOD	Low Self-regulators, low school connectedness, possible violence exposure
Class Prevalence	0.43	**0.57**
Self-regulation	**0.88**	0.40
Peers ATOD use (none)	0.08	0.04
Parent Smokes & Easy Home Access (neither)	0.48	0.39
Parent-child closeness	**0.86**	**0.54**
Parental Authority	**0.69**	**0.73**
School Connectedness	**0.94**	0.46
Exposure to Community Violence (none)	**0.86**	**0.66**
Neighborhood Connectedness	**0.94**	**0.69**

*IRP reflect probability of responses falling in the "health-promoting" category
Bold typeface used to emphasize probabilities higher than 0.50.

These findings imply that the individuals who belong to the same latent class, but who are from different subpopulations, do *not* have the same probability of providing any given observed response pattern (Millsap & Kwok, 2004, as cited in Collins & Lanza,

2010, p. 118). Therefore, the latent class prevalences could not be directly compared across the different substance-use groups. Although it's possible that *partial* measurement invariance existed, imposing partial measurement invariance for the purposes of comparing the latent class prevalences in nonusers, experimenters, and regular/risky users would introduce more complexity into the analysis than what was necessary for understanding the patterns of influencing factors for substance use among youth. The structure and prevalence of the latent classes for each of the subpopulations were then qualitatively described and compared for similarities and differences in item response probabilities.

Classification Accuracy and the Maximum Posterior Probability Assignment Rule. After conducting the latent class analysis within the subpopulations of nonusers, experimenters, and regular/risky users, as well as within females and males separately, each case was assigned to a class using the maximum posterior probability assignment rule (Collins & Lanza, 2010). Since the maximum posterior probability does not take into account classification uncertainty, Nagin's (2009) criteria for assessing classification accuracy were used (Table 9) to judge the accuracy of the posterior probabilities within each of the subpopulations. Nagin (2009) suggests that average posterior probabilities for each class greater than 0.70 along with odds of correct classification (OCC) greater than 5.0, small differences between estimated and actual proportions of the sample assigned to each class, and small standard errors of the latent class prevalences indicate adequate classification accuracy. After deeming the classification accuracy acceptable, characteristics of class members were explored using weighted cross-tabulations and 95% Confidence Intervals for the row percent.

Table 13.

Classification accuracy of the Latent Class models for Nonusers, Experimenters, and Regular/Risky ATOD users

	Average PP	OCC	Difference in Estimated vs. Actual Proportion Assigned	Standard Errors of Latent Class Prevalence
Nonusers				
Class 1	0.93	2.34	3%	5.16%
Class 2	0.83	28.71	3%	5.16%
Experimenters				
Class 1	0.86	3.17	4%	4.51%
Class 2	0.82	8.77	4%	4.51%
Regular/Risky Users				
Class 1	0.81	5.68	1%	7.2%
Class 2	0.86	4.62	1%	7.2%

PP = Posterior probability
OCC = Odds of correct classification

Latent Class Analysis with Covariates. For the first two specific aims, the contribution of covariates to predicting class membership was of interest. Analysis of the relationship between the covariates and the likelihood of being in a particular latent class, was performed using a multinomial logistic regression model with the latent variable as the outcome (or dependent) variable and fit to the data for the entire sample (*i.e.*, the overall group, not the substance use subpopulations). Before fitting the model, the categorical covariates (gender, race/ethnicity, SES, and residential location) were dummy coded (dichotomous variables) or vector coded (variables with at least three categories). The participants' age remained as a standardized continuous covariate. Cases with missing data on covariates were automatically excluded from the analysis due to list-wise deletion. Only covariates with <5% missing were included in the analysis to reduce missing values bias. No imputation was performed.

Measurement invariance across all levels of covariates was assessed before including them in the model (Collins & Lanza, 2010). The latent structure was different between females (3 classes) and males (2 classes), but across all other covariates was consistent. Therefore, gender was not included as a covariate in the models, and the latent structure was modeled and interpreted separately for each gender group.

To perform the multinomial logistic regression, the first latent class was designated as the reference category. In LCA with covariates, "the item-response probabilities are still estimated, but not the latent class prevalences. Instead of the latent class prevalences, regression coefficients (beta's) are estimated, and the latent class prevalences can be expressed as function of the regression coefficients and individuals' values on the corresponding covariates" (Collins & Lanza, 2010). Essentially this gives a picture of whether or not each covariate significantly predicts latent class membership, and odds ratios are used to represent the likelihood of being in a latent class depending on the covariate, relative to the reference class.

To test the significance of the covariates, a baseline model with no covariates was fit and compared to a model with the first block of covariates (age) using the likelihood-ratio test (Collins & Lanza, 2010). This procedure was followed by comparing the model with the first block of covariates with a third model that included the second block of covariates (race/ethnicity), controlling for the first block. A third block of covariates (SES) and fourth block (residential location) of covariates were also tested for significant likelihood-ratio test differences, controlling for the previous block effects. The odds and odds ratios relative to the reference class were then interpreted.

Latent Class Analysis with a Distal Outcome

The third aim of the study was to determine the predictive strength of latent class membership during adolescence for substance non-use during adulthood. In other words, the aim was to identify the probability of a distal outcome (*i.e.,* adult substance use behavior) given membership in a latent class during adolescence. The challenge of making this type of estimation is that "the predictor (true subgroup membership) is unknown" (Lanza, Tan, & Bray, 2011). Lanza et al. (2011) recently demonstrated that a model-based approach for estimating this relationship substantially reduces the bias introduced by the inherent classification error that exists with classify-analyze approaches such as the maximum-posterior probability assignment rule and multiple pseudo-class draws. Therefore, this approach, using the LCA Distal SAS macro (Yang et al., 2012) was used to make the estimation. The macro uses Bayes' theorem to calculate the conditional distribution of $f\{Z|C\}$, where Z is a categorical distal outcome and C is the latent class variable (Yang et al., 2012).

Using the 3-class overall model generated in the first latent class analysis, the model was estimated again but this time using the distal outcome variable as a grouping variable (Yang et al., 2012). Measurement invariance (*i.e.,* restricting item-response probabilities for each item-latent class combination to be equal across groups) was a required restriction of this estimation, and was assessed and confirmed across all levels of the distal outcome before imposing the restriction. The metric of the distal outcome was set to reflect its categorical nature, and the estimation resulted in probabilities associated with each level of the distal outcome given membership in each class.

Summary

Preparing data from large, complex survey data sets for secondary analysis requires careful consideration of survey research and design, psychometric measurement theory, and data management procedures. This chapter provided a detailed description of the procedures used to prepare data from the National Longitudinal Study of Adolescent Health for inclusion in a Latent Class Analysis. SPSS v. 20 (IBM, Inc., 2013) was used for initial stages of analyzing, computing scores, missing values analysis, and descriptive statistics. SAS v. 9.3 (SAS Institute, Cary, NC) was used to analyze the data while incorporating sampling weights, and SAS LCA macros from the Penn State Methodology Center (Lanza et al., 2013) were used to conduct the latent class analyses.

Appendix A. Distribution of Indicator Variables

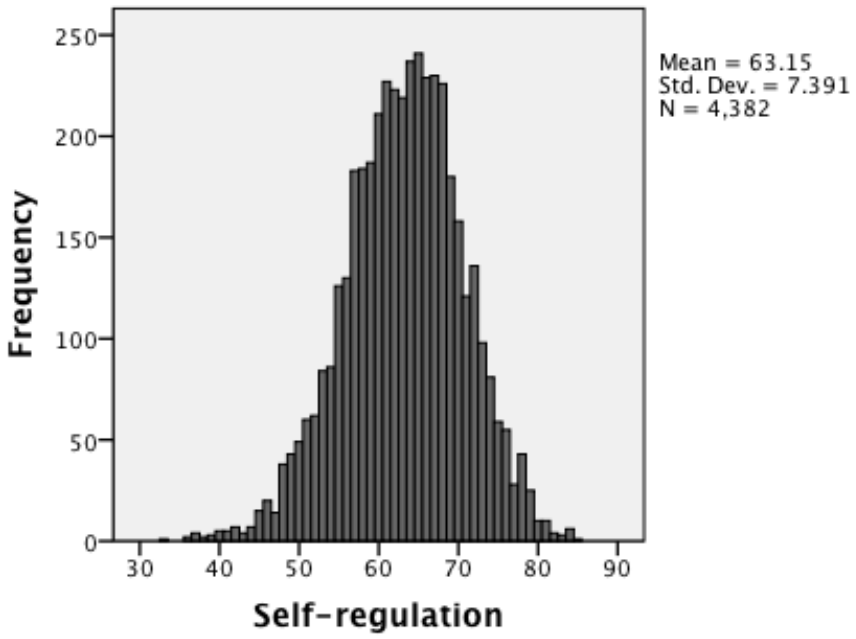

Figure 1. Distribution of self-regulation scores.

