

Deterioration of academic achievement and marijuana use onset among rural adolescents

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Abstract

This study utilizes discrete-time survival analysis to assess the effect of level of academic achievement (both contemporaneously and prospectively) and changes in academic achievement on initiation of marijuana use among rural adolescents in junior high school. In the sample under consideration, 36% of boys and 23% of girls initiated use of marijuana by the end of ninth grade. Consistent with our hypothesis, poor academic achievement is a salient predictor of initiation of marijuana use among both boys and girls. Both contemporaneous and lagged levels of achievement significantly predict initiation. In addition, change in academic achievement is an important predictor of initiation. That is, students who demonstrate a deterioration of their academic achievement over time are more likely to start using marijuana. Poor academic achievement and deterioration of academic achievement should be considered as risk factors for initiation of marijuana use among rural adolescents. Initiatives targeted at improving academic achievement and/or drug

use prevention initiatives designed for poor achieving students may help to prevent initiation of marijuana use.

Introduction

Drug use among adolescents has been the focus of many investigations. This period of development is critical in the study of drug-using behavior as it represents the time frame in which the majority of users begin experimenting with drugs [1–3]. Examining initiation processes during adolescence is critical because there is evidence to suggest that young people who start using drugs in early adolescence are more likely to develop abuse problems and/or experience more serious long-term consequences than adolescents who delay their debut [4–6]. Although most adolescent drug experimentation involves alcohol and cigarettes, an estimated 42% of marijuana users initiate use between the ages of 12 and 15 years [7].

Adolescent drug use, including use of marijuana, is related to many negative outcomes in both the short and long term. For example, adolescent marijuana users are more likely than non-users to dropout of high school, engage in human immunodeficiency virus risk behaviors and exhibit other forms of delinquency [8–10]. They are also more likely to be arrested [11] and use other illegal drugs such as cocaine, crack and heroine [10, 12, 13]. Adolescent marijuana use also threatens health. The Drug Abuse Warning Network reports that marijuana use was a contributing factor in 110 000 emergency department visits in the United States during 2001 [14]. Approximately 15% of those

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visits involved adolescents between the ages of 12 and 17 years. In addition, Tashkin [15] reports evidence that long-term abuse of marijuana may have harmful effects on the immune and pulmonary systems and may increase a user's risk of cancer of the head, neck and lungs.

Indeed, marijuana use among adolescents is a serious public health concern and further research to understand how best to prevent an adolescent's involvement with marijuana is necessary. In order to prevent adolescents from initiating use of marijuana, the personal and contextual factors that increase the likelihood that an adolescent will choose to make the transition from a non-user to a user must be considered. Ellickson *et al.* [16] grouped the risk factors for adolescent drug use into three categories: perceived environmental factors (e.g. exposure to deviant peers and parents who use drugs, poor family bonding, poor school bonding, low academic orientation); behavioral factors (e.g. poor academic achievement, tolerance of delinquency, prior involvement in delinquency, prior substance use) and intrapersonal factors (e.g. rebelliousness, depression and perceived risk). In this study, we will focus on one of these identified risk factors, academic achievement, to understand how both level of academic achievement and change in academic achievement affect initiation of marijuana use among young adolescents living in rural Pennsylvania. This study represents an important contribution to the literature because, while the existent literature provides strong evidence that a relationship between marijuana use and school adjustment problems exists, very few studies of the effect of school-related variables on drug use have considered the process of initiation. Indeed, preventing (or at least delaying) onset of drug use among young people is critical and a more in-depth understanding of the context at play at the time of initiation is a salient topic for research.

Academic achievement and use of marijuana

Low academic achievers are more likely to be drug users [17]. A recent report published by the Substance Abuse and Mental Health Services Admin-

istration [18] suggests that adolescents who receive grades of D or below are more likely than those in good academic standing to have recently used cigarettes, alcohol and/or other illicit drugs. These conclusions corroborate past research that has also reported a strong association between academic achievement and drug use [17, 19–27].

