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Contrasting Trajectories of Heroin, Cocaine, and Methamphetamine Use

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Abstract

Current literature has shown that heroin addiction is characterized by long periods of regular use persisting over the life course, whereas the course of stimulant use is less understood. The current study examined long-term trajectories of drug use for primary heroin, cocaine (crack/powder cocaine), and methamphetamine (meth) users. The analyses used data from five studies that collected longitudinal information using the Natural History Instrument, including 629 primary heroin users, 694 cocaine users, and 474 meth users. Drug use trajectories over the 10 years since initiation demonstrated the persistence of use over time for all three drugs, with heroin use at the highest level (13 to 18 days per month), cocaine at the lowest level (8 to 11 days), and meth in between (approximately 12 days per month). Application of growth mixture models revealed five distinctive groups: Consistently High Use ($n = 545$), Increasing Use ($n = 260$), Decreasing Use ($n = 254$), Moderate Use ($n = 638$), and Low Use ($n = 100$). Heroin users were disproportionately overrepresented in the Consistently High Use group and underrepresented in the Low Use group; cocaine and meth users were mostly in the Moderate Use group. Users in the High Use group also had earlier onsets of drug use and crime, longer incarceration durations, and were the least employed. Clinical/service policy and practice need to recognize and adapt to the specific patterns and needs of users of different drugs while being mindful of the stage drug users are at in their life course.

Keywords

Trajectory; heroin; cocaine; methamphetamine; growth mixture model

INTRODUCTION

Heroin, cocaine, and methamphetamine are considered “major” illicit drugs that are often associated with severe consequences, including mortality, morbidity, and criminality. For example, during 2004 the greatest portion of the 32,980 federal drug arrests in the United States involved cocaine (37%), followed by amphetamine/methamphetamine (16%) and heroin (6%).¹ In California, more than half (58%) of all felony drug arrests (159,944) in 2005 involved dangerous drugs (e.g., methamphetamine and barbiturates) and one-third involved narcotics like heroin and cocaine.² Cocaine (19%), heroin (8%), and methamphetamine/amphetamine (5%) were involved in the nearly 2 million drug-related emergency department visits that occurred nationally in 2004.³ Also in 2004, these three drugs were the most prevalent among the 1.8 million drug treatment admissions nationwide (heroin – 14%; cocaine – 14%; meth/

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amphetamines - 8%) and in California (meth/amphetamines accounted for 33% of 184,206 admissions, heroin for 19%, and cocaine for 12%).⁴

However, knowledge of the long-term patterns of use of heroin, cocaine, and methamphetamine is limited. Most research has approached drug abuse as an acute disorder and findings are mostly based on short-term observations.⁵⁻⁷ The few long-term follow-up studies have generally shown that severe or dependent users tend to persist in their drug use, often for substantial periods of their lifespan. For example, data from our 33-year follow-up study of heroin addicts have shown that heroin addiction is characterized by long periods of regular use and tends to persist over the life course.⁸ The existing literature on long-term patterns of drug use mainly focuses on studies of heroin users and no research has investigated whether trajectories of cocaine or meth use are similar to those of heroin use. A systematic mapping of drug use patterns over time by drug type and user characteristics would have important policy and service implications. Furthermore, identifying factors (including service exposure) associated with distinctive life course drug use patterns would assist in developing more targeted treatment services and policies.

In this article, we apply a life course drug use perspective⁶ to compare and contrast the trajectories of heroin, cocaine, and meth use, taking advantage of several long-term follow-up studies of users of these drugs. In contrast to the short-term observations based on the acute disorder model of drug addiction, the life course perspective highlights the heterogeneity of drug use patterns and the importance of understanding and addressing the full spectrum of drug use patterns over time. For many dependent drug users, drug addiction persists over a long period of time. Thus, studying long-term dynamic changes over the life course potentially allows for characterizing distinctive patterns of drug use trajectories and identifying critical factors contributing to persistence or change over the life span.

