



Published in final edited form as:

Int J Behav Dev. 2012 July 1; 36(4): 247–257. doi:10.1177/0165025412442870.

Parallel Development of Risk Behaviors in Adolescence: Potential Pathways to Co-occurrence

David Y.C. Huang^a, H. Isabella Lanza^b, Debra A. Murphy^c, and Yih-Ing Hser^d

^aUCLA Integrated Substance Abuse Programs, Semel Institute for Neuroscience and Human Behavior, 11075 Santa Monica Blvd., Suite 200, Los Angeles, CA 90025, USA, yhuang@ucla.edu

^bUCLA Integrated Substance Abuse Programs, Semel Institute for Neuroscience and Human Behavior, 11075 Santa Monica Blvd., Suite 200, Los Angeles, CA 90025, USA, hilanza@ucla.edu

^cUCLA Integrated Substance Abuse Programs, Semel Institute for Neuroscience and Human Behavior, 11075 Santa Monica Blvd., Suite 100, Los Angeles, CA 90025, USA, dmurphy@mednet.ucla.edu

^dUCLA Integrated Substance Abuse Programs, Semel Institute for Neuroscience and Human Behavior, 11075 Santa Monica Blvd., Suite 200, Los Angeles, CA 90025, USA, yhser@ucla.edu

Abstract

This study used data from 5,382 adolescents from the 1997 U.S. National Longitudinal Survey of Youth (NLSY97) to investigate developmental pathways of alcohol use, marijuana use, sexual risk behaviors, and delinquency across ages 14 to 20, examine interrelationships among these risk behaviors across adolescence, and evaluate association between risk behavior trajectories and depressive symptoms in adolescence. Group-based dual trajectory modeling, examining trajectories of two outcomes over time, revealed strong interrelationships among developmental trajectories of the four risk behaviors, and indicated potential pathways to co-occurring risk behaviors. Adolescents with higher levels of alcohol use or marijuana use were more likely to engage in higher levels of early sexual risk-taking and delinquency. Moreover, adolescents involved in higher levels of delinquency were at higher risk for engaging in early sexual risk-taking. Also belonging to the highest risk trajectory of any of the four risk behaviors was positively associated with depressive symptoms in adolescence.

Keywords

alcohol use; delinquent behaviors; group-based dual trajectory model; marijuana use; sexual risk behaviors

Introduction

A wealth of literature has highlighted the increase of risk-taking behaviors (i.e., substance use, sexual risk-taking, delinquency) in adolescence (Connell, Gilreath, & Hansen, 2009; D'Amico, Edelen, Miles, & Morral, 2008; Guo et al., 2002; Wu, Witkiewitz, McMahan, Dodge, & Conduct Problems Prevention Research Group, 2010), which has been attributed to significant biological, cognitive, and socio-emotional changes during this developmental

period (Lerner & Galambos, 1998; Steinberg, 2008). As a result of these developmental changes, risk behaviors in adolescence are also known to be highly interrelated (Grossman, Kaestner, & Markowitz, 2004; Mason & Windle, 2002; Pedersen, Samuelson, & Wichstrom, 2003; Schofield, Bierman, Heinrichs, Nix, & Conduct Problems Prevention Research Group, 2008). This co-occurrence is especially problematic as multiple risk behaviors are associated with more persistent and pernicious negative development outcomes in adolescence and young adulthood, including antisocial behaviors, school dropout, sexually transmitted infections (including HIV), substance use disorders, and unemployment (Grant & Dawson, 1997; Green & Ensminger, 2006; Millstein & Moscicki, 1995; Thornberry, Lizotte, Krohn, Smith, & Porter, 2003). Nonetheless, in spite of the abundant literature on adolescent risk behaviors, we know relatively little about the specific magnitude of associations between risk behaviors across adolescence, which risk behaviors predict greater engagement of other risk behaviors across this development period, and to what extent risk behaviors across adolescence are related to depressive symptoms in adolescence.

Currently, most empirical work demonstrating significant associations between risk behaviors in adolescence has focused on single time point measures of risk behaviors in adolescence; however, as recently discussed by Connell and colleagues (2009), there is a dearth of research examining associations among developmental trajectories of risk behaviors. Studies examining the interrelationships among risk behaviors longitudinally are relatively limited, particularly in assessment of the magnitude of associations among risk behaviors over time (e.g., Rashad & Kaestner, 2004). However, recent methodological developments have produced a variety of analytical approaches (Jones & Nagin, 2007; Muthén & Muthén, 2000) that more easily allow for the evaluation of interrelationships among multiple adolescent risk behaviors across time, such as growth mixture modeling (Hix-Small, Duncan, Duncan, & Okut, 2004), parallel-process growth mixture modeling (Greenbaum & Derick, 2007; Wu et al., 2010), and dual-trajectory modeling (Brezo et al., 2008). An examination of risk behaviors simultaneously across adolescence is necessary to identify the degree to which risk behaviors are related during adolescence, as well as identifying more common pathways to co-occurring risk behaviors in adolescence.

Adolescents, compared to children and adults appear to be more reward sensitive; that is, they need higher levels of stimulation and novelty, which can be gained from risk behaviors, to feel pleasure. This, combined with a slower development of higher-order self-regulation, is suggested to be at the root of increased risk-taking behavior in adolescence (Steinberg, 2006). As a result, engagement in multiple risk behaviors goes hand in hand. However, although delinquency, sexual-risk behaviors, and substance use are likely to co-occur in adolescence, disentangling these relationships is necessary in order to identify the common pathways by which one risk behavior poses a greater likelihood of engagement of another risk behavior during adolescence. Identifying the more common pathways to co-occurring risk behaviors across adolescence is likely to inform prevention efforts aimed at mitigating multiple problem behaviors by focusing on patterns of risk behavior engagement most likely to lead to additional risk behaviors. For instance, prior research has shown that adolescents involved in substance use are more likely to engage in earlier and unsafe sexual behavior (Dunn et al., 2008; Grossman et al., 2004; Guo et al., 2002; Tapert, Aarons, & Sedilar, 2001), as well as delinquent behaviors (D'Amico et al., 2008; Mason & Windle, 2002) compared to non-using adolescents. Potentially, substance use may increase involvement in risky sexual and delinquent behaviors through its effects on decreasing behavioral inhibition and rational decision-making (Bava & Tapert, 2010; Millstein & Moscicki, 1995; Wu et al., 2010), which may already be weak as the adolescent brain is experiencing heightened social awareness and immature self-regulation capabilities (Steinberg, 2008). Furthermore, affiliation with and influence of deviant peers may worsen this relationship (Dishion, Nelson, & Bullock, 2004; Kokkevi, Richardson, Florescu, Kuzman, & Stergar, 2007). Thus,

assessing the pathways from substance use to delinquency and sexual risk behaviors, and vice versa (e.g., Bui, Ellickson, & Bell, 2000; Wiesner & Windle, 2006), is warranted to know whether increased alcohol and marijuana use is a key pathway to increased delinquency and sexual risk engagement across adolescence.

