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Investigating the Long-Term Influence of Adolescent Delinquency on Drug Use Initiation

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Abstract

Prior research has found a positive relationship between delinquency and early onset of drug use. However, little is known about the influence of delinquency on drug initiation through mid-adulthood. This paper investigates the long-term relationship between serious adolescent delinquency and the onset of marijuana and cocaine use among an epidemiologically-defined community sample of African American males and females followed from first grade through age 42. Using propensity score methods we match individuals on several etiological variables that may explain both delinquency and drug use in an attempt to examine the extent to which there may be a causal link between delinquency and drug use initiation. Through a comparison of survival curves on the unmatched and matched samples of serious delinquents and non-serious delinquents, we find that serious adolescent delinquency has at least some causal influence on drug use initiation that extends into mid-life. We discuss how these results can inform future research and delinquency and drug prevention and intervention initiatives.

Keywords

propensity scores; survival analysis; delinquency; substance use; long-term

1. Introduction

Adolescence is a time of great physical, social, cognitive, and emotional change (Lerner and Galambos, 1998). It also marks a time of transition from childhood to adulthood when behavioral expressions of autonomy and adult status are prevalent (Moffitt, 1993). Minor delinquency is one of these expressions and is arguably a normative aspect of adolescent development. The National Youth Survey, a nationwide self-report survey of youth in the United States that includes minor offenses such as making obscene phone calls and skipping classes, shows delinquent behavior is ubiquitous in adolescence (see Elliott and Ageton, 1980). Moffitt comments that delinquency in adolescence “is not pathological behavior” since “its prevalence is so great that it is normative rather than abnormal” (1993: 692). However,

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while most juveniles violate the law in some way, only a minority of offenders violate the law with frequency and seriousness (Wolfgang et al., 1972).

Adolescence is also a time of experimentation with drugs. In 2005, according to the Monitoring the Future Study, 50 percent of twelfth graders had used an illicit drug in their lifetime and 38 percent had used an illicit drug in the past year. Moreover, 27 percent of twelfth graders had used an illicit drug other than marijuana in their lifetime with 20 percent using in the past year (Johnston et al., 2006). Although drug use is prevalent in adolescence among all races, there are interesting differences by race/ethnicity as substance use appears to be lower for African American adolescents compared to non-Hispanic White adolescents. For instance, 22% of Whites used marijuana in the past 30 days compared to 15% of Blacks in the Monitoring the Future sample (Johnston et al., 2006). A similar finding appears with the 1998 National Household Survey of Drug Abuse with 14% of Black adolescents (12 to 17 years) using an illicit substance in the past year compared to 17% of Whites that age (French et al., 2002). However, Blacks seem to either initiate later and/or continue their use farther into adulthood than Whites. In the 18 to 25 and 26 to 34 age ranges, these percentages begin to converge before Blacks surpass Whites with a significant difference of 8% of Blacks age 35 or older using an illicit drug in the past year compared to 5% of their White counterparts (French et al., 2002).

For all races, the concentration of delinquency and drug use in the teenage years is clearly depicted in their similar developmental patterns. Delinquent behaviors for nonviolent and violent crimes are highest in late adolescence (age 17–18), followed by a steady decline in adulthood (e.g., Farrington, 1986; Hirschi and Gottfredson, 1983; Wolfgang et al., 1987). The peak years for drug use initiation are similar (see De Wit et al., 1997); initiation tends to peak in adolescence and decline into early to mid adulthood (National Research Council, 1993). Kandel and her colleagues in their analysis of a predominantly White population cohort from New York State find that the hazard rates for marijuana initiation peak in adolescence, although initiation of other illicit drugs remains high to age 25 (Chen and Kandel, 1998; Kandel and Logan, 1984).

Another fact about delinquency and drug use is that a substantial proportion of delinquents use drugs. In a review of national and local studies on juveniles that use a wide variety of research designs, Huizinga and Jakob-Chien (1998) found that the overlap between delinquency and drug use was quite robust (see also Huizinga et al., 2000). Research among juvenile justice populations also indicates high rates of drug use. For instance, in a study of juvenile male arrestees from several cities, between approximately 23 percent and 64 percent of male delinquents test positive for an illicit drug (depending on the city) (National Institute of Justice, 1995). In another study comparing juvenile arrestees and non-arrestees, those who had been arrested in the past year were 3.5 times more likely to have used marijuana and more than 9 times as likely to have used cocaine (Horowitz et al., 2006). Moreover, research from the National Survey of Youth found that serious delinquents, defined as multiple index offenders, were significantly more likely to use cocaine than their minor delinquent counterparts; and those who reported both serious delinquency and substance use were responsible for a substantial proportion of the delinquent acts committed by the sample (Johnson et al., 1991). Therefore, while a certain amount of drug use and delinquency may be normative, of key concern for public health and criminal justice professionals are the serious delinquents (based on the type or frequency of offense or the level of involvement with the criminal justice system) who also use drugs.

As outlined above, the comorbidity of drug use and delinquency is clear, yet the temporal ordering of delinquency in relation to drug use initiation and the potential causal relationship between the two are not as readily apparent. Some studies show that substance use precedes criminal behavior (Brook et al., 1996; Loeber, 1988), yet others show that criminal behaviors

precede drug use (Deitch et al., 2000; Kandel et al., 1986). Elliott et al. (1989) state that the majority of studies show that adolescents engage in both minor and serious delinquency before illicit drug use begins and that this is especially true for cocaine use (see White and Gorman, 2000, for a review).

Assuming that delinquency does, in fact, precede illicit drug use developmentally, a more controversial question is to what extent does the preceding delinquency cause the initiation into drug use? One hypothesis which has received empirical support is that both behaviors are the result of some underlying propensity towards deviance rendering no causal effect from one behavior to the other. The temporal sequence of delinquency before drug use initiation then is merely one of opportunity and developmental stage as opposed to being indicative of a causal relationship. Proponents of this "common cause" hypothesis include Jessor and Jessor (1977) and their problem behavior syndrome hypothesis. Under this hypothesis, adolescents engage in both delinquency and drug use to express their independence and to gain peer acceptance (see also Moffitt, 1993). Similarly, latent trait theorists think that an unobservable trait or disposition (e.g., self control, impulsivity, IQ) that may be present at birth or established early in life and remains stable over time is responsible for both delinquency and drug use in adolescence and adulthood (see Gottfredson and Hirschi, 1990; Wilson and Herrnstein, 1985, for a review). For instance, Gottfredson and Hirschi in their general theory of crime state that a person's level of self-control will predict their involvement in both delinquency and drug use as well as sexual promiscuity and other non-criminal yet analogous behaviors (1990; see also Osgood et al., 1988).

However, there are still unanswered questions with regard to the common cause hypothesis. First, very few studies have adequately considered the influence of early explanatory factors on drug use and crime and investigated whether delinquency impacts drug use initiation once these factors have been taken into account (Newcomb and Bentler, 1988). Second, although researchers have noted the shared etiology of crime and drug use, few have studied the development of these behaviors prospectively over the life course (National Institute of Drug Abuse, 2003; Newcomb and Bentler, 1988; Spunt et al., 1990). Instead, the majority of studies relating crime and drug use have investigated the contemporaneous relationship between drug use and its effect on criminal behavior while intoxicated or during times of addiction (see White and Gorman, 2000, for a review). Finally, many studies use clinical or criminal justice samples which are less generalizable to the general population. Moreover, most prospective studies focus on Whites and adolescents leaving African American adolescents and adults, who are disproportionately involved in adult crime and drug problems, as an understudied population.