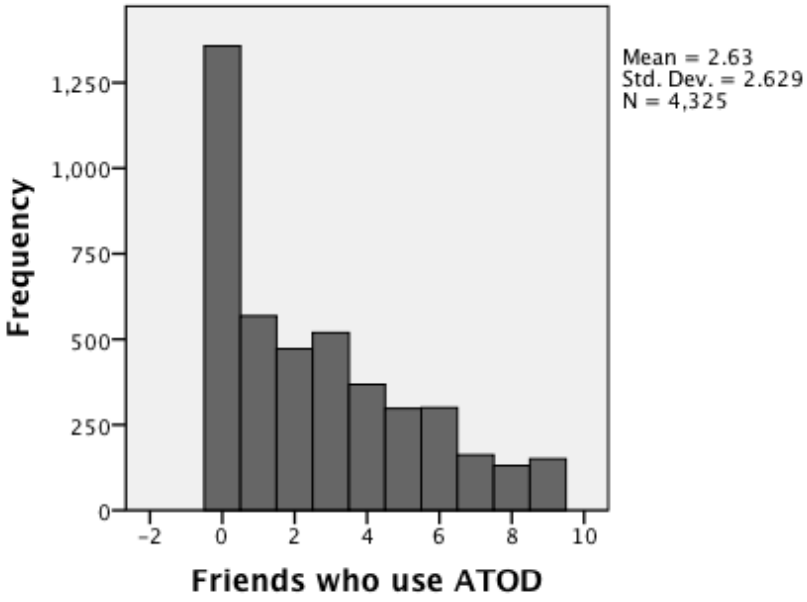

Figure 2. Distribution of indicator for number of close friends who use ATOD.

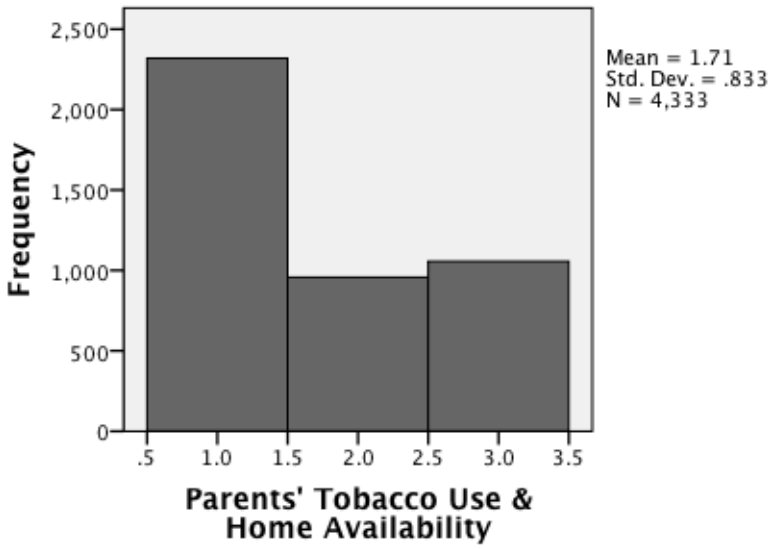

Figure 3. Distribution of indicator for parents' tobacco use and availability of tobacco in the home.

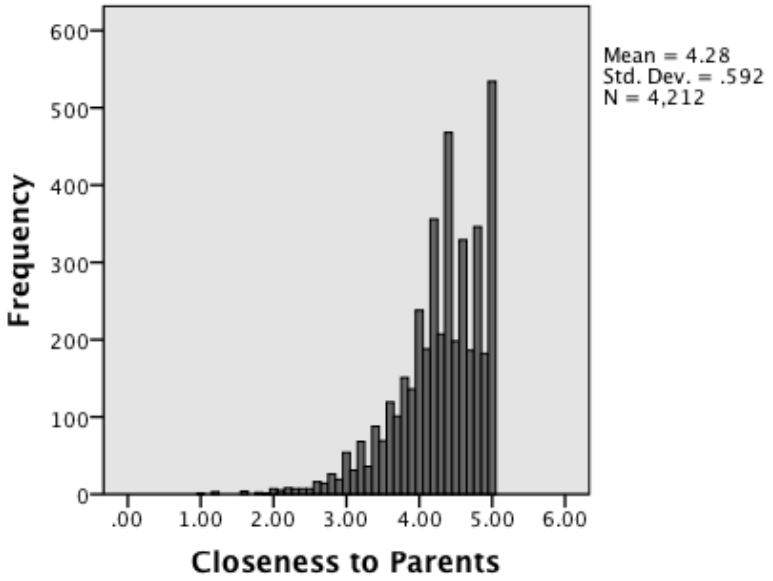

Figure 4. Distribution of closeness to parents score.

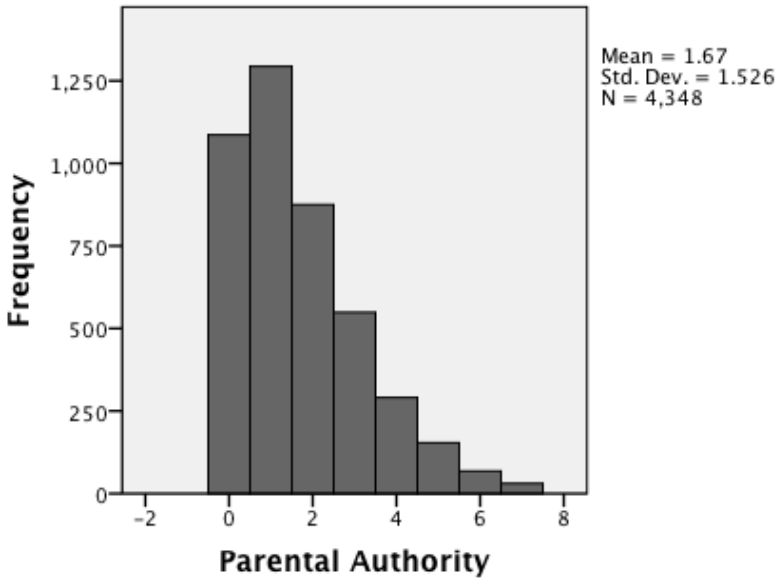

Figure 5. Distribution of parental authority score.

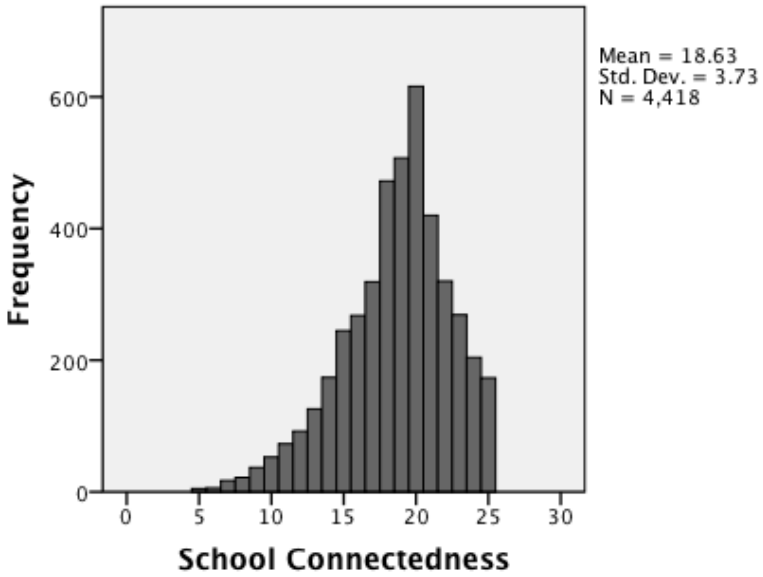

Figure 6. Distribution of school connectedness score.

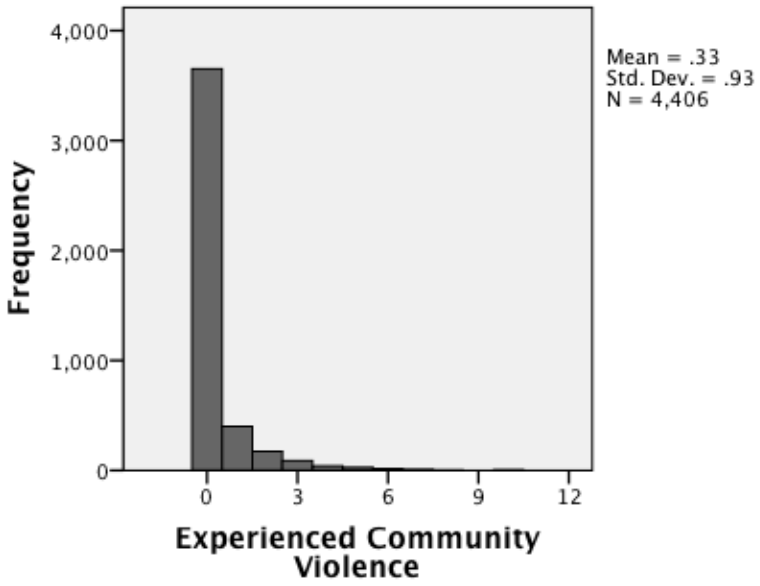

Figure 7. Distribution of indicator for experiencing community violence.

