Does Heavy Adolescent Marijuana Lead to Criminal Involvement in Adulthood? Evidence from a Multiwave Longitudinal Study of Urban African Americans

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Abstract

While marijuana use is common during adolescence, it can have adverse long-term consequences, with serious criminal involvement being one of them. In this study, we utilize longitudinal data from the Woodlawn Study of a community cohort of urban African Americans (N=702) to examine the effects of heavy adolescent marijuana use (20 or more times) on adult criminal involvement, including perpetration of drug, property and violent crime, as well as being arrested and incarcerated. Utilizing propensity score matching to take into account the shared risk factors between drug use and crime, regression analyses on the matched samples show that heavy adolescent marijuana use may lead to drug and property crime and criminal justice system interactions, but not violent crime. The significant associations of early heavy marijuana use with school drop-out and the progression to cocaine and/or heroin use only partially account for these findings. Results suggest that the prevention of heavy marijuana use among adolescents could potentially reduce the perpetration of drug and property crime in adulthood, as well as the burden on the criminal justice system, but would have little effect on violent crime.

Keywords

adolescent marijuana use; criminal involvement; African Americans; longitudinal; propensity scores

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1. Introduction

1.1 Background

Early marijuana use, especially heavy use, has been found to have negative long-term consequences, including reduced educational attainment, unemployment, early pregnancy, and poor health (Fergusson et al., 2008; Green and Ensminger, 2006; Hall and Degenhard, 2009; Lynskey and Hall, 2000; Moore et al., 2007). However, despite increasing evidence of negative consequences, data from the Monitoring the Future Survey show a recent upward trend in marijuana use among adolescents in the United States (Johnston, et al., 2009). Johnston explains that "the upward trending of the past two or three years stands in stark contrast to the steady decline that preceded it for nearly a decade" (p. 1). Accompanying this upward trend in use is a decline in perceived risk of harm from regular marijuana use (Johnston, et al., 2009), which may be driving the increase in use. Currently, only about half of U.S. high school seniors think there is great risk in regular marijuana use, down from close to 80% in the early 1990s. Similarly, public opinion polls in the U.S. since 1985 have shown increasingly favorable attitudes towards the legalization of marijuana (Millhorn, et al., 2009). Thus, there is a critical need to continue to elucidate the consequences of adolescent marijuana use and possible mechanisms driving those consequences.

One serious potential effect of early use is increased risk of perpetrating various types of crime and becoming involved with the criminal justice system, which can have detrimental health and social effects. While marijuana use and criminal involvement (other than drug use) have been shown to be highly related (see Bennett et al., 2008), it is unclear if the strong link between drug use and crime is causal (Macleod et. al, 2004). Instead the association may be a result of shared risk factors that predispose an individual to both use drugs more heavily than peers and to engage in criminal activities (Gottfredson and Hirschi, 1990; Jessor and Jessor, 1977). These shared risk factors include poor family relations, low socioeconomic status, family vulnerability to deviance, poor school achievement, behavioral problems, and a general disposition to non-conformity (Fergusson et al., 2008; Hawkins et al., 1992; Hawkins et al., 1998). While it is critical to adequately take these factors into account when investigating the association of earlier drug use and later crime, the use of randomized designs to test their causal relationship is impossible due to ethical concerns.

The aim of this paper is to examine whether heavy adolescent marijuana use increases the risk of adult criminal involvement once shared risk factors are taken into account with propensity score methods, an advanced statistical technique to adjust for observed confounders and examine potential causality in nonexperimental studies (Rosenbaum, 2009; Rosenbaum and Rubin, 1983). The goal of propensity score matching is to approximate an experimental design by matching "exposed" individuals, in this case heavy adolescent marijuana users, with "comparison" individuals (i.e., light and non-users), on a wide range of risk factors in order to attempt to replicate the distribution of (observed) covariates that would have occurred in a randomized design. This approach reduces selection bias when estimating the effects of adolescent marijuana use on crime and, through the properties of the propensity score, it captures all of the potentially confounding variation in the observed covariates. After matching, the resulting similarity of the heavy users and non-heavy users being compared means that the approach can produce inferences about marijuana use and crime that are substantially more robust and less sensitive to modeling assumptions than regression on unmatched samples (Ho et al., 2007).

However, while the propensity score approach to examining crime consequences of adolescent marijuana use represents a strength over work that uses traditional regression methods to adjust for confounding, it still falls short of a randomized design. In particular, propensity score methodology only allows for matching on observed confounders. Thus while this study

matches heavy adolescent marijuana users with light/non-users on a wide range of behavioral, academic, and family covariates (which enhances the robustness of the findings), any unmeasured confounders, particularly those that are uncorrelated with the measured confounders, may remain unbalanced between the groups and contribute to an observed association. Further, any measurement error within observed covariates remains a problem. Thus, while propensity score methods can help approximate a design in which marijuana use was randomly assigned to individuals, it still is not nearly as strong a design as a randomized experiment, which balances both observed and unobserved confounders.

1.2 Life Course Perspective

According to a life course perspective, there is a great deal of evidence of continuity in deviance throughout the life course (Sampson and Laub, 1992). For example, Lee Robins in the classic book *Deviant Children Grown Up* (1966) establishes that early conduct disordered children are more likely as adults to have a number of deviant behaviors, such as crime, drug use, and dishonorable discharges from the Armed Forces, to name a few. This finding has been replicated repeatedly in the literature. However, the reasons for this continuity are less clear. Thus, a primary question when considering continuity between drug use and crime is: is it that drug use and crime proceed from the same early risk factors or is there some direct or indirect effect of earlier substance use on the transition to crime, after controlling for these early risk factors? Two recent articles used propensity score methods to statistically control for a shared risk for drug use and crime. Slade and colleagues (2008) found that substance use disorders earlier in the life course (by age 16) predicted criminal arrest and incarceration, after matching on a wide variety of early risk factors. Odgers and colleagues (2008) found that those with a history of early substance use (multiple times by age 15) had almost four times more criminal convictions by age 32 than those without a history of early substance use after matching on relevant risk factors. Together these studies suggest that there may be a direct effect of substance use and disorders on crime; however, neither tested potential mechanisms.

