The relationship between marijuana initiation and dropping out of high school

By: Jeremy W. Bray, Gary A. Zarkin, Chris Ringwalt, and Junfeng Qi

Bray, J. W., Zarkin, G. A., Ringwalt, C., & Qi, J. (2000). The relationship between marijuana initiation and dropping out of high school. *Health Economics*, 9(1), 9–18.

Abstract:

The prevalence of marijuana use among young people has risen rapidly in recent years, causing concern over the potential impact on academic performance of such use. While recent studies have examined the effect of alcohol use on educational attainment, they have largely ignored the potential negative effects of other substances, such as marijuana. This paper examines whether the relationship between the initiation of marijuana use and the decision to drop out of high school varies with the age of dropout or with multiple substance use. Data are from a longitudinal survey of 1392 adolescents aged 16–18 years. The results suggest that marijuana initiation is positively related to dropping out of high school. Although the magnitude and significance of this relationship varies with age of dropout and with other substances used, it is concluded that the effect of marijuana initiation on the probability of subsequent high school dropout is relatively stable, with marijuana users' odds of dropping out being about 2.3 times that of non-users. Implications of these conclusions are considered for both policy makers and researchers.

Keywords: marijuana | high school dropout | initiation

Article:

INTRODUCTION

The prevalence of marijuana use among young people has risen in recent years, causing widespread concern among policy makers. Between 1990 and 1997, the percentage of youths aged 12–17 using marijuana more than doubled, increasing from 4.4% to 9.4% [1]. This increase in prevalence has prompted a vigorous debate concerning federal anti-marijuana legislation, a debate made even more heated by recent state-level legislation to relax medicinal marijuana use

restrictions [2]. Of special concern is the potential impact of marijuana use on the education of youth [3,4], especially in light of the substantial psychological and sociological research linking substance use to lowered educational attainment [5–9]. In spite of this evidence, few economists have incorporated substance use into a model of human capital formation, and those who have typically focused on alcohol use. Several studies have examined the effects of substance use on labour market outcomes, such as wages, employment and hours of work (e.g. Buchmueller and Zuvekas [10], DeSimone [11], French et al. [12], Gill and Michaels [13], Kaestner [14], Kaestner [15], Mullahy and Sindelar [16], Zarkin et al. [17,18]). However, these studies have not examined the effect of substance use on education but have instead treated education as an exogenous determinant of labour market outcomes.

Cook and Moore [19] used the 1979 National Longitudinal Survey of Youth (NLSY79) to examine the impact of alcohol consumption on years of schooling and college graduation. They found that heavy drinking in high school reduces the years of schooling completed after high school. Cook and Moore also estimated the relationship between state-level alcohol policies and the probability of college graduation. Results from logit models indicated that students who attended high school in states with relatively high alcohol taxes and high minimum legal drinking ages were more likely to graduate from college. Because these laws presumably reduce teenagers' consumption of alcohol, Cook and Moore interpreted their findings to mean that alcohol consumption by high school students reduces the likelihood of graduation from college.

Yamada et al. [20] used the NLSY79 to examine the impact of marijuana and alcohol use on high school graduation. They found significant adverse effects of current alcohol and marijuana use on high school graduation rates. Yamada et al. also examined the demand by youth for alcohol and marijuana. They found that beer taxes, minimum drinking age laws and marijuana decriminalization have a significant impact on the demand for alcohol and marijuana. Combining these two results, they concluded that changes in these policy variables could have a substantial impact on youths' educational attainment.

Dee and Evans [21] argued that studies like Cook and Moore [19] and Yamada et al. [20] may have biased results because they relied on variations in taxes and alcohol laws across states to identify the effects of alcohol on educational attainment. Dee and Evans contended that a study of variation in state regulations *over time* is needed to distinguish these effects from other state-level factors which might affect educational attainment, such as state expenditures on education. Using a two-sample instrumental variables estimator [22] and data from the Monitoring the Future surveys and from the Public Use Microdata Sample, Dee and Evans estimated the impact of alcohol regulations on high school completion, college entrance and college completion. They found that changes in the minimum legal drinking age have no significant effect on educational attainment. From this result, Dee and Evans concluded that alcohol use by teenagers does not significantly reduce educational attainment.