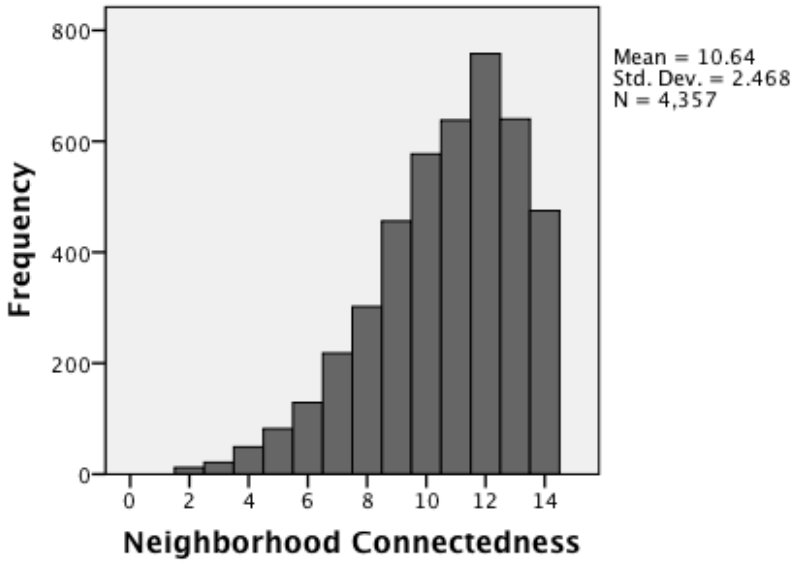

Figure 8. Distribution of neighborhood connectedness score.

CHAPTER 5: Manuscript Two

Patterns of Ecological Influences among Adolescents who

Never Use, Experiment With, or Regularly Use Substances

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Abstract

Universal youth substance use prevention programs may be missing important subgroups of youth and health-promoting factors that lead to more effective tailored interventions. Using data from the National Longitudinal Study of Adolescent Health, the purpose of the study was to identify hidden subgroups (latent classes) of youth differentiated by patterns of ecological influencing factors, and to test whether some patterns are more closely associated with substance nonuse, experimentation, and regular or risky substance use. For the best-fitting three-class solution, self-regulation, peer substance use, and school connectedness had the strongest associations with the latent classes. Relationships among influencing factors were different for nonusers, experimenters, and regular/risky users, as well as for females and males. Nonusers were more likely to have health-promoting influences across all ecological levels. Findings support the existence of hidden subgroups of youth that may benefit from tailored interventions to enhance health-promoting factors across multiple contexts.

Keywords: adolescents, substance nonuse, latent class analysis, ecological influences

Patterns of Ecological Influences among Adolescents who Never Use, Experiment With, or Regularly Use Substances

Despite efforts in schools, families, and communities to curtail the initiation of substance use, youth continue to use alcohol, tobacco, and other illicit drugs (ATOD) at problematic rates (National Institute on Drug Abuse [NIDA], 2011). Substance use during adolescence is a primary source of injury and addiction, and it impairs the processes of healthy development. A small majority of 12th graders (51%) have remained substance-free during the past 30 days (Child Trends, 2012). In addition, recent prevalence rates reveal that the historical decline in substance use among youth since the 1990s has slowed or stalled (NIDA, 2011).

Meta-analyses of prevention programs indicate that their effectiveness is usually short-lived, and many have only moderate effects (Faggiano et al., 2005; Foxcroft & Tsertsvadze, 2011). The most effective programs focus on teaching communication skills, assertiveness, drug resistance, coping with anxiety, decision-making, and the consequences of drug use (Griffin & Botvin, 2010; Mihalic et al., 2008). A current challenge is identifying which risk and protective factors need to be addressed most carefully and in whom (Edberg, 2007).

The positive youth development perspective views adolescence as a time when youth assets can be enhanced by aligning them with contextual resources (Lerner, Lerner, von Eye, et al., 2011), and resilience models are identifying the processes by which youth develop into healthy adults despite the presence of risk (Fergus & Zimmerman, 2005). However, few studies examine the complex interactions of health-promoting and health-negating factors in adolescents' lives (Syvertsen, Cleveland, Gayles, Tibbits, & Faulk,

2010), and the mediating and moderating effects of health-promoting factors occurring at the intraindividual, interpersonal, family, institutional, and community levels of context (Stone, Becker, Huber, Catalano, 2012).

This study draws on Bronfenbrenner's (2000) bioecological model of human development to identify the patterns of health-promoting and health-negating factors that are associated with nonuse of substances. Bronfenbrenner's theory emphasizes that the interactions between people and multiple levels of their context are the basis for human development and behavior and does not separate influencing factors into "risk" or "protective." Instead, each factor exists on its own valence ranging from health-negating to health-promoting. For example, having no friends who use ATOD is health-promoting, while having some friends who use is health-negating.

Previous studies have identified factors associated with youth substance nonuse and use that reflect the multiple levels of context for development. Self-regulation reflects the intra-individual level of context (Belsky & Beaver, 2011; Lerner, Lerner, Bowers, et al., 2011; Wills et al., 2002). Exposure to peer and parental substance use represent the interpersonal level of context (Hawkins, Catalano, & Miller, 1992). Parent-child closeness and parental authority indicate the family level of context (Guo et al., 2011; Peterson et al., 2010; Ryan et al., 2010). School connectedness represents aspects of institutional and community factors (Furlong et al., 2011; Resnick et al., 1997). Exposure to community violence (Taylor & Kliewer, 2006) and neighborhood connectedness (Choi et al., 2006; Mahatmya & Lohman, 2012; Roche et al., 2005; Tucker et al., 2013) reflect community-level influencing factors.

Because tailored and adaptive interventions may provide a stronger effect on positive health outcomes than interventions that focus on only one level of ecology or that use a universal approach (Collins et al., 2004), identifying hidden subgroups characterized by shared patterns of health-promoting and health-negating factors can help interventionists consider what variables should be used as tailoring variables and which subgroups could be targeted with special interventions. Using Bronfenbrenner's bioecological model of human development as a framework, the major purpose of the study was to identify latent classes of youth that reflect the complex interactions of health-promoting and health-negating ecological influencing factors, including self-regulation, exposure to peer and parental substance use, parent-child relationship, school connectedness, community violence, and neighborhood connectedness. Additional aims included testing the moderating effects of substance nonuse, experimentation, and regular or risky substance use on the interactions among the factors and describing the characteristics of latent class members according to demographic characteristics.

Methods

Design

To accomplish the aims of the study, a correlational, probabilistic design was used with an archival dataset of a nationally representative sample of adolescents. Because of the desire to reflect all of the interactions among the ecological factors, Latent Class Analysis (LCA) was used. LCA is a person-oriented analytic method that posits a categorical latent variable explaining the interactive relationships among multiple nominal or ordinal characteristics and that differentiates hidden subgroups of a population (Collins & Lanza, 2010).

Data source

Public-use data from the Add Health study were used for this study (Harris & Udry, 2013). Initiated in 1994 with four waves of data collection, Add Health used survey and biometric measures to assess factors related to health behavior among adolescents. A stratified cluster sampling design with constructed sampling weights allowed researchers to approximate a nationally representative sample (Harris, 2011). The current analysis utilized data from participants who completed the in-home adolescent interview at Wave 1 and 2, were ages 12-19 at Wave 2, and were in school (*i.e.,* not expelled or unable to attend school) at Wave 2 (unweighted N=4,431). Requirements of a multiple-group LCA model dictated the exclusion of 233 cases due to missing values on the substance-use variable, resulting in an analytic sample size of 4,198. Those excluded due to missing the substance-use variable were more likely to be in the *health-promoting* category of self-regulation (32.46%, 95%CL 25.78, 39.14) than those with complete data (21.81%, 95%CL 20.16,23.48). In addition, they were more likely to have *no* friends who use ATOD (52.28%, 95%CL 44.46,60.10) than those with complete data (29.85%, 95%CL 27.33,32.37). Descriptive statistics are summarized in Table 1.

Measures

Indicator variables representing each level of context were selected based on their known associations with adolescent substance use and availability in the Add Health study (Harris & Udry, 2013). All survey items used in the analysis came from the Adolescent In-Home Interview Questionnaires.

Self-regulation. The measure consisted of the sum of 20 items asked at Wave 2 (Beaver, Ferguson, & Lynn-Whaley, 2010). The items tap self-regulation experiences such as having trouble keeping their mind focused, liking to take risks, and sensitivity to other people's feelings, with response options on a 4- or 5-point likert-type scale (0=Never/rarely and 1,2, etc. reflect progressively higher frequency of the experience) (Cronbach's alpha for this study = 0.73).