Thus, a secondary question is: Do certain mechanisms along the life course explain the link between early marijuana use and adult criminal behavior? Here we propose school dropout, onset of drug disorders, and escalation of drug use to cocaine or heroin as three mechanisms potentially responsible for the link between adolescent marijuana use and crime. Research shows that frequent adolescent marijuana users have reduced educational attainment (Fergusson, Horwood, and Beautrais, 2003) and are more likely to be unemployed in adulthood as a result of limited education (Green and Ensminger, 2006). Further, reduced educational achievement and unemployment have been found to be strong predictors of crime (Fagan and Freeman, 1999; Thornberry et al, 1985). Drawing on the notion of cumulative disadvantage (Sampson and Laub, 1997), heavy adolescent marijuana use reduces the likelihood of school completion, a key life domain, which can reduce future opportunities of successful social adaptation, such as employment, which in turn facilitates criminal behavior.

Second, the life course perspective suggests continuity in drug use (Hser, Longshore and Anglin, 2007), including escalation to other drugs as well as onset of substance disorders, which have been linked to different types of criminal activity (Chaiken and Chaiken, 1990; Slade et al, 2008). For instance, transitioning from marijuana to cocaine, crack, or heroin, may increase the risk of violent crime as these drug markets of the inner cities are often violent and weapon carrying is commonplace (Korf et. al, 2008). Drug disorders have been linked to economic crime in particular with increases in crime coinciding with periods of daily use or addiction among users of heroin (Chaiken and Chaiken, 1990). Alternatively, treatment for narcotics addiction tends to reduce income-generating crimes (Anglin and Perrochet, 1998).

Moreover, the direct psychopharmacological effect of the drug can also lead to impaired judgment, as well as irritability from withdrawal symptoms, which makes crime more likely

(Brownstein and Goldstein, 1990). Data show that most male arrestees test positive for an illegal drug (National Institute of Justice, 2003) and that between a quarter and a third of federal and state inmates reported being under the influence of drugs at the time of their crime (Mumola and Karberg, 2006). Thus, heavy adolescent marijuana use may increase the likelihood of an onset of a substance disorder or simply continued substance use which, similar to school dropout, can reduce future opportunities of successful social adaptation in adulthood and facilitate criminal behavior.

1.3 The Current Study

This study tests the association between adolescent marijuana use and crime in a community cohort of urban African Americans followed prospectively from age 6 to age 42. The longitudinal design enables us to examine the potential influence of earlier marijuana use on later crime, setting up necessary temporal ordering for causality. To isolate the impact of marijuana on crime, we use propensity scores to match numerous confounders, including aggression, achievement, family factors, adolescent smoking, and non-drug delinquent behavior. We study three potential causal mechanisms linking drug use and crime to elucidate the longitudinal process — high school dropout, onset of a drug disorder, and escalation to cocaine and heroin use. We focus on various types of criminal involvement to take into account that heavy marijuana use may increase the risk of certain types of crime but not others (Pedersen and Skardhamar, 2010). We examine both official criminal arrest records and self-reports of criminal offending to safeguard against underreporting of criminal involvement. In sum, the current study improves upon much of the current work in the field by examining the potential causal relationship between marijuana use and crime by (1) utilizing prospectively gathered data spanning over 35 years, (2) using official and self-reports of crime by crime type, (3) employing a statistical approach that minimizes bias due to observed confounding, and (4) investigating potential mediating mechanisms.

2. Methods

2.1. Woodlawn Study

Data come from the Woodlawn Study, a prospective study of an African American community on the Southside of Chicago (Crum et. al, 2006; Ensminger et. al., 2002; Kellam et al., 1975). In 1966 when the study began, Woodlawn was one of the most disadvantaged of the 76 community areas of Chicago, with some of the highest rates of unemployment, overcrowding, poverty, and welfare participation. Despite the pervasive disadvantage in the community, there was also diversity, with some blocks having high rates of employment, home ownership, and high levels of education, primarily due to racial segregation within Chicago at the time.

In 1966, the Woodlawn Study recruited all first graders in the public and private schools in the Woodlawn community to participate in this longitudinal study. Only thirteen families declined. In first grade, mothers and teachers reported on the children's social adaptational status, their mental health, and the family and classroom contexts (N=1242). In adolescence (1975-77), those remaining in the Chicago area were followed up. Mothers again provided extensive in-person interviews (N=939) while adolescents (age 16, N=705) completed a questionnaire administered in a group format with an audio tape to control for reading differences (Petersen and Kellam, 1977). The teenagers reported on their alcohol and drug use, delinquency, family and peer relationships, participation in school, church, and other activities, as well as their psychological well-being. In adulthood, attempts were made to locate all original participants. In young adulthood (1992-93), 952 individuals completed the interview (ages 32). In mid-adulthood (2002-03), 833 completed the interview (ages 42). Thus, 1,053 respondents completed at least one of the adult assessments, which represent about 85% of the original cohort. During the adult assessments interviewers assessed depression and alcohol and drug

abuse/dependence, living arrangements, family relationships, education and employment histories, health, social support, participation in church and other associations, criminal activities, and economic situation. Criminal arrest records were obtained for the Woodlawn population from the Chicago Police Department in 1985 and again in 1992. FBI arrest records were collected in 1993. School and death records were also obtained periodically. Inclusion in the current analysis is based on having an adolescent assessment and complete data on marijuana use during adolescence. This was necessary so we could match heavy adolescent marijuana users with light/nonusers. Thus, the study population for this paper is 702, a subset of the larger Woodlawn Study.

