Published in final edited form as:

Addict Behav. 2018 January ; 76: 34–40. doi:10.1016/j.addbeh.2017.07.019.

Adolescent Peer Networks and the Moderating Role of Depressive Symptoms on Developmental Trajectories of Cannabis Use

Michael S. Pollard^a, Joan S. Tucker^a, Harold D. Green^a, Kayla de la Haye^b, and Dorothy L. Espelage^c

^aRAND Corporation, 1776 Main Street, P.O. Box 3128, Santa Monica, CA 90407-2138, United States

^bUniversity of Southern California, Keck School of Medicine

^cUniversity of Florida, Department of Psychology

Abstract

This paper investigated how depressive symptoms moderate the role of peer cannabis use on developmental patterns of individual cannabis use from adolescence to young adulthood, controlling for a broad set of individual and family factors. Data from two sources were analyzed separately: two saturated schools in the National Longitudinal Study of Adolescent to Adult Health Waves I – III ($N=1,550$) covering 1994–2001; and three schools in the CARBIN study, covering 2012–2014. Discrete mixture models identified developmental trajectories of cannabis use in each data source, and logit models linked network and depressive symptom information to the trajectories. Five similar cannabis use trajectories were identified in both datasets: Nonuse, Low, Moderate, Increasing, and High. Peer cannabis use at baseline predicted higher individual cannabis use trajectories, controlling for a wide range of factors. However, the association between peer cannabis use and higher levels of use (Moderate and High) attenuated as the adolescent's level of depressive symptoms increased. Although these results may suggest that depression dampens adolescents' susceptibility to peer influence, these results are also consistent with the notion that depressed adolescents withdraw from their peer groups, distancing them from the initial source of peer influence over time. The resulting isolation may place adolescents at higher risk of adverse outcomes.

Corresponding Author: Michael S. Pollard, mpollard@rand.org, Phone 310-393-0411 x7627, Fax 310-260-8160.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Contributors

Dr. Pollard was primarily responsible for the design of the study and conducting the data analysis. Dr. Tucker assisted with the design of the study and literature review, as well as co-wrote the first draft of the manuscript with Dr. Pollard. Drs. de la Haye, Green, and Espelage provided assistance in interpretation of findings and feedback on drafts of the manuscript. All authors have read and approved the final version of the manuscript.

Conflict of Interest

All authors declare that they have no conflicts of interest.

1. Introduction

Past-year cannabis use among high school seniors now exceeds one in three, up from one in five in 1991 (Johnston et al. 2016). Cannabis use during adolescence is associated with abuse of other drugs and other deviant behaviors, such as theft and selling drugs, in young adulthood (Tucker et al. 2005). Peer relationships are a key context in which adolescents are acculturated and learn social behaviors (Brechwald & Prinstein, 2011). Exposure to substance-using peers is positively associated with cannabis *initiation* (Buu et al. 2009; de la Haye et al 2013; Dishion & Loeber 1985; Hoffman 1995; Tucker et al. 2013) and *level of use* (Juon et al 2011; Tucker et al. 2014; Washburn & Capaldi 2014; Windle & Wiesner 2004). There is substantial variation in the patterns of adolescent cannabis use over time (Epstein, Hill & Nevell 2015; Johnson & Hopfer 2016), and the influence of peers on the overall *developmental trajectory* of cannabis use from adolescence to young adulthood is substantially less clear.

Depression – one of the most common mental health issues among adolescents – is also rising, with 12-month major depressive episode prevalence up from 8.7% in 2005 to 11.3% in 2014 (Mojtabai, Olfson & Han 2016); most adolescents report some depressive symptoms during this critical developmental period (Bluth et al 2016). Subclinical levels of depression also contribute to negative outcomes among adolescents (Cantwell & Baker 1991; Kessler et al. 1994). The majority of studies on adolescent depression and substance use focus on alcohol and tobacco, but a small number include depression as a predictor of cannabis use. These studies tend to focus on clinical or high levels of depressive symptoms, but a few examine the more common experience of subclinical depressive symptoms. Kelder et al. (2001) found that among middle school students in Houston, adolescents with more depressive symptoms were also more likely to use cannabis. Diego, Field, and Sanders (2003) found the same result among high school seniors in Florida. Explanations for the link between depression and cannabis use invoke Khantzian's (1985) self-medication hypothesis, which suggests adolescents use substances to cope with psychological distress, or that depressed people will be more motivated to believe substance use will improve their mood (Friedman-Wheeler et al., 2007; Fucito & Julianao 2009).

The trends of increasing cannabis use and depression during adolescence suggest that this is a high-risk period for the confluence of these two problems that could lead to serious consequences (Brent & Birmaher 2002), particularly as evidence indicates that the co-occurrence of substance use disorders and depression is associated with especially poor clinical prognoses (Rao, 2006). A recent literature review of studies from 1991–2013 found that many individual-level factors moderated and magnified the influence of peers on adolescent cannabis use, including personality factors such as risk-taking, sensation-seeking, and social anxiety (Marschall-Lévesque et al, 2014). However, none of these studies considered depression. Only one study examined whether depressive symptoms moderated the association between peers' and adolescents' substance use (as well as violent and suicidal behaviors) – a cross-sectional study with 527 adolescents at an urban New England high school (Prinstein, Boergers, & Spirito 2001). Although depression moderated peer effects on fighting and suicidal behaviors, depression did not moderate peer behaviors on cannabis use, smoking, or drinking.