1.1 Current Study

The current study proposes to fill these gaps in the research. First, this study uses prospective and longitudinal data, which allows temporal sequencing to be taken into account. Second, this study focuses on a community population of African Americans who have a high rate of crime and drug use among both males and females. Third, this study looks developmentally at the relationship between delinquency and drug use over the life course, focusing on initiation of drug use into mid-adulthood. Finally, in an attempt to tease out the potential causal influence of serious adolescent delinquency on drug use, this study uses the technique of propensity score matching, which has been a prominent method in economics since the 1980s but has recently been adapted to address questions pertinent to public health. This strategy simulates a randomized design by matching individuals on a wide selection of etiological variables that may explain both drug use and delinquency and overcomes the limitations of regression on unmatched samples.

Thus, the motivating questions of this study are (1) Does serious adolescent delinquency increase the risk of marijuana and cocaine use initiation in an urban sample of African Americans?;[1] and (2) To what extent might serious adolescent delinquency play a causal role in initiation into drug use throughout the life course?[2] Since cocaine use begins at an older age than marijuana use, for the second question, we present our findings with respect to cocaine as this allows for proper temporal ordering between delinquency and drug use to be established for the majority of the sample.

2. Method

2.1 The Woodlawn Sample

The Woodlawn sample is an epidemiologically-defined community sample of African American males and females from Woodlawn, which is an inner-city community in Chicago. This research is part of a larger long-term project, which began in the mid-1960s and takes a life-course approach to studying the developmental patterns and correlates of substance use and crime across the life course (Kellam et al., 1975).

This sample was first assessed in 1966 when the participants were in the first grade (N=1242, 13 families declined participation) and has been followed longitudinally at three additional time points through mid-adulthood (age 16, 32, and 42). During first grade, teachers were asked about each child's classroom behavior; clinicians observed the children in standardized play situations; and mothers (or mother surrogates) were interviewed about their first grade child and his or her family background. The mother interview included questions about the family itself (such as income, family structure, residential mobility, social integration, and mother's education) and questions concerning the family's child rearing practices (such as discipline and affection) among others.

In 1975–1976, ten years later, a subset of the original cohort still living in the Chicago area were interviewed at age 16 (N=705). In addition, the mothers or mother surrogates were re-interviewed at this time. In 1992 and again in 2002, when the "children" were 32 and 42, respectively, a search was performed to locate all those from the 1966 sample. In 1992, 952 of the living participants were interviewed about a variety of social, psychological, and behavioral domains. In 2002, 833 of the living participants were interviewed using a similar interview schedule (see Figure 1).

At the time of the initial study, Woodlawn was a socially disadvantaged, predominantly African American, inner-city community in Chicago.[3] One criticism of previous studies investigating the drug-crime relationship in general populations is that they often have a very limited number of people who engage in delinquency and drug use. A distinguishing feature of this longitudinal study is the high rate of criminal activity both within the cohort and within the community where the cohort lived when the study was initiated. During the period from 1966 to 1972, Woodlawn had the highest rate of male juvenile delinquents of the 76 community areas of Chicago (33.5 per 100 males between the ages of 12 and 16) (Council for Community Services, 1975). The cohort members themselves also reported high rates of criminal activity -- 96

[1]While this question is important for any type of drug and for drug disorders, a thorough investigation of all drug types and disorders is beyond the scope of this research. Since we are in the preliminary stages of investigating the relationship between delinquency and drug use using propensity scores, we chose to focus on use as opposed to disorders as a first step in this investigation. In addition, we focus on marijuana and cocaine use, as opposed to other drug types, as these are two commonly used drugs in the US and internationally.

[2]It is also important to note that this study investigates the onset of drug use for all users. Therefore, the effects of experimentation versus persistent use are not analyzed in this study.

[3]Although Woodlawn was one of the most socially disadvantaged communities in Chicago at the time, it was also economically heterogeneous because of the residential segregation of African Americans in the 1960s. As a result, there were working-class, middle-class, and welfare families; 68% of the families were not on welfare, 47% were above poverty level, and 42% of the mothers had twelve or more years of education.

percent of those interviewed in adolescence self-reported at least one delinquent act between the ages of 13 and 16. Moreover, 38 percent of the cohort had an official arrest record between the ages of 17 and 32. Although drug use among the Woodlawn population was similar to national estimates in adolescence, current use became comparatively higher as the cohort aged. For instance, while the lifetime prevalence at age 32 was similar to the prevalence of those in the National Comorbidity Study of a similar age (age 31–34), the past year prevalence of marijuana and cocaine use at that age was at least twice as high among the Woodlawn population (Ensminger et al., 1997).

2.2 Measures

2.2.1 Marijuana and Cocaine Use—The onset of drug use information is drawn from the 1,053 people who were interviewed at age 32 and/or age 42 (see Figure 1). Both the early (1992) and mid-adult (2002) assessments of substance use were modeled after the modules developed at the University of Michigan for the National Comorbidity Survey (NCS) from the Composite International Diagnostic Interview (CIDI) (Anthony et al., 1994;Kessler et al., 1994). For each drug type, the person was asked whether he or she had used it and if so, the age of first use.[4] While this information was taken for several types of drugs, the focus here is on marijuana and cocaine. In this cohort, 58 percent of the sample had used marijuana by age 42 with a mean age of onset of 17 and 30 percent had used cocaine by age 42 with a mean age of onset of 24. These lifetime estimates are higher than those reported from national cross-sectional samples but lower than those reported by other longitudinal cohort samples (see Brunswick and Messeri, 1999;Chen and Kandel, 1998;Vega et al., 2002).

2.2.2 Adolescent Delinquent Behavior—Serious delinquent behavior is measured from self-reports administered in adolescence and in young adulthood. From the adolescent interview, the frequency of 18 non-drug related self-report items were combined into an index of delinquency where higher scores indicate more frequent and a wider variety of offenses. From the young adult interview, nine dichotomous items of delinquent activities engaged in before age 15 were combined into an index of delinquency seriousness where higher values indicate a wider variety of offenses. Appendix A outlines the items and descriptive statistics for the 27 individual items used to create these adolescent delinquency indices.[5]

In order to determine a group of serious delinquents, we cut both delinquency indices at one standard deviation above the mean to distinguish those who were serious delinquents at each assessment. A person is labeled as a serious delinquent in adolescence if he or she is considered to be a serious delinquent according to the adolescent scale, the young adulthood scale, or both.[6]

As shown in Table 1, the result is two groups of adolescents (N=1,053). One group comprises serious and frequent offenders as adolescents, labeled serious delinquents (18 percent of the sample), and the other group comprises non-serious, experimental, or non-offenders as adolescents, labeled non-serious delinquents (82 percent of the sample). A variety of analyses

[4]For those participants who started using before age 32 and have data from both the early and mid-adult interviews, the early adult information on age of first use is used because it is the reporting time closest to the time of the behavior. While the use of retrospective data is not ideal, it is necessary given the time lag between each assessment in our data. In examining the consistency between age of onset reported at young adulthood and mid-adulthood, we found strong correlations (r=.482 for marijuana, r=.494 for cocaine, r=.839 for heroin, p's<.01), suggesting adequate concurrence over time.

[5]Illicit drug use and other drug-related crimes are not included in the index of delinquent behavior. Although these are considered delinquent acts, the inclusion of these behaviors in the delinquency index would confound and inflate the relationship between delinquency and drug use.

[6]Both the prospective information from adolescence and the retrospective information from young adulthood were used to increase the potential sample size from 56% of the sample to 85% of the sample. A comparison of those with information at both assessments (N=594) reveals a significant correlation between those labeled as seriously delinquent based on the adolescent measure and on the young adult measure (χ^2 = 11.45, df=1, p = .002).

indicate that this measure is valid; those who are labeled serious delinquents were significantly more likely to be males who committed both violent and non-violent acts and committed them frequently. In contrast, those who are labeled non-serious delinquents tended to be female, who were either nonoffenders or non-violent offenders only and committed these offenses infrequently. Additionally, those who were labeled serious delinquents were significantly more likely to be arrested in adulthood (ages 17 to 32) (χ^2= 29.551, p < .001).