Despite their rigorous methods, these studies have some notable limitations. First, because all of these studies estimated a single model for all ages, they implicitly assumed that the educational decision is constant over time. Given the rapid developmental changes that occur in teenagers as they make the transition from childhood to adulthood, it is possible that the relationship between substance use and schooling may be different from one age to the next. Second, these studies

have not explicitly considered the impact of multiple substance use on their estimates. For example, while Cook and Moore [19] studied both alcohol use and cigarette use, Dee and Evans [21] considered only alcohol use and Yamada et al. [20] included alcohol and marijuana use, but not cigarette use. Previous research has shown that because of the high correlation among alcohol, cigarette and marijuana use, failing to include all three substances may bias results that look at any given substance in isolation [23].

In this paper we examine the role of multiple substance use and age of dropout in the relationship between marijuana initiation and dropping out of high school. Using data on students from a southeastern US school system, we estimate models of high school dropout separately by age at dropout. We estimate each of these models twice, first including only marijuana use and second including marijuana, alcohol, cigarette and other illicit drug use. In all models we measure substance use by a set of indicator variables that reflect initiation of use prior to dropping out. Our results suggest that marijuana initiation is positively related to dropping out of high school. Although the magnitude and significance of this relationship varies with the age of dropout and with the other substances used, we conclude that the effect of marijuana initiation on the probability of subsequent high school dropout is relatively stable, with marijuana users' being about 2.3 times more likely to drop out than non-users.

THE ECONOMICS OF SCHOOLING

Economists have long been interested in educational attainment because education is one of the key determinants of wages. One of the first economic studies to examine schooling was that of Becker [24]. In this seminal work, Becker put forth the idea of education as a form of 'human capital', which would make a person more productive and therefore allow him or her to earn a higher wage. Thus, education can be thought of as an investment, with higher wages as the return to that investment. Since Becker's work first appeared, many studies have consistently supported this theory by demonstrating a positive and robust link between education and wages [25].

This link suggests that higher wages are a key motivation for continuing education. However, empirical evidence suggests that the relationship between education and wages is not continuous, but rather that there is a discontinuous and substantial wage increase associated with the completion of a degree [26]. In the presence of these discontinuities, either an individual will drop out of high school as early as possible, and therefore begin his or her earnings as soon as possible, or he or she will continue until graduation.

This brief review of economic theory suggests at least two different types of high school dropout. The first are those who drop out at age 16 because they believe that continuing their education will not significantly improve their lifetime earnings: more succinctly, those who drop out of school to get a job. The second are those who believe that continued education will increase their lifetime earnings but who (unknowingly) do not have the academic ability to obtain a high school diploma. This describes those individuals who drop out at age 18. Individuals who drop out at age 17 represent a mix of these two types. Because the motivation for dropping out of high school varies with age, the relationship between marijuana initiation and high school dropout may also vary with age.

DATA AND METHODS

Data

To estimate the possible impact of age of dropout on the relationship between marijuana use and high school dropouts, we used data from four longitudinal surveys of students in a southeastern US public school system. Surveys were conducted in four waves from 1985 to 1994. Combining data from all four survey waves with demographic and other information from the school system yields data on students' family background, race, gender, academic ability, age of initiation for a variety of substances, age of leaving school, and the reason the students left school (e.g. graduated, dropped out of school or transferred to another school system).

The first survey was conducted on all 7550 middle school students during the 1985–1986 (urban school students) and 1986–1987 (rural school students) school years. As shown in Figure 1, four survey waves were conducted between the initial wave in 1986 and the final wave in 1994. Generally, the students were in grades 6, 7 or 8 at wave 1; grades 7, 8 or 9 at wave 2; and grades 9, 10 or 11 at wave 3. Wave 4 data were collected in autumn 1993 and autumn 1994 (for those previously enrolled in urban and rural schools, respectively), after the original study participants had left high school. Because of the costs associated with tracing the entire cohort of the original study participants, a stratified random sample of participants was selected from the original wave 1 study participants for wave 4 data collection. The overall response rate for the wave 4 data collection was 55.1%. Our analysis sample consists of the 1392 wave 4 respondents with non-missing data for our analysis variables.