Peer substance use behavior. The current study used the sum of responses to three items (response options: 0,1,2, or 3) assessing the respondent's perception of friends' smoking behavior, alcohol use, and marijuana use (*e.g.*, Of your 3 best friends, how many smoke at least 1 cigarette a day?) (Cronbach's alpha for this study = 0.74).

Tobacco exposure at home: Parents' smoking behavior and access to tobacco at home. First, an item reflecting whether either resident parent had ever smoked since the Wave 1 interview was created using two separate items (*i.e.,* one for each resident parent) so that 1 = at least one resident parent smoked, and 0 = no resident parent smoked. The tobacco exposure at home variable was the sum of the parent-smoking dichotomous item and the response to another dichotomous question "Are cigarettes easily available to you in your home?" (For this study, KR-20 = 0.71).

Parent-child closeness. The average of five items (assessing how close, how much care, warmth and loving, talks about wrong behaviors, and satisfaction with communication) pertaining to the resident mother was the *mother-closeness* score (Gault-Sherman, 2012). Items were reverse coded as needed so that higher scores reflected greater parent-child closeness. A *father-closeness* score was the average of responses to the paternal items. Finally, if both averages were present, they were summed and

averaged for a *parent-child* closeness score (Cronbach's alpha for this study = 0.86). Where only the mother or paternal average score was present, then the *parent-child* closeness score took the value of the available parent (either mother or father) closeness score.

Parental authority. The sum of seven dichotomous items pertaining to respondents' perceptions of whether the parent(s) allow him/her to make independent decisions about daily activities (*e.g.,* weekend curfew, the people he/she hangs around with, what he/she wears) comprised the parental authority score (Gault-Sherman, 2012). Items were reverse coded so that higher scores indicated more parental authority (for this study, KR-20 = 0.63).

School connectedness. This indicator was computed by summing five items reflecting sense of closeness to people at school, happiness about being at the school, feeling a part of the school, that teachers treat students fairly, and feeling safe at school (Furlong, O'brennan, & You, 2011). Participants rated each statement using a 5-point scale (1 = strongly disagree, 5 = strongly agree). Higher values indicated stronger connection to school (Cronbach's alpha for this study = 0.78).

Exposure to community violence. This item was the sum of five items inquiring whether the participant had experienced the following events during the past year: "You saw someone shoot or stab another person, Someone pulled a gun on you, Someone pulled a knife on you, Someone shot you, and Someone stabbed you" (Hagan & Foster, 2001). Responses could be *never* (1), *once* (2), or *more than once* (3). Higher scores indicated a higher exposure to violence (Polychoric ordinal reliability alpha for this study = 0.90).

Neighborhood connectedness. The sum of six items reflected the youths' perceptions of safety in their neighborhood, as well as their sense of connection to neighbors and satisfaction with living in the neighborhood. Four items had dichotomous response options (True/False, yes/no), while two items were on a 5-point likert scale. (Chronbach's alpha using standardized items for this study = 0.64).

Categorizing the Indicator Variables. Since LCA detects homogeneous subgroups based on similarities of response patterns to categorical variables, it was necessary to convert each continuous indicator variable to a categorical variable representing a discrete level of presence in the individual participants (Collins & Lanza, 2010; Syvertsen et al., 2010). Examination of the distribution of variables (Appendix A), as well as the approach used in a previous study (Syvertsen et al., 2010), provided the basis for categorizing the continuous items. Four variables that approximated a normal distribution most closely were dichotomized at the 25th percentile: self-regulation, closeness to parents, school connectedness, and neighborhood connectedness. Those at or below the 25th percentile were considered to be experiencing "health-negating" levels of an influence, while those above the 25th percentile are reporting "health-promoting" levels. The four other indicators, friends' ATOD use, tobacco exposure at home, parental authority, and exposure to community violence, were dichotomized at the difference between "none" and "at least some" because of severely skewed distributions. Table 2 depicts the frequencies and percent of the dichotomized indicators.

Assessment of overall relationships among the indicator items determined if any could be partially redundant of the latent variable (Collins & Lanza, 2010). Cross-tabulations and Cramer's V analysis revealed some significant bivariate associations

(p<0.001), but none of the associations was greater than 0.30. The assumption of local independence, *i.e.,* the assumption that once the latent variable is taken into account, the indicators are independent (Vermunt & Magidson, n.d.), was not rigorously tested, but implicitly assessed by comparing model fit criteria to select an adequate number of classes (Dziak, 2013).

Subpopulation grouping variable: Substance nonuse, experimentation, and regular/risky use. A categorical variable reflected whether the participant had remained a *nonuser* of ATOD, had *experimented* with ATOD, or had participated in *regular* or *risky* ATOD use (*i.e.,* regular cigarette smoking, binge drinking, and multiple substance use). A tripartite schema was chosen for its ability to capture a greater spectrum of substance use compared to the traditional dichotomy of substance nonuse vs. use (McCusker et al., 1995; Nonnemaker et al., 2003). The construction of this variable included items from the Wave 1 and Wave 2 interviews. If adolescents reported no use of alcohol, tobacco, marijuana, chewing tobacco, cocaine, inhalants, and other drugs at both Wave 1 and Wave 2, they were coded as *nonusers*. *Experimenters* were those who reported having tried or used alcohol, tobacco, marijuana, chewing tobacco, cocaine, inhalants, and other drugs during Wave 1 or Wave 2, but who reported (a) *no use* during the past 30 days during Wave 2, (b) *no regular smoking* at Wave 2 (defined as smoking "at least one cigarette every day for 30 days"), and (c) *alcohol use no more than once a month* at Wave 2. This category may have included those who were regular or risky users during Wave 1, but who had quit this type of use within 30 days before the Wave 2 interview. Finally, *regular/risky* substance users included those who responded positively at Wave 2 to any substance-use items reporting use during the past 30 days

(except only cigarette triers), or if they indicated they smoked regularly, or that they used alcohol more than once a month.

Covariates. Age (standardized), sex, race/ethnicity (coded: White, non-Hispanic (1), African American, non-Hispanic (2), and Other Minority (3)), family socioeconomic status (SES), residential location (rural, suburban, and urban) and neighborhood socioeconomic status were included as covariates. Since many of the common indicators for family SES had more than 20% missing, a variable reflecting whether the resident parent(s) receives public assistance was a proxy measure. A single block-level variable was used to reflect neighborhood SES by the proportion of the block group that live under poverty (Harris, 2011). An item completed by the Add Health trained interviewer assessing the dominant land-use of the surrounding area indicated residential location. The item was recoded to collapse three of the options ("3 or more commercial properties/mostly retail" and "3 or more commercial properties/mostly wholesale/industrial" and "other") into the "urban" category.

Data analysis plan

Model specification and selection. Procedures described in Collins and Lanza (2010) and Lanza et al. (2013) were followed to specify and select the overall latent class model using PROC LCA for SAS v.9.3 (SAS Institute, Cary NC). The first step was a comparison of a series of latent class models with varying numbers of classes (Table 2). All models included sampling weights and the school cluster variable to account for sampling design effects (Lanza et al., 2013). Each indicator included in the latent class model had some missing data (Table 2); however, none were missing >5% and a missing values analysis supported the interpretation that missing values were at random (Little &

Rubin, 2002). Full information maximum-likelihood estimation (FIML) was implemented within the latent class model procedures to adjust for the missing responses (Collins & Lanza, 2010).

Model identification was assessed by checking the modal G^2 (likelihood ratio statistic) of models with different numbers of classes and generated from 100 different sets of random starting values (*i.e.,* seeds). Models with one-, two-, and three-classes had from 99% to 100% of the random seeds associated with the best-fitted model. A model with four classes had 53% of the random seeds associated with the best-fitted model. A model with 5-classes had only 19% of random seeds associated with the modal G^2. Comparisons of the G^2 likelihood ratio test statistic, Akaike's Information Criterion (AIC; Akaike, 1974), the Bayesian Information Criterion (BIC; Schwarz, 1978), and interpretability of results between the different class solutions helped to determine that the three-class model was the most optimal. Of the models with 100% of random seeds associated with the best fitting model, the three-class solution had the lowest G^2, AIC and BIC, and was selected based on the principle of parsimony over the four-class solution. The item response probabilities (IRP) showed that the indicators had a modest relationship to the latent variable (*i.e.*, the strength of the IRP did not vary widely across classes, nor did they reach values near .9 or .1 very often). However, the latent class homogeneity and separation was adequate for assigning meaningful descriptions to the latent classes (Collins & Lanza, 2010).