2.2. Measures

2.2.1. Heavy Adolescent Marijuana Use—Heavy adolescent marijuana use, the key independent variable, is based on self-reports from the adolescent assessment, during which respondents were asked to indicate their lifetime frequency of marijuana use. Categories include: no use, 1-2 times, 3-9 times, 10-19 times, 20-39 times, and 40 or more times. We collapsed categories to create a variable that represented use 20 or more times in their lifetime. Twenty-six percent of adolescents were coded as heavy adolescent marijuana users (=1). Those who used marijuana fewer than twenty times or not at all were coded as light/non-users (=0). This cut-off was selected to represent significant drug involvement as opposed to experimental involvement. It was based on the literature (Fergusson and Horwood, 1997; Milich et. al, 2000) and previous examinations in the Woodlawn population of consequences of adolescent marijuana use (Green and Ensminger, 2006; Stuart and Green, 2008), and confirmed as appropriate based on sensitivity analyses. In these sensitivity analyses, we redefined "heavy use" as both 10 or more times and 40 or more times. Using either of these cut-offs did not have any major impact on conclusions drawn between adolescent marijuana use and adult crime. Instead, results suggest a dose-response type relationship with heavier use resulting in stronger associations with crime than lighter use.

2.2.2. Criminal Involvement—We measure the dependent variable, criminal involvement, through self-reported involvement and official arrest records from the Chicago Police Department and Federal Bureau of Investigation (FBI) rap sheets. Integrating FBI arrest records with Chicago records allows for both serious and non-serious crimes outside of the Chicago area to be included in our analysis. Of the 2,523 total arrests in our population, 21.7% were provided only by FBI information.

We operationalize crime as total crime and by type of offense (i.e., drug-related, property, and violent). The Chicago and FBI arrest records were coded by type, disposition, and age/date of arrest, beginning at age 17, which was the age of majority in Illinois at the time. They were last collected in 1992/1993 and represent crime up to about age 32.

We include a variable of 'any crime' that represents having an official arrest record from either the FBI or Chicago Police Department, regardless of offense type. Forty percent of those with an adolescent interview were arrested by 1992/1993. We also consider drug, property, and violent arrests separately. All outcomes are coded as a binary item of whether or not the participant was arrested for that type of crime. *Drug-related crimes* include the violation of laws prohibiting the production, distribution, and/or use of controlled substances and the equipment or devices utilized in their preparation and/or use (e.g., manufacture/delivery of controlled substance, possession with intent to sell); 15.1% of the sample was arrested for a drug-related crime. *Property crimes* include burglary, larceny/theft, arson, forgery, fraud, criminal damage, and criminal trespassing (26.4%). *Violent crimes* include murder, assault, battery, robbery, and domestic violence (22.4%).

For the self-reports of crime, respondents were asked about lifetime participation in various acts at the young adulthood assessment (age 32), as well as the frequency and recency of participation. In the mid-life interview (age 42), the same information was collected but restricted to the 10 years between interviews, and thus the self-reports span a longer timeframe than the official records. *Drug dealing* is a single item asked of the respondent at the young adult and mid-life interview about involvement in selling of illegal substances, coded as yes or no; 17.0% reported drug dealing at some point in adulthood. *Self-reported property crime* is a binary measure of perpetration of any of thirteen acts, such as shoplifting, automobile theft, pick-pocketing/purse snatching, arson, breaking into a home or business, spraying graffiti, and swindling or conning someone (52.8%). *Self-reported violence* is a binary measure of whether the individual perpetrated any of seven violent acts, including beating up someone for money or other valuables, using a weapon in a fight, purposely injuring someone physically, beating up someone within the family, beating up someone outside the family, forcing someone to have sex, and being in a gang fight (48.7%).

We also include a measure of whether or not the individual had ever been incarcerated. This item is based on incarceration data from multiple sources including self-reports at the two adult interviews, being interviewed in prison or jail, and being sentenced to prison or jail based on disposition information in the arrest record (23.2% of the study population; 47.0% of those arrested).

2.2.3. Matching Variables—In order to isolate the impact of heavy adolescent marijuana on criminal offending in adulthood, we match on numerous covariates expected to confound the association between marijuana use and crime. We further control for these variables in our regression analyses, as recommended by Ho et al. (2007). These variables include indicators of sex, socioeconomic status, family background, school adaptation, school achievement, other substance use, and delinquency.

2.2.3.1. Childhood Socioeconomic Status and Family Background: We match on poverty status based on mother's reports in first grade of family income and household size. This binary variable represents whether the family was living below the federal poverty line when the child was in first grade. Welfare receipt is used to fill in missingness on poverty status since eligibility for public assistance in Illinois in 1966-67 required the family to be living below the poverty line. Further, welfare payments were not sufficient to increase family income enough to be above the poverty level. We also match on four other variables reported by mothers during the first grade assessment: mother's education (range 0-22 years), family mobility (number of residential moves between the child's birth and first grade, range 0-9), whether or not the child lived in a female-headed household (mother alone) or not, and the number of children in the household (range 1-15), all indicators of socioeconomic well-being.

We also match on family activities and discipline to take into account family functioning. The family activities construct is the sum of two questions on how frequently the mother plays with or reads to the child (1= less often to 3=every day) and how often the child gets taken out (0=never to 4=weekly) (r=.19, p<.001) asked of the mother during the first grade assessment. The family discipline construct is comprised of the sum of two items in which the mother at the first grade assessment reports on the frequency of spanking, ranging from never (=0) to almost every day (=5), and the frequency of punishment for misbehavior, ranging from hardly ever (=1) to always (=4) (r=.27, p<.001, see also Juon et al., 2006).

Finally, we include family history of drug and alcohol use as two variables; one is mother's self-report in adolescence of regular alcohol use or any illicit drug use. The other is mother's report in adolescence of anyone in the family's regular alcohol use or any illicit drug use.