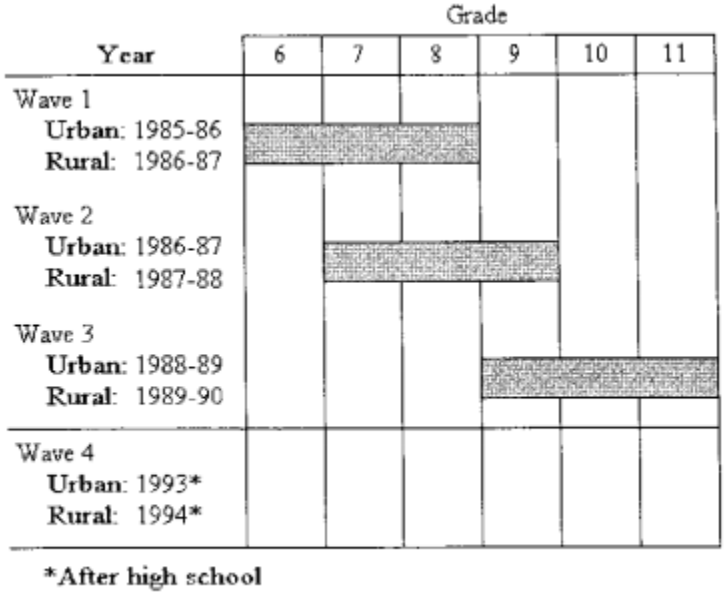

Figure 1. the four waves used in the analysis

Based on the sampling design and actual response patterns, weights that adjust for non-response were calculated for students appearing in all waves. The stratified sampling design creates clusters of observations that are potentially intracorrelated. Because intracluster correlation represents a specific form of error correlation that violates standard independence assumptions,

we used Stata statistical software [27] to estimate all statistics. Stata has a set of survey estimation commands designed to yield correct standard errors based on the sampling design. When a survey command was unavailable for a specific estimation technique (e.g. two-stage least squares), we used a White/Huber standard error correction [27–29] in our analyses to account for the effects of clustered data.

Variable definitions

The dependent variables are indicator variables reflecting whether an individual dropped out of high school between the ages of 16 and 18 inclusive. Because state law requires school attendance until age 16 and most students graduate from high school at age 18, there were not enough students dropping out prior to age 16 or after age 18 to examine these ages separately. Data on the dropout status of all students in our sample were obtained from the school system. These data included a status code indicating whether the student had transferred to another school system, had dropped out or was expelled, had died, had completed the current grade and was expected to return the following year, or had graduated. In addition to this status code, the school system data also included the date on which that status code became effective. Based on these data, we defined a high school dropout as any student who had a status code indicating dropout or expulsion, and we set the age of dropout for that student as his or her age as of the effective date. We then defined three indicators for dropout status for a given age:

- DROP16 equals 1 if a student dropped out on or after his or her 16th birthday but before his or her 17th birthday and equals 0 otherwise;
- DROP17 equals 1 if a student dropped out on or after his or her 17th birthday but before his or her 18th birthday and equals 0 otherwise, conditional on having not previously dropped out of high school; and
- DROP18 equals 1 if a student dropped out on or after his or her 18th birthday but before his or her 19th birthday and equals 0 otherwise, conditional on having not previously dropped out of high school.

To examine the impact of multiple substance use on youths' propensity to drop out of high school at a given age, we defined four categories of substances used: alcohol, cigarettes, marijuana and other illicit drugs (i.e. cocaine or crack, hallucinogens, stimulants, sedatives or inhalants). For each of these substances, we measured use with three indicator variables reflecting initiation of that substance prior to age 16, 17 or 18. In earlier analyses we included a variable reflecting the age of initiation. Statistical testing rejected these age-of-initiation specifications in favour of the models reported here. A complete set of results is available from the first author upon request. Initiation is defined as any use and is not contingent upon some form of regular use. Variations in the survey instrument across the four waves of data collection prohibited us from examining the age of first regular use. Because the reported age of initiation relied on recall, there are some inconsistencies among different waves of data. Assuming the earliest report is the most accurate, we used wave 1 data if a student had reported initiation of a certain drug; otherwise we used data from subsequent waves.