Given this limited literature, much remains to be learned about the potential for depressive symptoms to moderate the role of peer influence on personal cannabis use. The present study aimed to address this critical gap in our understanding of: (1) peer effects on adolescent cannabis use trajectories, and: (2) whether the influence of peer substance use is moderated by depressive symptoms. We used data from two sources, separated by twenty years, to address these questions. Using multiple data sources, capturing different eras, and complimentary analyses, helped validate our results.

2. Material and Methods – Add Health

2.1 Participants and Data Collection

Add Health—Data came from Waves I–III of Add Health, a school-based probability sample of American adolescents in Grades 7–12 during the 1994–95 school year. The analytic sample for this study focused on the two “saturated” schools, in which all enrolled students were invited to participate, and that met the data requirements for our network analysis (excluded schools were too small in size or had too much missing data; see de la Haye et al. 2013), resulting in a total sample of $N=1,550$. These two schools comprised 66% of the total Add Health saturated sample and had the most complete network information, allowing valid inferences to be made about school-based peer network structures. Retention rates at Wave II were 88% in School 1 and 87% in School 2, with 80% retained at Wave III (2001–02). See Harris et al. 2008 for more details on the study design and longitudinal data. An important strength of this dataset is that all students in the “saturated” schools completed a similar friendship nomination process, allowing for rigorous identification of friendship networks, as well as providing reports of substance use behaviors from each respondent, rather than relying on an individual’s perception of his or her friends’ substance use.

CARBIN—Data came from waves 6 (spring 2012), 7 (spring 2013), and 9 (spring 2014) of CARBIN¹. Participants were part of the University of Illinois Bullying and Violence Study (Espelage, Basile & Hamburger 2012). All students in 6th–8th grades from three diverse Midwestern public middle schools were initially invited to participate in the study during Spring 2008. Data were collected through in-school paper surveys biannually from Spring 2008 until Spring 2010 (Waves 1–5), and then again in Spring 2012 (Wave 6) and 2013 (Wave 7). Incoming students were recruited into the study at each wave. The analytic sample included those students with observations in at least two of the three analytic waves ($N=1,304$; 1,020 students appeared only once).

2.2 Measures

Add Health—Cannabis use trajectory group membership was based on the following item at each wave: “During the past 30 days, how many times did you use marijuana?” Trajectories were based on the number of cannabis uses per month at each of these waves. See section 2.3.1 for how these trajectories were identified. Peer substance use was based on proportions of school-based friendship network members who were cannabis users and

¹Wave 8 (fall 2013) only collected data from a small subsample of students as a pilot of the EgoWeb computerized data collection tool, used in Wave 9. Only these three waves are considered as they begin to cover the high school years of interest.

heavy drinkers, and were derived from those individuals' own responses. Respondents were asked to nominate up to five male and five female friends. Nominated friends were linked to their own survey responses to assess peer substance use. From this information we calculated the proportion of friendship network members (other than the ego) who reported: a) any past month cannabis use; and b) any past year heavy drinking, defined as "five or more drinks in a row" (past month heavy drinking was not assessed). See section 2.3.2 for how these networks were identified. Depressive symptoms were measured with a 10-item derivative of the CES-D scale (range 0–30, $\alpha=.81$; see Meadows, Brown & Elder 2006 for scale details). Control variables previously linked to substance use included gender, race/ethnicity, household income (reported by parent), baseline frequency of heavy drinking during the past 30 days (total past-year heavy drink episodes were converted to a monthly average), delinquency (assessed using 14 items from the Add Health delinquency scale – one item on drug selling was excluded – which asked how often the adolescent engaged in various behaviors in the past 12 months [0 = never to 3 = 5 or more times] range 0–39, $\alpha=.83$), low school engagement (6 items, assessing whether the student felt close to people at school, felt like a part of the school, and how often they had trouble getting along with teachers and other students; higher scores indicated less closeness and integration range 0–24, $\alpha=.76$), a self-esteem scale assessed by averaging respondents' agreement (1 = strongly disagree, 5=strongly agree) with three statements ("you have a lot of good qualities," "you like yourself the way you are," and "you feel loved and wanted") (3 items; range 0–12, $\alpha=.72$), closeness to mother (1 item; range 0–5), and whether illegal drugs are "easily available" in their home (1 item). We included a four-item active coping index (range 0–16, $\alpha=.74$). We also controlled for overall peer group size (mean = 8.4), and number of nominated friends who did not attend that school (were outside-of-school friends; mean = 1.75).