2.2.3. Matching Variables—In order to compare the drug use of the serious delinquents with the drug use of the non-serious delinquents, we need to take into account the many variables on which these two populations could differ. Controlling for these variables within a conventional regression analyses may not adequately take into account the many ways the two populations are likely to differ. Thus, we will use propensity score analyses, discussed in detail later, to match the two populations on several variables before examining their drug use, which allows for a causal attribution to be more strongly supported (Rosenbaum and Rubin, 1983).

In our matching procedure, we include a large number of potential common factors associated with substance use in adolescence and young adulthood (Hawkins et al., 1992) and of youth violence (Hawkins et al., 1998) to exclude the possibility that drug use and delinquency are related spuriously. In our propensity score analyses we match individuals on measures of economic deprivation; family size, structure, and mobility; family history of substance use; family discipline; family affection; first grade teacher ratings of school adaptation; first grade academic achievement; and early onset of marijuana use. Since this is a community cohort of African Americans who were all in the first grade in 1967, race and age are controlled by the nature of the sample. In addition, since each child grew up in Woodlawn, regional location is similar for all individuals.

We use two measures of economic deprivation assessed through the initial mother interview, poverty and mother's education. *Poverty* is measured by a dichotomous variable of whether the family's income in 1967 fell below the poverty line for the household size. For those who were missing data on this variable, poverty was assessed using the measure of whether the family was supported by welfare. Those who received welfare were considered to be below the poverty line since the eligibility requirement for receiving welfare in Illinois at this time was living below the poverty level. Moreover, welfare benefits were not sufficient to raise a family income to above the poverty level (US Department of Health and Human Services, 2007).[7] *Mother's education* is a continuous measure of the number of years of school the mother had completed at the time of the interview (range 0–18). *Family size* is a continuous measure that indicates the number of children under 19 years old in the household during childhood and ranges from 1 to 15. *Family type* was based on the combinations of adults in the family of the first graders and included four types: mother and father present, mother alone, mother and other adults (not the father), and families with no mother present (mother absent). This variable was dichotomized into female-headed household (mother alone) or not. *Residential mobility* measures the number of times a child had moved in the six years between his or her birth and the time of the interview in 1966–1967 (range 0 to 9).

Family substance use is measured through mother's self-reported substance use which was asked of the mothers at the time of the adolescent interview. Any amount of an illicit substance (i.e., marijuana, cocaine, heroin, hallucinogens, inhalants, stimulants, amphetamines, sedatives, tranquilizers) and/or regular use of alcohol (i.e., used alcohol on a "regular basis" in the past 12 months, as opposed to once/twice or occasionally) was coded as lifetime

[7]Poverty and welfare are highly associated in this sample; among the participants with both measures available, those who received welfare were highly likely to also be defined as falling below the poverty line (χ^2 = 392.65, p<.001).

substance use by the mother. Thirteen percent of the mothers interviewed reported illicit drug use or regular use of alcohol at some point in their lifetime. *Family discipline* is measured through two questions asked of the mothers at the time of first grade: how often the child was spanked, ranging from never to almost every day, and how often the child got punished for misbehavior, ranging from hardly ever to always (r=.27 for 2 items, $p < .001$). The composite score of family discipline was a sum of these two items with a range of 1 to 9. *Family affection* was assessed through two questions: how often did the mother play with or read to the child and how often did the child get taken out, ranging from never to every week. The summed score of family affection was constructed with a range of 1 to 7 (r = .19 for 2 items, $p < .001$) (see also Juon et al., 2006).

In first grade, teachers also rated each child in their classroom on five aspects of school adaptation, including *aggressive behavior*, *shyness*, *inattention*, *underachievement*, and *immaturity* (Kellam et al., 1975). All of these variables were measured by the Teacher's Observation of Classroom Adaptation (TOCA) scale, which ranges from 0 to 3, adapting to severely maladapting. In addition, the teacher graded each child's general *classroom conduct* as unsatisfactory, fair, good, or excellent (0 to 3). These measures are important individual predictors of delinquency and drug use and are also an attempt to approximate the potential existence of an unobservable latent trait that may be predictive of both of these behaviors.

Two additional indicators of academic failure are included: child's first grade *reading* and *math* grades. Each teacher graded a student as unsatisfactory, fair, good, or excellent in reading and math separately. Finally, early onset of drug use is a known indicator of later drug use. *Early onset of marijuana use* is used to measure the propensity towards cocaine use. Fifty-eight percent of the cohort used marijuana at some point in their lives (through mid-adulthood) with the majority of users initiating in adolescence (mean age = 16.6, median age = 16, standard deviation = 3.4). Early onset of marijuana use is a dichotomous variable with early onset defined as initiating marijuana use by age 15.

The sample is reduced to those individuals who had information on all of the matching variables. Also, for fair comparisons and to ensure temporal ordering between delinquency and cocaine use, we include all non-users of cocaine and users with an onset at age 16 or older, which is the majority of cocaine users as only 8 individuals had an onset of cocaine use prior to age 16 (N=633 total, 127 serious delinquents and 506 non-serious delinquents) (see Figure 1).

2.2.4 Attrition Analyses—It is important to consider attrition since some measures were assessed at the first grade interview, some from the mother's interview when the participants were adolescents, and the outcome variable was assessed in adulthood. As Figure 1 outlines, the Woodlawn Study has experienced attrition due to the inability to contact every participant at each wave. In order to address the potential biases with the attrition, we conducted several analyses to assess whether there are systematic reasons for missing cases. To begin we tested for attrition biases by comparing those who had at least one adult interview (N=1,053) with those who did not.[8] We found no difference on such key variables as gender (86% of females and 83% of males were interviewed), socioeconomic status (e.g., mother's education, welfare participation at baseline), adolescent drug use (e.g., alcohol, cigarettes, marijuana, cocaine), early childhood behavior (e.g., teacher reported aggression and shyness in first grade), adolescent problem behavior (e.g., status offenses such as self-reported suspension and fighting with parents), adolescent self-reported delinquency (e.g., violent and property crimes), information from adult criminal records (e.g., age of first arrest, arrest for a property crime),

[8]It is important to note that 85% of the study population was assessed in adulthood at one or both time-points.

and 1970 and 1980 census variables such as percent white collar workers, percent unemployed, percent below poverty and percent Black. However, there were some significant differences that should be noted. Those interviewed in adulthood were more likely to have graduated from high school and less likely to be in poverty in first grade or adolescence. Interestingly, cohort members with a criminal record for a violent or drug-related crime were significantly more likely to have an adult interview than not.

Further, because only the participants who remained in Chicago and their mothers were interviewed at adolescence, we also compared the children who were missing in adolescence with those who had an adolescent interview. In terms of early (first grade) variables, those interviewed in adolescence did not differ by gender, early family type, mothers' education, early family income, or poverty from those who were not assessed during adolescence. In terms of later (adulthood) variables, those assessed in adolescence did not differ from those not assessed with respect to having an official adult arrest record, using drugs, or having a substance use disorder. Individuals not assessed in adolescence were more likely to have dropped out of high school and to have low first grade math scores. Those missing in adolescence were also less likely to have an adult interview. Overall, although there are some differences between those who were and were not followed, these analyses indicate very few areas of concern.

2.3 Analyses

2.3.1 Marijuana and Cocaine Initiation—We identify the onset and prevalence of marijuana and cocaine use through mid-adulthood using discrete time survival analysis (see Lee and Wang, 2003). The axis for time in these models is age in years of first use. Figure 2 shows the hazard rates of marijuana and cocaine which indicate the instantaneous potential for drug use at each age among those who have not yet initiated by that age. Marijuana is commonly considered to be a precursor of cocaine use (see, e.g., Kandel and Faust, 1975;Kandel and Logan, 1984); thus, a solid understanding of marijuana initiation among this cohort can inform the analyses on cocaine use and speak to the generalizability of the results.