Based on previous literature on predictors of high school dropout [5,8,9,19,30,31], we included the following socio-demographic variables in our analyses: race, gender, enrolment in a rural

versus an urban school, parents' education, number of parents living in the household, and the youths' self-report of typical grades earned in school.

Race, gender and rural versus urban status of the school were obtained from school records. Parents' education is measured in years and was only collected in wave 4. It is, therefore, assumed that the parents' education has not changed significantly over time. If the student lived with both parents, we set the parents' education as the higher of the two reported. If the student lived with only one parent, we used that parent's education. If the student lived with neither parent, we set parents' education equal to the overall wave 4 sample mean of 14 years. We also included an indicator variable equal to 1 if no parents were present. This variable was included, in part, to control for our imputation on parent's education. However, this variable was not significantly different from an indicator reflecting the absence of one or both parents, so we have omitted it from the specifications reported here.

The self-reported typical grades earned in school (grade point average or GPA) are available in each wave. We assume that the GPA from wave 1 is less likely to have been affected by substance use and thus is a better measurement of a student's academic ability before the effects of substance use. Therefore, we use the student's self-reported GPA from wave 1. The number of parents with whom a student lived is also available in all waves. Because we wanted to reflect the family structure as close to the dropout decision as possible, we used data on the number of parents with whom the student lived from wave 3, when most students were between the ages of 15 and 17. To reduce the loss of observations due to missing values, we used the information on the number of parents present from wave 2 if wave 3 data were missing, and from wave 1 if wave 2 data were also missing.

Empirical model

Previous studies have hypothesized that the benefits and/or costs of schooling depend in part on past academic performance [19]. Under this hypothesis, the physiological effects of substance use may affect students' propensity to continue in school by adversely affecting their academic abilities. For example, both marijuana and alcohol use adversely affect the cognitive and psychomotor skills necessary for academic success [32]. While these effects are primarily short-term, prolonged use can lead to chronic deficits [33,34]. Other substances, such as the nicotine found in cigarettes, can sometimes increase performance and sometimes decrease it [35,36].

Based on the above discussion, we can define the following equation (see also Dee and Evans [21]):

$$\mathrm{DO}_{it} = f(\beta_0 + \beta_1 X_{it} + \beta_2 M_{it} + \varepsilon_{it}) \qquad (1)$$

where DO_{it} equals 1 if individual i drops out at age t, and 0 otherwise; X_{it} is a vector of sociodemographic variables described above; M_{it} is an indicator variable reflecting initiation of marijuana use prior to age t by individual i; ε_{it} is an individual-specific error term; and the β are coefficients to be estimated. The impact of marijuana initiation on the probability of high school dropout is captured by β_2. If initiation of marijuana use (M_{it}) increases the probability of dropping out of school, β_2 will be positive.

We estimate Equation (1) with a series of logit models. For each age (i.e. 16, 17 and 18) we estimate separate models, allowing all parameters to differ from one age to the next. For each age, we estimate two specifications: one that includes only the marijuana initiation variables and one that includes all of the substance use categories described above. This estimation approach allows us to monitor explicitly the changes in the marijuana initiation coefficient that occur as a result of controlling for other substances used.

RESULTS

Table 1 provides definitions and weighted sample means of all variables used in our analyses. Results in all tables were weighted to represent the overall student population. By age 16, 62.4% of students had initiated cigarette use; 65.1% had initiated cigarette use prior to age 17, and 66.6% had initiated cigarette use prior to age 18. For alcohol use, these percentages are 75.5%, 79.3% and 82.2%, respectively; for marijuana use they are 41.3%, 45.8%, and 48.6%, respectively; and for other drug use they are 40.0%, 42.5%, and 44.3%, respectively. Although these prevalence rates may seem high, they reflect any use at *any* time in a student's life prior to the given age, including one-time experimentation, and, therefore, are higher than other, nationally reported prevalence estimates that only consider use within the past month or year.