CARBIN—Cannabis use trajectory group membership reflected the number of cannabis use days per month, and was based on the following item at each wave: "During the past 30 days, how many days did you use marijuana?" See section 2.4.1 for how these trajectories were identified. Peer substance use was assessed at each wave by asking students: "who are the kids at school that you hang out with the most [excluding siblings]?" They could nominate up to eight students. Nominated individuals were considered part of the adolescent's *peer group*, and peer group *size* and *mean monthly peer group use* of alcohol and cannabis at baseline were based on these nominated individuals' reports of their own behaviors. Note that in CARBIN analyses we focused on overall level of peer substance use, rather than on proportion of the network using substances (as in the Add Health analysis) to maximize variation. Depressive symptoms were assessed with mean rating on the 5-item Modified Depression Scale (Dunn et al., 2012) (range 0–3, $\alpha=.79$). Control variables included gender, race/ethnicity, days used alcohol in the past 30 days, delinquency (5 items, range 0–4, $\alpha=.66$), and peer group size assessed at the first analytic wave. Participants' "degree centrality" – the total number of friendship ties they sent and/or received from other participating school-mates – was computed as a measure of popularity within each school. Friendship nominations were also used to construct broader *friendship community* structures for each school, at each wave, using community detection algorithms. Mean levels of alcohol and cannabis use among the broader friendship communities were also constructed using individuals' own reports of substance use (see 2.4.2).

2.3 Analytic Approach: Add Health

2.3.1 Identifying trajectory group membership—We used PROC TRAJ in SAS 9.1.3 to perform latent class growth analysis (Nagin 1999) and identify the discrete developmental trajectories of cannabis use from the number of use episodes per month each year. Unlike latent growth curve analysis techniques that combine structural equation modeling and hierarchical linear modeling (Duncan et al 1999), in which the model structure is severely hampered with only three data points, the latent class analysis method relies on a multinomial modeling strategy (estimating the parameters of finite mixture models by maximum likelihood), permitting cross-group differences in the level and shape of trajectories in a fashion that is much more flexible with few data points (Jones, Nagin & Roedder 2001; Nagin & Tremblay 2001). This procedure has previously been applied to Add Health data to identify trajectories of smoking (Pollard et al. 2010), depression (Costello et al 2008) and delinquency (Aalsma & Tong 2008). Because of the high proportion of non-users, we used a zero-inflated Poisson (ZIP) model specification. See Jones et al. (2001) for a detailed discussion of the likelihood function and estimation of these models.

Trajectories were calculated based on grades 10 and 11 at baseline in the two saturated schools. Note that as a consistency check we were able to replicate a similar model in the full Add Health (grades 10 and 11) sample. The BIC criterion is generally used to determine the optimal number of trajectory groups when testing latent class growth models (e.g. Laub, Nagin & Sampson 1998). The model with the smallest absolute BIC is chosen. The BIC rewards parsimony and tends to favor fewer groups. Respondents were assigned to the trajectory for which they had the largest posterior probability estimate (Muthén & Shedden 1999). The probability of membership was also used to adjust the sample weights (multiplied by the probability), so that individuals with better fit to their assigned trajectory had higher weights in subsequent analysis, while those with poorer fits had lower weights (see Jones et al., 2001).

2.3.2 Identifying peer networks—Wave I peer networks were modeled using NEGOPY, which is based on Eigenvector decomposition and detects groups via iterative averaging (comparing percentage of ties within groups versus between groups). NEGOPY derives groups of connected nodes in the data, where “peer network groups” are comprised of those ties with 50% or more ties directed to members of the same group. Network ties were also weighted to incorporate information about tie strength, based primarily on reciprocated tie nominations and an additional series of questions regarding the level of dyadic activity (e.g., whether the focal individual visits the nominee’s home or talks with the nominated over the phone; see Pollard et al. 2010). The resulting school-based friendship network groups had a mean group size of 23 (standard deviation 13.45).

2.3.3 Predicting trajectory group membership from network cannabis use and depressive symptoms—Once trajectory groups were identified, and individuals were assigned to trajectories, a multinomial logit model of trajectory group membership was estimated, including information on proportion of network using cannabis, depressive symptoms, all controls, as well as interactions between depressive symptoms and proportion of the network using cannabis. We incorporated sample weights in Add Health analyses.

2.4 Analytic approach: CARBIN

Analysis of the CARBIN data was analogous to the Add Health analyses described in section 2.3, although the specific variables used in the estimation of trajectories and peer networks differed.

2.4.1 Identifying trajectory group membership—Unlike the Add Health trajectory estimation, where observations for grades 10 and 11 were pooled and modeled for individuals with all three time points, for the CARBIN data we constructed a synthetic cohort of grade 9 students through grade 12 in order to maximize the available data. Respondents with at least two observations in grades 9–12 in the three waves were included in the estimation. Thus, although we had observed data for three waves, we were able to construct synthetic cohorts across four data points. PROC TRAJ was used with a ZIP specification.