The age associated with the highest risk of initiating marijuana is 16, which is consistent with hazard rates for these drugs reported in previous studies (Kandel and Logan, 1984; National Research Council, 1993). With this sample of African Americans, at age 16, those who have yet to initiate marijuana use have a 16% chance of initiating in that year (see left-hand axis of Figure 2). This percentage decreases between ages 16 and 18 and again sharply decreases between ages 18 and 20 before reducing to a 1% chance of initiating marijuana use by the age of 24.

In contrast, an individual in the cohort has a much lower risk of initiating cocaine use with approximately a 2% to 3% chance between the ages of 19 and 30 before the hazard sharply declines at age 30 with a very low risk of cocaine initiation after age 33 (see right-hand axis of Figure 2). Although the risk is low after age 30, it should be noted that 8 percent of the cocaine users initiate after this age.[9] These findings indicate the importance of an investigation into the long-term developmental indicators of cocaine use initiation into early to mid-adulthood.

2.3.2 Nonparametric Survival Analysis—We estimated the cumulative survival rates for marijuana and cocaine, which indicate the probability that a person has used that drug by a certain age. Nonparametric survival curves (i.e., Kaplan Meier curves) are used to estimate the

[9]Interestingly, while late adolescence and early adulthood are the high risk years for initiation of cocaine use, the highest risk of initiation is age 26, which coincides with the year 1986 and the crack epidemic in inner cities.

cumulative incidence rate for these drugs comparing the unmatched and propensity-matched samples of serious delinquents and non-serious delinquents.[10]

3. Results

3.1 Investigating the Relationship between Serious Adolescent Delinquency and Drug Use

Figure 3 shows the differences in the cumulative incidence rates of marijuana among serious and non-serious delinquents in the Woodlawn cohort. As this figure indicates, the cumulative incidence rate increases dramatically from around age 12 until age 20 for both groups before leveling off in the early twenties. By age 26, the cumulative incidence increases to 74 percent for the serious delinquents where it remains throughout mid-adulthood. A similar pattern occurs for the non-serious delinquents with 58 percent initiating marijuana use by age 20 where it remains through age 42. The statistical significance of the lower rate of the non-serious delinquents is evident based on a log-rank test ($\chi^2 = 36.33$, $p<.001$) and on the fact that the confidence intervals (depicted by the dashed lines) do not overlap. Notably, there is virtually no initiation after age 20 and marijuana is somewhat common for both the serious delinquents and the non-serious delinquents.

A survival analysis for the unmatched sample on cocaine initiation with serious delinquents reveals similar results to marijuana use, yet at lower incidence rates. With cocaine, serious delinquents have a cumulative incidence of 53 percent by age 42 while those in the non-serious delinquent group having a cumulative incidence of 26 percent ($\chi^2 = 59.40$, $p<.001$). In addition, initiation of cocaine begins later and continues well into the 30s for both groups.

To adequately address the second question of the potential causal impact of serious delinquency on substance use, we focus the next phase of our analysis on cocaine use while controlling for early marijuana use. The relatively early onset of marijuana use and its common nature among this sample for both the serious and non-serious delinquents makes it very difficult to tease out the temporal ordering of serious delinquency and initiation of marijuana use. For instance, among the Woodlawn cohort, 38% of those who used marijuana started at age 15 or younger and 58 percent started at age 16 or younger. Thus, since temporal ordering is a crucial component of establishing causality, we present the methods and results for propensity matching and the survival analysis results of cocaine use for the propensity-matched sample. However, it is important to note that a separate analysis with a propensity-matched sample was conducted for marijuana use yielding statistically significant results similar to those found with cocaine use.

3.2 Investigating the Potential Causal Relationship between Serious Adolescent Delinquency and Cocaine Use

3.2.1 Propensity Scores—While it is difficult to show causality with non-experimental data, the propensity score approach is a novel one that can estimate causal effects in observational studies. Thus, to reduce selection bias and simulate a randomization process of serious delinquency versus non-serious delinquency, we employ a propensity score approach to examine the potential causal role of serious delinquency on cocaine use. This approach, although still not creating a randomized experiment, simulates one through statistically controlling for the dissimilarities in background characteristics between serious delinquents (i.e., the treatment group) and matched controls (non-serious delinquents). The purpose of this approach is to preprocess the data before the analysis in order to take into account the association between being a serious delinquent and background covariates without introducing inefficiency or bias. One advantage of propensity score matching is the ability to include a

[10]To assess significant differences, we conducted log-rank tests, Wilcoxon tests, and Tarone-Ware tests yielding similar results.

number of possible confounding factors that are highly correlated with one another. For instance, we included a number of measures of family socioeconomic status and functioning, as well as multiple teacher ratings of first grade behavior and performance (e.g., aggression and restlessness are strongly and significantly correlated, $r = .699$ $p < .001$). A second advantage is that matching is conducted without knowledge of the outcome. Further, propensity scores capture all of the potentially confounding variation in the covariates, enabling us to match on one score instead of many variables. Propensity scores also avoid the heavy dependence on the model assumptions of standard regression and produces inferences that are substantially more robust than standard regression on unmatched samples, since standard regression analyses ignore that treatment group and control group members may not overlap enough on background variables to allow for a meaningful comparison (Rosenbaum and Rubin, 1984; Tan, 2006).

Using the MatchIt program (Ho et al., 2005), a component of the R statistical package (R Development Core Team, 2005), we first estimated the probability of being a serious delinquent for each respondent using logistic regression. This propensity score is a numerical summary of all the background covariates for each individual. Next, we used the one-to-one nearest neighbor matching method to match males with males and females with females (Rosenbaum and Rubin, 1983). Nearest neighbor matching selects the best overall control match for each individual in the serious delinquent group -- the "treatment" group -- based on a distance measure defined by the propensity score, estimated using a binomial generalized linear model with a logit link function (Venable and Ripley, 2002). Matches were chosen for each treatment unit sequentially without replacement. For each treatment unit, the control unit that was not yet matched but was closest to the treatment unit on the distance measure was chosen. Control units not selected as a match were discarded. The resulting matched data set consisted of the 127 serious delinquents and their 127 matched non-serious delinquent controls with equal number of males and females. We excluded 379 individuals from the non-serious delinquent group (see Figure 1).

Once matches were selected, a variety of approaches were taken to examine the adequacy of the propensity score matching, including numerical and graphical summaries.[11] The result of these analyses is a group of serious and non-serious delinquents with comparable propensities towards delinquency and cocaine use based on a wide variety of risk factors. As Table 2 indicates, the sample of unmatched serious and non-serious delinquents differed significantly on key confounding variables that would predict delinquency and cocaine use. For instance, the serious delinquents were significantly more likely to be male, to have harsher and frequent punishments as children, to have poorer classroom conduct scores and to have an early onset of marijuana use. After the matching procedure, all of these variables become non-significant rendering the two groups comparable on their propensity to offend and to use cocaine.

Although these serious and non-serious adolescent delinquents are similar on a wide range of predictors for delinquency, it is important to highlight that the two groups still differ significantly with respect to their adolescent offending behavior. As seen with the unmatched sample, although the two groups are now equal in their proportion of males and females by design, those who are labeled serious delinquents are still significantly more likely to have committed both violent and non-violent acts in adolescence and committed them frequently while their non-serious counterparts were significantly less likely to have committed violent

[11]We examined quantile-quantile and jitter plots to ensure that matching improved balance in the distribution on covariates (Ho et al., 2005, 2007). We also examined numerical summaries including the difference in means in the original sample and the matched group. Examining the standardized bias, which is the difference in means of the covariate in the treated and control groups divided by the treated group's standard deviation, for all covariates, their squares, and every two-way interaction, we determined the matches to be adequate. That is, all standardized biases were less than a quarter of a standard deviation difference in means across groups (Ho et al., 2005, 2007).

offenses and were less likely to report criminal behavior in young adulthood. However, it is important to note that among the matched sample, the serious delinquents were no longer more likely to be arrested than their non-serious counterparts (χ^2 = 1.323, p=.250).