2.2.3.2. Childhood School Adaptation and Achievement: We match on first grade teacher's ratings of social adaptational status in five areas: aggression, shyness, immaturity, inattention, and achievement (see Kellam et al., 1975). Ratings are on a four-point scale from adapting to severely maladapting. We also include teacher's assessment of conduct problems and reading and math achievement by first grade teachers, which are also on a four-point scale from excellent to unsatisfactory.

2.2.3.3. Adolescent Substance Use and Delinquency: We match on adolescent reports of smoking at least occasionally before age 15. Finally, we match on an overall frequency of perpetrating 18 possible adolescent non-drug delinquent activities. The construct ranged from zero to 69 and frequency was measured on a five-point scale (0, 1, 2, 3-4, 5 or more). Items included carrying a weapon, hitting a teacher, participating in a gang fight, taking a non-family car without permission, damaging school property on purpose, getting into a serious fight with a student at school, running away from home, trespassing, getting something by threatening, shoplifting, skipping school, and hitting parents.

2.2.3.4. Mediators: High school dropout was a self-reported binary variable of whether or not the student finished high school. Those who graduated or obtained a GED were coded as non-dropouts (81.0%) and those who did not finish school were coded as dropouts (19.0%).

Diagnosis of a drug disorder was assessed at the adult interviews using the Composite International Diagnostic Interview (CIDI) (Kessler et al., 1994; Kessler and Üstün, 2004) and was defined as meeting lifetime criteria for abuse and/or dependence for any illegal drug. Criteria are based on the Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition (DSM-III-R) (American Psychiatric Association, 1987) for the young adult interview and the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) (American Psychiatric Association, 2000) for the mid-adult interview. Twenty-two percent of those with an adolescent interview met lifetime criteria for drug abuse or dependence in adulthood. For the mediation analyses this variable was modified to include only those who reported an age of onset that was before their age of first arrest, to ensure the drug disorder preceded the first arrest (15.0%).

The cocaine and heroin use construct was based on self-reports in adulthood. At the young adult interview, respondents were asked separately if they had ever used heroin or cocaine (including crack cocaine). During midlife they were asked about use since the last interview. Age of first use was also reported at both interviews. Those who reported lifetime use of either cocaine or heroin were coded as yes (35.4%). Again, to ensure time ordering for the mediation analyses, cocaine/heroin use was limited to those who had used before their first arrest; 25.3% reported age of first use of either cocaine or heroin before the age of their first arrest.

2.3 Attrition

The sample for this analysis is based on those who took part in the adolescent assessment and responded to the questions about marijuana use (N=702). Due to funding considerations, those targeted for follow-up in adolescence were those who remained in the Chicago area and whose mother was interviewed during adolescence and thus was able to provide consent for their child to be contacted (N=867). Attrition analyses show that mothers not interviewed were younger overall, were younger when they began childbearing, and had greater residential mobility by the child's first grade year. Comparing adolescents who were assessed and those who were not, no differences were found on sex, childhood poverty status, welfare receipt, family structure in the home, early social adaptational status or psychological well-being (Fleming et al., 1982; Kellam et al., 1983). Overall, there were no differences in adult crime between those assessed during adolescence and those not, with one exception. Those with an official report

of violence were actually slightly more likely to be assessed during adolescence than those who had not perpetrated violence in adulthood, though adolescent participation did not vary by mean number of violent arrests or self-reports of violence. Nor were there differences in adult drug use (marijuana, cocaine, or heroin), having a drug disorder diagnosis, or adult depression. Those not assessed during adolescence were more likely to drop out of high school. These attrition analyses suggest that those interviewed during adolescence are relatively representative of the original Woodlawn population.

2.4. Statistical Analyses

2.4.1 Propensity Score Matching—After some descriptive statistics were run to compare arrest rates and ages between heavy adolescent marijuana users and light/non-users, the multivariate analysis was conducted in stages, as suggested by Ho et al. (2007). Propensity score matching was conducted using the MatchIt Program (Ho et. al, 2006), a component of the R Statistical package. We utilized the full matching approach, as described by Rosenbaum (1991) and Hansen (2004). This approach allows us to retain all adolescents in our data analysis sample, and has been shown to be particularly effective at reducing bias due to observed confounding variables (Stuart and Green, 2008). Unlike k:1 matching, full matching is a more flexible approach. It creates a series of matched sets grouping together, in an optimal way, individuals with similar propensity scores, with each set including at least one exposed individual (i.e., heavy marijuana user) and at least one comparison individuals (i.e., light/non-user).

The purpose of this approach was to preprocess the data before the parametric analysis in order to reduce the association between heavy adolescent marijuana use and the confounding variables. This approach assumes that after conditioning on the observed covariates, there are no other differences between the heavy marijuana users and light/non-users; i.e., that all confounding is taken into account by the observed covariates. Therefore, bias (to the extent which the observed variables capture confounding) is removed and potential causal impacts of heavy adolescent marijuana can be estimated.

Within the propensity score analysis, the first step is to estimate the probability of being a heavy adolescent marijuana user for each individual using logistic regression in which heavy adolescent marijuana use is the outcome and the matching variables are the covariates. After estimating the propensity score, full matching uses these propensity scores to group all of the individuals into a series of matched sets based on their overall likelihood of being a heavy marijuana user, with similar individuals (defined by the propensity score) placed into the same set.

Next, we assessed the adequacy of matching by performing a series of diagnostic checks as described in Stuart and Green (2008). The assessment included an examination of the balance of each covariate, its square, and every two-way interaction as determined by standardized bias. Standardized biases of less than .25, that is less than a quarter of a standard deviation difference in means between heavy users and light/non-users, were considered good matches (Ho et. al, 2007). To improve the matching, we included various squared terms and interactions in the matching equation and re-estimated the propensity scores. The final model included a squared term of adolescent delinquency and of shyness and interactions between female-headed household and maternal substance use and between poverty status and maternal substance use. Once adequate sets were formed, each individual was then assigned a weight based on the ratio of heavy users to light/non-users within a set.