2.4.2 Identifying peer networks—Peer groups were assessed by focal adolescent nominations. To capture broader peer network effects we also assessed school peer community groups, conceptually akin to the peer groups identified using NEGOPY – albeit with a more contemporary implementation. To identify communities within each network (for each grade and wave) we employed an edge-betweenness algorithm, which is an approach to maximize Girvan-Newman modularity (i.e., a community has greater proportion of internal connections relative to external connections, as in NEGOPY) (Girvan & Newman, 2002). At the completion of the algorithm, each individual in the network was assigned to a mutually exclusive community subgroup at each Wave.

2.4.3 Predicting trajectory group membership from network cannabis use and depressive symptoms—The multinomial logit approach described in 2.3.3 was also used for CARBIN data, including information on peer group and community level use of alcohol and cannabis, depressive symptoms, control variables, as well as interactions between depressive symptoms and peer level cannabis use.

3 Results

3.1 Estimated cannabis use trajectories

Latent class growth analyses results are shown in Figures 1 (Add Health) and 2 (CARBIN). Sequential comparisons of models with k and $k + 1$ classes indicated that a five-class model provided the best fit to the data in both cases. The five-class model also produced well-defined classes; mean group assignment probabilities for the five classes range from 82% to 99% for Add Health, and 76% to 91% for CARBIN. These predicted probabilities are generally in keeping with similar trajectory analyses (e.g., Orlando et al. 2004; Pollard et al. 2010). The five classes are Non-use (Add Health: 43%; CARBIN: 73%), Low (Add Health: 45%; CARBIN: 10%), Moderate (Add Health: 7%; CARBIN: 4%), Increasing (4% in both datasets), and High (Add Health: 1%; CARBIN: 9%).

For Add Health, the Non-use group consistently reported no cannabis use, the Low group reported no or very low levels of use, and the Moderate group reported using roughly 15

times per month over the six year follow-up period. The Increasing group was initially similar to the Non-use group, but after six years they were among the heaviest users, averaging roughly daily use. The High group consistently used cannabis between 25–50 times per month throughout the follow-up period. For CARBIN, the Non-use group consistently reported no cannabis use, the Low group reported no or very low levels of use, and the Moderate group reported using roughly 5 days per month between grades 9 and 12. The Increasing group was initially similar to the Non-use group, but as with the Add Health trajectories, by grade 12 they were the heaviest users, averaging use roughly every other day. The High group used cannabis between 9 and 14 days per month throughout the observation period. Note that in the more recent CARBIN data, cohort trends in cannabis use are reflected in the lower proportion of adolescents reporting non-use than in the Add health data from two decades earlier.

3.2 Predicted trajectory group membership

Using the set of identified trajectories, a multinomial logistic regression was estimated for the Add Health sample and summarized in Table 2. The model predicted trajectory membership as a function of social network substance use, controlling for behavioral risk and family factors, as well as an interaction between depressive symptoms and proportion of network using cannabis. Results indicated that the proportion of network members using cannabis predicted a higher likelihood of being in the Moderate and High trajectory groups, and lower likelihood of being in the Non-use trajectory group (compared to the Low use trajectory group). However, the interaction between depressive symptoms and proportion of network members using cannabis indicated that there was a significant, albeit slight, attenuation of the peer effect for membership in the Moderate trajectory group. A similar attenuation was observed for the High trajectory group, but was not significant.

Table 3 similarly presents the results predicting trajectory membership based on the CARBIN data. Results indicated that the frequency of peer cannabis use predicted a higher likelihood of belonging to the High trajectory, while community level cannabis use predicted a lower likelihood of belonging to the Non-use trajectory. As in the Add Health models, the interaction between depressive symptoms and peer group cannabis use indicated that there was a significant, (this time substantial), attenuation of the peer effect for membership in the High trajectory.

4 Discussion

Our results identified a conceptually similar set of five developmental trajectories of adolescent cannabis use in both the Add Health and CARBIN data: Non-use, Low, Moderate, High, and Increasing use over time. Further, in both data sets, greater friendship network cannabis use (either proportion of friends or quantity of use) at baseline predicted membership in higher cannabis use trajectories over time, controlling for a range of factors. However, in both data sets, the impact of peer cannabis use on the higher use trajectories was attenuated as the level of depressive symptoms increased: peer effects on Moderate cannabis use attenuated as level of depressive symptoms increased in Add Health, and peer effects on High cannabis use attenuated with higher levels of symptoms in CARBIN.

This could suggest that depressive symptoms dampen adolescents' susceptibility to peer influence. Laboratory studies have shown that the subjective effects of tobacco and nicotine vary by depression status, such that people with greater depressive symptoms are more motivated to smoke as a means to elevate mood than people with fewer symptoms (Fucito & Juliano 2009; Malpass & Higgs 2007; Spring et al. 2008). However, in this study we saw an opposite effect; adolescents with greater depressive symptoms may have been less motivated to use cannabis to elevate their mood than those with fewer depressive symptoms.