3.2.2 Cocaine Initiation—Figure 4 shows a comparison of cocaine initiation for the serious and non-serious delinquents after they have been matched based on their propensity scores. Although the extent of the difference in cumulative incidence is lower than those found with the unmatched sample, the general results remain once the matched samples are compared (χ^2 = 6.46, p=.011). Serious delinquents continue to initiate cocaine at a higher rate than their non-serious matched counterparts with 53% initiating by age 35 before stabilizing throughout mid-adulthood. For the non-serious delinquents, this pattern is apparent yet at a lower rate with 39% initiating by age 36 where it remains through age 42. In addition, the slope of the incidence continues to increase for both groups before becoming parallel around age 35. Thus, the fact that these rates do not begin to converge with age indicates that the relationship between serious adolescent delinquency and initiation into cocaine use remains regardless of age of onset.[12]

One concern with these results on cocaine initiation is whether we have adequately controlled for the fact that those who initiate marijuana are more likely to initiate cocaine. Although early marijuana use was included as a matching variable in the propensity score analysis, to safeguard against additional potential confounding of marijuana use, we estimated several Cox proportional hazards models that included the matched serious and non-serious delinquency indicator along with whether the person had ever used marijuana, whether someone used marijuana before age 16, and age of first use of marijuana for the matched sample (N=254). The results indicate that serious delinquents in adolescence have close to twice the hazard of initiating cocaine as their matched non-serious delinquent counterparts after controlling for whether a person had ever used marijuana ($p < .01$). When either marijuana use before age 16 or age of first marijuana use is used in the model instead of the dichotomous measure of ever used marijuana, serious delinquents are still approximately 1.5 to 2 times more likely to initiate cocaine (p=.011 and p=.018, respectively). In each model, the marijuana variable also significantly influences the hazard of initiating cocaine at $p<.01$, controlling for delinquency.

4. Conclusion

Overall, serious adolescent delinquency appears to increase the risk of drug use initiation for marijuana and cocaine – we see this in both the differences in cumulative incidence and in the significant log-rank tests among the unmatched samples. However, serious delinquents differed from non-serious delinquents on a number of important background variables that may influence drug initiation (e.g., conduct problems, family discipline, early onset of marijuana use). The fact that serious delinquents were matched with similar non-serious delinquents on a wide range of confounding variables such as these using propensity score methods further suggests that serious adolescent delinquency may have at least some causal impact on illicit drug use initiation such as cocaine. Although previous investigations may have controlled for a variety of confounding factors in a traditional regression framework, the propensity score method goes beyond these studies by removing the potential violations of collinearity and of the assumption of non-overlapping comparison groups (Rosenbaum and Rubin, 1984; Tan, 2006). By using a matched sample, we were better able to test the potential causal association between serious delinquency and drug initiation, which is a major strength of this investigation. Thus, this study adds to the considerable debate about whether delinquency is a cause of drug

[12]To safeguard against potential bias from including retrospective measures with prospective measures to define serious delinquency, we re-matched serious delinquents with non-delinquents using the prospective adolescent measure only to define serious delinquency. We then re-ran the survival analysis for cocaine use. Although the results fall to non-significance presumably due to the reduced sample size, the substantive estimates and patterns were sim6ilar to those reported here.

use, exacerbates drug use, or if there is a common underlying cause. Our findings do not support the common cause hypothesis (Jessor and Jessor, 1977) and latent trait hypotheses (Gottfredson and Hirschi, 1990) which predict no association between serious delinquency and drug use once propensity is taken into account. Our findings assume that we were able to capture the propensity for deviance using propensity score matching, and thus results should be interpreted with this consideration in mind.

In addition, there are some limitations with this research that need to be mentioned. First, drug use initiation is recalled retrospectively due to the design of the Woodlawn study, with a potential of an over 20-year recall for those with an interview at age 42 and an early onset. Though there is little literature to draw upon, existing research suggests that there may be some bias in the retrospective reporting of age of drug use onset. Beyond denying illicit use altogether, the concern is that individuals tend to forward telescope; that is, individuals often increase their reported age of first use as they age (Golub et al., 2000), especially when the interval between the report and the first use is large (Johnson, et al., 1998). However, after examining the consistency between ages of onset reported at young adulthood and mid-adulthood, we found strong and significant correlations, which suggest that this is not an overriding concern. Further, in a published report of the Woodlawn data, which analyzed the consistency between adolescent reports and adult retrospective reports of adolescent marijuana use and frequency of use, Ensminger et al (2007) found that the majority of participants were consistent in their retrospective reports. Moreover, only about 9 percent were inconsistent in their reporting of the age of initiation between adolescence and adulthood. Therefore, while the potential bias of misreporting age of onset, especially among early onset users, is unclear, in general we expect the patterns to be similar regardless of whether the person was off by a few years in their reporting of age of first use.

A related limitation is the fact that we used both a prospective measure and retrospective measure of adolescent delinquency to establish our group of serious adolescent delinquents. While the sole use of prospective data would have been ideal, that would have limited our sample size to half the original cohort potentially biasing the results (N=637 with drug use onset information). On the other hand, the inclusion of retrospective data for those with an interview in young adulthood but no adolescent interview (N=353) introduces bias through retrospective recall. We chose to increase the sample size and use all of the information available to us. While sensitivity analyses indicated that the results are robust regardless of the measure used and a chi-square test relating those labeled as seriously delinquent based on the adolescent measure and on the young adult measure showed a significant relationship (χ^2 = 11.45, df=1, p = .002)., the potential bias due to the retrospective nature of that information is unknown and should be considered when interpreting the results.

In light of these limitations, there are several offsetting strengths that should be highlighted. For instance, much of the research on drug use and crime has not extended beyond early adulthood yet it is clear that drug use initiation, especially of cocaine, continues into adulthood. The fact that we have longitudinal data over 35 years and can assess the long-term impact of adolescent delinquent behavior into adulthood is a significant strength. In addition, the use of propensity score methods, with matching on a wide-range of individual and family characteristics and a careful consideration of time ordering, provides evidence that there may be a causal association between delinquency and drug initiation. Further, these background variables come from multiple informants, including cohort members, mothers, and teachers, who have provided independent assessments. Another significant strength is that this is a community sample with high rates of delinquency and adult drug use. Thus, while the generalizability of this study is restricted due to the fact that the sample is African American from one neighborhood in the Southside of Chicago who were born in the early 1960s, its generalizability is an improvement over other studies which focus on pathological samples.

Finally, this study focuses on an understudied population which, along with other studies of its kind, contributes to our understanding of delinquency and drug use patterns in general.

Beyond replication studies on a variety of samples that could increase the knowledge about the generalizability of these results, there are a number of areas for future research stemming from these findings. One area for future work is an investigation into the plausible explanations as to why adolescent delinquency has a long-term impact on the onset of drug use. Some potential mechanisms include affiliations with deviant peers or situations and labeling effects due to arrest, incarceration, or informal appraisals to name a few. The literature has consistently shown that peers influence both drug use and delinquency (e.g., Akers, 1998; Dishion and Patterson, 2006), both of which may increase drug opportunity or affect norms regarding drug use. In addition, a good deal of research finds evidence of a labeling argument, proposing that continuity in behavior results from the criminal status placed upon those who have contact with the criminal justice system (Becker, 1963). Once stigmatized as deviant, the individual begins to accept the label which in turn leads to continuing deviance. Moffitt (1993 Moffitt (1994) argues that adolescent deviance may be extended if the individual hits “snares,” such as getting arrested. Another way criminal sanctions may increase the risk for illicit drug use is by negatively impacting opportunities for achieving conventional social roles and accomplishments (e.g., Bernburg and Krohn, 2003; Davies and Tanner, 2003). For example, those who have been subject to criminal sanctions have reduced employment opportunities and lower job stability which in turn reduces social integration and facilitates future crime and drug use (Pager, 2003; Sampson and Laub, 1993). Although in the Woodlawn sample the serious delinquents and their matched non-serious counterparts did not differ in terms of the likelihood of being arrested, these labeling effects have also been extended to informal labeling through parental appraisals and the youths’ reflected appraisal of themselves (Matsueda, 1992). Future research on the issues of peer influence, opportunity, formal and informal labeling may help explain the relationship between serious adolescent delinquency and drug use revealed in this study.