Specifically, we address the following research questions and hypotheses: What are the temporal trajectories of drug use for primary heroin, cocaine (including crack and powder cocaine), and meth? Are use trajectories similar or dissimilar for different drugs? What are the other user characteristics and service exposure (e.g., drug treatment and criminal justice system involvement) associated with variations in trajectory patterns? We hypothesize that heroin addiction will have longer periods of regular use that are persistent over the life course, while cocaine and meth use have trajectories that are less persistent compared to heroin use. We also explore correlates of distinctive trajectory patterns based on the application of a growth mixture modeling approach.^{9,10}

METHODS

Datasets and Samples

To address these research questions, analyses used data from five studies that collected longitudinal information using the Natural History Instrument (described below). All studies were conducted in California. We relied on projects with Natural History Interview (NHI) data to maximize coverage of the drug use career, and we selected subjects for whom the primary drug problem reported by the subject was heroin, cocaine, or meth from each study. Projects include the 33-year Heroin Follow-up Study (n = 472),⁸ the 12-year Cocaine Follow-up Study (n = 319),¹¹ the Methamphetamine Natural History Study (n = 350),¹² the Treatment Process Study (n = 391),¹³ and the Treatment Utilization and Effectiveness (n = 265).¹⁴ The primary drug (i.e., drug for which the subject was in treatment at the baseline assessment) was heroin for the 33-year Heroin Follow-up Study, cocaine for the 12-year Cocaine Follow-up Study, and meth for the Methamphetamine Natural History Study. The Treatment Utilization and Effectiveness study included subjects recruited from non-treatment settings (emergency rooms, sexually transmitted disease clinics, and jails) and the primary drug type was self-identified.

Although many of these subjects reported use of drugs other than their primary drug, a separate analysis showed that use of other drugs was generally at a much lower level than the primary drug. Each database provides sufficient numbers of cases of primary drug type; when data are totaled ($N = 1,797$), the number of subjects was 629 for heroin (35%), 694 for cocaine (39%), and 474 for methamphetamine (26%).

Characteristics for the total sample and by drug type are provided in Table 1. Overall, 72.8% were male, and 34.3% were white, 32.1% were black, 29.9% were Hispanic, and 3.6% were Asian or another racial/ethnic group. On average, onset of primary drug use occurred at 21 years of age, regular use began at 23 years, and first drug treatment at 29 years. Criminal involvement (indicated by arrest) started at a mean age of 18 years. Over the first 10 years of addiction careers, the sample spent an average of 4.5 months in drug treatment and 17 months in prison or jail.

Instruments/Measures

The NHI, from which the variables for this analysis were derived, was used in all five studies. The NHI was adapted from instruments designed by Nurco et al.¹⁵ and has been used with various drug-abusing populations. The NHI was designed to collect retrospective longitudinal, quantitative data on drug use and related behaviors. The instrument consists of a set of “static” and a set of “dynamic” forms that permit the capture of longitudinal, sequential data on drug use, employment, criminal involvement, treatment, and other behaviors over the life course of the subjects.¹⁶ The static forms collect background information on the subject and are administered once during the interview. The dynamic forms are used to collect retrospective and current data on the drug-use history of the subjects as well as data on events that might have shaped or have been shaped by drug use (e.g., crime, incarceration, employment, social support network, medical status, psychiatric status, and drug treatment).

The dynamic part of the interview consists of the repeated administration of these forms for as many life segments (defined by major changes in behaviors or life events being assessed) as necessary. The procedure requires that the interviewer work closely with the respondent to structure the periods of interest, using corroborative information and memory aids (e.g., major life events and historical events). In this way, drug use, criminal behavior, and periods of legal supervision and treatment participation are anchored to major life events, such as the birth of a child, the death of a family member, a move to a new location, or a loss of a job. The NHI has been shown to have generally high reliability;¹⁷ correlation coefficients of inter-variable relationships, based on 46 variables measured at two interviews 10 years apart, ranged as high as 0.86 and 0.90.¹⁸

Natural history data provide a monthly record of drug use and service system exposure since age at first drug use. For the current analyses, monthly observations of drug use, treatment participation, and criminal justice system interaction are based on the NHI. The major outcome is drug use, which is defined as the number of days per month using a specified substance. Other measures include user characteristics (e.g., age, gender, and race/ethnicity), drug history (ages of initiation and regular use), drug treatment history (age of initial treatment and cumulative months of treatment for the entire period), and criminal history (age at first arrest and months incarcerated). Time-variant covariates include months of incarceration during the year.

Analytic Approach

Temporal patterns of drug use (mean number of days of primary drug use each month during the year) are displayed graphically in Figure 1, adjusted for incarceration. The zero time point designates the month of initiation of the primary drug. The plot represents the observed pattern

over time for drug use over the first 10 years of observation by the three primary drugs. The values are based on non-incarcerated or at-risk time to reflect behaviors “on the street.” This adjustment is necessary because many addicts have extensive incarceration experience, and abstinence or reduced use when incarcerated does not reflect behaviors when not living in a controlled environment.¹⁹ Mixed model with SAS PROC MIXED procedure was conducted to test differences in intercepts or slopes across the three drug use trajectories.