The result is consistent with other work from Add Health indicating that depressed adolescents withdraw from their peer groups over time, leaving them with fewer friends (e.g., Schaefer, Kornienko & Fox 2011; Van Zalk et al. 2010). Thus, they may be distancing themselves from the initial source of peer influence over time. As depressed adolescents withdraw, they become more marginalized in the broader network and are left in network positions that are less conducive to forming new relationships. Although this may serve to constrain their cannabis use to lower levels, the resulting isolation may place depressed cannabis users at higher risk of other adverse outcomes due to a relative disconnect from the social contexts in which adolescents develop social skills and learn appropriate social behaviors. However, we did not see the same social disengagement from the adolescents in CARBIN, in terms of reducing numbers of friendship ties over time, or in terms of movement to network structures that are less conducive to creating new ties. Future research should directly examine the impact of changes in friendship networks on substance use behaviors among depressed adolescents, and vice-versa.

Several study limitations should be noted. Analyses were based on a small number of schools, and there is no nationally representative adolescent social network data with which to broaden the basis of these findings. We also could not distinguish between minor depression and severe depression, nor determine whether adolescents were on prescription medications for depression or other reasons. If cannabis use causes unpleasant side effects of certain types of antidepressant medication to worsen, or if some medications reduce craving for cannabis, it could be a possible mechanism that contributed to our results. Depressive symptoms and peer use were assessed here only at baseline, although it was possible that both varied throughout the observation period. The lack of temporal precedence for depressive symptoms or peer measures at baseline also introduced the possibility of an alternate interpretation of the results: that peer cannabis use moderated the role of depression (rather than depression moderating peer effects), such that depressive symptoms were less predictive of higher cannabis use trajectories when a greater proportion of peers used cannabis. That is, adolescents who reported greater levels of depressive symptoms were more likely to belong to higher use trajectories, but less so when they also had greater levels of peer use.²

The measurement of key variables also differed in each dataset. While the persistence of significant results despite these differences speaks to the robustness of the conclusions, some

²We thank an anonymous reviewer for suggesting this interpretation. However, the main effects of depressive symptoms are consistently less prevalent than the main effects of peer use, which suggests to us that the interpretation that peer effects are moderated by depression, rather than the reverse, is more likely.

further limitations should be noted. Friendship nomination approaches differed: the Add Health approach collected up to five male and five female friends, while the CARBIN data collected up to eight of any sex. The extent to which these kinds of variations impact the measurement of network structures should be examined in future research. The measures of depressive symptoms were not identical, although they did reflect the same recall period, the same range, and overlapped on several items. Similarly, the measures of cannabis use were not identical: in Add Health the measure referred to the number of uses, while CARBIN collected information on the number of use days. Both measures were single-item variables, which may be subject to bias in self-reporting of substance use behaviors. Further, as the use measures were not identical in each of the data collection periods, we do not suggest directly comparing the magnitudes of effects to identify cohort (and/or period) differences. Rather, we suggest focus be limited to the presence and absence of variable effects.

Despite these limitations, the significant predictive power of these differing baseline measures on the adolescent's developmental trajectory indicates the strength and importance of these characteristics. This study demonstrated the robustness of the moderating effect of depressive symptoms on the influence of peer cannabis use on developmental trajectories of personal cannabis use in two distinct data sets, reflecting two separate periods, and with complementary variables and measures of peer networks. This suggests that role of depression on adolescent cannabis use is worthy of expanded attention, particularly given the recent increases in both.

Acknowledgments

Funding for this study was provided by NIDA grants R01DA030380 (PI: Joan S Tucker) and R01DA033280-01 (PI: Harold D. Green) and grant # 2011-90948-IL-IJ from the National Institute of Justice (PI: Dorothy Espelage)

Role of Funding Sources

Funding for this study was provided by NIDA grants R01DA030380 (PI: Joan S Tucker) and R01DA033280-01 (PI: Harold D. Green). NIDA had no role in the study design, collection, analysis, or interpretations of the data, writing the manuscript, or the decision to submit the paper for publication.

This research uses data from Add Health, a program project designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris, and funded by a grant P01-HD31921 from the National Institute of Child Health and Human Development, with Cooperative funding from 17 other agencies. Special acknowledgment is due Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Persons interested in obtaining data files from Add Health should contact Add Health, Carolina Population Center, 123 W. Franklin Street, Chapel Hill, NC 27516-2524 (addhealth@unc.edu).

References

- Aalsma M, Tong Y. Delinquency trajectories and young adult health care access. *Journal of Adolescent Health*. 2008; 42:15–15.
- Avenevoli, S., Knight, S., Kessler, RC., Merikangas, KR. *Epidemiology of Depression in Children and Adolescents*. New York: Guilford Press; 2008.
- Bluth K, Campo RA, Futch WS, Gaylord SA. Age and gender differences in the associations of self-compassion and emotional well-being in a large adolescent sample. *Journal of Youth and Adolescence*. 2016; doi: 10.1007/s10964-016-0567-2
- Brechwald WA, Prinstein MJ. Beyond homophily: A decade of advances in understanding peer influence processes. *Journal of Research on Adolescence*. 2011; 21:166–179. [PubMed: 23730122]