In addition, future research could address the potential differences between experimental drug users and non-experimental drug users. Preliminary analyses with the Woodlawn data indicate that serious delinquency impacts cocaine initiation for experimental and non-experimental drug users, defined as using cocaine for two years or more. A more rigorous analysis of this issue could concentrate on the extent of the influence of serious adolescent delinquency on more serious and extensive cocaine use over the life course. Moreover, although cocaine use is a serious public health concern both in the US and internationally (Ilse et al., 2006), more research is needed to address the potential relationship between serious adolescent delinquency and drug use for additional drugs and for substance abuse and dependence.

Finally, we believe that the differences in drug policies in other countries will not refute our core findings. While future research is needed to substantiate this claim, we believe that the general finding that serious adolescent delinquency has at least some causal effect on drug use initiation can be extended to other countries where delinquency and drug use are of concern. Additional work is necessary to determine if these findings can also be extended to other deviant behaviors that may or may not be illegal.

The results of this study suggest that a comprehensive public health approach is needed. Thus, the prevention of serious and frequent delinquency in adolescence should be included among the preventive, harm reductive, and rehabilitative approaches to combat substance use. In addition, the results indicate that targeting serious adolescent delinquents who have yet to begin serious drug use could have a long term impact on cocaine initiation and perhaps other drugs along the progression of drug use such as heroin.

Therefore, treatment and prevention programs designed to curb drug use should broadly conceptualize delinquent behavior and include serious delinquents. The juvenile justice system may be an early point of contact where the increased risk of substance use could be addressed along with the multitude of factors contributing to both serious delinquency and drug use. The juvenile justice system could also focus on alternative responses that combine law enforcement with preventive efforts to address the interrelated problems of serious delinquency and drug use. The results from observational studies such as this can contribute to the knowledge gained from prevention and intervention-oriented studies in the endeavor to understand and prevent serious delinquency, drug use, and their consequences.

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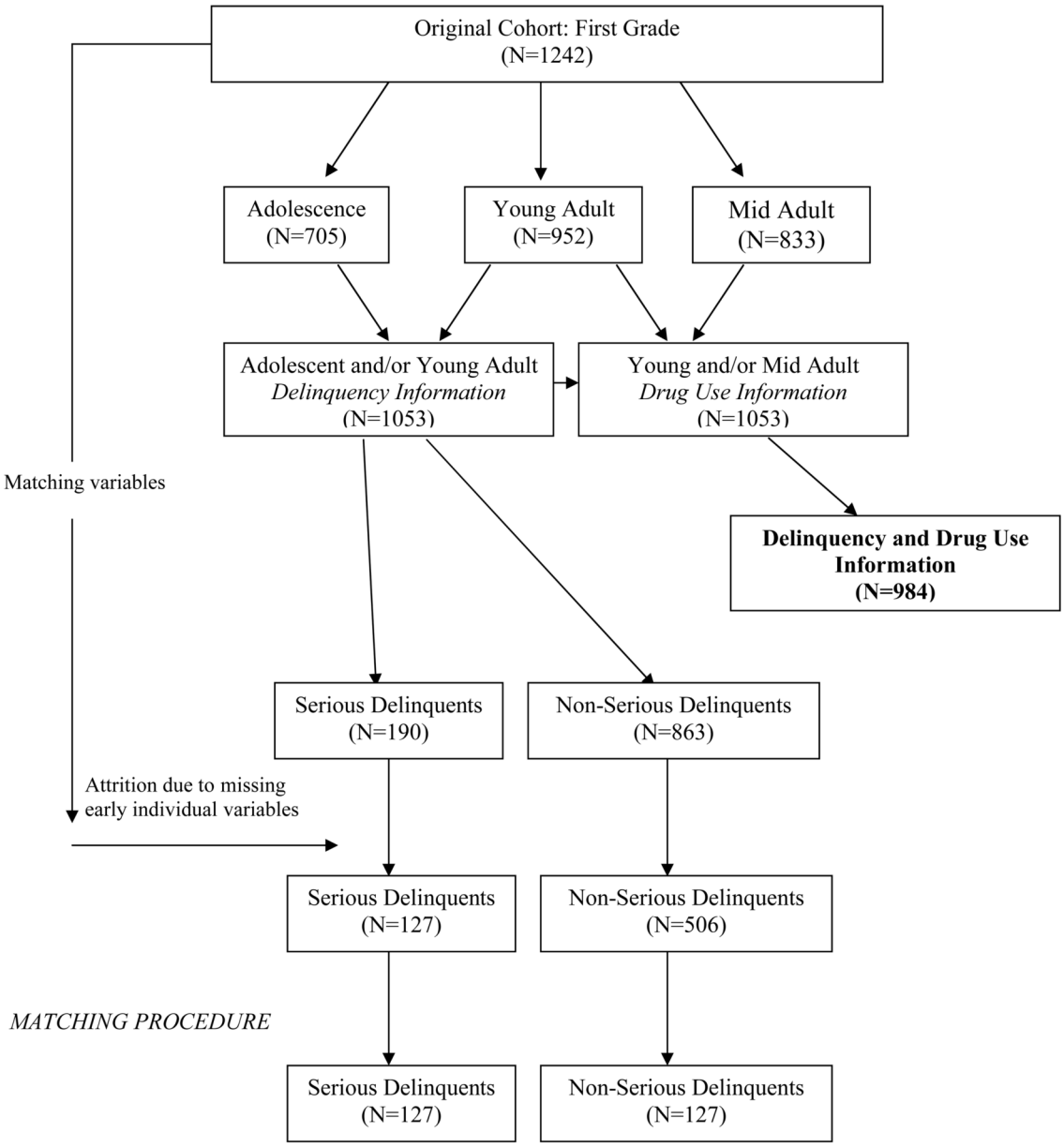

Fig 1.
Sample selection: attrition of the Woodlawn Cohort and matching procedures