Analyses including the covariates resulted in list-wise deletion of cases missing on covariates (Collins & Lanza, 2010). Total sample size reduction due to list-wise deletion (n = 207) during the covariates analysis was less than 5%, rendering minimal

confounding effects (Little & Rubin, 2002). A hierarchical multinomial logistic regression was conducted with the latent variable as the dependent variable for covariates meeting the assumption of measurement invariance. Covariates were entered in blocks, with more proximal, non-modifiable demographics entered first, followed by progressively more ecologically distal factors (1:age, 2:race/ethnicity, 3:family SES, 4:residential location, 5:neighborhood SES). The output included odds ratios with 95% confidence intervals to interpret the regression coefficients.

Collins and Lanza (2010) recommend assessing measurement invariance across all levels of covariates and grouping variables before proceeding with multiple-group LCA and LCA with covariates. This procedure revealed that measurement invariance did not hold across gender and the substance-use grouping variable. Therefore, the latent class model was specified and interpreted separately in each of these subpopulations (Collins & Lanza, 2010). Nagin's (2009) classification accuracy criteria were used to decide that assigning and describing class members using the maximum-posterior probability assignment rule would be appropriate for the models in the gender and substance-use subpopulations.

Results

The pattern of item-response probabilities (IRP) for each class (Table 3) was the basis for labeling and characterizing the three classes identified in the overall best-fitting model. The label for the first class, with a prevalence of 53%, was "Health-promoting Influences." The label for the second class (29% prevalence) was "Low self-regulators with Mixed Influences." The third class (18% prevalence) was labeled "Friends Use ATOD, Parents Smoke, and Possible Violence Exposure."

When covariates were included in the model, age, family SES, and neighborhood SES significantly predicted class membership relative to the "Health-promoting Influences" class (p <0.01) (Table 5). As age increased by one standard deviation, and after controlling for all other covariates, the likelihood of being in the "Low Self-regulators with Mixed Influences" class increased 8.47-fold, and being in the "Friends Use ATOD, Parents Smoke, and Possible Violence Exposure" class increased 1.75-fold. A participant reporting low family SES was associated with a 2.24 times greater likelihood of being in the "Friends Use ATOD, Parents Smoke, and Possible Violence Exposure" class, relative to the "Health-promoting Influences" class. Finally, after controlling for all other covariates, living in a neighborhood with a high proportion of families under poverty was associated with a very small increase in the odds of being in class three relative to class one.

The latent class models fit separately for each of the subpopulations of nonusers, experimenters, and regular/risky users, revealed that a two-class model fit each group best. Table 6 shows the labels and IRPs for each class within the subpopulations. Exploring the cross-tabulations (adjusted for sampling design) between latent class membership and the demographic characteristics showed that there was no significant variation in the covariates between the two classes of nonusers and between the two classes of experimenters. However, for the regular/risky users, there was a significantly larger percent of females (48.56, 95%CI 44.17, 52.96) in the low self-regulators class than in the health-promoting influences with friends who use ATOD class (39.22, 95%CI 34.87, 43.56).

The latent class structure was also assessed within the subpopulations of females (n=2,205) and males (n=1,993) separately. These models did not include the substance use status of participants. Females fit a two-class model the best, with one class (59%) characterized by overall health-promoting influences, and the other class (41%) characterized by low self-regulation, low school connectedness, and greater probability of exposure to violence. Males fit a three-class model the best, with the largest class (55%) characterized by high self-regulation, and otherwise positive influences; the second largest class (26%) characterized by risky friends and parents who smoke with otherwise moderate probabilities of health-promoting influences; and the smallest class (19%) was characterized by low self-regulation and a high probability of health-promoting parental authority.

Discussion

The overarching purpose of the study was to identify latent classes of adolescents according to unique patterns of ecological influencing factors, and to assess whether this structure related to substance nonuse, experimentation, regular/risky substance use, and other demographic covariates. The overall latent class model explained the relationships among ecological influencing factors for three hidden subgroups, strongly differentiated by a few factors (self-regulation, friends' ATOD use, and school connectedness). Among the nonusers, experimenters, and regular/risky substance users, the hidden subgroups were different from the overall model, indicating that the patterns of health-promoting and health-negating influences are not the same for all youth, especially in relation to their substance nonuse, experimentation, or use. Modeling the multilevel influencing factors together represented the complex bidirectional relationships that exist between the

factors among individual adolescents (Magnusson, 2003). Few studies have approached the relationships among multilevel factors in this way (Lanza, Rhoades, Nix, & Greenberg, 2010; Syvertsen et al., 2010).

The models revealed variables that might be useful to tailor health-promotion efforts among youth, and revealed potential target subgroups. The overall model class "Health-promoting Influences" included slightly more than half the population. These youth experienced many health-promoting influences yet had slightly less than a 50% probability of having close friends who do not use ATOD. While this group appears to be fairly protected, and perhaps not needing much outside support, they might benefit from focusing on choices surrounding friendships and substance use (Pollard et al., 2010), as well as encouraging their overall constellation of health-promoting factors. The next largest group in the overall model (29%) was characterized by low self-regulation, high probabilities of health-promoting parental authority, and moderate probabilities of other influences. Although self-regulation is likely a combination of state and trait features of individuals, health-promotion programs that specifically address the modifiable aspects offfff self-regulation for those who are low self-regulators might increase the overall effectiveness of the program (Baumeister, Gailliot, DeWall, & Oaten, 2006). The overall model smallest group (19%) was particularly likely to be exposed to friends' ATOD use and tobacco at home, and of all the classes had the largest probability of having witnessed or experienced a violent act. Interestingly, this group also had a high probability of health-promoting neighborhood connectedness. This may indicate that the neighborhood culture for these youth is one in which substance use among adolescents

and adults is normative and where violence may be more common, but neighborhood cohesion is a way of coping with adversity.

When the model included covariates, the effect of age was somewhat counter-intuitive. An increase in age was associated with a much greater likelihood of being in the class of low self-regulators and mixed influences. While younger age is typically associated with less self-regulation (Gestsdottir, Urban, Bowers, Lerner, & Lerner, 2011), this finding indicates that low self-regulation at an older age is strongly associated with membership in this class and this association can be used to further differentiate youth who need attention to their self-regulation skills. In this class, the low likelihood of having a close relationship with the parent(s) and the high likelihood of having parents who set rules may be describing the home environment of youth who are struggling with self-regulation as they age. Those in the "Low self-regulation with Mixed Influences" class might benefit from programs that specifically address self-regulation and the parent-child relationship as youth move towards greater autonomy.

Low family SES and neighborhood SES were associated with membership in class three, "Friends Use ATOD, Parent(s) Smoke, and Possible Violence Exposure." This was not entirely surprising due to known associations between poverty, substance use and community violence (Cooley-Strickland et al., 2009; Goodman & Huang, 2002). One could argue that for this group, while peer and parent substance use is a concern, the likelihood of these influences changing is low without addressing the associated poverty. An important direction for this group is to use the existing neighborhood connectedness, which had a high probability of being at health-promoting levels, to engage the larger community in addressing substance use and violence.

Lack of measurement invariance between the pre-defined subpopulations of substance nonusers, experimenters, and regular users prompted modeling the latent classes separately for each of these groups. This modeled the moderating effects of being a substance nonuser, experimenter, or regular/risky user on the relationships among all the indicators (Collins & Lanza, 2010). The nonusers had two classes with overall strong probabilities of having health-promoting influences. Although this does not imply that the conglomeration of health-promoting influences *causes* nonuse, when compared to the classes within experimenters and regular/risky users, it appears that having health-promoting factors across multiple levels has a beneficial synergy with the adolescents' choice to abstain from substance use. This supports the need to continue developing health-promotion programs that work across all levels of youth's biopsychosocial ecology (McLeroy, Bibeau, Steckler, & Glanz, 1988). For example, low probabilities of school connectedness with high probabilities of parental authority and other ecological factors characterized one of the nonuser classes. For this group, if school resources are particularly lacking, encouraging positive family interactions and parental authority while working to improve the school environment might foster resilience. Healthcare providers and psychosocial practitioners working with children where school resources are limited may consider parenting and adolescent development classes to help support children in remaining substance-free.

Some of the overlap in class characteristics across the subpopulations points to interesting comparisons between the class' prevalence. For example, the trend across nonusers, experimenters, and regular/risky users is that the prevalence of the class with mostly health-promoting influences but with friends who use ATOD (class one)

diminishes in size from 85%, to 66%, to 43%. Although it cannot be determined whether this is a statistically significant finding, it supports the known positive association between friends' ATOD use and personal ATOD use (Pollard et al., 2010). Trends also point to diminishing probabilities of having health-promoting ecological factors within the family, school, and neighborhood system when comparing nonusers, experimenters, and regular/risky users. This might reflect that youth who experiment with or regularly use ATOD fall into a cycle of antisocial interactions with their environment, and breaking this cycle needs priority in order to prevent substance abuse and addiction. Finally, gender and latent class membership were significantly dependent within the regular/risky users, where females were a larger proportion of the low self-regulators class than males. Females who struggle with low self-regulation likely need a tailored intervention to promote a substance-free lifestyle. Individual counseling sessions and assistance with developing self-regulation skills should be emphasized.