In this analysis, we created 142 matched sets based on the propensity score. Propensity scores ranged from .01 (very low) to .95 (high). Each matched set contained an average of five individuals. Although sets varied in terms of the number of marijuana users and comparison

individuals, each included at least one of the 185 heavy marijuana users (mean 1.30, median 1.00) and at least one of the 517 light/non-users (mean 3.64, median 1.00). The average difference in propensity scores within a set ranged from 0 to .05, with a mean of .002, demonstrating similarity of propensity scores within sets.

2.4.2 Weighted Logistic Regression—After matching, we first used weighted logistic regression in StataIC 10, to estimate the association of heavy adolescent marijuana use with each criminal outcome. All regression models include the matching variables as controls in order to further adjust for small differences remaining in the matched samples after matching (Ho et al., 2007). We also included the interaction of shyness and family history of substance use since the standardized bias of this interaction was greater than .25 in the final model. For the mediation analyses, we test the mediators in a three step approach as suggested by Baron and Kenny (1986) when the main analysis indicates a statistically significant association with the crime outcome. This approach first tests whether the independent variable, in this case heavy adolescent marijuana, is related to the mediators of interest. Next we test whether the potential mediators are associated with each crime outcome. Finally, we adjust for each mediator individually in a regression analysis and examine if the mediator accounts for the association of the independent and dependent variables. Partial mediation is determined when the coefficient for the independent variable is reduced but still statistically or marginally significant. Total mediation is determined when the coefficient becomes non-significant.

2.5 Missing Data

In order to retain all individuals who completed the adolescent assessment, had complete marijuana information, and were not deceased before adulthood (N=702), multiple imputation was used to deal with missingness on covariates, mediators, and outcomes, resulting in a final sample size of 702 after multiple imputation. Multiple imputation has been shown to be a significantly better approach than listwise deletion in reducing bias (Little and Rubin, 1987). There was no missing data on criminal records as it was assumed that individuals without a criminal record were never arrested (though we recognize we likely underestimate arrests as some arrests may not be recorded, arrests outside of Chicago may not have been reported to the FBI, and some individuals may have arrest records with incomplete or inaccurate demographic information precluding a good match). There was some missingness on adult self-reports of crime and mediators due to non-participation in either adult interview. Of the 702 with adolescent assessments, 634 (90%) had at least one of the adult assessments (472 had both, 124 had the young adult only, and 38 had the mid-life only). There was also some minimal missingness on matching variables due to item non-response. Multiple imputation by chained equations approach was implemented by ICE in Stata 10. Thus, for all multivariate analyses, we conducted weighted regression analyses on multiply imputed data (N=702).

3. Results

Descriptive analyses that do not adjust for confounders show that heavy adolescent marijuana users are much more likely than non-users to have interactions with the criminal justice system. We find that 58.9% of heavy adolescent marijuana users have an arrest record compared to 34.8% of light/non-users (χ^2=34.96, p<.001). Heavy adolescent marijuana users who were arrested also had more arrests on average (mean=6.5, median=4) than light /non-users who were arrested (mean=4.5, median=3) (t=1.967, p=.02). Heavy users were also more likely to be arrested at younger ages than light/non-users. The mean age of first arrest for heavy users was 21.4 compared to 22.5 for light/non-users (t=2.02, p=.045). We also see differences in rates of arrest for the three types of crimes considered (violent, property, and drug), with heavy adolescent marijuana users having 2-3 times the rate of arrest of light/non-users. Specifically, 35.1% of heavy users and 17.8% of light/non-users had an arrest for a violent crime, 40.5% of

heavy users and 21.3% of light/non-users had an arrest for a property crime, and 28.7% of heavy users and 10.3% of light/non-users had an arrest for a drug-related crime (p's<.001). Similar patterns exist for self-reported crime; 59.9% of heavy users engaged in violence compared to 44.7% of light/non-users, 69.0% of heavy users committed a property crime compared to 46.9% of light/non-users, and 30.4% of heavy users engaged in drug dealing compared to 12.3% of light/non-users. Similarly, in terms of incarceration rates, 41.6% of heavy adolescent marijuana users have been incarcerated compared to 16.6% of light/non-users.

To attribute differences in rates of crime to marijuana use and not shared risk factors, we next present results on the propensity score matching. Table 1 shows the distribution of covariates among the 185 heavy adolescent marijuana users compared to the 517 light/non-users. Before propensity score weighting, heavy users are more likely to be male, to come from a female-headed household in childhood, and to begin smoking by age 15. Heavy adolescent marijuana users also had higher teacher assessments of aggressive behavior, had higher teacher ratings on conduct problems, lower math achievement, and higher scores on the measure of adolescent self-reported delinquency. Once propensity score weighting was incorporated, none of the covariates significantly predicted heavy adolescent marijuana use in bivariate or multivariate analyses (all p's >0.05), and all standardized biases were .20 or less (see Table 1).

Table 2 shows the multivariate association between marijuana use and criminal outcomes using the propensity score matched and multiply imputed data and with adjustment for confounders in the regression equations. We find that heavy adolescent marijuana use increases the risk of being arrested for a drug-related crime and self-reported drug dealing. Those who used marijuana twenty or more times during adolescence were over twice as likely to be arrested for a drug crime and 1.7 times more likely to report the selling of illegal drugs in adulthood than those who used marijuana fewer than 20 times or not at all. There is also a statistically significant association between heavy adolescent marijuana use and property crime. Those who use marijuana heavily during adolescence have 1.5 times the risk of being arrested for a property crime based on official records and 1.8 times the risk of self-reported property crime by midlife compared to light/non-users. Heavy adolescent users also have 1.6 times the risk of an arrest in general and double the risk of having served time in jail or prison in adulthood compared to light/non-users. There is no statistically significant association between heavy adolescent marijuana use and violent crime based on either self-reports or official arrest records.