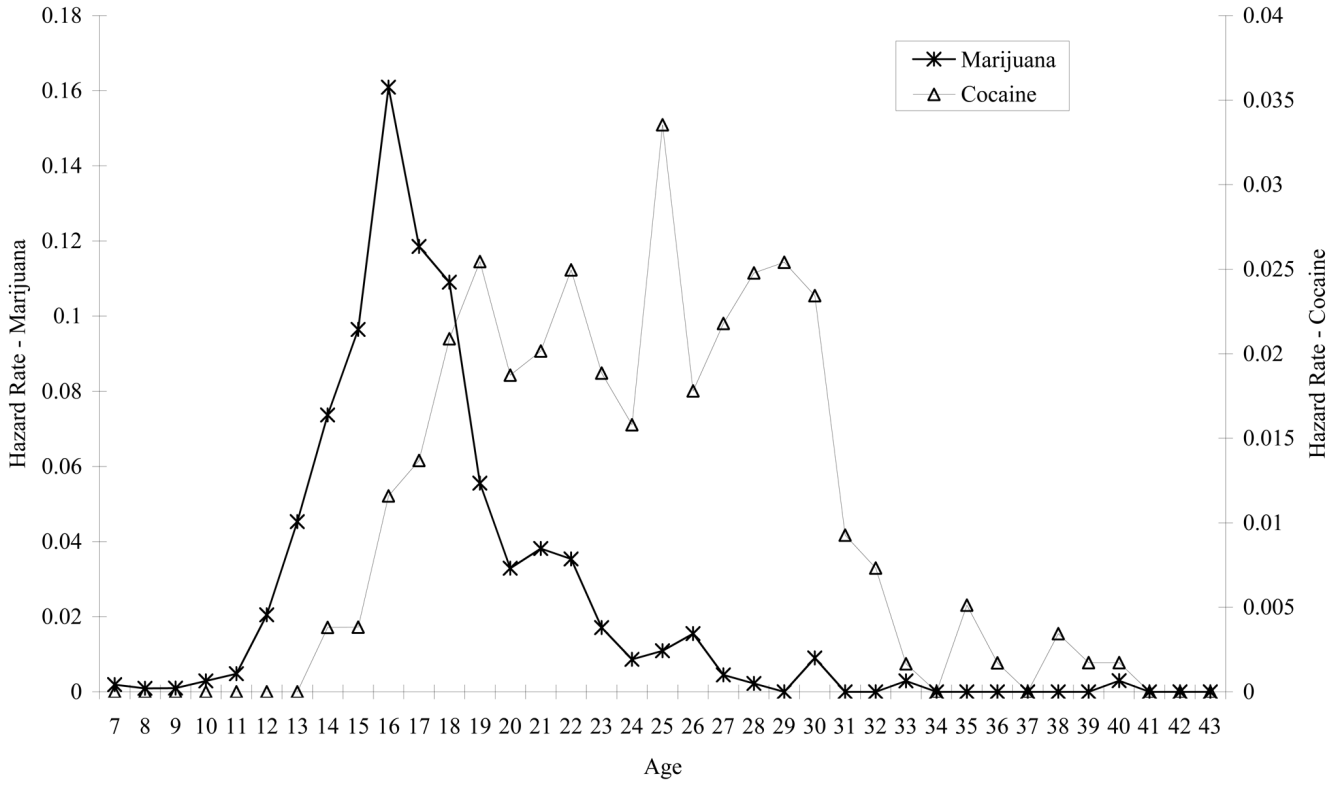

Fig 2.
Hazard rates for marijuana and cocaine initiation

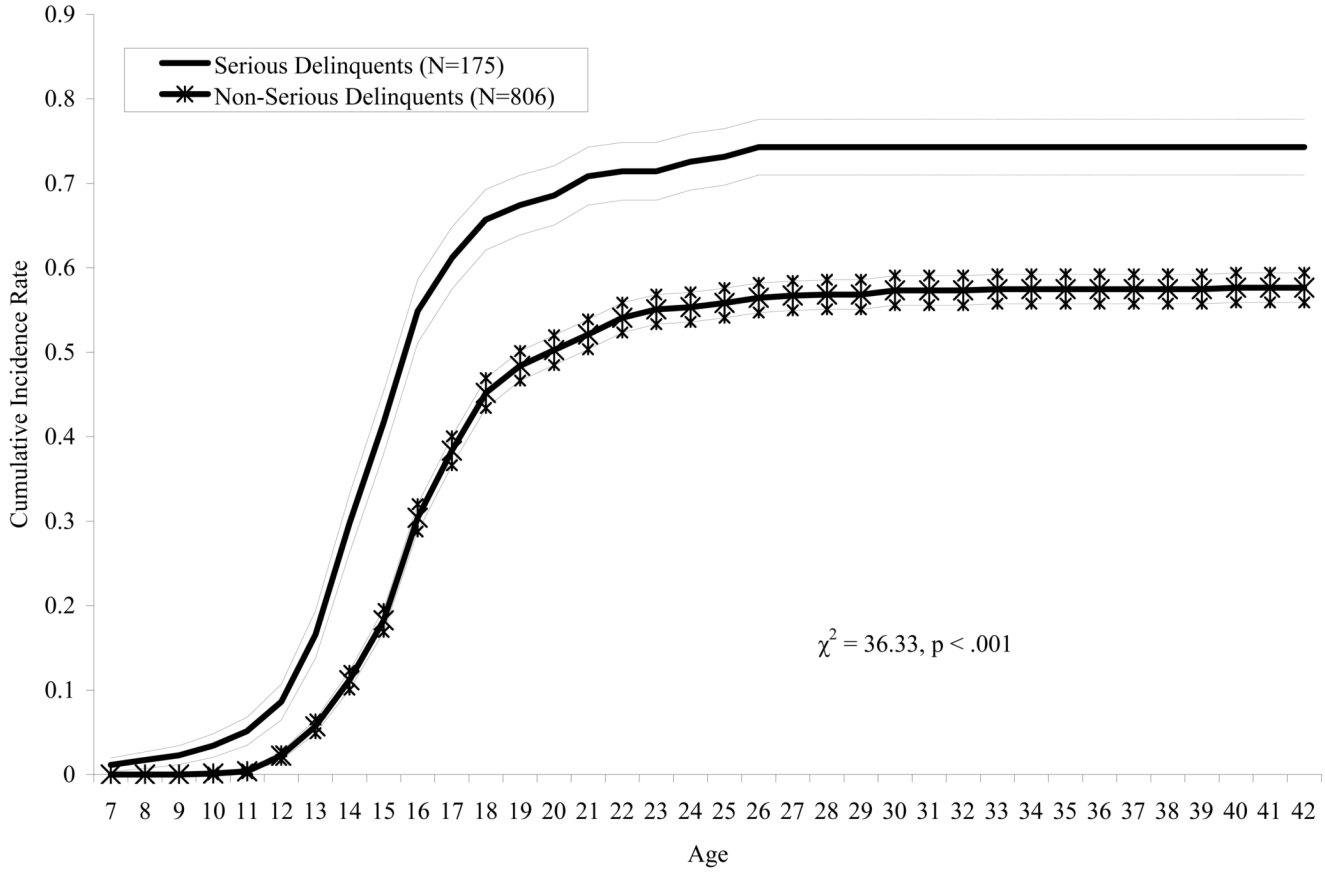

Fig 3.
Incidence of marijuana: a comparison of serious and non-serious adolescent delinquents (unmatched)