Limitations

While this study contributed interesting new knowledge about the relationships among multilevel influences in youths' lives, some limitations affect potential conclusions. First, the study was largely exploratory because it was unknown, *a priori,* which of the influencing factors would most strongly indicate the latent classes. The exploratory nature means that the findings may be more dependent on sample characteristics. The fact that measurement invariance did not hold across gender and substance use subpopulations exemplifies this fact. Future work should replicate the findings in other samples, and should carefully consider the effects of gender and substance nonuse and use.

Second, the moderating effects of substance nonuse and use, and gender, and the predictive effects of other covariates should not be interpreted as causal. The goal of the study was to identify the latent classes and determine if there were significant associations between the latent structure and various moderators and covariates. Future work assessing transitions in membership between classes could help reveal the ecological precursors to behavior change.

Third, almost all of the indicators in their original form were continuous yet highly skewed, and were converted to categorical variables using somewhat arbitrary cut-points. Although results did not appear to be sensitive to different cut-points (25^{th} vs. 50^{th} percentile), and the 25^{th} percentile was chosen in order to be consistent with another study (Syvertsen et al., 2010), other techniques such as using the Receiver Operating Curve (ROC) could have provided a statistically-based justification (Lanza et al., 2010) for cut-points.

Fourth, with covariates in the subpopulation analyses the latent class models became particularly complex and unstable. Even with the inclusion of a beta prior, and increasing the maximum number of iterations, the models would not converge. Therefore, the maximum posterior probability assignment rule was used to explore demographic characteristics associated with these classes. Inherent to this technique is the confounding effects of misclassification, and interpretation should be made with caution.

Finally, the influencing factors included in the model were not exhaustive of all the known "risk and protective factors" for substance use (Hawkins et al., 1992). It is

possible that other factors would have stronger relationships to the latent class structure. Future studies should work to identify the strongest indicators.

Implications for Practice and Future Research

Results imply that the interaction of multilevel factors promotes healthy behavior more than individual factors alone. Yet, there are also resilient youth who, despite the presence of health-negating factors such as low school and neighborhood connectedness, engage in abstinence from substance use, likely related to the presence of positive intrapersonal and interpersonal influences. The findings from this study inform the efforts of adults who work with youth, to consider ways in which the youth are heterogeneous in their patterns of multilevel influencing factors. Those individuals practicing and working with community and school health programs and policy related to youth should address all levels of the ecological context in order to provide the best health promotion for youth.

Since there were no tests of temporal associations in this study, future research should examine whether certain factors predict a transition from one class to another over time (Latent Transition Analysis). Additionally, identifying the associations between adolescent latent class membership and more distal outcomes such as health behavior during adulthood would reveal the predictive validity of latent classes.

Time and financial support are limited resources, and reducing costs and delivery time while increasing effectiveness is a high priority in all areas of health promotion and disease prevention. Using person-oriented approaches to study the layered relationships between multiple influencing factors offers a complementary perspective to the more traditional variable oriented studies (Magnusson, 2003), and should be used more often in

understanding actual school or community populations. Variables that differentiate latent classes could be tested as tailoring variables in adaptive prevention programs (Collins et al., 2004), or latent classes could point to target subpopulations in selective health-promotion programs (Glanz, Rimer, & Viswanath, 2008). While universal substance abuse prevention programs have shown some benefit to youth (Griffin & Botvin, 2010), more work needs to be done to improve the strength of the effects.

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Table 1.

Demographic Characteristics of the Sample by Predefined Substance Use Groups (Means and Percentages adjusted for sampling design, 95% Confidence Interval)

	Overall	Nonusers	Experimenters	Regular/Risky Users
Age (*m*)	15.77(15.57,15.97)	15.31(15.08,15.53)$_a$	15.74(15.53,15.94)	16.08(15.87,16.29)$_b$
Sex (female) (%)	49.83(47.95,51.70)	54.13(50.44,57.82)$_a$	52.57(49.51,55.63)$_a$	44.53(41.47,47.59)$_b$
Race/ethnicity (%)				
Caucasian	69.57(63.97,75.17)	65.47(57.89,73.04)	65.07(58.86,71.28)$_a$	76.46(71.67,81.26)$_b$
AfricanAmerican	13.73(9.75,17.72)	17.33(11.49,23.18)	15.62(11.31,19.94)	9.71(6.27,13.15)
Other	16.70(12.66,20.73)	17.20(12.04,22.37)	19.31(14.37,24.24)	13.82(10.32,17.33)
Low Family SES* (%)	7.75(6.26,9.24)	7.27(5.03,9.51)	7.59(5.79,9.39)	8.20(6.29,10.12)
Residential location (%)				
Rural	26.11(21.22,30.99)	25.54(20.24,30.85)	27.34(21.78,32.91)	25.22(20.07,30.37)
Suburban	41.69(35.91,47.47)	38.82(32.92,44.72)	39.73(33.75,45.70)	45.37(38.46,52.28)
Urban	32.20(26.64,37.77)	35.64(29.14,42.14)	32.93(26.60,39.26)	29.41(23.66,35.15)
Neighborhood SES (%)				
Low PP	57.76(51.28,64.25)	57.32(50.40,64.23)	55.65(49.08,62.22)	60.12(52.38,67.86)
Medium PP	23.47(19.63,27.32)	20.82(16.69,24.94)	24.55(20.61,28.48)	24.01(18.95,29.07)
High PP	18.76(14.22,23.30)	21.86(15.86,27.87)	19.81(14.84,24.78)	15.87(11.22,20.53)

*Percent of participants reporting parent receives public assistance.
PP = Proportion of block group households under poverty.
Subscripts (a,b,c) used to highlight significant differences in proportions, $p<0.05$.

Table 2.

Distribution of Dichotomized Indicators (unweighted frequency, %)

(*N*=4,431)	Frequency	Percent
Self-regulation		
Health-negating*	1134	25.6
Health-promoting*	3248	73.3
Missing	49	1.1
Close Friends' ATOD use		
Friends do not use	1357	30.6
Some friends use	2968	67.0
Missing	106	2.4
Parents' Tobacco Use & Home Availability		
Health-negating	2013	45.4
Neither parent smokes nor home availability	2320	52.4
Missing	98	2.2
Parent-Child Closeness		
Health-negating	980	22.1
Health-promoting	3232	72.9
Missing	219	4.9
Parental Authority		
Health-negating	1086	24.5
Health-promoting	3262	73.6
Missing	83	1.9
School Connectedness		
Health-negating	1118	25.2
Health-promoting	3300	74.5
Missing	13	0.3
Exposure to Community Violence		
None	3653	82.4
At least once	753	17.0
Missing	25	0.6
Neighborhood Connectedness		
Health-negating	813	18.3
Health-promoting	3544	80.0
Missing	74	1.7

*Health-negating defined as levels of the factor which likely contribute to poor health outcomes; Health-promoting defined as levels of the factor which likely contribute to positive health outcomes

Table 3.

Summary of Fit Information for Selecting Number of Latent Classes (n = 4,198)

Number of Latent Classes	Number of Parameters Estimated	G^2*	*df*	AIC	BIC	Log-likelihood	Percentage of Seeds associated with best fitted model
1	8	1518.56	247	1534.56	1585.30	-18531.83	100%
2	17	445.31	238	479.31	587.13	-17995.20	99%
3	26	338.74	229	390.74	555.64	-17941.91	100%
4	35	297.75	220	367.75	589.73	-17921.42	53%
5	44	266.56	211	354.56	633.62	-17905.82	19%

**p*-values not reported due to large *df*

Note: Fit indices based on the pseudo-likelihood incorporating weights.

Table 4.

*Latent class (LC) Prevalence and Conditional Item-Response Probabilities (IRP)**

	Class 1	Class 2	Class 3
Class Description	Health-promoting influences	Low Self-regulators, Mixed influences	Friends Use ATOD, Parents Smoke, Possible Violence Exposure
LC membership probability	0.53	0.29	0.18
Item-response probabilities			
Self-regulation	**0.92**	0.37	**0.76**
Friends' ATOD use (none)	0.46	0.19	0.00
Parent Smokes & Home Access to tobacco (neither)	**0.63**	0.45	0.32
Parent-child closeness	**0.88**	**0.53**	**0.78**
Parental Authority	**0.78**	**0.79**	**0.66**
School Connectedness	**0.92**	0.40	**0.79**
Exposure to Community Violence (none)	**0.95**	**0.73**	**0.61**
Neighborhood Connectedness	**0.90**	**0.61**	**0.91**

*IRP reflect probability of responses falling in the "health-promoting" category
Bold used to emphasize probabilities greater than 0.50

Table 5.