While the existent literature provides strong evidence that a relationship between use of marijuana and poor academic achievement exists, no studies have simultaneously examined the effect of contemporaneous, lagged and changing levels of academic achievement on initiation of marijuana use. In the study presented here, we assess the contemporaneous effect of academic achievement on initiation (i.e. Does an adolescent's concurrently reported grades affect the probability of initiation), the lagged effect of academic achievement on initiation (i.e. Does an adolescent's grades reported during the previous assessment affect the probability of initiation) and the effect of change in academic achievement on initiation (i.e. Does an adolescents degree of change in academic achievement affect the probability of initiation). This latter research question assesses the extent to which the probability of initiation increases during times when a student's academic achievement has deteriorated.

It should be noted that in this paper, we are explicitly concerned with the onset of marijuana use; that is, the extent to which an adolescent's academic performance contemporaneously, prospectively and from a framework of change is related to the onset of marijuana use. We explicitly consider the prospective or lagged model in order to determine if level of academic achievement demonstrated 'before' the onset of marijuana use occurs affects the likelihood of initiation. This is a critical addition to the analyses because, while the contemporaneous model carefully considers academic achievement and onset of marijuana use during the same time frame, it cannot indicate if marijuana use onset was affected by academic achievement or if marijuana use onset led to a deterioration of academic achievement. This is a particularly salient component of the analysis strategy given that there is evidence in the

literature that poor academic achievement leads to drug use [20, 21, 25] and drug use leads to poor academic achievement [21, 23, 28–30]. We do not deny that, ‘once marijuana use begins’, it may affect subsequent academic achievement and that this reciprocal relationship is an important topic for further study. However, given that initiation of marijuana use is a critical process to understand, our focus for this paper is on the context with regard to academic achievement that occurs both before and during the period of time in which an adolescent begins to use marijuana.

Theoretical framework

The idea that school-related problems and substance use coexist has been incorporated into many theories that provide explanations for substance use and other problem behaviors. For example, one of the most influential theories, Hirschi’s social control theory [31], proposes that the major sources for establishing social norms are the school, the family and peers. He proposes that students who lack strong bonds to these pro-social people/institutions are more likely to be involved in delinquency. One of the most well known (and applied) theories that includes a strong social control component is the social development model. Hawkins and Weis [32] stress the importance of school bonding as a critical component of their model. They suggest that a strong school bond is characterized by a student’s attachment to pro-social peers, a commitment to conventional academic and social endeavors at school and a demonstrated belief in established, pro-social norms. The social development model hypothesizes that students who are not well bonded to school are more likely to follow an anti-social path through adolescence.

Another prominent theory, primary socialization theory [33], emphasizes the mediating role of peers and social learning. Adolescents with delinquent peers are more likely to obtain social reward for delinquent behavior, including marijuana use, and therefore both learn and adopt attitudes favorable to marijuana use. Primary socialization theory posits that students who lack a strong commitment to school will be more likely to become involved

with delinquent peers, which in turn may lead to their own involvement in delinquency (including drug use).

One other theoretical framework that is important to consider is Cloward and Ohlin’s strain theory [34]. This theory hypothesizes that adolescents are more likely to engage in delinquency, including marijuana use, when faced with a significant discrepancy between their personal aspirations and their perceived opportunities. That is, students who desire success but perceive that success is not personally obtainable are more likely to engage in delinquent behavior. Lack of success at school is considered as one of the major sources of strain.

Methods

Participants in this study are 571 male and female students from seven schools participating in two larger drug prevention trials in rural Pennsylvania from 1999 to 2003. The schools were not randomly selected, however, as part of the larger study schools were randomly selected to receive various school-based intervention programs. Only students who attended one of the control schools (and received no intervention from the programs) are used in this study. Two of the schools are middle schools (i.e. sixth, seventh and eighth grades are together), while the remaining five schools are junior high schools (i.e. seventh, eighth and ninth grades are together). The first trial was called Project Adoption of Drug Abuse Prevention Trial (ADAPT) and included a total of three control schools, data were collected from 1999 to 2002. The second trial was called TIMEWISE and included five control schools, data were collected from 2000 to 2003. One school served as a control school in both interventions, thereby allowing a total of seven schools to be used in the study presented here. All schools initially selected for the trials were deemed eligible based on two main characteristics: (i) low socioeconomic status, as indicated by a minimum of one-third of the student body qualified to receive free or reduced lunch and (ii) relatively small size, as indicated by a school district enrollment of <1000.