Apart from examining the interrelationships among risk behaviors and common pathways to multiple risk behaviors, a growing literature has focused on the relationship between externalizing-type behaviors (including delinquency and substance use) and depression in adolescence (Bovasso, 2001; Chung, Naisto, Cornelius, Martin, & Jackson, 2005; Hallfors, Waller, Bauer, Ford, & Halpern, 2005; McCarty et al., 2009; McGee, Williams, Poulton, & Moffitt, 2000). It has been posited that externalizing and internalizing-type behaviors in childhood and adolescence may be a result of shared risk factors as well as mediating mechanisms linking two seemingly unrelated behaviors (Angold, Costello, & Erkanli, 1999; Patterson & Capaldi, 1990). It is possible that both deficits in self-regulation and negative peer interactions increase risk of depressive symptoms among adolescents engaging in risk behaviors (Beauchaine, Gatzke-Kopp, & Mead, 2007; Capaldi, 1992). Lack of self-regulation is linked to higher negative emotionality and impulsive behavior, which underlie depressive symptoms and risk behaviors (Capara, Gerbino, Paciello, Di Giunta, & Pastorelli, 2010; Hallfors et al., 2005; Silk, Steinberg, & Morris, 2003). Furthermore, the relationship between risk behaviors and depression may be explained by poor peer interactions in adolescence, as posited by the dual failure model (Patterson & Capaldi, 1990), where disruptive behavior contributes to failures in peer interactions and academic functioning, ultimately leading to development of depressive symptoms. Adolescents engaging in risk behaviors, particularly of a deviant or delinquent quality, are known to experience peer victimization and rejection (Deater-Deckard, 2001; Hawker & Boulton, 2000; Snyder et al., 2003), and this poor peer status may indeed contribute to development of depressive symptoms (Hodges & Perry, 1999; Juvonen & Graham, 2001; Kochenderfer-Ladd, 2004; Storch, Nock, Masia-Warner, & Barlas, 2003). Also, it has been reported that substance use, including alcohol, are used by youth experiencing depressive symptoms as a way to cope with negative feelings (Brooks, Harris, Thrall, & Woods, 2002; Hallfors et al., 2004). However, prior to testing the role of self-regulation and peer processes in associations between risk behavior trajectories and depression, a preliminary assessment is necessary to ascertain which, if any, risk behavior trajectories are positively associated with depression in adolescence.

Using a longitudinal sample representative of U.S. adolescents, the current study applied group-based dual-trajectory modeling (Jones & Nagin, 2007) to extend the prior literature on co-occurring risk behaviors by identifying trajectories of risk behaviors in adolescence in order to: 1) evaluate the magnitude of associations between specific risk behaviors across adolescence; 2) determine which risk behavior trajectories are more likely to predict engagement in other risk behavior trajectories; and 3) assess whether higher engagement in specific risk behaviors across adolescence is associated with depressive symptoms in adolescence. In other words, the study aimed to identify trajectories of each risk behavior, then combine pairs of risk behavior trajectories to assess the degree to which higher risk trajectories are interrelated, and identify the most probable pathways to co-occurring risk behaviors (e.g., alcohol to sexual risk, delinquency to sexual risk, etc). Given the strong evidence for risk of delinquency and sexual risk behaviors among individuals involved in substance use, we hypothesized engagement in high risk substance use trajectories would predict a higher likelihood of engaging in high risk delinquency and sexual risk trajectories. Furthermore, given the interest in the development of co-occurring externalizing-type behaviors and depression in adolescence, we examined whether specific trajectories across risk behaviors would be more or less associated with depressive symptoms in adolescence. Given past evidence indicating delinquent behaviors may contribute to depression via poor

self-control and negative peer interactions, we expected a strong association between delinquent behaviors and depressive symptoms. Additionally, we also hypothesized that alcohol would be strongly associated with depressive symptoms, as alcohol is commonly used as a maladaptive coping mechanism to mitigate negative feelings.

Method

Sample

The study used a subsample from the U.S. 1997 National Longitudinal Survey of Youth (NLSY97; U.S. Department of Labor, 2008). The NLSY97 is a nationally representative survey of youth ($n = 8,984$) initiated in 1997 by the U.S. Department of Labor to study labor market behavior and experiences. Adolescents born between 1980 and 1984 (aged 12 to 16 in 1997) were assessed annually from 1997 to 2008 with a battery of cognitive, personality, social, and behavioral measures. Informed consent was obtained from caregivers and assent from adolescents. One-hour interviews were conducted at home for the majority of participants (96.8% at Wave 1, and the rest were conducted by phone). Sensitive information was collected via audio computer-assisted self-interview (ACASI) technology. Youth data from eleven assessment points (1997–2007) were examined in the present study.

In order to have comprehensive data to identify developmental pathways of adolescent risk behaviors from ages 14 to 20, the study included 5,382 adolescents (2,785 males and 2,597 females) who were 12 to 14 years old as of December 31, 1996 and responded to questions on risk behaviors. This study sample consisted of three birth cohorts born in 1982 ($n=1,841$; 51.8% males), 1983 ($n=1,796$; 51.8% males), and 1984 ($n=1,745$; 51.7% males). In addition, the calendar year in each wave of data corresponded to each individual's age at the interview. For instance, those born in 1984 were age 12 at wave 1 and were 13 to 20 years across waves 2 to 9, respectively. Consequently, data regarding risk behaviors from ages 14 to 20 were drawn from seven waves: waves 1 to 7 (1997–2003) for participants born in 1982, waves 2 to 8 (1998–2004) for those born in 1983, and waves 3 to 9 (1999–2005) for those born in 1984 (see Table 1). The seven waves of data by calendar year were then temporally rearranged based upon the participant's age at each interview for studying trajectories of risk behaviors from ages 14 to 20. For example, a participant's measures on alcohol use for age 14 were obtained from a corresponding wave of interviews at which the respondent was age 14.

Of the 5,382 adolescents, 51.8% were male; 49.3% were White, 25.6% African American, 21.4% Hispanic, and 3.7% of other ethnic groups. The follow-up rate ranged from 94.9% at Wave 2 to 84.7% at Wave 11. Other than the significant age difference due to the selection criterion of the study, the selected and excluded subjects were similar on main study variables, including gender, ethnicity, depressive symptoms, prevalence of cigarette smoking, alcohol use, and marijuana use, and delinquency, suggesting a selection bias in the current study is unlikely.

Measures

Participants' demographic characteristics, including gender and ethnicity, were obtained from baseline data at Wave 1 (1997). In addition to gender and ethnicity, the following measures were utilized in the study.

Alcohol and marijuana use—For each type of substance, adolescents were asked to report whether they had ever consumed the substance, age of first use, and quantity and frequency of use. Specific questions on alcohol use included: in the past 30 days, (1) number of days had one or more drinks; (2) number of drinks per day; and (3) number of days had

five or more drinks. Questions on marijuana use included number of days used marijuana and number of times used marijuana before or during school/work in the past 30 days. Measures were collected at each assessment from Waves 1 to 11. The number of days of use in the past 30 days was used to indicate level of alcohol and marijuana use, separately.