Heavy adolescent marijuana use is highly associated with dropping out of high school (OR=2.67, p<.001), meeting criteria for a drug disorder (OR=2.21, p=.001 data not shown), and using cocaine and/or heroin (OR=2.61, p<.001, data not shown). However, as shown in Table 2, once the time order of these variables is taken into account (requiring the mediator to occur before the age at first arrest) having a diagnosis of a drug disorder no longer qualifies as a mediator since heavy adolescent marijuana use is no longer a statistically significant predictor of it (OR=1.54, p=.15). Thus, 33% of heavy users developed a drug use disorder in their lifetime compared to 18% of light/non-users, but these numbers are reduced to 20% and 13%, respectively, once drug use disorders before first arrests are considered.

On the other hand, after taking time order into account, the first use of cocaine/heroin remains statistically significant (see Table 2). We find that 35% of heavy users experimented with cocaine and/or heroin before first arrest compared to 22% of light/non-users. Time order was not a concern for high school dropout as we assumed dropping out to occur before an adult arrest. Almost 29% of heavy adolescent users dropped out of high school compared to 16% of light/non-users, Thus, only high school dropout and cocaine/heroin use were tested as mediators in subsequent analyses.

Table 3 shows the association of heavy adolescent marijuana use with the statistically significant crime outcomes (Model 1) when the potential mediators are included in the regression equation (Models 2-4). While adolescent marijuana use is highly associated with dropping out of high school (see Table 2), Table 3 Model 2 shows that school dropout does not fully mediate the effects of marijuana on crime. Dropping out of high school partially mediates three of the six outcomes considered; the association between heavy marijuana use and having a property crime arrest, having an arrest record for any crime, and self-reports of drug dealing become marginally statistically significant. Adding dropping out of high school to the multiple logistic regression equations does not significantly affect the association between heavy adolescent marijuana use and having a drug-related crime arrest, ever being incarcerated, or self-reports of property crime as all three remain statistically significant.

Model 3 in Table 3 tests the association of heavy adolescent marijuana use with criminal involvement after adjusting for cocaine and/or heroin use. In this model, the use of cocaine and/or heroin accounts for the association between heavy adolescent marijuana use and self-reports of drug dealing as the initial association becomes statistically non-significant (OR=1.46, p=.163). The associations between heavy adolescent marijuana use and having a drug-related arrest (p<.01), having a property crime-related arrest (p=.01), having an arrest record (p=.01), ever being incarcerated (p<.01), and self-reports of property crime (p=.03) remain.

Model 4 presents the results of testing high school dropout and cocaine/heroin use together as potential mediators. There is little evidence that together these variables account for the association between heavy adolescent marijuana use and crime beyond their individual contributions.

4. Discussion

4.1 Associations Between Marijuana Use and Crime

As previous work with this population and other populations has shown, heavy adolescent marijuana users are significantly different from light/non-users on a variety of background characteristics. Since these risk factors are also the risk factors for crime, in order to estimate the potential causal impact of heavy adolescent marijuana use on later crime, it is crucial to estimate the independent association of marijuana with crime. Therefore, we employed full matching, a type of propensity score matching. This advanced statistical technique allows us to approximate an experimental design and equate heavy users and light/non-users on observed shared risk factors. By using matching to identify groups who are similar on all background confounders but vary in their levels of marijuana use, we can more clearly separate the effects of heavy marijuana use on crime from the effects of other possible confounders.

Employing the propensity score matching approach shows that heavy adolescent marijuana use increases the risk of engaging in crime, but only drug-related and property crime and not violent crime, lending support to the notion that marijuana use may lead to economically-driven crime. This finding is somewhat in line with the findings of Pedersen and Skardhamar (2010), which found that the majority of the association between marijuana use and crime is through drug-related crime; however, our results clearly show the risk of committing a property crime is also higher for heavy adolescent marijuana users than light/nonusers. Our findings also show that heavy adolescent marijuana users also have increased risk of ever being incarcerated and of having an arrest record, which is likely the result of engagement with drug and property crime. Almost 80% of those in our sample with an arrest record have been arrested for a drug or property crime and almost 75% of those in our sample who have been incarcerated have an arrest for a drug or property crime. Moreover, heavy adolescent marijuana users have

more arrests, on average, than their light/non-using counterparts, resulting in a more extensive criminal history which in turn increases their chances of being incarcerated.

The concordance of results found between self-reported data and official arrest records demonstrates the robustness of the findings. The utilization of both types of data addresses the limitation of previous work that relied only upon self-report or relied only on official records. However, our measurement of crime is not without limitations. For one, not all crimes are reported to the FBI, and what gets reported to the FBI varies by locality (see Geerken, 1994) and thus, arrests are likely underestimated, particularly for those residing outside of Chicago (16% of our population at young adulthood, with no differences by heavy adolescent marijuana use). Second, self-reports of offending may suffer from under-reporting or over-reporting and are limited to those crimes in the interview schedule. Finally, the way the crime categories are defined and the timeframe for measuring crime vary somewhat between the two sources. So, while we find similar results for self-reported and official reports of violence, drug-related crime, and property crime, direct comparisons are limited.

This study examined the consequences of "heavy" adolescent marijuana use, defined as twenty times or more by age 16. Sensitivity analyses suggest that using twenty times does not mark a particular threshold of risk. Instead, as the frequency of use increased, so did the strength of the association with later crime. The use of the propensity score methodology required us to dichotomize marijuana use; however, changing the threshold to ten or more times or forty or more times led to similar findings. Therefore, we conclude that "significant" or non-normative involvement with marijuana during adolescence seems to have adult crime consequences.