Sample characteristics

The students were surveyed four times over a period of 3 years. For both studies, the first survey was administered in the beginning of the student's seventh-grade school year. The second survey was administered at the end of seventh grade, the third survey was administered at the end of eighth grade and the final survey was administered at the end of ninth grade. The sample is 52% male and >95% white. Retention in both studies was reasonably good. At the final assessment, 80.0% of the total sample completed the survey. In total, 75.0% of the sample provided data at all four measurement occasions, 12.6% provided data on three of the four measurement occasions, 6.8% provided data on two of the four measurement occasions and 5.6% of the students provided data on just one occasion.

Protocol

Following a protocol approved by The Pennsylvania State University Institutional Review Board, active parental permission was received from all students participating in the survey. Assent was also obtained from each student. Students who did not receive permission from their parents or who refused to participate themselves did not participate in the survey. Trained staff members administered all written surveys in regular classes with no school staff members in attendance to ensure an environment in which the students felt safe to answer the survey items honestly. The confidential nature of the survey was stressed to the participants orally by the staff members at the time of data collection. In addition, unique identification codes were utilized in place of names.

Measures

Academic performance over the four measurement occasions serves as the independent variable. The item assesses the general, self-reported grades achieved by the adolescent at each survey and is measured on the following scale: (1) Mostly D's and F's, (2) Mostly D's, (3) Mostly C's and D's, (4) Mostly C's, (5) Mostly B's and C's, (6) Mostly B's, (7) Mostly A's and B's and (8) Mostly A's.

Students' self-report of marijuana use was collected at all four surveys. The variables measure the frequency with which the adolescents tend to use marijuana: 1 (never), 2 (a few times, but not in the last year), 3 (a few times per year), 4 (once per month), 5 (a few times per month), 6 (once per week), 7 (a few times per week), 8 (once per day) and 9 (more than once per day). The variable at each year is dichotomized to compare students who have 'never' used with those who have initiated use of marijuana ('a few times, but not in the last year' or more frequently). In this way, we have constructed a variable that captures the grade in school (e.g. seventh, eighth or ninth grade) when the student first indicated that they had tried marijuana.

Analysis

Our research questions of interest concern the association between academic achievement and initiation of marijuana use. We utilize a type of event history model (or survival model) called a discrete-time proportional odds model [35, 36] to analyze the data. We begin our analyses with an unconditional discrete-time survival model in order to obtain the hazard function for initiation of marijuana use. The hazard probability at a particular time interval is the proportion of previous non-users who initiate use during that interval of time, while the hazard function is the chronological pattern of the hazard probabilities [36].

After specification of the unconditional model for onset of marijuana use, we extend the model through the inclusion of our time-dependent covariate of interest, academic achievement. In the first conditional model, our time-dependent covariate is in the form of contemporaneous academic achievement. In the second conditional model, our time-dependent covariate is lagged academic achievement (i.e. academic achievement during the preceding assessment). In the final conditional model, we include two covariates—academic achievement at the beginning of seventh grade (a time-INdependent covariate) and change in academic achievement from the beginning of seventh grade (a time-dependent covariate). To test these

conditional models, we employ Singer and Willet's [36] logistic hazard function.

In order to adjust for the nesting of students in seven different schools, six dummy-coded variables representing each school (with one school serving as the reference category) are included as independent variables in all models. All of the dummy-coded variables are grand-mean centered. These variables adjust for all differences between schools. Because these coefficients are intended to adjust for differences between schools and are not of substantive interest, their values are not presented in this manuscript.