Age, Race/Ethnicity, Family SES, Residential Location, and Neighborhood SES as Predictors of LC Membership

	Reference Class	Block 1		Block 2		Block 3		Block 4		Block 5	
Latent Class	1	2	3	2	3	2	3	2	3	2	3
Intercept	ref										
β_0's		-0.94	-0.14	-0.88	-0.19	-0.94	-0.21	-0.97	0.05	-0.72	-0.03
Odds		0.39	0.87	0.42	0.83	0.39	0.81	0.38	1.05	0.49	0.97
Block 1: Age (standardized)	ref										
β_1		2.03	0.62	2.04	0.59	2.12	0.59	2.08	0.60	2.14	0.56
Odds ratio		7.64**	1.86**	7.70**	1.80**	8.33**	1.81**	8.01**	1.81**	8.47**	1.75**
Block 2: Race/Ethnicity (cf. Caucasian)	ref										
African American β_2				-0.70	0.12	-0.60	0.09	-0.51	0.02	-0.17	-0.04
Odds ratio				0.50	1.13	0.55	1.09	0.60	1.02	0.85	0.96
Other race/ethnicity β_3				-0.70	0.24	-0.82	0.17	-0.92	0.07	-0.75	0.06
Odds ratio				0.50	1.28	0.44	1.19	0.40	1.07	0.47	1.06
Block 3: Family SES	ref										
β_4						0.69	0.84	0.78	0.85	0.82	0.81
Odds ratio						1.99	2.31**	2.18	2.35**	2.27	2.24**
Block 4: Residential Location (cf. Urban)	ref										
Rural β_5								-0.35	-0.50	-0.39	-0.48
Odds ratio								0.70	0.61	0.71	0.62
Suburban β_6								0.23	-0.24	0.07	-0.22
Odds ratio								1.26	0.78	1.07	0.80
Block 5: Neighborhood SES (cf. Low PP)	ref										
Medium PP β_7										-0.41	0.20
Odds ratio										0.67	1.23
High PP β_8										-1.11	0.17
Odds ratio										0.33	1.18*

Note. Cases with missing data on covariates were automatically excluded from the analysis. Total sample size loss due to missing on covariates did not exceed 5% overall. $N = 3{,}991$ for model with all covariates.

Latent class 1: Health-promoting influences; Class 2: Low Self-regulators, Mixed influences; Class 3: Friends Use ATOD, Parents Smoke, Possible Violence Exposure

PP = Proportion under poverty

**$p < 0.001$; *$p < 0.01$

Table 6.

2-class Structure of Influencing Factors in Subpopulations of Adolescents

Nonusers *(n=1,025)*	Class 1	Class 2
Class Description	All Health-Promoting Influences	Mixed Influences with Health-negating School Connectedness
Class Prevalence	0.85	0.15
*Item Response Probabilities (IRP)**		
Self-regulation	**0.94**	**0.57**
Peers ATOD use (none)	**0.69**	**0.54**
Parent Smokes & Easy Home Access (neither)	**0.67**	**0.55**
Parent-child closeness	**0.89**	**0.67**
Parental Authority	**0.81**	**0.85**
School Connectedness	**0.94**	0.27
Exposure to Community Violence (none)	**0.94**	**0.87**
Neighborhood Connectedness	**0.90**	**0.57**

Experimenters *(n=1,616)*	Class 1	Class 2
Class Description	Health-promoting Influences with Friends who use ATOD	Low self-regulators, low school connectedness
Class Prevalence	0.66	0.34
*Item Response Probabilities (IRP)**		
Self-regulation	**0.92**	0.47
Peers ATOD use (none)	0.32	0.31
Parent Smokes & Easy Home Access (neither)	**0.58**	0.46
Parent-child closeness	**0.88**	**0.60**
Parental Authority	**0.74**	**0.81**
School Connectedness	**0.93**	0.47
Exposure to Community Violence (none)	**0.89**	**0.74**
Neighborhood Connectedness	**0.91**	**0.63**

Regular/Risky Users (n=1,557)	Class 1	Class 2
Class Description	Health-promoting influences with Friends Who Use ATOD	Low Self-regulators, low school connectedness, possible violence exposure
Class Prevalence	0.43	0.57
*Item Response Probabilities (IRP)**		
Self-regulation	**0.88**	0.40
Peers ATOD use (none)	0.08	0.04
Parent Smokes & Easy Home Access (neither)	0.48	0.39
Parent-child closeness	**0.86**	**0.54**
Parental Authority	**0.69**	**0.73**
School Connectedness	**0.94**	0.46
Exposure to Community Violence (none)	**0.86**	**0.66**
Neighborhood Connectedness	**0.94**	**0.69**

*IRP reflect probability of responses falling in the "health-promoting" category

Chapter 6: Manuscript Three

Ecological Influencing Factors During Adolescence

and the Probability of Adult Substance Use Behavior

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(Prepared for submission to American Journal of Public Health, Research Brief format: Preliminary or novel findings may be reported as briefs, up to 800 words in the main text, an unstructured abstract of up to 80 words, and up to 2 tables/figures. The main text of briefs must follow the standard AJPH research and practice format including AMA citations, with an introduction and separate sections for the Methods, Results, and Discussion.)

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Abstract

The ecology of biopsychosocial development influences long-term health behavior. The purpose of the study was to assess the probability of adult substance nonuse, moderate use, and regular/risky use, given constellations of multilevel factors present during adolescence. Using Add Health data (N=3,594) and latent class analysis, results revealed that adults with health-promoting factors across all ecological levels during adolescence were more than seven times as likely to be nonusers as compared to adults with low self-regulation and mixed factors during adolescence.

Ecological Influencing Factors During Adolescence

and the Probability of Adult Substance Use Behavior

The constellation of health-promoting and health-negating factors present in adolescents' ecology influences their engagement in or abstinence from alcohol, tobacco, and other substance (ATOD) use.[1,2] Less clear is how patterns of multilevel factors existing during adolescence relate to substance use behavior during adulthood.

Recent advances in statistical modeling techniques provide a means for assessing how well patterns of risk and protection, identified using latent class analysis,[3] predict a distal outcome.[4] Exploiting these advances helps answer the question: Is there a pattern of influences during adolescence that is strongly related to long-term non-use of substances?

Methods

Analysis of public-use data from Add Health[5] using the LCA Distal SAS macro v. 2.0[4,6] yielded conditional probability estimates of substance use behavior during adulthood (Wave 4) given latent class membership during adolescence (Wave 2). Add Health is a longitudinal study of 7-12th graders beginning in 1994, with Wave 4 data collected in 2008.

A code for three types of substance use behavior was assigned to Wave 4 participants (ages 24-32) (unweighted N=3,594). *Nonusers* were coded based on responding positively to all items assessing *never use* of ATOD (*n*=638). M*oderate users* included participants who may have tried tobacco and other drugs before the past

30 days, but who reported never having been a regular smoker and no more than moderate alcohol use for age and gender[7] (*n*=445). *Regular/risky users* included responders who were ever regular smokers, those who had smoked or used illicit substances during the past 30 days, and those who had engaged in excessive or binge alcohol use during the past year (*n* = 2,511). The latent classes during adolescence represented patterns of health-promoting and health-negating influences that differentiated youth into three subgroups: "Health-promoting influences" (53%), "Low Self-regulators with Mixed Influences" (29%), and "Friends Use ATOD, Parents Smoke, and Possible Violence Exposure" (18%). Model estimation and interpretation of classes are described elsewhere (Yoder, in preparation).

The original three-class model of influencing factors was fit using the distal substance use outcome as a grouping variable to reduce classification error bias.[4] Sampling weights and the school cluster variable were included to account for sampling design effects.

Results

Marginal probabilities and conditional probabilities are presented in Table 1. In terms of relative risk, adults who were members of the "Health-promoting Influences" class were 7.25 times as likely to be nonusers compared to adults who had been members of the "Low Self-regulators, Mixed influences" class, and were more than two times as likely to be nonusers compared to adults who had been in the "Friends Use ATOD, Parents Smoke, Possible Violence Exposure" class. Adults who were members of the "Health-promoting influence" class were 0.56 times as likely (or 44% less likely) to be regular/risky substance users compared to adults who had been members of the "Low-self

Regulators, Mixed Influences" class, and were 0.64 times as likely (or 36% less likely) to be regular/risky users compared to adults who had been members of the "Friends Use ATOD, Parents Smoke, Possible Violence Exposure" class.

Discussion

Self-reported substance nonuse in adulthood was most probable when a constellation of health-promoting factors, including self-regulation, no friends who use ATOD, parents who don't smoke, parent-child closeness, parental authority, school connectedness, no exposure to community violence, and neighborhood connectedness were present during adolescence. While these findings resonate with studies that have identified risk and protective factors for substance use in adulthood,[8] other predictors of long term substance nonuse likely exist. Combinations of religiousness,[9–11] future expectations,[12] non-parental adult role models,[13] and anti-substance use media exposure,[14] may be even more strongly associated with adult substance nonuse than factors included in the model and merit future research.