4.2 Mechanisms

In testing mediating mechanisms, we find some support for the idea of continuity in behavior over the life course stemming from reduced opportunities in adulthood and cumulative disadvantage as dropping out of school accounts for some of the association found between heavy adolescent marijuana use and crime. Adding high school dropout to our model reduces the association somewhat between heavy adolescent marijuana use and property crime, drug crime, incarceration, and crime overall. Thus, while high school drop-out seems to be a result of heavy adolescent marijuana use and high school drop-out predicts later crime, there still remain additional mechanisms operating, one of which may be employment, a key indicator of successful social adaptation according to a life course perspective. This is an area for future research.

Because of the known continuity in drug use, we also considered the development of a drug use disorder and the escalation to cocaine and heroin as potential mediators; however, they did not prove to be particularly relevant. Once the time order of the age of first symptom of a substance use disorder and age of first arrest is considered, heavy adolescent marijuana users are not more likely than light/non-users to develop a substance use disorder before first arrest. Therefore, the development of a substance use disorder is not useful in explaining the association of adolescent marijuana use and initial criminal involvement. Thus, there is no justification to attribute the link between early marijuana use and, at least first, criminal arrest, to drug abuse or dependence. Instead, since so many of our participants developed a substance use disorder after their interactions with the criminal justice system, it may be that criminal justice system involvement contributes to the escalation from drug use to drug problems as those with arrest records face job limitations, which may continue the cycle of drug use and crime (Anthony and Forman, 2003). Alternatively, onset of a drug disorder may increase the rate of crime as the criminal career progresses as opposed to instigate an onset of crime, an area we were not able to study. More work is necessary in teasing out these associations.

We did find one instance of total mediation. Our results show that heavy adolescent users are more likely to self-report drug dealing than light or non-using adolescents, and this association is completely mediated by a progression from marijuana to cocaine and/or heroin use. Results suggest heavy adolescent marijuana use increases the risk of cocaine and/or heroin use, and it is this escalation that may lead to drug dealing. The implication of this finding is that preventing the progression from marijuana to these other drugs should decrease involvement of heavy adolescent marijuana users in drug dealing and potentially decrease their involvement with the criminal justice system, which has long-term consequences. On the other hand, the common progression to cocaine/heroin has little impact on the association with other types of crime or criminal outcomes. Adding this variable to the model does not change the level of statistical significance of any of the associations of heavy adolescent marijuana use with self-reported property crime, incarceration, or official arrest records of property, drug, or crime overall. More work is needed to tease out the mechanisms through which heavy adolescent marijuana use leads to property crime, in particular.

4.3 Additional Considerations

In order to place our findings in context, it is important to consider our population. We used data gathered over 35 years on a community cohort. Following a community-based cohort longitudinally represents a significant strength as it overcomes the biases of a sample of drug users or offenders and of cross-sectional samples. The Woodlawn Study cohort was identified in first grade and comprised of all but 13 families with children in one of Woodlawn's first grade classrooms (public and private). Because this study was on those who remained in Chicago during adolescence, when interpreting the results, our population should be considered a cohort of individuals who grew up in an inner city environment during a culture of drug use (i.e., the crack epidemic) and potentially not representative of a national sample. However, previous work shows that it is similar to national samples on some key measures such as lifetime drug use (Ensminger et. al, 1997), and it is similar in many ways to other inner city samples and other African American samples growing up at that time (Doherty et al,, 2008). Drug use and crime are rampant in poor inner city communities (Walker, Spohn and DeLone, 2007) and studying a population in which these topics are highly relevant is necessary to tease out crucial associations among those who may benefit most from interventions.

4.4 Additional Considerations

Despite significant strengths, there are a number of considerations that should be pointed out. First, it is important to reiterate that propensity score matching methods only work as well as the range of confounders that are included in the propensity score matching. Thus, while we matched on a rich set of confounders, there may remain unobserved differences between the groups that could account for the association between heavy adolescent marijuana use and crime, and future work should test the sensitivity of these results. However, the use of propensity score methodology represents a strength. Regression analyses on unmatched samples have difficulty with collinearity – that is the high correlation between the risk factors and the "exposure" variable of interest – and putting highly correlated variables together in a regression equation can lead to invalid estimates. A related issue with traditional regression adjustment involves the potential extrapolation between heavy marijuana users and light/non users, who are quite different from each other on the observed confounders. However, because of potential unobserved confounders, this study only provides evidence *consistent with* a causal association between heavy marijuana use and crime.

Another limitation is that we focused on the effects of adolescent marijuana use on later crime and do not have the data about use at the time of the crime. Nor did we ask directly if drug use played a role in committing the crime. Therefore, we can provide insight into the effect of adolescent use on later crime but can only speculate on the effect of concurrent use on crime.

In this paper, we did not tease out the ordering of crime. We find an association with both drug and property crime, but we do not know if drug use leads to drug crime, which acts as a stepping stone for property crime, for example. Further, due to a relatively small sample of female heavy adolescent marijuana users and offenders, we are unable to analyze our data separately by gender despite prior work suggesting that the drug use crime association may diff for women and men (French et al., 2000). Also, our findings do not rule out that crime can also cause drug use. The fact that a large percentage of those with arrest records in our sample developed a drug use disorder after their arrest offers support for this idea. Menard and Mihalic (2001, p. 906) describe a relationship where "substance use and crime directly influence one another in a pattern of mutual causation." More work studying populations longitudinally is necessary to understand how drug use influences crime and crime influences drug use over time.

4.5 Conclusions and Implications

Prior research suggests that it is unlikely that a single model can account for the drug-crime relationship among all drug and crime types. Overall, while others have shown that the association between marijuana and crime is not as strong as that of crime and heroin or cocaine (Bennett et. al, 2008), we find in particular that the association of adolescent marijuana use and later crime impacts non-violent crimes and does not solely operate through education, escalation to cocaine or heroin, or developing a drug problem. Programs aimed at the prevention of heavy marijuana use among adolescents are clearly necessary considering the durable relationship with crime and the major toll crime takes on a nation. Additionally, our results suggest that criminal justice system policies that incarcerate marijuana users may have little impact on reducing violent crime, and therefore, adolescent marijuana prevention efforts may only impact the perpetration of violence if they address the shared risk factors for drug use and crime. Efforts that directly target violence prevention instead of general drug and delinquency programs seem warranted. Finally, because dropping out of high school partially mediates some associations of heavy adolescent marijuana use and crime, GED programs targeted at adolescent marijuana using dropouts may have an impact on crime, especially those who come into contact with the criminal justice system.