Table 1. Weighted means and standard deviations of analysis variables

Variable	Mean (standard deviation)	Definition
Socio-demographic variables		
Female	0.490 (0.500)	0/1 Indicator variable with 1 indicating female
Black	0.258 (0.438)	0/1 Indicator variable with 1 indicating black
Rural	0.383 (0.486)	0/1 Indicator variable with 1 indicating rural
Missing at least one parent	0.300 (0.459)	0/1 Indicator variable with 1 indicating at least one parent missing from household
Parents' education	14.595 (2.287)	Years of education obtained by parent
Grade point average (GPA)	2.940 (0.789)	Grade point average from wave 1
Substance initiation		
Marijuana initiation before age:		0/1 Indicator variable with 1 indicating tried marijuana at least once before age of dropout
16	0.413 (0.493)	
17	0.458 (0.498)	
18	0.486 (0.500)	
Cigarette initiation before age:		0/1 Indicator variable with 1 indicating tried at least one cigarette before age of dropout
16	0.624 (0.485)	
17	0.651 (0.477)	
18	0.665 (0.472)	
Alcohol initiation before age:		0/1 Indicator variable with 1 indicating tried at least one drink of alcohol before age of dropout
16	0.755 (0.430)	
17	0.792 (0.405)	
18	0.822 (0.382)	
Other drug initiation before age:		0/1 Indicator variable with 1 indicating tried other drugs at least once before age of dropout
16	0.400 (0.490)	
17	0.425 (0.495)	
18	0.443 (0.497)	

$N = 1,392$.

Table 2 presents the dropout rates by substance use initiation and age. Even in this simple analysis, we see a relationship between substance use initiation and high school dropout. Across

all substances, the dropout rates among students who initiated substance use is higher than among those who have not, and in many cases it is more than double the rates of students who have not initiated substance use.

Table 2. Dropout rate by substance use initiation

Variable	Proportion of sample dropping out at age:			
	16 ($N = 1,392$)	17 ($N = 1,302$)	18 ($N = 1,191$)	All ages ($N = 1,392$)
All respondents	0.027 (0.003)	0.040 (0.003)	0.038 (0.003)	0.099 (0.003)
Marijuana use				
Did not initiate prior to age of dropout	0.009 (0.003)	0.021 (0.004)	0.016 (0.004)	0.047 (0.006)
Initiated prior to age of dropout	0.052 (0.007)	0.063 (0.007)	0.063 (0.007)	0.153 (0.008)
Cigarette use				
Did not initiate prior to age of dropout	0.008 (0.004)	0.015 (0.004)	0.024 (0.006)	0.046 (0.008)
Initiated prior to age of dropout	0.038 (0.005)	0.054 (0.005)	0.046 (0.005)	0.125 (0.006)
Alcohol use				
Did not initiate prior to age of dropout	0.011 (0.005)	0.023 (0.007)	0.030 (0.011)	0.068 (0.013)
Initiated prior to age of dropout	0.032 (0.004)	0.044 (0.004)	0.040 (0.004)	0.105 (0.004)
Other drug use				
Did not initiate prior to age of dropout	0.018 (0.004)	0.026 (0.004)	0.031 (0.005)	0.073 (0.007)
Initiated prior to age of dropout	0.041 (0.006)	0.059 (0.007)	0.047 (0.007)	0.131 (0.008)

Standard errors in parentheses.

Table 3 reports our estimated logit models of the probability of dropping out of school at different ages. Ages 16, 17 and 18 are presented separately, as well as in combination. The combined models include all person–years included in the age-specific models (see [5] for a similar estimation approach). Under each age we present two models. Model 1 includes only the indicator variable for marijuana initiation, while Model 2 includes the indicator variables for all substances. All models include the socio-demographic variables discussed earlier. In Model 1, marijuana initiation is significantly related to an increased probability of dropping out for all ages. Furthermore, the estimated relationship is surprisingly similar in magnitude, corresponding to an approximate odds ratio of 3, suggesting that marijuana users are three times more likely to drop out of high school than non-users (the odds ratio for a coefficient β is calculated as e^{β}). When we look at Model 2, however, we see that controlling for initiation of multiple substance use changes this result slightly. For ages 16 and 18, the relationship between marijuana use and high school dropout is similar from Model 1 to Model 2. For age 17, however, the relationship between marijuana initiation and high school dropout is somewhat different if we control for multiple substance use. Specifically, the coefficient on marijuana initiation is reduced by half and becomes insignificant.