Missing data

Missing data usually have a salient effect on longitudinal studies as some individuals leave the study over time and/or have intermittent missing assessments. One method for handling missing data within an event history framework is to employ artificial censoring in which all data after a missed assessment are discarded. However, Bacik *et al.* [37] demonstrate that this approach discards information that is likely to be very informative and exerts a negative effect on power. They suggest that multiple imputation (MI) is a more appropriate choice. Following their protocol, we created MIs using IVEware, a program developed at the University of Michigan, Survey Research Center [38]. The program is able to handle non-normal variables (including binary, polytomous, count and

mixed variables). In total, 10 imputed sets were created. The parameter estimates were then combined using the procedures outlined by Rubin [39].

Results

Figs 1 and 2 present the hazard and corresponding survival probabilities for initiation of marijuana. The hazard probabilities displayed in Fig. 1 present the probability that a student will initiate use of marijuana between the Grade $j-1$ and Grade j assessment (e.g. between the end of seventh grade and the end of eighth grade), given that he/she had not used marijuana coincident with or prior to the grade $j-1$ assessment (e.g. at or before the end of seventh grade). Once a student has started using marijuana, he/she is no longer at risk for initiation and therefore leaves the risk set. The hazard probability associated with the beginning of seventh grade describes the probability that an adolescent has already initiated use of marijuana by the first survey. The probability is 0.04 for boys and 0.03 for girls. Among boys and girls who were lifetime non-users at the first seventh-grade assessment, the probability of initiation by the end of seventh grade is 0.05 for boys and 0.06 for girls (that is, in the sample 5% of boys and 6% of girls initiated use of marijuana between the beginning of seventh grade and end of seventh grade). By the end of eighth grade, the probability of initiation

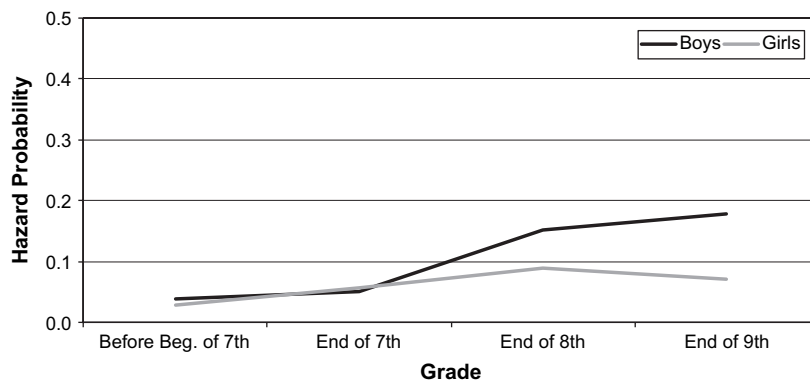


Fig. 1. Fitted hazard probabilities for onset of marijuana use.

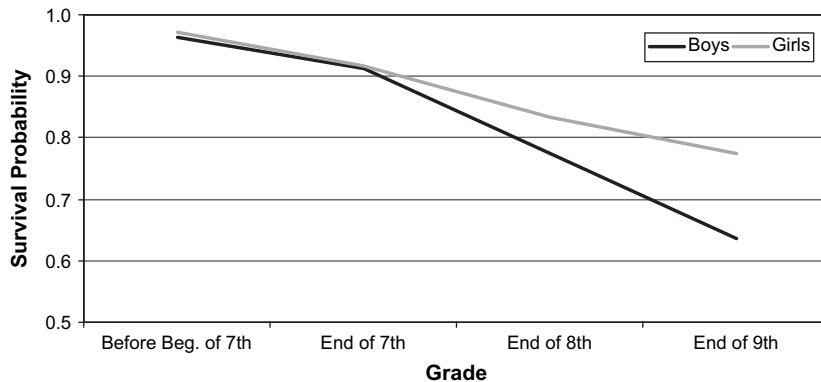


Fig. 2. Fitted survival probabilities for onset of marijuana use.

increases for both boys and girls (probability of initiation is 0.15 for boys and 0.09 for girls). While this difference between boys and girls is not statistically significant, it does constitute a strong trend ($P < 0.10$). By the end of ninth grade, the probability of initiation continues to increase for boys (to a probability of 0.18) but does not increase for girls (the probability of initiation at the end of ninth grade is 0.07). The difference in the probability of initiation at the end of ninth grade between boys and girls is significantly different (OR = 2.59; 95% CI = 1.36, 4.95; $P < 0.05$), that is, the odds that a boy will initiate between the end of eighth and the end of ninth grade is between 1.36 and 4.95 times higher than the odds that a girl will initiate.