- Brent DA, Birmaher B. Adolescent depression. *New England Journal of Medicine*. 2002; 347:667–671. [PubMed: 12200555]
- Buu A, DiPiazza C, Wang J, Puttler LI, Fitzgerald HE, Zucker RA. Parent, family, and neighborhood effects on the development of child substance use and other psychopathology from preschool to the start of adulthood. *Journal of Study of Alcohol and Drugs*. 2009; 70:489–498.
- Cantwell DP, Baker L. Manifestations of depressive affect in adolescence. *Journal of Youth and Adolescence*. 1991; 20:121–133. [PubMed: 24265002]
- Chantala, K., Tabor, J. Strategies to Perform a Design-Based Analysis Using the Add Health Data. University of North Carolina at Chapel Hill; 1999.
- Compass BE, Ey S, Grant KE. Taxonomy, assessment, and diagnosis of depression in adolescence. *Psychological Bulletin*. 1993; 114:323–344. [PubMed: 8416035]
- Costello DM, Swendsen J, Rose JS, Dierker LC. Risk and protective factors associated with trajectories of depressed mood from adolescence to early adulthood. *Journal of Consulting and Clinical Psychology*. 2008; 76:173–183. [PubMed: 18377115]
- de la Haye K, Green HD, Kennedy DP, Pollard MS, Tucker JS. Selection and influence mechanisms associated with marijuana initiation and use in adolescent friendship networks. *Journal of Research on Adolescence*. 2013; 23:474–486.
- Diego MA, Field TM, Sanders CE. Academic performance, popularity, and depression predict adolescent substance use. *Adolescence*. 2003; 38:35–42. [PubMed: 12803452]
- Dishion TJ, Loeber R. Adolescent marijuana and alcohol use: The role of parents and peers revisited. *American Journal of Drug and Alcohol Abuse*. 1985; 11:11–25. [PubMed: 4061428]
- Duncan, TE., Duncan, SC., Stryker, LA., Li, F., Alpert, A. An Introduction to Latent Variable Growth Curve Modeling: Concepts, Issues, and Applications. Mahwah, NJ: Erlbaum; 1999.
- Dunn EC, Johnson RM, Green JG. The Modified Depression Scale (MDS): A Brief, no-cost assessment tool to estimate the level of depressive symptoms in students and schools. *School Mental Health*. 2012; 4:34–45. [PubMed: 22639697]
- Epstein M, Hill KG, Nevell AM, Guttmanova K, Bailey JA, Abbott RD, Kosterman R, Hawkins JD. Trajectories of marijuana use from adolescence into adulthood: Environmental and individual correlates. *Developmental Psychology*. 2015; 51:1650–1663. [PubMed: 26389603]
- Espelage DL, Basile KC, Hamburger ME. Bullying perpetration and subsequent sexual violence perpetration among middle school students. *Journal of Adolescent Health*. 2012; 50:60–65. [PubMed: 22188835]
- Friedman-Wheeler DG, Ahrens AA, Haaga DAF, McIntosh E, Thorndike FP. Depressive symptoms, depression proneness, and outcome expectancies for cigarette smoking. *Cognitive Therapy and Research*. 2007; 31:547–557. [PubMed: 18074003]
- Fucito LM, Juliano LM. Effects of instructions on responses to the nicotine patch: A laboratory study. *Psychopharmacology*. 2007; 194:475–483. [PubMed: 17619862]
- Fucito LM, Juliano LM. Depression moderates smoking behavior in response to a sad mood induction. *Psychology of Addictive Behaviors*. 2009; 23:546–551. [PubMed: 19769439]
- Furr-Holden CD, Lee MH, Milam AJ, Johnson RM, Lee K, Ialongo NS. The growth of neighborhood disorder and marijuana use among urban adolescents: A case for policy and environmental interventions. *Journal of Study of Alcohol and Drugs*. 2011; 72:371–379.
- Girvan M, Newman MEJ. Community structure in social and biological networks. *Proceedings of the National Academy of Sciences in the United States of America*. 2002; 99:7821–7826.
- Harris, KM., Halpern, CT., Entzel, P., Tabor, J., Bearman, PS., Udry, JR. The National Longitudinal Study of Adolescent Health: Research Design. 2008. [WWW document]. URL: <http://www.cpc.unc.edu/projects/addhealth/design>
- Hoffman JP. The effects of family structure and family relations on adolescent marijuana use. *The International Journal of the Addictions*. 1995; 30:1207–1241. [PubMed: 7591341]
- Johnson C, Hopfer CJ. Ten-year trajectory of adolescent marijuana use. *Child & Adolescent Psychiatry*. 2016; 55:S147–S147.
- Johnston, LD., O'Malley, PM., Miech, RA., Bachman, JG., Schulenberg, JE. Overview, Key Findings on Adolescent Drug Use. Ann Arbor: Institute for Social Research, The University of Michigan; 2016. Monitoring the Future: National Results on Drug Use: 1975–2015.