Sexual risk score—Adolescents aged 14 or older reported their sexual activity at each wave of the survey. Measures included age of first sexual intercourse, number of acts of sexual intercourse, and number of sexual partners in the past 12 months (Wave 1) or since the last interview (subsequent interviews). Questions regarding condom use, including whether a condom was used during first sexual intercourse and the number of times a condom was used since the last interview, were asked starting at Wave 2. Using a previously validated approach in prior studies (Coley, Votruba-Drzal, & Schindler, 2009; Huang, Murphy, & Hser, 2011), a standardized sexual risk score was computed from three items at each assessment: number of sexual partners, number of acts of sexual intercourse, and frequency of condom use within each year. Each item was first standardized on a 0-to-10 scale based on decile distribution of the measure. Based on the corresponding location of each individual's response on the distribution, a value of 1 to 10 for each item was allocated (a response of “none” was indicated by a value of zero). The assigned values across the three measures were summed; with frequency of condom use reversed before summation, to create a sexual risk score. Scores ranged from 0 to 30 with higher scores indicating higher sexual risk-taking.

Delinquent behaviors—Delinquent behaviors were assessed by asking adolescents 14 and older if they had engaged in a wide range of activities, including: carried a handgun, joined a gang, committed property crimes, attacked someone, sold illicit drugs, stole a car or others. Any one of the above activities occurring during the observation period (ages 14 to 20) was considered to be an incident of delinquency. As a result, delinquency at each age was analyzed as a binary outcome (occurred vs. not occurred).

Depressive symptoms—Depressive symptoms were measured with the five-item Mental Health Index (MHI-5), which has been used previously to assess depressive symptoms (Berwick et al., 1991; Rumpf, Meyer, Hapke, & John, 2001; Yamazaki, Fukuhara, & Green, 2005). Respondents were asked how often in the past month they had: (1) been a nervous person; (2) felt calm and peaceful; (3) felt down or blue; (4) been a happy person; and (5) felt depressed. Response options ranged along a 4-point scale (*1 = all of the time to 4 = none of the time*). Higher scores indicated greater depressive symptoms. The measure was given at Waves 4, 6, 8 and 10 (2000, 2002, 2004, and 2006). The four waves of assessment comprise, respectively, ages 15 to 21 for those born in 1984, ages 16 to 22 for those born in 1983, and ages 17 to 23 for those born in 1982. To avoid age differences between the three birth cohorts, the average score across ages 17 to 21 was used as an indicator of depressive status for each participant.

Analyses

Group-based trajectory modeling (Jones, Nagin, & Roeder, 2001) was first applied to identify distinctive trajectory patterns of alcohol use, marijuana use, sexual risk, and delinquency, separately, from ages 14 to 20. The modeling aimed to examine the heterogeneity of trajectories among individuals and assumed that each individual developed his/her own trajectory over time independently. The trajectory shape was estimated with a quadratic function. Individuals with similar trajectories were assigned to a given group. The number of distinctive trajectory groups for each risk behavior was indicated by a latent class variable. The Bayesian Information Criterion (BIC), in conjunction with the Lo-Mendell-Rubin likelihood ratio test (LMR-LRT) (Lo, Mendell and Rubin, 2001; Muthén & Muthén,

2007), was used to select the most optimal model from a series of models differing in number of trajectory groups. The optimal model should have a reasonably high BIC value, and identified trajectories should be distinct and interpretable. Additionally, differentiation on depressive scores among the identified trajectory groups for each risk behavior was respectively examined with multivariate analyses (e.g., SAS PROC GLM). These analyses also included gender and ethnicity as covariates.

The next step of analysis extended the group-based trajectory modeling framework by examining the developmental course of two risk behaviors simultaneously using group-based dual trajectory modeling (Jones & Nagin, 2007). This dual model was designed to analyze the developmental course of two distinct but related outcomes (Nagin & Tremblay, 2001). The interrelationship between two specific risk behaviors over time (e.g., alcohol use and sexual risk behaviors) was assessed by examining the association of distinctive trajectories between the two risk behaviors. Based upon the trajectory groups that were initially identified in Step 1, joint probability of membership in two risk behavior trajectories was estimated across all possible pairs of trajectory membership. This analysis provided the marginal probability of membership in each identified trajectory group and conditional probabilities of membership in the trajectory groups of one behavior given membership in a trajectory group of another behavior. The group-based trajectory modeling and the dual trajectory modeling were conducted using SAS PROC TRAJ (Jones, Nagin, & Roeder, 2001; Jones & Nagin, 2007). Both modeling procedures included all available participants in the analysis. Trajectories for participants who were missing data at a few assessment points were estimated by using all available observations on dependent measures.

Results

Trajectories of Alcohol Use, Marijuana Use, Sexual Risk Behaviors and Delinquency

A series of group-based trajectory models (from two- to five-group models) were fitted to determine the optimal model for each risk behavior. Table 2 presents the goodness-of-fit indices. For alcohol and marijuana use, changes on the BIC between the four-trajectory and five-trajectory models were not statistically significant. The four-trajectory model was the most parsimonious and also provided the most informative description of the data. For delinquency and sexual risk behavior, the five-trajectory models did not appropriately converge; consequently, the four-trajectory models were selected as optimal due to having a reasonably high BIC value with interpretable distinctive trajectories.

Alcohol use trajectories—Adolescents exhibited four alcohol trajectories (Figure 1A); 33.7%, 51.8%, and 8.8% of adolescents were respectively classified in the Low, Occasional, and Moderate groups. Another 5.7% of adolescents, who were characterized as being in a High-Increasing group, exhibited an accelerated trajectory of alcohol consumption from ages 14 to 20. These individuals started a low level of drinking at age 14 and reported a significant increase in level of alcohol use throughout adolescence.

Marijuana use trajectories—As demonstrated in Figure 1B, the majority of adolescents (Low, 71.5%) maintained low levels of marijuana use from ages 14 to 20. About 5.2% of adolescents (High-Increasing) started sporadic marijuana use at age 14, significantly increased their use from ages 14 to 20, and sustained a high level of marijuana use by the end of the observation period (age 20). In contrast to adolescents in the High-Increasing group, 9.5% of adolescents (Decreased) initiated sporadic marijuana use at age 14, but exhibited a significant decrease of use afterwards. Another 13.8% of adolescents (Increased)

had relative low levels of marijuana use during early adolescence (ages 14 to 15) but started a significant increase of use after age 15.

Sexual risk trajectories—As shown in Figure 1C, 37.3% of adolescents (Early-Increasing) initiated sexual risk at age 14 or earlier and continued to remain at a high level of risk throughout adolescence; 3.9% (Decreased) exhibited a decelerated trend, with sexual risk behaviors decreasing as they aged. Another 35.7% of adolescents (Late-Increasing) started with a relatively low level of sexual risk before age 16, but then significantly increased sexual risk behaviors afterwards. About 23% of adolescents (Low) remained at a very low level of sexual risk throughout adolescence.

Delinquency trajectories—The majority of adolescents belonged to a Low trajectory (56.3%), engaging in a low level of delinquency involvement across adolescence. On the other hand, 9.8% (High) and 18% (Moderate) of adolescents exhibited a high and a moderate level of delinquency involvement from ages 14 to 20 (Figure 1D), respectively. Another 15.9% (Decreased) exhibited a decelerated trajectory, with delinquent behaviors relatively high at age 14, but significantly decreasing throughout adolescence.