While the hazard function assesses the unique risk of initiation at each grade, the survival function cumulates the risk of initiation at each age to assess the probability that a randomly selected adolescent will survive (i.e. not initiate use of marijuana) past time period j . In other words, the survival probability presents the probability that an adolescent will have not initiated use of marijuana at assessment j or any time prior to j (e.g. they have not initiated use of marijuana through the end of ninth grade). The probability that a randomly selected male in the population will have not initiated use of marijuana by the end of ninth grade is 0.64. For girls, this same probability is 0.77. In other words, the probability that a randomly selected boy from the population will initiate use of marijuana by the

end of ninth grade is 0.36 and the probability that a girl will initiate is 0.23.

Combining boys and girls, we find that the probability that a randomly selected student from the population will initiate use of marijuana by the end of ninth grade is 0.31 (or ~31% had used marijuana). We compare this with the Monitoring the Future initiation of marijuana use estimate by the end of ninth grade to determine the extent to which initiation of marijuana use is similar in this population as compared with a nationally representative sample of adolescents. In the 2001 wave of the Monitoring the Future (MTF) study [40], 33% of 10th-grade students reported that they had initiated use of marijuana by the end of ninth grade. It would seem then that this sample of rural adolescents demonstrated initiation rates similar to those reported by adolescents across the United States.

Due to the observed differences in the hazard probabilities by gender, all subsequent analyses were performed separately for boys and girls. Before turning to the results of the conditional survival models, let us first consider the mean scores for academic achievement at each assessment. For boys, the mean academic achievement score at the beginning of seventh grade was 6.10 (SD = 1.45), at the end of seventh grade was 5.93 (SD = 1.64), at the end of eighth grade was 5.61 (SD = 1.76) and at the end of ninth grade was 5.74 (SD = 1.75). For girls, the mean academic achievement score at the beginning of seventh grade was 6.41 (SD = 1.35), at

the end of seventh grade was 6.43 (SD = 1.41), at the end of eighth grade was 6.15 (SD = 1.64) and at the end of ninth grade was 6.33 (SD = 1.58). Regarding assessment to assessment deterioration of academic achievement, we estimate that at the end of seventh grade, 26% of boys and 19% of girls demonstrated a decline in academic achievement; at the end of eighth grade, 40% of boys and 30% of girls demonstrated a decline in academic achievement and at the end of 9th grade 38% of boys and 28% of girls demonstrated a decline in academic achievement.

Next, consider the results of the conditional survival models, Tables I (boys) and II (girls) present the results of these models. The interpretation of the time variables in each of the models now depends upon the identification of the baseline group (i.e. students who have a 0 score for academic achievement). Since academic achievement has been grand-mean centered, a score of 0 represents the average score in the sample. Therefore, the time

variables represent the odds of initiation for an adolescent demonstrating an average level of achievement. For example, the odds that a boy who demonstrates an average level of academic achievement in ninth grade will initiate use of marijuana between the eighth- and ninth-grade assessments are 0.18 (see the estimate corresponding to 'end of ninth grade' for boys in Model 1—the contemporaneous model).

In the first model, we consider the contemporaneous effect of academic achievement on initiation. For both boys and girls, the odds of initiation are lower for students who demonstrate better academic achievement. Specifically, among boys, the estimated odds of initiation are 30% less [i.e. $(1 - 0.70) \times 100$] for each unit increase in academic achievement. Among girls, the estimated odds of initiation are 33% less for each unit increase in academic achievement.