The high probability of regular/risky use during adulthood given Class 2 or 3 membership (*i.e.,* latent classes characterized by at least one health-negating factor), points to the need to improve health-promoting influences across all levels of adolescents' ecology. Focusing entirely on intrapersonal factors such as self-regulation and drug refusal skills while neglecting family, school, and neighborhood ecological factors may result in poorer outcomes for youth in the long-run.[8]

While these results offer new insight into the predictive validity of latent classes, there are limitations. First, the substance use behavior of the participants during adolescence was not included in the model. It is possible that without accounting for past

substance use the probabilities were attenuated. Second, the distal outcome was a fairly crude representation of the spectrum of substance use during adulthood. Future analyses should consider a different coding schema for the distal outcome.

Supporting adolescents in their pursuit of autonomy while encouraging them to maintain a substance-free lifestyle presents many challenges. While these study findings add to evidence that multilevel ecological influences during adolescence predict substance nonuse or moderate use during adulthood, more studies are needed to identify which combinations of health-promoting influences have the greatest effects.

Table 1.

Probability of ATOD Use at Wave 4 Conditioned on Latent Class Membership at Wave 2

Distal Outcome (Z)	Marginal P(Z)	P(Z|Class 1)	P(Z|Class 2)	P(Z|Class 3)
Nonuse	0.18	0.29	0.04	0.14
Moderate Use	0.12	0.21	0.05	0.08
Regular/Risky Use	0.70	0.50	0.90	0.78

Class 1: Health-promoting influences
Class 2: Low Self-regulators, Mixed influences
Class 3: Friends Use ATOD, Parents Smoke, Possible Violence Exposure

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CHAPTER 7: Conclusion

Over 150 evidence-based programs for preventing adolescent alcohol, tobacco, and other drug use are indexed in the National Registry for Evidence Based Programs and Prevention (Substance Abuse and Mental Health Services Administration [SAMHSA], 2013). Some are designed for use in schools at various grade levels, some are for families, and some are for communities. Most of them focus on one area of adolescents' ecological context (*e.g.*, interpersonal skills), likely because this is a cost-effective and focused way to deliver a program that reaches as many youth as possible. The strength of these programs for effecting long-term substance nonuse among youth continues, however, to be limited. Few programs have reduced substance use initiation rates beyond a two-year time frame, and meta-analyses indicate small effect sizes and sometimes no effect of the interventions compared to controls (Foxcroft & Tsertsvadze, 2011; Thomas, McLellan, & Perera, 2013). Adaptive interventions that use tailoring variables and target subgroups may be a way to boost the effects of health promotion and substance use prevention programs for youth (Collins, Murphy, & Bierman, 2004; Rivera, Pew, & Collins, 2007). Furthermore, understanding the health promoting and health-negating influences of youth who abstain from substance use across time could add to our understanding which factors most strongly support substance-free lifestyles. The study aim was to identify the tailoring variables, target subgroups, and unique patterns of influencing factors for substance-free youth in order to advance the evidence base for effective adolescent health promotion.

The results of the study indicate that several patterns of ecological influencing factors differentiate subgroups of adolescents that have specific needs for health-

promotion and for developing and maintaining substance-free lifestyles. Almost 25% of the sample were substance nonusers and were characterized by high probabilities of having health-promoting influences across intra-individual, interpersonal, school, and community levels of their ecology. While these youth appeared to have many resources, they still had a relatively low probability of their closest friends not using substances of any kind. In other words, even the nonusers were unlikely to report that all of their closest friends abstained from substance use. The other subgroup of nonusers was characterized by a low probability of having health-promoting school connectedness, but high probability of having health-promoting parental authority and parent-child closeness. The nonusers whose main threat is close friends who use substances would likely benefit from training on how to negotiate friendships and situations in which they feel pressured to use substances, while those who have poor school connectedness need encouragement to maintain healthy family relationships concurrent with efforts to address school connectedness. Experimenters and regular/risky users also had differentiated patterns of influences, with generally lower probabilities of health-promoting influences across the levels of ecology.

Modeling the ecological influencing factors for substance nonuse and use as indicators of latent classes pointed to possible tailoring variables for health promotion programs. Of all of the ecological influencing factors included in the current study, self-regulation, peers' substance use, and school connectedness had the strongest associations with differentiating the hidden subgroups of youth. This means that youth who are experiencing different levels (health-promoting vs. health-negating) of these influencing factors may benefit from a tailored intervention in relation to these factors. Since

substance use status (nonuser, experimenter, and regular/risky user) significantly moderated how the patterns of influencing factors differentiated the hidden subgroups, attention should also be given to whether or not youth have actually initiated use. For one of the regular/risky users classes, being female and having low self-regulation were strongly related to class membership. Other important predictors of being in the latent classes characterized by health-negating influences included older age, low family socioeconomic status, and low neighborhood socioeconomic status. While none of these findings can be interpreted as causal, they tell us about which factors might need to be prioritized in interventions should we discover that they are present in youths' ecological context. Future studies should incorporate other influencing factors in a similar model to determine if they are more strongly related to differentiating the latent classes.

When testing how well latent class membership during adolescence predicted substance non-use during adulthood, the conditional probability of this positive health behavior was not high (29%). However, the relative risk indicated that members of the "Health-promoting Influences" class were 7.25 times as likely to be adult nonusers and 4.2 times as likely to be adult moderate users than members of the "Low Self-regulators, Mixed Influences" class. In contrast, they were 0.56 times as likely (or 45% less likely) to be adult regular/risky users than members of the "Low Self-regulators, Mixed Influences" class, and 0.64 times as likely (or 36% less likely) to be adult regular/risky users compared to members of the "Friends Use ATOD, Parents Smoke, and Possible Violence Exposure" class. These findings indicate the synergistic health-promoting effect between having positive influences across all levels of adolescents' biopsychosocial ecology and the outcome of adult substance-free lifestyles.

Although the highest probability of substance *nonuse* during adulthood was linked to membership in the latent class with mostly health-promoting influences across all levels, there are likely other important influencing factors that predict long-term substance non-use, possibly with even greater relative risk indices. For example, religious affiliation (Jones & Rossiter, 2009) and future intentions (Smith, Bean, Mitchell, Speizer, & Fries, 2007) should be tested for their relationships to long-term substance-free lifestyles. The latent classes that exist during late adolescence, college-age youth, and as young people leave their childhood home, might also reveal more salient health-promoting patterns linking to substance-nonuse during adulthood.

The latent class model provides a rigorous way to identify targetable subgroups and important tailoring variables, and to understand what would otherwise be a complex array of categorical or ordinal data (Collins & Lanza, 2010). The findings of this study are novel in that no other study has tested the patterns among multilevel influences and the heterogeneity of youth in relation to substance nonuse, experimentation, and regular use. Incorporating substance nonuse, experimentation, and regular use as a moderator emphasized that youths' engagement in any substance use interacts with other contextual influencing factors, and it is not always clear whether changes in the behavior or the contextual influences occurred first. Longitudinal analyses, such as latent class transition analysis, could help to more clearly identify the patterns of ecological influencing factors that are precursors to substance use initiation and abuse, as well as those patterns that support sustaining substance nonuse.

The results of this study provide new information about adolescents, their ecological influencing factors for health behavior, and their substance nonuse,

experimentation, and regular or risky use. School nurses, primary care providers, counselors, and researchers in health promotion and health behavior can use the findings to advance their work with adolescents. For example, instead of teaching self-regulation skills to all adolescents, a program might be designed to assess which students have the most need for self-regulation development and incorporate specific computer games or role-playing activities into the intervention for these students, while for other students who have been assessed as having adequate self-regulation, there would be activities reinforcing leadership skills and the ability to influence peers who are susceptible or experimenting with substances to abstain from substance use. Since school connectedness also emerged as an important factor in differentiating the latent classes, a pre-intervention assessment of students' perceptions of school connectedness could also help identify which students need or don't need an intervention related to school connectedness.

Those developing health policy surrounding the needs of adolescents should use the study findings to emphasize the need for holistic programs that address all levels of adolescents' ecological context. Since family socioeconomic status and neighborhood socioeconomic status were predictors of membership in the two latent classes with lower probabilities of health-promoting factors, those working in youth health promotion must continue to advocate for resources that serve youth with few economic assets. Preventing youth exposure to violence must also be prioritized.

Finally, health policy should also support research in adolescent development and health promotion and health behavior. Indeed, this study would not have been possible without the federal grant support for the design and data collection of the National

Longitudinal Study of Adolescent Health, nor without the support for the statistical analysis software resources provided by Penn State Methodological Center. Further areas of research have already been suggested. Most importantly, more work is needed concerning the effects of changing ecological influences over time in maintaining substance-free lifestyles from adolescence into adulthood.

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