Joint Trajectories of Alcohol Use, Marijuana Use, Sexual Risk Behaviors, and Delinquency

Figure 2 presents conditional probabilities of membership in one risk behavior trajectory, given membership in another risk behavior trajectory; thus indicating the likelihood of engaging in one risk behavior (e.g., sexual risk behaviors) when engaging in another risk behavior (e.g., alcohol use).

Dual trajectories of alcohol use and sexual risk behaviors—Adolescents belonging to the Moderate (75%) and High-Increasing (57%) alcohol trajectories were more likely to belong to the Early-Increasing sexual-risk trajectory than other sexual-risk groups. Also, among the four alcohol trajectories, the majority of adolescents in the Occasional alcohol trajectory (53%) were classified in the Late-Increasing sexual-risk trajectory (Figure 2, Panel A1). Conversely, examining sexual-risk trajectory membership did not reveal robust associations with the High-Increasing alcohol trajectory. Of adolescents in the Early-Increasing sexual-risk trajectory, 18% exhibited the High-Increasing alcohol use but another 18% exhibited the Low alcohol use (Figure 2, Panel A2).

Dual trajectories of marijuana use and sexual risk behaviors—Belonging to the Increased, Decreased, or High-Increasing marijuana trajectories was associated with membership in the Early-Increasing sexual-risk trajectory, with 76%, 76% and 45% of adolescents, respectively, belonging to the Early-Increasing sexual-risk trajectory. Among those in the Low marijuana trajectory, only 22% belonged to the Early-Increasing sexual-risk trajectory (Figure 2, Panel B1). Conversely, membership in the Early-Increasing sexual-risk trajectory was not associated with belonging to the High-Increasing marijuana trajectory. Only 12% of adolescents in the Early-Increasing sexual-risk trajectory were classified in the High-Increasing marijuana trajectory, with 41% classified in the Low marijuana trajectory (Figure 2, Panel B2).

Dual trajectories of alcohol use and delinquency—Adolescents in the High-Increasing alcohol trajectory were more likely to belong to the High (35%) and Moderate (43%) delinquency trajectories than the Low delinquency group. Furthermore, adolescents in the Low-alcohol trajectory exhibited the lowest risk of delinquent behavior, with 82% belonging to the Low delinquency trajectory (Figure 2, Panel C1). Conversely, examining the association from the High delinquency to the High-Increasing alcohol trajectories indicated a less robust linkage. Of adolescents in the High delinquency trajectory, only 20%

belonged to the High-Increasing alcohol trajectory, with 32% and 42% being classified in the Moderate and Occasional alcohol trajectories, respectively (Figure 2, Panel C2).

Dual trajectories of marijuana use and delinquency—The level of marijuana use among the four marijuana trajectories corresponded to the levels of delinquent behavior among the four trajectories of delinquency (Figure 2, Panel D1), and vice versa. Adolescents in the Low, Increased and High-Increasing marijuana trajectories showed a higher likelihood of belonging to the Low (76%), Moderate (57%) and High (72%) delinquency trajectories, respectively. Similarly, adolescents in the Decreased marijuana trajectory were more likely to be classified in the Decreased delinquency trajectory (59%). Conversely, adolescents in the Low, Moderate and High delinquency trajectories showed a higher likelihood of belonging to the Low (94%), Increased (46%) and High-Increasing (37%) marijuana trajectories, respectively (Figure 2, Panel D2).

Dual trajectories of sexual risk behaviors and delinquency—The Early-Increasing sexual-risk trajectory was associated with the High delinquency trajectory; 22% of adolescents in the Early-Increasing sexual-risk trajectory were classified into the High delinquency trajectory. On the other hand, only 8% of those in the Late-Increasing sexual-risk trajectory belonged to the High delinquency group. Furthermore, a decrease of sexual risk was accompanied by a decrease in delinquent behaviors; 39% of adolescents in the Decreased sexual-risk trajectory belonged to the Decreased delinquency trajectory (Figure 2, Panel E1). Conversely, evaluating associations from delinquency to sexual-risk trajectories revealed that the High delinquency trajectory was associated with the Early-Increasing sexual-risk trajectory, with 67% of those in the High delinquency trajectory also belonging to the Early-Increasing sexual-risk trajectory (Figure 2, Panel E2).

Dual trajectories of alcohol use and marijuana use—Overall, an increase of alcohol use was associated with an increase of marijuana use, and vice versa. Of adolescents in the High-Increasing alcohol trajectory, 29% and 43% belonged to the High-Increasing and Increased marijuana trajectory, respectively (Figure 2, Panel F1). Similarly, 50% and 37% of adolescents in the High-Increasing marijuana trajectory were classified into the High-Increasing and Moderate alcohol trajectory, respectively (Figure 2, Panel F2).

Association of Identified Trajectories with Depressive Symptoms

Table 3 presents findings on associations among trajectories of alcohol use, marijuana use, sexual risk behaviors, and delinquency with depressive symptoms in adolescence. In contrast to females, males exhibited lower levels of depressive symptoms in adolescence. Among the four alcohol trajectory groups, adolescents in the Occasional, Moderate, and High-Increasing trajectories all had higher levels of depressive symptoms in adolescence compared to the Low trajectory. Similarly, relative to adolescents in the Low marijuana trajectories, adolescents in the High-Increasing, Increased and Decreased marijuana trajectories exhibited significantly higher depressive symptoms. Of the four sexual-risk trajectories, adolescents in the Early-Increasing trajectory reported the highest depressive symptoms. Level of delinquency involvement significantly corresponded to depressive symptoms; reported depressive symptoms sequentially increased among the Low, Decreased, Moderate, and High delinquency trajectories, with adolescents in the High delinquency trajectory indicating highest levels of depressive symptoms.

Discussion

Risk behaviors in adolescence have been studied extensively, as their occurrence, and particularly co-occurrence, pose heightened risk for myriad negative developmental

outcomes (Grant & Dawson, 1997; Green & Ensminger, 2006; Millstein & Moscicki, 1995; Thornberry et al., 2003). However, despite the fact that risk behaviors are known to be heavily interrelated as a result of shared biological risk factors and mediating contextual processes (Dishion et al., 2004; Kokkevi et al., 2007; Steinberg, 2006, 2008), the degree to which certain risk behavior trajectories are interrelated and the pathways from specific risk behavior trajectories to others is not as clear. Neither is the relationship between risk behavior trajectories and depressive symptoms in adolescence. In the current study, it was found that adolescents classified in higher risk trajectories of alcohol and marijuana use had a greater probability of belonging to higher sexual risk and delinquency trajectories. Furthermore, belonging to the highest risk trajectory of any risk behavior category was associated with the highest level of reported depressive symptoms in adolescence.