The lagged effect of academic achievement (i.e. academic achievement at the previous assessment)

Table I. Results of fitting three conditional discrete-time survival models among boys

Parameter estimate	Contemporaneous effect of AA		Lagged effect of AA		Effect of change in AA	
	OR	95% CI	OR	95% CI	OR	95% CI
End of seventh grade	0.04*	0.02–0.08	0.05*	0.03–0.09	0.04*	0.02–0.08
End of eighth grade	0.14*	0.09–0.20	0.16*	0.11–0.23	0.14*	0.09–0.21
End of ninth grade	0.18*	0.12–0.29	0.19*	0.12–0.30	0.19*	0.12–0.30
Beginning of seventh grade AA					0.70*	0.59–0.83
AA	0.70*	0.61–0.80	0.77*	0.67–0.89	0.70*	0.60–0.83

AA = academic achievement. The estimates for the time variables are odds (i.e. the odds of initiation), not odd ratios. * $P < 0.05$.

Table II. Results of fitting three conditional discrete-time survival models among girls

Parameter estimate	Contemporaneous effect of AA		Lagged effect of AA		Effect of change in AA	
	OR	95% CI	OR	95% CI	OR	95% CI
End of seventh grade	0.06*	0.03–0.11	0.06*	0.03–0.10	0.06*	0.03–0.11
End of eighth grade	0.09*	0.05–0.14	0.10*	0.06–0.16	0.08*	0.05–0.14
End of ninth grade	0.08*	0.04–0.13	0.07*	0.04–0.13	0.07*	0.04–0.14
Beginning of seventh grade AA					0.73*	0.57–0.92
AA	0.67*	0.56–0.80	0.74*	0.61–0.89	0.61*	0.47–0.79

AA = academic achievement. The estimates for the time variables are odds (i.e. the odds of initiation), not odd ratios. * $P < 0.05$.

is also a salient predictor of initiation. The estimated odds of initiation are 23% less among boys and 26% less among girls for each unit increase in academic achievement during the previous assessment.

In the third model, the effect of change in academic achievement since the beginning of seventh grade is assessed. For both boys and girls, a decline in academic achievement is associated with an increased likelihood of initiation. The estimated odds of initiation are 30% less for each unit increase in the change score among boys and 39% less for each unit increase in the change score among girls.

Fig. 3 describes the findings of the change model by depicting the predicted probability of initiation of marijuana use between the end of seventh grade and the end of eighth grade for four different scenarios. We used the model-based estimates derived from the third model to solve for the probability of initiation for each of these four scenarios. Of these four scenarios, boys and girls who maintain an A/B average have the lowest probability of initiation (~ 0.09 for boys and 0.06 for girls). The A/B maintainers are less than half as likely to initiate as compared with the C maintainers. Among girls, dropping from an A/B average to a C average results in a predicted probability of initiation that is higher than students who maintained a C average. For boys, the negative effect of deterioration is not as robust (although a decline in academic achievement is still predictive

of initiation). Among the scenarios presented in the figure, the type of student most likely to initiate is the student who drops from a B average to a D average. Boys who show this type of decline have a 0.37 probability of initiation and girls who show this type of decline have a 0.39 probability of initiation. Compared with students who maintain an A/B average, boys who drop from a B average to a D average are about four times more likely to initiate use of marijuana and girls who demonstrate this same drop are about seven times more likely to initiate use of marijuana.

An important assumption of discrete-time survival models is the proportionality assumption which states that the effect of the independent variables is constant across time. By adding time by academic achievement interactions, we may test this assumption. We find no evidence that the effect of academic achievement changes over time for boys in any of the models or for girls in the lagged and change models. However, there is significant evidence ($P < 0.05$) that the contemporaneous effect of academic achievement does change over time among girls. Evaluation of the interaction terms reveals that contemporaneous academic achievement is a salient predictor of initiation at the end of seventh grade (OR = 0.65; 95% CI = 0.46, 0.92) and eighth grade (OR = 0.54; 95% CI = 0.41, 0.71) but not a significant predictor of initiation at the ninth-grade (OR = 0.92; 95% CI = 0.64, 1.32).