Table 3. Logit models of the probability of dropping out of high school

	Logit model of the probability of dropping out at age:							
	16 ($N = 1, 392$)		17 ($N = 1, 302$)		18 ($N = 1, 191$)		All ages ($N = 3, 885$)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Marijuana initiation prior to age of dropout	1.353*** (0.368) [3.869]	1.182*** (0.449) [3.262]	0.804*** (0.262) [2.235]	0.367 (0.286) [1.443]	1.238*** (0.335) [3.448]	1.115*** (0.423) [3.050]	1.091*** (0.178) [2.977]	0.839*** (0.225) [2.314]
Cigarette initiation prior to age of dropout		0.641 (0.636) [1.898]		0.872** (0.436) [2.392]		0.250 (0.495) [1.283]		0.570* (0.296) [1.768]
Alcohol initiation prior to age of dropout		−0.210 (0.587) [0.811]		−0.341 (0.447) [0.711]		−0.280 (0.561) [0.756]		−0.292 (0.305) [0.747]
Other drug initiation prior to age of dropout		−0.016 (0.367) [0.984]		0.431 (0.277) [1.539]		0.242 (0.311) [1.274]		0.243 (0.192) [1.275]
Hosmer and Lemeshow goodness-of-fit	3.49	3.03	26.45	6.99	6.35	5.76	13.47	14.71

Standard errors in parentheses. Odds ratios in square brackets.
All models include the socio-demographic variables described in Table 1.
* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.

Looking at the other substance use coefficients, we see that alcohol use is related negatively, but insignificantly, to high school dropout for all ages. Although the cigarette initiation coefficient has a similar magnitude and direction across all ages, it is significant only for age 17. The coefficient on the initiation of other drugs is insignificant in all models and is never greater than 0.5 in absolute value. These results suggest that the practical effects of initiating the use of substances other than marijuana on the probability of dropping out of high school are relatively stable between the ages 16 and 18, with the possible exception of age 17.

To examine the statistical significance of the changes in our coefficient estimates across the age 16, 17 and 18 models, we conducted a Wald test of the null hypothesis that all coefficients in Model 2 were the same across all ages. We rejected the null at a p value of less than 0.01. We also tested the restriction that only the substance initiation coefficients were the same across all ages. For this test, however, we failed to reject the null (p=0.76), indicating that the differences in the substance use initiation coefficients across the ages are not statistically significant.

The estimates reported in the last two columns of Table 3 impose the restriction that the substance use initiation coefficients are the same across all ages but allow the (unreported) coefficients on the socio-demographic variables to vary across ages. After combining the age cohorts, we see a similar pattern of results as in the age-specific models. The marijuana initiation coefficient is smaller in magnitude when we control for the other substances, and the only other significant coefficient is cigarette initiation, which is marginally significant at the 0.10 level.

Thus, we conclude that the effect of marijuana initiation on the probability of dropping out of high school is approximately the same across all ages at an odds ratio of approximately 2.3.

To examine the possible endogeneity of marijuana initiation, we conducted Hausman–Wu tests of the exogeneity of marijuana use in Model 1 in Table 3 [37]. Results from these tests failed to reject the null hypothesis of exogeneity at the 0.80 level for ages 16 and 17, and at the 0.29 level for age 18. We also implemented tests for overidentification [37]. These procedures tested whether our instruments were correlated with marijuana initiation but not with high school dropout. Results of this testing failed to reject the null of no correlation between our instruments and the error term in the high school dropout equation at the 0.10 level for ages 16 and 17 but did reject the null for age 18. Based on evidence from the Hausman and overidentification tests, we conclude that there is little empirical gain to using 2SLS estimates. We also estimated bivariate probit models of the joint decision to drop out of high school and to initiate marijuana use. For ages 16 and 17, the estimated correlation between the two equations was insignificant, while the age 18 bivariate probit failed to converge after 100 iterations. Again, we concluded that there was little empirical gain to treating marijuana initiation as endogenous, and we therefore reported the logit results. All estimation results are available upon request.

DISCUSSION AND CONCLUSION

In this paper we examined the relationship between the initiation of marijuana use and the decision to drop out of high school and whether this relationship is exacerbated by multiple substance use. Our results suggest that marijuana initiation is positively related to high school dropout. Although the magnitude and significance of this relationship varies with the age of dropout and the other substances used, the overall effect represents an odds ratio of approximately 2.3. This suggests that an individual who has initiated marijuana use is approximately 2.3 times more likely to drop out of school than an individual who has not initiated marijuana use. This result is consistent with that found by other studies on the relationship between high school dropout and marijuana use (e.g. Yamada et al. [20]).