Adolescents involved in either a moderate or increasingly high amount of alcohol use are more likely to engage in sexual risk-taking earlier in adolescence compared to those not engaging in or decreasing their alcohol use. This confirms previous research suggesting the disinhibitory effects of alcohol compromise on adolescent's already vulnerable rational decision-making processes (Bava & Tapert, 2010; Millstein & Moscicki, 1995; Wu et al., 2010), which promotes engagement in sexual activity at younger ages, with multiple partners, and without condoms (Dunn et al., 2008; Grossman et al., 2004; Guo et al., 2002; Tapert et al., 2001). Moreover, similar results were noted with marijuana use. With marijuana it appears that belonging to any trajectory besides a low use trajectory increases sexual risk-taking earlier in adolescence. The non-specificity of marijuana use to earlier sexual risk-taking is noteworthy, as it suggests adolescents involved in any level of marijuana use across adolescence may be more susceptible to sexual risk behaviors, which is in line with evidence that adolescents engaged in any level of marijuana use have worse developmental outcomes than those solely consuming alcohol (Flory, Lynam, Milich, Leukefeld, & Clayton, 2004). Our results show that substance use is related to higher risky sexual behaviors across adolescence, and not the other way around; thus, public health efforts to prevent sexual risk-taking among adolescents should place more emphasis on those who are more than the occasional alcohol user and also those who engage in any level of marijuana use.

Furthermore, it appears that belonging to high-risk alcohol and marijuana trajectories are associated with a greater likelihood of engaging in delinquency across adolescence. Adolescents belonging to the trajectory with a high increase of alcohol use over time were also more likely to engage in moderate and high levels of delinquency across adolescence. In addition to the disinhibitory effects that may increase vulnerability to commit delinquent acts, alcohol consumption among peers also creates a context where high-risk behavior is seen as a popular form of entertainment (Dishion, McCord, & Poulin, 1999). Alcohol fuels the need for peers to find stimulating and novel recreation, which leads to engagement in deviant and delinquent acts (Barnes, Hoffman, Welte, Farrell, & Dintcheff, 2006). Additionally, marijuana risk was directly related to risk level of delinquency. Similarly, this deviant peer context may drive marijuana users to commit delinquent acts, as marijuana is usually consumed among deviant peers (Andrews, Tildesley, Hops, & Li, 2002; Strand, 2002). Again, increased efforts on substance use prevention across adolescence may translate to decreases in other risk behaviors, such as delinquency, as the mechanisms (substance use) that drive deviant acts among peers diminish.

In addition to the findings that attribute substance use to increased probability of engaging in risky sexual behavior and delinquency, this study also indicated a strong interrelationship between early sexual risk-taking and high-risk delinquency trajectories, as well as significant overlap between high-risk alcohol and marijuana use. This is not surprising, as the risk-taking involved in delinquent acts and unsafe sexual behaviors likely result from a

combination of heightened need for deviant peer approval and lack of self-control (Steinberg, 2006, 2008). Use of alcohol and marijuana also goes hand in hand, which likely explains its strong overlap (Choo, Roh & Robinson, 2008; Kandel, 2002). Overall, although it appears that involvement in one risk behavior increases probability of involvement in another risk behavior, the pathways that may be especially important in identifying the development of co-occurring risk behaviors are those from alcohol and marijuana use to sexual-risk taking and delinquency, and from delinquency to sexual risk-taking.

The present study was also interested in examining associations between risk behavior trajectories and depression in adolescence. The findings indicate that belonging to the highest risk trajectory of any risk behavior is associated with higher levels of depressive symptoms. The strong links between risk behavior and depression across type of risk behavior supports the idea that these externalizing-type of behaviors may also signify higher depressive symptoms through shared risk factors, like poor self-regulation, or contextual mediators, such as peer victimization and rejection (Silk et al., 2003; Snyder et al., 2003). However, because of timing of depression and risk behaviors in the study, it is unknown whether one is more likely to precede the other. This is an important question as some have posited that risk behaviors, like substance use, are used to cope with depressive symptoms (Brooks et al., 2002; Hallfors et al., 2004), while others state that externalizing-type behaviors increase risk of depression through negative peer interactions (Capaldi, 1992; Patterson & Capaldi, 1990). Future work should focus on identifying which biological and contextual factors and processes link risk behaviors and depression in adolescence. Potentially, prevention efforts aimed at decreasing depressive symptoms in adolescence may seek to identify those adolescents engaging in higher and co-occurring risk behaviors as a primary target group. Also, future work on the relationship between risk behaviors and depression may find that prevention efforts aimed at mitigating risk behaviors may indirectly decrease depressive symptoms in a significant proportion of adolescents.

Our findings need to be considered in light of several limitations. First, measures of risk behaviors were self-reported, which may result in the under-reporting of such behaviors. However, the NLSY97 survey applied a computer-assisted personal interview system (CAPI) to enhance reliability of responses to sensitive questions. Second, depressive symptoms were assessed using the five-item Mental Health Index (MHI-5), which is not a comprehensive measure of clinical diagnosis of depression. Although the MHI-5 measure has been indicated as a reliable measure of depressive symptoms (Berwick et al., 1991; Yamazaki et al., 2005), replication with measures corresponding more closely to the DSM-IV (American Psychiatric Association, 2000) major depressive disorder (MDD) will increase the validity of findings. Additionally, measures of the MHI-5 were only collected in four waves of surveys. The lack of completed measures from ages 14 to 20 limited the ability to examine developmental pathways of depressive symptoms across adolescence and their temporal associations with risk behaviors trajectories. Third, although the group-based dual-trajectory modeling estimates the magnitude of associations between each pair of risk behavior trajectories, this approach is unable to delineate causal relationships among the studied behaviors. However, this approach did allow us to identify possible pathways by which co-occurring behaviors develop across time. To establish possible causal relationship from one behavior to another, though, additional statistical approaches, such as cross-lagged panel analyses, may be considered in future studies. Finally, this statistical approach also limits comparisons to pairs of risk behaviors; thus, understanding how all four sets of risk behavior trajectories are interrelated over time is not feasible. Another technique, such as parallel process growth curve modeling, may be considered for examining multiple risk behaviors simultaneously.

Despite these limitations, this study substantially adds to the co-occurring risk behavior literature by capturing the degree to which risk behaviors are related across adolescence, and also pathways that co-occurring risk behaviors are more likely to follow across adolescence. Evaluation of longitudinal, bidirectional relationships across four types of risk behaviors trajectories indicates that special attention should be paid to high-risk alcohol use and marijuana use, as these behaviors are strongly related to earlier sexual-risk behavior and delinquency in adolescence. Furthermore, as the positive association between risk behaviors and depressive symptoms in adolescence is further explored, prevention and intervention efforts may need to become more integrative of different types of adolescent maladaptive behavior. Finally, a greater understanding of the mechanisms underlying linkages among risk behaviors, and risk behaviors and depression, is warranted to improve developmental outcomes into young adulthood.

Acknowledgments

This study is supported in part by Grants 1R03MH084434-01A1 and 1R03MH084434-02 from the National Institute of Mental Health and by the University of California, Los Angeles, Center for Advancing Longitudinal Drug Abuse Research (CALDAR) under Grant P30DA016383 from the National Institute on Drug Abuse (NIDA). Dr. Hser is also supported by a Senior Scientist award from NIDA (K05DA017648). Dr. Lanza is also supported by the University of California, Los Angeles, Drug Abuse Research Training Center sponsored by NIDA (5T32DA007272-19).