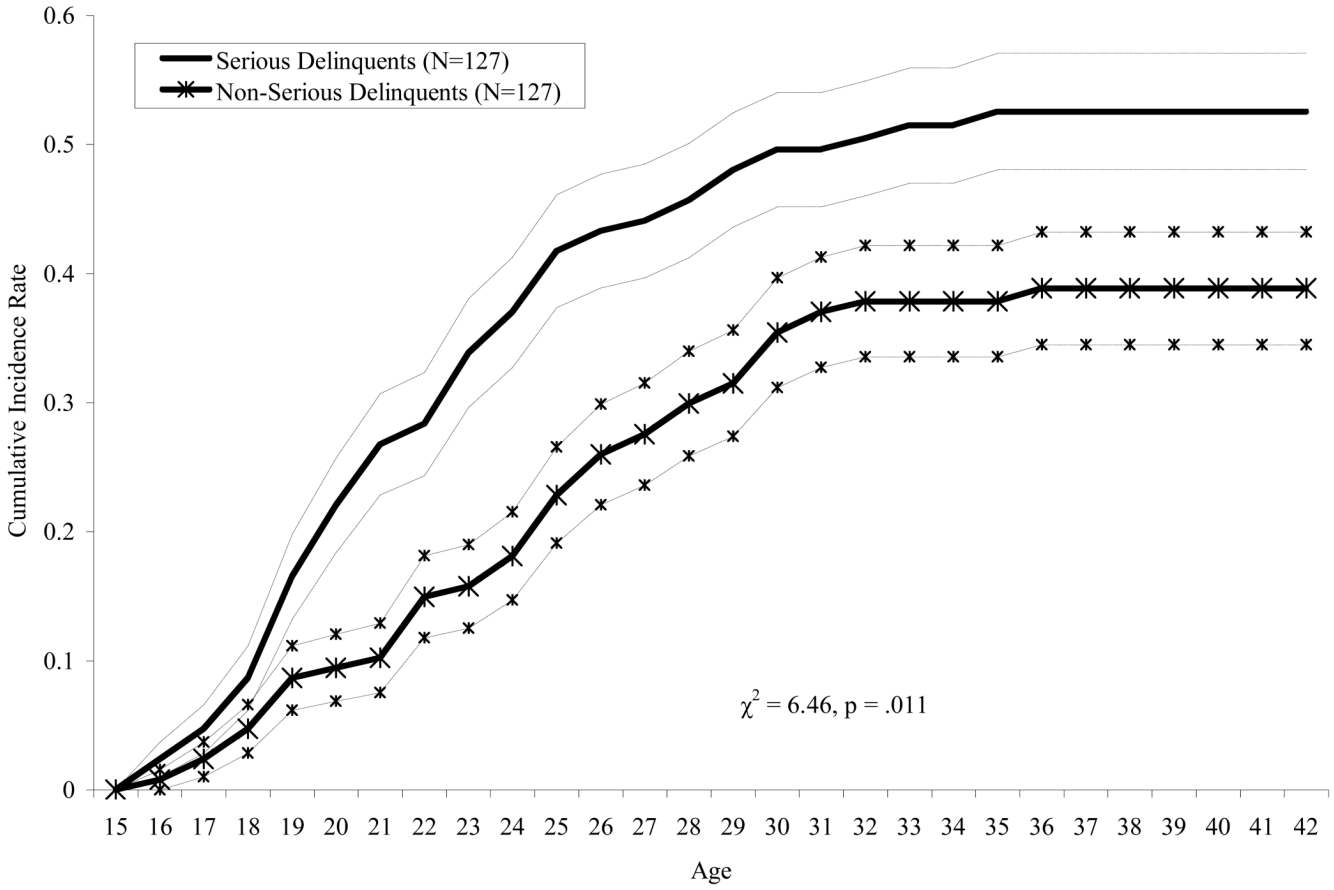

Fig 4.
Incidence of cocaine: a comparison of serious and non-serious adolescent delinquents (matched)

Table 1

Descriptive Statistics of Adolescent Delinquency Scale

	Total Sample N=1053	Males N=509	Females N=544
Serious delinquent	190 (18.0%)	371 (27.1%)	52 (9.6%)
Non-serious delinquent	863 (82.0%)	138 (72.9%)	492 (90.4%)

Table 2

Comparison of Serious and Non-Serious Delinquents Before and After Propensity Matching Procedure

	Serious Delinquents (*N*=127)	Matched Non-Serious Delinquents (*N*=127)	Unmatched Non-Serious Delinquents (*N*=506)	χ^2 or *t* (*p*-value) before matching	χ^2 or *t* (*p*-value) after matching
Gender (% male)	70.87	70.87	43.87	χ^2=29.59 (*p*<0.001)	χ^2=0.00 (*p*=1.00)
Poverty (% below)	55.12	57.48	53.56	χ^2=0.10 (*p*=0.75)	χ^2=0.14 (*p*=0.70)
Mother's Education (0–18)	10.30	10.47	10.53	*t*=0.91 (*p*=0.37)	*t*=0.55 (*p*=0.58)
Family Size (1–15)	4.38	4.48	4.49	*t*=0.52 (*p*=0.60)	*t*=0.36 (*p*=0.72)
Family Type (% female-headed)	37.79	44.09	35.57	χ^2=0.22 (*p*=0.64)	χ^2=1.04 (*p*=0.31)
Residential Mobility (0–9)	2.13	2.44	2.16	*t*=0.17 (*p*=.90)	*t*=1.42 (*p*=0.16)
Family Substance Use(% mothers used)	15.75	20.47	12.65	χ^2=0.85 (*p*=0.36)	χ^2=.956 (*p*=0.33)
Family Discipline (1–9)	5.86	5.92	5.47	*t*=−2.10 (*p*=.04)	*t*=0.27 (*p*=0.78)
Family Affection (1–7)	4.68	4.74	4.76	*t*=0.61 (*p*=0.54)	*t*=0.36 (*p*=0.72)
TOCA – Aggression (0–3)	0.62	0.70	0.53	*t*=−1.05 (*p*=0.29)	*t*=0.63 (*p*=0.53)
TOCA – Shyness (0–3)	0.42	0.46	0.51	*t*=1.04 (*p*=0.30)	*t*=0.48 (*p*=0.63)
TOCA – Underachievement (0–3)	0.74	0.85	0.70	*t*=−0.41 (*p*=0.68)	*t*=0.87 (*p*=0.39)
TOCA - Immaturity (0–3)	0.63	0.71	0.62	*t*=−0.14 (*p*=0.89)	*t*=0.63 (*p*=0.53)
TOCA – Restlessness (0–3)	0.69	0.79	0.56	*t*=−1.34 (*p*=0.18)	*t*=0.70 (*p*=0.48)
Reading Score (0–3)	2.56	2.68	2.48	*t*=−0.95 (*p*=0.34)	*t*=1.26 (*p*=0.21)
Math Score (0–3)	2.48	2.61	2.57	*t*=0.34 (*p*=0.74)	*t*=1.26 (*p*=0.21)
Classroom Conduct (0–3)	2.54	2.62	2.24	*t*=−3.78 (*p*<0.001)	*t*=0.80 (*p*=0.42)
Early Marijuana Use (% <15)	29.13	28.35	10.67	χ^2=28.11 (*p*<0.001)	χ^2=0.02 (*p*=0.89)

Appendix A

Delinquency Classification Items

From Adolescent Interview						
In the last 3 years, how many times did you:	**N of Cases**	**Never (%)**	**Once (%)**	**Twice (%)**	**3–4 times (%)**	**5^{+} times (%)**
Stay out later than your parents said you could?	702	16.1	9.8	15.8	19.4	38.9
Get into a serious fight with a student at school?	702	58.4	19.8	9.8	5.8	6.1
Run away from home?	700	86.9	6.3	2.9	2.3	1.7
Trespass?	702	71.8	13.0	7.1	4.1	4.0
Get something by threatening?	698	75.5	10.0	6.6	3.7	4.2
Argue or fight with your parents?	697	61.5	15.8	9.6	5.2	7.9
Hurt someone to the point they needed bandages and/or a doctor?	701	72.2	14.7	6.4	3.0	3.7
Damage school property on purpose?	698	77.8	12.2	3.7	2.4	3.9
Steal or shoplift from a store?	699	45.6	23.5	11.6	8.7	10.6
Hit a teacher?	699	76.0	12.2	6.4	2.3	3.1
Carry a weapon?	702	59.5	13.1	9.1	6.1	12.1
Take a non-family car without permission?	700	91.4	4.4	2.1	.4	1.6
Take part of a car without permission?	697	90.8	5.2	1.7	1.0	1.3
Participate in a gang fight?	701	70.2	13.1	7.1	4.1	5.4
Skip school with no real excuse?	702	39.6	19.8	13.0	12.1	15.5
Take something that did not belong to you?	701	50.2	25.0	9.4	7.7	7.7
Hit your father?	700	91.4	4.4	1.6	.6	2.0
Hit your mother?	701	91.6	4.0	2.4	.3	1.7

From Young Adult Interview			
Before the age of 15, did you:	**N of Cases**	**No (%)**	**Yes (%)**
More than once, steal things from someone you knew?	949	80.4	19.6
Deliberately set a fire?	949	96.5	3.5
Deliberately destroy something by other than fire?	947	96.0	4.0

From Young Adult Interview			
Before the age of 15, did you:	**N of Cases**	**No (%)**	**Yes (%)**
Physically hurt animals on a number of occasions?	951	97.0	3.0
Often start physical fights?	950	90.5	9.5
Use a weapon in a fight more than once?	950	95.1	4.9
Physically hurt other people a number of times?	950	94.6	5.4
Rob or mug someone?	951	98.4	1.6
Force someone to have sex?	949	99.7	.3