Our study has three main limitations that should be considered. First, our sample of students is not nationally representative. In spite of this limitation, our results are nonetheless important. The majority of economic research on the relationship between substance use and educational attainment has relied on a single data source—the NLSY79. It is important for policy makers and researchers to consider results from a broad array of data sources to determine which of those results reflect underlying relationships and which merely reflect the idiosyncrasies of the data source used. This study provides policy makers and researchers with important results from an alternative and novel data source.

Second, our conclusions are based on simple logit estimates that assume no correlation between substance initiation and unobservable factors, such as motivation. Although empirical testing suggested that this assumption was valid, prudence dictates that our results should be interpreted as correlational, and not as causal.

The last limitation of our study is that we defined initiation of substance use based on any use of a substance in the student's life and not on some level of regular use. It is likely that a single

instance of substance use has little to no impact on the decision to drop out of high school. If this is the case, then our results underestimate the effect of regular marijuana use on a high school dropout by including the smaller impact of experimental use with the larger impact of regular use. Future work should examine the sensitivity of this relationship to differing levels and frequency of use.

Despite these limitations, our results have broad implications for both policy makers and researchers. For policy makers, this study suggests that marijuana initiation is a potentially important precursor of high school dropout. For researchers, our findings indicate the need to incorporate a broader appreciation of the developmental and motivational changes that adolescents undergo toward the end of their high school careers. Such a broader appreciation will be necessary if research is to inform policy makers not just about the extent of high school dropout, but also about effective ways to prevent this problem.

ACKNOWLEDGEMENTS

Research for this paper was partially funded by a grant from the National Institute on Drug Abuse, grant number R01 DA07972. The authors thank two anonymous referees for comments that improved the paper. The authors also thank Joanne Kempen for editorial assistance. Opinions expressed here are those of the authors and do not represent the views of the NIDA, Research Triangle Institute, or DFI/Aeronomics.

REFERENCES

1. US Department of Health and Human Services. Preliminary estimates from the 1995 National Household Survey on Drug Abuse. Rockville, MD: Office of Applied Studies, SAMHSA, USDHHS, Ad6anced Report No. 18, 1996.
2. Kassirer, J.P. Federal foolishness and marijuana. New England Journal of Medicine 1997; 336: 336– 367. 3. Riley, R.W. Safe and drug-free schools press conference. Remarks of the US Secretary, Washington, DC, 9 February 1996; <http://www.ed.gov/updates/sec-209.html>
4. Riley, R.W. Education: the gateway to America's future. Third Annual State of American Education Address, Maplewood-Richmond Heights Senior High School, St. Louis, MO, 28 February 1996; <http://www.ed.gov/Speeches/021996/secretar.html>
5. Mensch, B.S. and Kandel, D.B. Dropping out of high school and drug involvement. Society of Education 1988; 61: 95–113.
6. McCarthy, W.J. and Anglin, M.D. Narcotics addicts: effect of family and parental risk factors on timing of emancipation, drug use onset, pre-addiction incarcerations and educational achievement. The Journal of Drug Issues 1990; 20: 99–123.
7. Kandel, D.B. and Davies, M. High school students who use crack and other drugs. Archi6es of General Psychiatry 1996; 53: 71–80.
8. Kaplan, H.B. and Liu, X. A longitudinal analysis of mediating variables in the drug use–dropping out relationship. Criminology 1994; 32: 415–439.
9. Ekstrom, R.B., Goertz, M.E., Pollack, J.M. and Rock, D.A. Who drops out of high school and why? Findings from a national study. Teachers College Record 1986; 87: 356–373.