References

- American Psychiatric Association. Diagnostic and statistical manual of mental disorders. Fourth edition-Text revision. Author; Washington, DC: 2000. DSM-IV-TR
- Andrews JA, Tildesley E, Hops H, Li F. The influence of peers on young adult substance use. *Health Psychology*. 2002; 21:349–357. [PubMed: 12090677]
- Angold A, Costello EJ, Erkanli A. Comorbidity. *Journal of Child Psychology and Psychiatry*. 1999; 40:57–87. [PubMed: 10102726]
- Barnes G,M, Hoffman JH, Welte JW, Farrell MP, Dintcheff BA. Effects of parental monitoring and peer deviance on substance use and delinquency. *Journal of Marriage and Family Therapy*. 2006; 68:1084–1104.
- Bava S, Tapert SF. Adolescent brain development and the risk for alcohol and other drug problems. *Neuropsychology Review*. 2010; 20:398–413. [PubMed: 20953990]
- Beauchaine TP, Gatzke-Kopp L, Mead H. Polyvagal theory and developmental psychopathology: Emotion dysregulation and conduct problems from preschool to adolescence. *Biological Psychiatry*. 2007; 74:174–184.
- Berwick DM, Murphy JM, Goldman PA, Ware JE, Barsky AJ, Weinstein MC. Performance of a five-item mental health screening test. *Medical Care*. 1991; 29:169–176. [PubMed: 1994148]
- Bovasso GB. Cannabis abuse as a risk factor for depressive symptoms. *American Journal of Psychiatry*. 2001; 158:2033–2037. [PubMed: 11729021]
- Brezo J, Barker ED, Paris J, Hebert M, Vitaro F, Tremblay RE, Turecki G. Childhood trajectories of anxiousness and disruptiveness as predictors of suicide attempts. *Archives of Pediatric and Adolescent Medicine*. 2008; 162:1015–1021.
- Brooks TL, Harris SK, Thrall JS, Woods ER. Association of adolescent risk behaviors with mental health symptoms in high school students. *Journal of Adolescent Health*. 2002; 31:240–246. [PubMed: 12225736]
- Bui KVT, Ellickson PL, Bell RM. Cross-lagged relationships among adolescent problem drug use, delinquent behavior, and emotional distress. *Journal of Drug Issues*. 2000; 30:283–304.
- Capaldi DM. Co-occurrence of conduct problems and depressive symptoms in early adolescent boys: II. A 2-year follow-up at grade 8. *Development and Psychopathology*. 1992; 4:125–144.
- Capara GV, Gerbino M, Paciello M, Di Giunta L, Pastorelli C. Counteracting depression and delinquency in late adolescence: The role of regulatory emotional and interpersonal self-efficacy beliefs. *European Psychologist*. 2010; 15:34–48.

- Choo T, Roh S, Robinson M. Assessing the “Gateway Hypothesis“ among middle and high school students in Tennessee. *Journal of Drug Issues*. 2008; 2:467–492.
- Chung T, Naisto SA, Cornelius JR, Martin CS, Jackson KM. Joint trajectory analysis of trend adolescents' alcohol use and symptoms over 1 year. *Addictive Behaviors*. 2005; 30:1690–1701. [PubMed: 16098681]
- Coley RL, Votruba-Drzal E, Schindler H. Fathers' and mothers' parenting predicting and responding to adolescent sexual risk behaviors. *Child Development*. 2009; 80:808–827. [PubMed: 19489905]
- Connell CM, Gilreath TD, Hansen NB. A multiprocess latent class analysis of the co-occurrence of substance use and sexual risk behavior among adolescents. *Journal of Studies on Alcohol and Drugs*. 2009; 70:943–951. [PubMed: 19895772]
- D'Amico EJ, Edelen MO, Miles JNV, Morral AR. The longitudinal association between substance use and delinquency among high-risk youth. *Drug and Alcohol Dependence*. 2008; 93:85–92. [PubMed: 17977669]
- Deater-Deckard K. Annotation: Recent research examining the role of peer relationships in the development of psychopathology. *Journal of Child Psychology and Psychiatry*. 2001; 42:565–579. [PubMed: 11464962]
- Dishion TJ, McCord J, Poulin F. When interventions harm: Peer groups and problem behavior. *American Psychologist*. 1999; 54:755–764. [PubMed: 10510665]
- Dishion TJ, Nelson SE, Bullock BM. Premature adolescent autonomy: Parent disengagement and deviant peer process in the amplification of problem behaviour. *Journal of Adolescence*. 2004; 27:515–530. [PubMed: 15475044]
- Dunn MS, Ilapogu V, Taylor L, Naney C, Blackwell R, Wilder R, Givens C. Self-reported substance use and sexual behaviors among adolescents in a rural state. *Journal of School Health*. 2008; 78:587–593. [PubMed: 18844811]
- Flory K, Lynam D, Milich R, Leukefeld C, Clayton R. Early adolescent through young adult alcohol and marijuana use trajectories: Early predictors, young adult outcomes, and predictive utility. *Development and Psychopathology*. 2004; 16:193–213. [PubMed: 15115071]
- Grant BF, Dawson DA. Age at onset of alcohol use and its association with DSM-IV alcohol abuse and dependence: Results from the national longitudinal epidemiologic survey. *Journal of Substance Abuse*. 1997; 9:103–110. [PubMed: 9494942]
- Green KM, Ensminger ME. Adult social behavioral effects of heavy adolescent marijuana use among African Americans. *Developmental Psychology*. 2006; 42:1168–1178. [PubMed: 17087550]
- Greenbaum PE, Dedrick RF. Changes in use of alcohol, marijuana, and services by adolescents with serious emotional disturbance: A parallel-process growth mixture model. *Journal of Emotional and Behavioral Disorders*. 2007; 15:21–32.
- Grossman M, Kaestner R, Markowitz S. Get high and get stupid: The effect of alcohol and marijuana use on teen sexual behavior. *Review of Economics of the Household*. 2004; 2:413–441.
- Guo J, Chung I, Hill KG, Hawkins JD, Catalano RF, Abbott RD. Developmental relationships between adolescent substance use and risky sexual behavior in young adulthood. *Journal of Adolescent Health*. 2002; 31:354–362. [PubMed: 12359381]
- Hallfors DD, Waller MW, Bauer D, Ford C, Halpern CT. Which comes first in adolescence—sex and drugs or depression? *American Journal of Preventive Medicine*. 2005; 29:163–170. [PubMed: 16168864]
- Hallfors DD, Waller MW, Ford CA, Halpern CT, Brodish PH, Iritani B. Adolescent depression and suicide risk association with sex and drug behavior. *American Journal of Preventive Medicine*. 2004; 27:224–230. [PubMed: 15450635]
- Hawker DSJ, Boulton MJ. Twenty years' research on peer victimization and psychosocial maladjustment: A meta-analytic review of cross-sectional studies. *Journal of Child Psychology and Psychiatry*. 2000; 41:441–455. [PubMed: 10836674]
- Hix-Small H, Duncan TE, Duncan SC, Okut H. A multivariate associative finite growth mixture modeling approach examining adolescent alcohol and marijuana use. *Journal of Psychopathology and Behavioral Assessment*. 2004; 26:255–270.
- Hodges EVE, Perry DG. Personal and interpersonal antecedents and consequences of victimization by peers. *Journal of Personality and Social Psychology*. 1999; 76:677–685. [PubMed: 10234851]