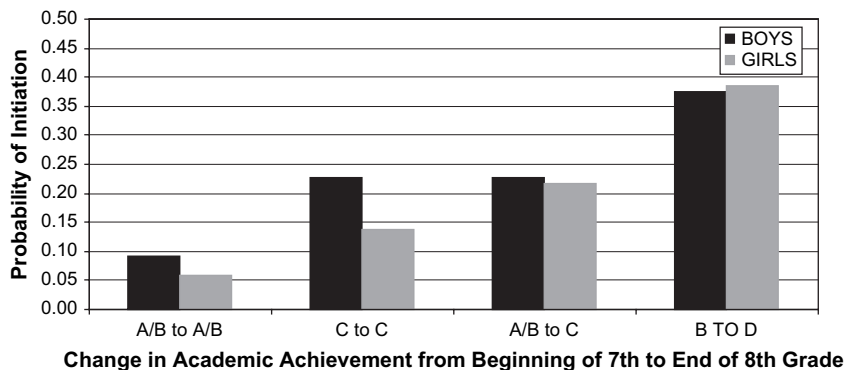


Fig. 3. Predicted probability of initiation of marijuana in eighth grade.

Discussion

Most students enter elementary school eager to learn [41]; however, for some, this optimism and enjoyment for school diminish over time [42]. Often, this disconnect with school is accompanied by poor academic achievement. In this study, we have shown that students who are poor academic achievers and students whose academic achievement has deteriorated are more likely to initiate use of marijuana. This latter point represents the key contribution of this paper to the existent literature. That is to say, this paper provides important evidence that a decline in academic achievement is a risk factor for initiation of marijuana use among rural adolescents.

The students in the sample considered here had recently made the transition from elementary school to junior high or elementary school to middle school. A robust commitment to school may be an especially important protective factor in early adolescence. For some students, making the transition from elementary school to junior high/middle school may have deleterious effects on their commitment because the transition is often associated with heightened academic stress, increased school misbehavior, decreased academic achievement and weakened school bonds [43–45]. These years can be an especially trying and difficult experience for students who are academically deficient [46]. Students who encounter particular difficulty may be more prone to become involved with drug use and other forms of delinquent behavior. Simons-Morton *et al.* [47] hypothesize that these students may become apathetic or develop anti-social attitudes and behaviors (including rebelliousness, disengagement from their academic duties, treatment of teachers and students in a disrespectful manner and destruction of school property) in order to protect themselves from feelings of inadequacy. Oetting and Donnermeyer [33] propose a different mechanism for the relationship between school disengagement and substance use. Their theory, called the primary socialization theory, postulates that weak school bonds enhance identification with

deviant peers and communication of deviant norms and behaviors. Primary socialization theory posits that it is this deviant peer association that increases the probability of drug use. In other words, the relationship between school disengagement and substance use may be mediated by delinquent peer association. Of course, the data presented in this study do not provide information to determine why academic achievement is a salient predictor of initiation of marijuana use; future work is needed to better understand the mechanisms.

The primary finding of the present study (i.e. that poor academic achievers and students who demonstrate declines in academic achievement are more likely to initiate use of marijuana) offers important implications for prevention. First, programs aimed at improving and/or maintaining good academic achievement may have a deterrent effect on adolescent drug use. That is, programs aimed at keeping all students engaged in school and performing well are likely to have a desirable effect on drug use. Second, students who are demonstrating poor academic grades or a deterioration of academic grades may be candidates for more targeted initiatives. As presented in Fig. 3, students who are poor academic achievers and students who demonstrate a decline in their academic achievement are much more likely than students who maintain an A/B average to initiate use of marijuana. Indeed, schools hold the information necessary to identify these types of at-risk adolescents. It may be a prudent measure for schools to consider poor academic achievement and rapid declines in academic achievement as leading indicators of marijuana use initiation. That is, schools may be well-served to use their academic records to identify adolescents at risk and provide additional programming to help these students get back on track. Of course, providing students who are performing poorly in school with extra help/programming may benefit both their academic achievement and involvement in pro-social behavior (i.e. avoidance of problem behaviors such as drug use). The World Health Organization's [48] concept of a 'health promoting school' is an exemplary example of this type of comprehensive focus. A health promoting school

operates under the auspices that schools have an equal responsibility to educate youth and promote healthy development. The World Health Organization has developed standards and recommendations for health promoting schools, and this framework has been broadly adopted in Europe and Australia [49]. Flay [50] also advocates for comprehensive health promotion programming in schools, an approach which considers the whole student—including academic achievement, commitment to school and pro-social development.