- Jones BL, Nagin DS, Roeder K. A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods and Research*. 2001; 29:374–393.
- Juon H-S, Fothergill KE, Green KM, Doherty EE, Ensminger ME. Antecedents and consequences of marijuana use trajectories over the life course in an African American population. *Drug and Alcohol Dependence*. 2011; 118:216–223. [PubMed: 21514749]
- Kelder SH, Murray NG, Orpinas P, Prokhorov A, McReynolds L, Zhang Q, Roberts R. Depression and substance use in minority middle-school students. *American Journal of Public Health*. 2001; 91:761–766. [PubMed: 11344884]
- Kessler RC, McGonagle KA, Zhao S, Nelson CB, Hughes M, Eshleman S, Wittchen H-U, Kendler KS. Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. *Archives of General Psychiatry*. 1994; 51:8–19. [PubMed: 8279933]
- Khantzian EJ. The self-medication hypothesis of addictive disorders: Focus on heroin and cocaine dependence. *American Journal of Psychiatry*. 1985; 142:1259–1264. [PubMed: 3904487]
- Laub JH, Nagin DS, Sampson RJ. Trajectories of change in criminal offending: Good marriages and the desistance process. *American Sociological Review*. 1998; 63:225–238.
- Malpass D, Higgs S. Acute psychomotor, subjective and physiological responses to smoking in depressed outpatient smokers and matched controls. *Psychopharmacology*. 2007; 190:363–372. [PubMed: 17136518]
- Marschall-Lévesque S, Castellanos-Ryan N, Vitaro F, Séguin JR. Moderators of the association between peer and target adolescent substance use. *Addictive Behaviors*. 2014; 39:48–70. [PubMed: 24183303]
- Meadows S, Brown SJ, Elder GH. Depressive symptoms, stress, and support: Gendered trajectories from adolescence to young adulthood. *Journal of Youth and Adolescence*. 2006; 35:93–103.
- Mojtabai R, Olfson M, Han B. National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics*. 2016; 138:1–10.
- Muthén B, Shedden K. Finite mixture modeling with mixture outcomes using EM algorithm. *Biometrics*. 1999; 55:463–469. [PubMed: 11318201]
- Nagin DS. Analyzing developmental trajectories: A semiparametric group-based approach. *Psychological Methods*. 1999; 4:139–157.
- Nagin DS, Tremblay RE. Analyzing developmental trajectories of distinct but related behaviors: a group-based method. *Psychological Methods*. 2001; 4:139–177.
- Orlando M, Tucker JS, Ellickson PL, Klein DJ. Developmental trajectories of smoking and their correlates from early adolescence to young adulthood. *Journal of Consulting and Clinical Psychology*. 2004; 72:400–410. [PubMed: 15279524]
- Pollard MS, Tucker JS, Green HD, Kennedy D, Go M-H. Friendship Networks and Trajectories of Adolescent Tobacco Use. *Addictive Behaviors*. 2010; 35:678–685. [PubMed: 20332061]
- Prinstein MJ, Boergers J, Spirito A. Adolescents' and their friends' health-risk behavior: Factors that alter or add to peer influence. *Journal of Pediatric Psychology*. 2001; 26:287–298. [PubMed: 11390571]
- Rao U. Links between depression and substance abuse in adolescents: Neurobiological mechanisms. *American Journal of Preventative Medicine*. 2006; 31:161–174.
- Raudenbush, SW., Bryk, AS. *Hierarchical Linear Models: Applications and Data Analysis Methods* (Second Edition). Thousand Oaks, CA: Sage; 2002.
- Schaefer DR, Kornienko O, Fox AM. Misery does not love company: Network selection mechanisms and depression homophily. *American Sociological Review*. 2011; 76:764–785.
- Snedker KA, Herting JR, Walton E. Contextual effects and adolescent substance use: Exploring the role of neighborhoods. *Social Science Quarterly*. 2009; 90:1272–1297.
- Spring B, Cook JW, Appelhans B, Maloney A, Richmond M, Vaughn J, Vanderveen J, Hedeker D. Nicotine effects on affective response in depression-prone smokers. *Psychopharmacology*. 2008; 196:461–471. [PubMed: 17960366]
- Tucker JS, de la Haye K, Kennedy DP, Green HD, Pollard MS. Peer Influence on marijuana use in different types of friendships. *Journal of Adolescent Health*. 2014; 54:67–73. [PubMed: 24054813]

- Tucker JS, Ellickson PL, Orlando M, Martino SC, Klein DJ. Substance use trajectories from early adolescence to emerging adulthood: A comparison of smoking, binge drinking, and marijuana use. *Journal of Drug Issues*. 2005; 35:307–332.
- Tucker JS, Pollard MS, de la Haye K, Kennedy DP, Green HD. Neighborhood characteristics and the initiation of marijuana use and binge drinking. *Drug and Alcohol Dependence*. 2013; 128:83–89. [PubMed: 22938829]
- Van Zalk MH, Kerr M, Branje SJT, Stattin H, Meeus WHJ. It takes three: Selection, influence, and de-selection processes of depression in adolescent friendship networks. *Developmental Psychology*. 2010; 46:927–938. [PubMed: 20604612]
- Washburn IJ, Capaldi DM. Influences on boys' marijuana use in high school: A two-part random intercept growth model. *Journal of Research on Adolescence*. 2014; 24:117–130. [PubMed: 24976739]
- Windle M, Wiesner M. Trajectories of marijuana use from adolescence to young adulthood: Predictors and outcomes. *Development and Psychopathology*. 2004; 16:1007–1027. [PubMed: 15704825]