- Huang, DYC.; Murphy, DA.; Hser, YI. Youth & Society. May 26. 2011 Developmental trajectory of sexual risk behaviors from adolescence to young adulthood. e-published ahead of printdoi: 10.007/0044118x11406747
- Jones BL, Nagin DS. Advances in group-based trajectory modeling and an SAS procedure for estimating them. *Sociological Methods and Research*. 2007; 35:542–571.
- Jones BL, Nagin DS, Roeder K. A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods and Research*. 2001; 29:374–394.
- Juvonen, J.; Graham, S. An attributional approach to peer victimization. In: Juvonen, J.; Graham, S., editors. *Peer harassment in school: The plight of the vulnerable and victimized*. Guilford; New York: 2001. p. 332-351.
- Kandel, DB. Examining the Gateway Hypothesis: Stages and pathways of drug involvement. In: Kandel, DB., editor. *Stages and pathways of drug involvement: Examining the Gateway Hypothesis*. Cambridge University Press; New York: 2002. p. 3-18.
- Kochenderfer-Ladd B. Peer victimization: The role of emotions in adaptive and maladaptive coping. *Social Development*. 2004; 13:329–349.
- Kokkevi A, Richardson C, Florescu S, Kuzman M, Stergar E. Psychosocial correlates of substance use in adolescence: A cross-national study in six European countries. *Drug and Alcohol Dependence*. 2007; 86:67–74. [PubMed: 16837140]
- Lerner RM, Galambos NL. Adolescent development: Challenges and opportunities for research, programs, and policies. *Annual Review of Psychology*. 1998; 49:413–46.
- Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. *Biometrika*. 2001; 88:767–778.
- Mason WA, Windle M. Reciprocal relations between adolescent substance use and delinquency: A longitudinal latent variable analysis. *Journal of Abnormal Psychology*. 2002; 111:63–76. [PubMed: 11866180]
- McCarty CA, Kosterman R, Mason WA, McCauley E, Hawkins JD, Herrenkohl TI, Lengua LJ. Longitudinal associations among depression, obesity and alcohol use disorders in young adulthood. *General Hospital Psychiatry*. 2009; 31:442–450. [PubMed: 19703638]
- McGee R, Williams S, Poulton R, Moffitt T. A longitudinal study of cannabis use and mental health from adolescence to early adulthood. *Addiction*. 2000; 95:491–503. [PubMed: 10829326]
- Millstein SG, Moscicki A. Sexually-transmitted disease in female adolescents: Effects of psychosocial factors and high risk behaviors. *Journal of Adolescent Health*. 1995; 17:83–90. [PubMed: 7495830]
- Muthén B, Muthén LK. Integrating person-centered and variable-centered analyses: Growth mixture modeling with latent trajectory classes. *Alcoholism: Clinical and Experimental Research*. 2000; 24:882–891.
- Muthén, LK.; Muthén, B. *Mplus User's Guide*. Third Edition. Muthén & Muthén; Los Angeles, CA: 2007.
- Nagin DS, Tremblay RE. Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychological Methods*. 2001; 6:18–34. [PubMed: 11285809]
- Patterson, GR.; Capaldi, DM. A mediational model for boys' depressed mood. In: Rolf, JE.; Masten, AS.; Cicchetti, D.; Nuechterlein, KH.; Weintraub, S., editors. *Risk and protective factors in the development of psychopathology*. Cambridge University Press; New York: 1990. p. 141-163.
- Pedersen W, Samuelsen SO, Wichstrom L. Intercourse debut age: Poor resources, problem behavior, or romantic appeal? A population-based longitudinal study. *Journal of Sex Research*. 2003; 40:333–345. [PubMed: 14735407]
- Rashad I, Kaestner R. Teenage sex, drugs and alcohol use: Problem identifying the cause of risky behaviors. *Journal of Health Economics*. 2004; 23:493–503. [PubMed: 15120467]
- Rumpf H, Meyer C, Hapke U, John U. Screening for mental health: Validity of the MHI-5 using DSM-IV Axis I psychiatric disorders as gold standard. *Psychiatry Research*. 2001; 105:243–253. [PubMed: 11814543]
- Schofield HT, Bierman KL, Heinrichs B, Nix RL, Conduct Problems Prevention Research Group. Predicting early sexual activity with behavior problems exhibited at school entry and in early adolescence. *Journal of Abnormal Child Psychology*. 2008; 36:1175–1188. [PubMed: 18607716]

- Silk JS, Steinberg L, Morris AS. Adolescents' emotion regulation in daily life: Links to depressive symptoms and problem behavior. *Child Development*. 2003; 74:1869–1880. [PubMed: 14669901]
- Snyder J, Brooker M, Patrick MR, Snyder A, Schrepferman L, Stoolmiller M. Observed peer victimization during early elementary school: Continuity, growth, and relation to risk for childhood antisocial and depressive behavior. *Child Development*. 2003; 74:1881–1898. [PubMed: 14669902]
- Steinberg L. Risk taking in adolescence: What Changes, and Why? *Annals of the New York Academy of Sciences*. 2006; 1021:51–58. [PubMed: 15251873]
- Steinberg L. A social neuroscience perspective on adolescent risk-taking. *Developmental Review*. 2008; 28:78–106. [PubMed: 18509515]
- Storch EA, Nock MK, Masia-Warner C, Barlas ME. Peer victimization and social-psychological adjustment in Hispanic and African-American children. *Journal of Child and Family Studies*. 2003; 12:439–452.
- Strand PS. Treating antisocial behavior: A context for substance abuse prevention. *Clinical Psychology Review*. 2002; 22:707–728. [PubMed: 12113202]
- Tapert SF, Aarons GA, Sedilar G. Adolescent substance use and sexual risk-taking behavior. *Journal of Adolescent Health*. 2001; 28:181–189. [PubMed: 11226840]
- Thornberry TP, Lizotte AJ, Krohn MD, Smith CA, Porter PK. Causes and consequences of delinquency: Findings from the Rochester youth development study. *Longitudinal Research in the Social and Behavioral Sciences: An Interdisciplinary Series*. 2003:11–46.
- U.S. Department of Labor. Bureau of Labor Statistics. The NLSY97. 2008. Retrieved March 14, 2008, from <http://www.bls.gov/nls/nlsy97.htm>
- Wiesner M, Windle M. Young adult substance use and depression as a consequence of delinquency trajectories during middle adolescence. *Journal of Research on Adolescence*. 2006; 16:239–264.
- Wu J, Witkiewitz K, McMahon RJ, Dodge KA, Conduct Problems Prevention Research Group. A parallel process growth mixture model of conduct problems and substance use with risky sexual behavior. *Drug and Alcohol Dependence*. 2010; 111:207–214. [PubMed: 20558013]
- Yamazaki S, Fukuhara S, Green J. Usefulness of five-item and three-item mental health inventories to screen for depressive symptoms in the general population of Japan. *Health and Quality of Life Outcomes*. 2005; 3:1–7. [PubMed: 15634354]