Recognizing the importance of a comprehensive approach, and considering the salient role of academic commitment in the development of pro-social youth, several problem behavior/drug prevention program developers and researchers have incorporated the protective role of academic engagement/achievement into their theories, research and/or programs. For example, Promoting Alternative Thinking Strategies (PATHS) [51] seeks to enhance the educational process by promoting emotional and social competencies and by reducing aggression and problem behaviors.

While many programs, including PATHS, focus largely on the individual, other programs take an environmental approach. These types of programs focus primarily on improvement of the school environment in an effort to impact youth. For example, The School Transitional Environment Program (STEP) [52] seeks to ease the transition from elementary to middle school/junior high school and/or the transition from middle school/junior high school to senior high school. This goal is accomplished by improving social support and mitigating logistical difficulties. Specifically, the role of homeroom is transformed in such a way that teachers act as advisors to the students and their families. In addition, smaller learning communities are created, allowing students to remain with the same group of students (their homeroom class) for all of their primary subject courses. Studies have shown that students participating in STEP adjust better to a new school and are more likely to maintain positive perceptions of the school environment. In addition, the program has a desirable effect on academic achievement and school misbehavior.

STEP and other environmental approaches are based on research suggesting that many aspects of the school environment play important roles in determining the likelihood that an adolescent will follow a pro-social path through adolescence as opposed to becoming involved in delinquent behavior. In a review of the literature, Gottfredson [53] concluded that school context variables (e.g. level of school functioning, ethos of caring, student-teacher bonds, physical environment of the buildings and grounds, etc.) have a moderate effect (i.e. effect sizes ranging from 0.58 to 0.85) on several problem behaviors and negative outcomes, including victimization, involvement in delinquent activities, substance use, school misbehavior, suspension, school failure, truancy and dropout. Gottfredson noted in her review that the effect sizes of school contextual variables are somewhat larger than the average effect sizes demonstrated by traditional school-based drug prevention and intervention trials. She suggests that improvement of the school context (i.e. initiatives aimed at improving school-level factors) may have important and beneficial outcomes on student behavior. This promising line of research needs much more attention.

It is important to note that many other school-based drug prevention programs seek to prevent drug use via the promotion of school engagement. However, many of these programs have yet to be thoroughly or adequately evaluated. In addition, many evaluations fail to properly measure their effectiveness on school engagement variables. Indeed, new programs and better evaluations of existing programs aimed at preventing school disengagement are needed.

Limitations

Although this study adds to the literature in several important ways, it is important to recognize its limitations. The sample of youth represents students in rural Pennsylvania and it is unclear if these results would generalize to other rural adolescents. Rural Pennsylvania represents one type of rural setting and many other rural areas in the United States have much different demographic characteristics

(including ethnic makeup). In addition, while levels of participation in the longitudinal study were reasonably high and study mortality across the 3 years of the study reasonably low, students (and their parents) chose to participate under their own volition. Using data from the ADAPT study, Henry *et al.* [54] showed that lower academic achievers were less likely to obtain parental permission to participate in the study; therefore, some of the poorest achieving students in the schools are not included in the analyses presented in this study. Finally, academic achievement in this study is self-reported. It is unclear then if students accurately reported their academic performance and if Grade Point Average (GPA) from school records would similarly predict onset of marijuana use. Despite these limitations, this study provides evidence that academic achievement is an important predictor of initiation of marijuana use.

Future directions

This study demonstrates that academic achievement is lower both before and during the period when initiation of marijuana use occurs. However, it is likely that once initiation occurs, escalation of marijuana use may have a deleterious effect on academic achievement. Further research is needed to assess the reciprocal relationship between escalation of marijuana use (and other drug use) and academic achievement. Further research is also needed to assess the role of other school-related variables such as school-reported GPA, truancy, school misbehavior and poor school attachment.

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Conflict of interest statement

Linda Caldwell is the developer of Timewise.

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