Finally, our work suggests that preventing adolescent use should be a top priority in that there seem to be crime consequences of heavy marijuana use, as well as increased risk of dropping out of school, developing a drug use disorder, and escalating to cocaine or heroin use among heavy adolescent marijuana users. While some of the crime consequences are likely attributable to marijuana being an illegal substance, clearly the negative health and social consequences of marijuana for adolescents, including those we and others have found in previous work (e.g., Fergusson et al, 2003; Green and Ensminger, 2006; Hall and Degenhard, 2009; Stuart and Green, 2008), provide an imperative to increase and develop effective adolescent prevention programs. This is particularly necessary now in the United States as recent evidence suggests that marijuana use among adolescents is on the rise, and beliefs about its risks and rates of disapproval among adolescents is declining (Johnston et. al, 2009).

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Table 1

Comparison of Heavy and Non/Light Marijuana Users Before Propensity Score Matching on Covariates: Means or Percents, Standardized Biases, and Statistical Significance (N=702)

Covariates	Heavy Marijuana Users (n=185)	Non/Light Marijuana Users (n=517)	Standardized Bias Before Matching[a]	Standardized Bias After Matching[a]
Male	67.6%	41.8%	0.55**	−0.05
Poverty Status	54.1%	50.5%	0.06	0.02
Mother's Years of Education	10.56	10.53	0.01	0.20
Number of Residential Moves	2.19	2.16	0.02	−0.14
Female-Headed Household	42.7%	34.2%	0.17*	−0.01
Number of Children in the Household	4.35	4.34	0.004	−0.03
Family Activities	4.80	4.75	0.03	0.07
Family Discipline	5.45	5.41	0.02	−0.03
Mother's Regular Use of Alcohol or Illicit Drug Use	11.9%	12.6%	−0.02	0.05
Other Family Members Regular Use of Alcohol or Illicit Drug Use	43.8%	39.3%	0.09	−0.08
TOCA Aggression	0.67	0.45	0.22**	−0.01
TOCA Shyness	0.44	0.47	−0.04	−0.02
TOCA Immaturity	0.61	0.60	0.02	−0.07
TOCA Inattention	0.65	0.53	0.12	0.04
TOCA Achievement	0.61	0.66	−0.06	0.05
Teacher's Rating of Conduct Problems	2.45	2.24	0.27**	0.02
Teacher's Assessment of Reading Achievement	2.50	2.50	−0.01	−0.02
Teacher's Assessment of Math Achievement	2.39	2.53	−0.20*	−0.13
Smoking before Age 15	62.2%	33.5%	0.78**	−0.07
Adolescent Self-Reported Delinquency	18.60	10.50	0.59**	0.03

[a]Compares Heavy Marijuana Users to Light/Non-Users

*p<.05

**p<.01: variables significantly different based on t-tests for continuous variables and χ^2 tests for categorical variables.

Table 2

Multivariate Association of Heavy Adolescent Marijuana Use (20+ times by age 16) After Propensity Score Adjustments with Adult Criminal Involvement and Mediating Variables (N=702)

	Model 1		
	Odds Ratio	95% Confidence Interval	p-value
Official Crime Record of:			
Drug-Related Crime	2.38	1.49-3.81	<.001
Property Crime	1.54	1.05-2.27	.027
Violent Crime	1.09	0.72-1.65	.679
Any Crime	1.58	1.06-2.35	.025
Ever Incarcerated[a]	2.10	1.37-3.21	.001
Self-Report of:			
Drug Dealing	1.72	1.08-2.75	.023
Property Crime	1.80	1.19-2.70	.005
Violent Crime	1.41	0.93-2.13	.141
Potential Mediators:			
High School Dropout	2.67	1.60-4.46	<.001
Drug Disorder Diagnosis	1.54	0.86-2.77	.145
Cocaine/Heroin Use	1.72	1.13-2.61	.012

Note: Analyses use matched, multiply imputed data. Regression analyses also adjust for all covariates shown in Table 1.

[a] Incarceration history is derived from several sources including self-reporting incarceration during one or more of the adult interviews, having been interviewed in prison or jail, or having an official arrest record indicating sentencing to prison or jail.

Table 3

Evaluation of Mediation of the Association of Heavy Adolescent Marijuana Use with Crime Outcomes: Odds Ratios and Significance (N=702)

	Model 1: Baseline Model	Model 2: Adding High School Dropout	Model 3: Adding Cocaine/Heroin Use	Model 4: Adding Dropout and Cocaine/Heroin
Official Crime Record of:				
Drug-Related Crime	2.38[**]	2.47[**]	2.43[**]	2.51[**]
Property Crime	1.54[*]	1.43[†]	1.65[*]	1.52[*]
Any Crime	1.58[*]	1.48[†]	1.71[*]	1.59[*]
Ever Incarcerated[a]	2.10[**]	1.95[**]	2.10[**]	1.96[*]
Self-Report of:				
Drug Dealing	1.72[*]	1.58[†]	1.46	1.39
Property Crime	1.80[**]	1.66[*]	1.61[*]	1.53[†]

Note: Analyses use matched, multiply imputed data. Regression analyses also adjust for all covariates shown in Table 1.

[†] $p<.10$

[*] $p<.05$

[**] $p<.01$

[a] Incarceration history is derived from several sources including self-reporting incarceration during one or more of the adult interviews, having been interviewed in prison or jail, or having an official arrest record indicating sentencing to prison or jail.