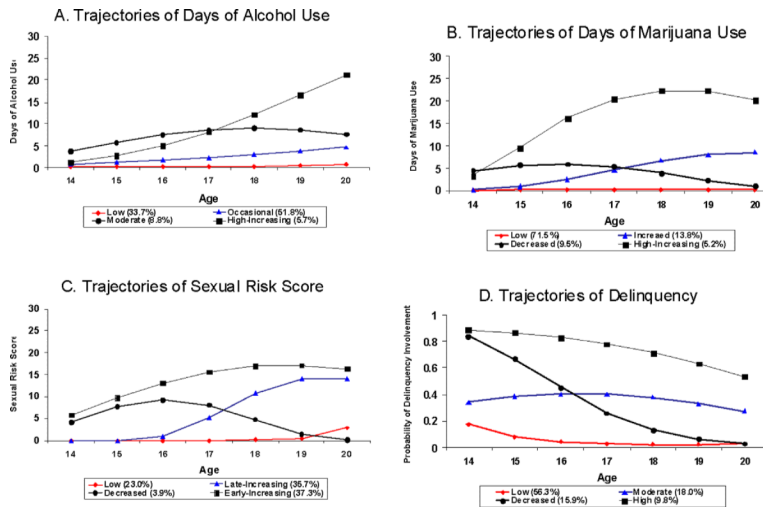


Figure 1. Distinctive Trajectories of Adolescent Risk Behaviors from Ages 14 to 20

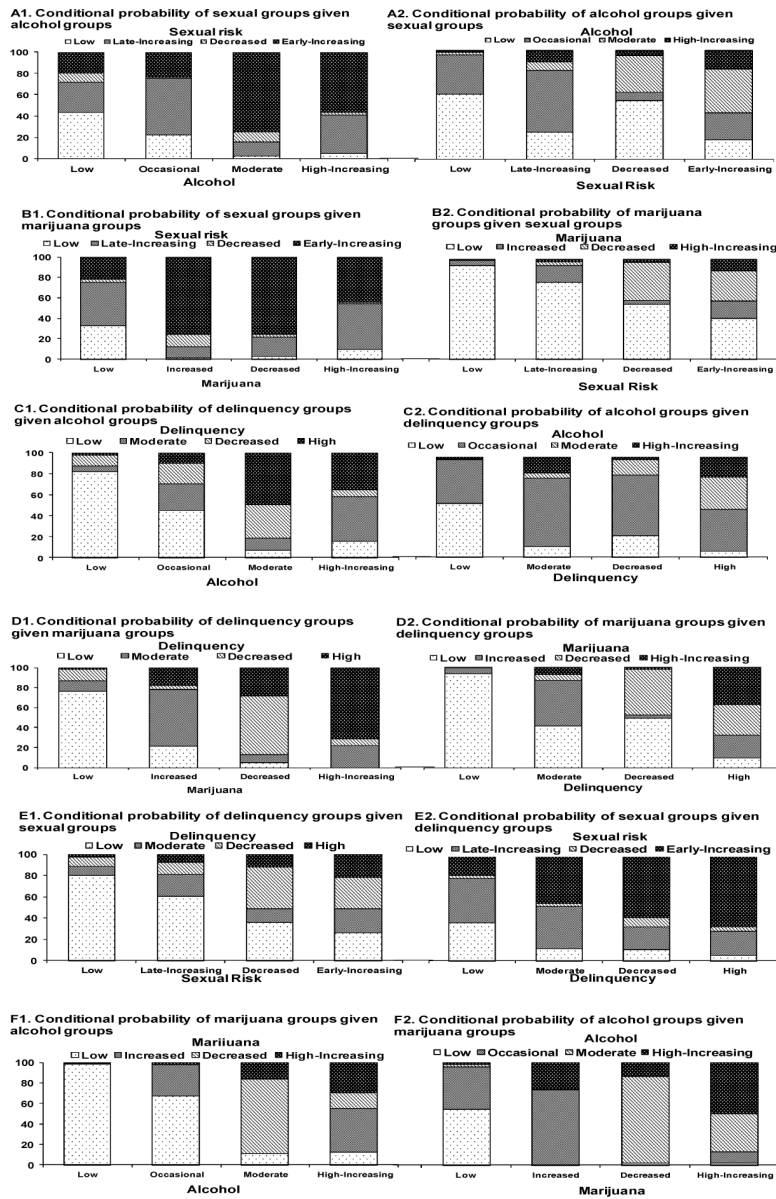


Figure 2. Conditional Probabilities of Trajectory Memberships between Two of the Four Behaviors

Table 1

Age of participants across survey years

Wave of survey	Year of survey	<u>Age of birth cohort</u>		
		1982	1983	1984
1	1997	14	13	12
2	1998	15	14	13
3	1999	16	15	14
4	2000	17	16	15
5	2001	18	17	16
6	2002	19	18	17
7	2003	20	19	18
8	2004	21	20	19
9	2005	22	21	20
10	2006	23	22	21
11	2007	24	23	22

Table 2

Goodness of model fit: Bayesian Information Index (BIC) by number of trajectory groups

	Alcohol use	Marijuana use	Delinquency	Sexual risk
Number of trajectory groups	BIC	BIC	BIC	BIC
2	-60138.3	-29001.3	-14788.8	-68329.1
3	-59443.2	-28565.2	-14683.4	-66756.8
4	-59267.6	-28448.6	-14638.9	-66480.1
5	-59134.6 ^a	-28380.7 ^b	Not-converged	Not-converged

^aNon-significant LMR-LRT on five-trajectory model vs. four-trajectory model with $p = 0.20$.

^bNon-significant LMR-LRT on five-trajectory model vs. four-trajectory model with $p = 0.05$.

Table 3

Multiple regression analysis on association of the identified trajectory groups with depressive symptom score

Covariates	Alcohol use	Marijuana use	Sexual risk	Delinquency
	Estimate ^a	Estimate ^a	Estimate ^a	Estimate ^a
Alcohol use trajectories				
Occasional (vs. Low)	0.10**			
Moderate (vs. Low)	0.09**			
High-Increasing (vs. Low)	0.07**			
Marijuana use trajectories				
Decreased (vs. Low)		0.09 ^a		
Increased (vs. Low)		0.09**		
High-Increasing (vs. Low)		0.09**		
Sexual risk trajectories				
Decreased (vs. Low)			0.04*	
Late-Increasing (vs. Low)			0.06**	
Early-Increasing (vs. Low)			0.11**	
Delinquency trajectories				
Decreased (vs. Low)				0.08**
Moderate (vs. Low)				0.15**
High (vs. Low)				0.18**
Males (vs. females)	-0.18**	-0.19**	-0.18**	-0.22**
Hispanics (vs. Whites)	-0.01	-0.01	-0.02	-0.01
African-Americans (vs. Whites)	0.02	0.00	-0.02	-0.01
Others (vs. Whites)	0.01	0.00	0.00	0.00

^aThe estimate of depressive symptom score is the standardized β .* $p < 0.05$;** $p < 0.01$