10. Buchmueller, T.C. and Zuvekas, S.H. Drug use, drug abuse, and labor market outcomes. Working Paper, August; 1994.
11. DeSimone, J. Illegal drug use and labor supply. Microeconomic Workshop on Labor and Population. Working Paper, Yale University, 1996.
12. French, M.T., Zarkin, G.A. and Dunlap, L.J. Illicit drug use, absenteeism, and earnings at six worksites in the US. Contemporary Economic Policy 1998; 16: 334–346.
13. Gill, A.M. and Michaels, R.J. Drug use and earnings: accounting for the self-selection of drug users. Working Paper Series 11-90, 1992.
14. Kaestner, R. The effect of illicit drug use on the labor supply of young adults. The Journal of Human Resources 1993; 29: 126–155.
15. Kaestner, R. New estimates of the effect of marijuana and cocaine use on wages. Industrial and Labor Relations Re6iew 1994; 47: 454–470.
16. Mullahy, J. and Sindelar, J.L. Health, income, and risk aversion: assessing some welfare costs of alcoholism on poor health. The Journal of Human Resources 1995; 30: 439–459.
17. Zarkin, G.A., Mroz, T., Bray, J.W. and French, M.T. The relationship between substance use and labor supply for young men. Labour Economics 1998; 17: 57–71.
18. Zarkin, G.A., French, M.T., Mroz, T. and Bray, J.W. Alcohol use and wages: New results from the national household survey on drug abuse. Journal of Health Economics 1998; 17: 53–68.
19. Cook, P.J. and Moore, M.J. Drinking and schooling. Journal of Health Economics 1993; 12: 411– 429.
20. Yamada, T., Kendix, M. and Yamada, T. The impact of alcohol consumption and marijuana use on high school graduation. Health Economics 1996; 5: 77–92.
21. Dee, T.S. and Evans, W.N. Teen drinking and educational attainment: evidence from two-sample instrumental variables (TSIV) estimates. Cambridge, MA: National Bureau of Economics Research, Working Paper 6082, July 1997.
22. Angrist, J.D. and Krueger, A.B. Split-sample instrumental variables estimates of the return to schooling. Journal of Business and Economic Statistics 1995; 13: 328–336.
23. Bray, J.W., Zarkin, G., Dennis, M. and French, M. Symptoms of dependence, multiple substance use, and labor market outcomes. American Journal of Drug and Alcohol Abuse (forthcoming).
24. Becker, G.S. Human capital: a theoretical analysis with special reference to education. New York: Columbia University Press for NBER, 1964.
25. Willis, R.J. Wage determinants: a survey and reinterpretation of human capital earnings functions. In: O. Ashenfelter and R. Layard (eds.), Handbook of labor economics, vol. I. Amsterdam: Elsevier Science, 1986, pp. 525–602.
26. Frazis, H. Human capital, signaling, and the pattern of returns to education. BLS Working Paper c258, 1998.
27. StataCorp. Stata statistical software: Release 5.0. College Station, TX: Stata Corporation, 1997.
28. Huber, P.J. The behavior of maximum likelihood estimates under nonstandard conditions. In Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability, vol. 1, 1967, pp. 221–233.
29. White, H. A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. Econometrica 1980; LVIII: 817–838.

30. Saner, H. and Ellickson, P. Concurrent risk factors for adolescent violence. Journal of Adolescent Health 1996; 19: 94–103.
31. Osgood, D.W. Drugs, alcohol, and adolescent 6iolence. Lincoln, NE: Institute of Behavioral Science, Regents of the University of Colorado, 1995.
32. Heishman, S.J., Arasteh, K. and Stitzer, M.L. Comparative effects of alcohol and marijuana on mood, memory, and performance. Pharmacology Biochemistry and Beha6ior 1997; 58: 93–101.
33. Pope, H.G. and Yurgelun-Todd, D. The residual cognitive effects of heavy marijuana use in college students. Journal of the American Medical Association 1996; 275: 521–527.
34. Block, R.I. and Ghoneim, M.M. Effects of chronic marijuana use on human cognition. Psychopharamacology 1993; 110: 219–228.
35. Langreth, R. Why smokers don't quit: new clues to how nicotine affects the brain. Wall Street Journal, 5 May 1997: B1.
36. National Institute on Drug Abuse, National Institutes of Health. NIDA Infofax: Tobacco 010; <http://www.nida.nih/gov/infofax/tobacco.html>
37. Davidson, R. and MacKinnon, J.G. Estimation and inference in econometrics. New York: Oxford University Press, 1993, p. 235.