Highlights

- We model longitudinal trajectories of adolescent cannabis use in two data sets, separated by 18 years.
- We examine peer, family, and individual factors.
- Peer network marijuana use predicted higher trajectories.
- Greater levels of depressive symptoms attenuated the role of peer cannabis use.
- Results suggest depressed adolescents withdraw from peers, may become isolated.

Figure 1.
Trajectories of Monthly Cannabis Use: Grades 10–11 at Wave 1 (Add Health).

Figure 2.
Trajectories of Monthly Cannabis Use: (CARBIN).

Table 1

Description of Study Variables

Variable	Add Health		CARBIN	
	Mean or Proportion	(SD)	Mean or Proportion	(SD)
Male	0.53	0.50	0.45	0.50
White	0.28	0.45	0.44	0.50
Low Engagement	4.66	1.76	---	---
Drugs Available at Home	0.45	0.21	---	---
Closeness to Mother	4.38	0.87	---	---
Delinquency	5.10	5.77	0.39	0.45
Depressive Symptoms	13.59	7.81	0.39	0.45
Binge Drinking Days	1.20	3.82	1.22	1.70
Percent Friends Using Cannabis	22.22	17.18	---	---
Percent Friends Binge Drinking	31.98	20.77	---	---
Peer Group Size	23.00	13.45	5.12	2.21
Income	1.40	2.95	---	---
Self Esteem	6.37	2.10	---	---
Coping	8.52	2.46	---	---
Number of Outside-of-school Friends	1.75	1.92	---	---
Degree Centrality	---	---	8.42	4.58
Peer Group Alcohol Use Frequency	---	---	0.48	0.67
Peer Group Cannabis Use Frequency	---	---	0.70	1.00
Community Alcohol Use Frequency	---	---	0.49	0.32
Community Cannabis Use Frequency	---	---	0.82	0.56

Table 2
Estimated Relative Risk Ratios for Multinomial Logistic Regression Models Predicting Trajectory Membership

Add Health Data	Nonuse (N=700)	Increasing (N=68)	Moderate (N=107)	High (N=18)	Low (reference) (N=719)
Male	0.766 *	1.916 *	1.908 *	4.578	
White	0.77	1.208	0.723	0.894	
Low Engagement	0.975	1.054	1.164 *	1.649 ***	
Drugs Available at Home	0.866	2.459	4.228 ***	0.949	
Closeness to Mother	1.008	1.046	0.849	1.541	
Delinquency	0.937 ***	0.986	1.060 ***	1.083 *	
Depressive Symptoms	0.974 *	0.974	1.031	1.005	
Binge Drinking Days	0.938 **	1.013	1.041 *	0.929	
Percent Friends Using Cannabis	0.982 *	1.011	1.032 **	1.040 *	
Percent Friends Binge Drinking	0.996	1.000	1.006	1.008	
Group Size	0.998	0.990	1.009	0.997	
Income	0.992	0.889	1.05	0.783 *	
Self Esteem	1.03	1.038	0.983	0.901	
Coping	0.953 *	0.988	0.977	1.019	
Number of Outside-of-school Friends	0.936 *	1.066	1.113 *	1.075	
Dep. Symptoms * Proportion Using Cannabis	1.000	1.000	0.998 *	0.999	

*
p<.05,

**
p<.01,

p<.001

Table 3
Estimated Relative Risk Ratios for Multinomial Logistic Regression Models Predicting Trajectory Membership

CARBIN Data	Nonuse (N=950)	Increasing (N=56)	Moderate (N=56)	High (N=116)	Low (reference) (N=126)
Male	0.854	2.191	1.784	1.703	
White	1.533	1.178	0.947	0.905	
Depressive Symptoms	0.853	0.799	1.032	1.383	
Delinquency	0.417 ***	1.501	2.108 **	2.805 ***	
Alcohol Use Frequency	0.735 ***	1.073	1.094	0.966	
Degree Centrality	0.99	1.225 ***	1.098	0.906	
Peer Group Mean Alcohol Use	1.195	0.75	1.081	0.836	
Peer Group Mean Cannabis Use	1.02	1.328	1.098	1.701 *	
Community Mean Alcohol Use	0.673	0.27	1.828	0.991	
Community Mean Cannabis Use	0.472 **	1.204	0.86	1.248	
Peer Group Size	1.022	0.724 **	0.783	0.988	
Dep. Symptoms * Mean Peer Cannabis Use	0.705	0.965	0.846	0.527 **	

* $p < .05$,

**

$p < .01$,

$p < .001$