We then applied growth mixture modeling analysis to identify groups with distinctive trajectory patterns during the first 10 years of addiction careers since the onset of primary drug use. The main outcome measure again was the number of days using the primary drug per month. Incarceration time was controlled as a time-varying covariate in the growth mixture model. The procedures for model selection consisted of identifying the number of groups and selecting the best fitted model. The model fitting was assessed by goodness-of-fit index, including log-likelihood values, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC, and was also visually inspected by plotting observed values against model-predicted values. Lower values of AIC, BIC, and adjusted BIC but higher values of log likelihood were expected for a well-fitted model. We conducted this analysis using Mplus 4.0.²⁰

Group differences in accord with the three drug types or the latent classes identified by the growth mixture models were tested using the SAS GLM procedure for continuous variables and the SAS CATMOD procedure for categorical variables. In these analyses, the project (or “study” from which the data came) was included as a covariate to control for potential confounding effects. Unless otherwise indicated, the significance level (two-tailed) was set at $p < 0.05$.

RESULTS

User Characteristics by Primary Drug Type

Background characteristics and onset of primary drug use, drug treatment, and criminality were all significantly different by the primary drug type (Table 1). Most primary heroin users in the sample were male (89%), Hispanic (53%) or white (36%), started their heroin use at about 19 years and regular use at about 20 years, were first arrested at 16 years, initiated drug treatment at 26 years, and spent almost 3 years in prison or jail and only 5 months in treatment during the first 10 years of their addiction careers. In contrast, although most primary cocaine users were male (71%), the majority were black (66%), started cocaine use and treatment at much later ages (23 at first use, 26 at first regular use, and 33 at first treatment), spent slightly shorter duration in treatment (4 months), and had much less criminal involvement (about 6 months of incarceration) during the 10 years. Relative to users of heroin and cocaine, primary meth users were more likely to be female (46%) and to be white (54%); meth users initiated both meth use and crime at around 19 years, were first treated at 28 years, and spent approximately 5 months in treatment and less than a year in prison during the first 10 years after initiating use of meth.

Primary Drug Use Trajectories

The mean number of days per month using the primary drug during the first 10 years since the onset of use was plotted for each primary drug type in Figure 1. Given the extensive incarceration experiences among these drug users, drug use trajectories were adjusted for at-risk periods (i.e., the mean use days over the year was based on the number of non-incarcerated months). As shown in the graph, use for all three drug types persisted over the 10 years, with heroin at the highest level (13 to 18 days per month), cocaine at the lowest level (8 to 11 days), and meth in between (around 12 days). The intercepts and slopes of trajectories of the three

drugs were significantly different among drugs ($p < 0.001$ for both the intercept and slope). Pairwise comparisons between each pair of the three drugs were also significant in all pairs.

Latent Class of Use Trajectories

To identify subgroups with distinctive trajectory patterns and to determine whether such patterns are associated with the primary drug type, we applied a growth mixture modeling approach to the primary drug use trajectory. Using a growth mixture modeling approach, the best-fitted model was with five distinctive latent classes (adjusted BIC = 122608) shown in Figure 2: Consistently High Use ($n = 545$; 30.3%), Increasing Use ($n = 260$; 14.5%), Decreasing Use ($n = 254$; 14.1%), Moderate Use ($n = 638$; 35.5%), and Low Use ($n = 100$; 5.6%).

Characteristics of these five groups demonstrating distinctively different patterns of use trajectories are presented in Table 2. Primary drug type was significantly associated with trajectory group, with heroin users most likely to be in the High Use group (52.2%) and cocaine (50%) and meth (35%) most likely to be in the Moderate Use group. Additionally, drug users in the High Use group had the earliest onset of arrest and primary drug use, spent the longest time incarcerated and the shortest time employed, and many of them (44%) had their first drug treatment in prison. In contrast, users in the Low Use group were the smallest group, and were oldest when first arrested, spent the least time in prison, and had the longest duration of employment.

DISCUSSION

The scientific and medical communities increasingly acknowledge that drug dependence can be a chronic disorder that requires long-term care or management.^{6,8,21,22} However, existing studies are mostly limited to short-term observations. Although long-term studies of heroin addiction generally demonstrate persistent use over a long period of time, similar empirical evidence for cocaine and meth dependence has not been reported, mostly due to limited long-term follow-up studies. Consistent with previous literature, our study has demonstrated that heroin addiction is characterized by long periods of regular use. Stimulants such as cocaine and methamphetamine are generally used at lower levels, reflective of an episodic pattern (e.g., weekend users). Despite the varying levels of use, the group means of use for all three types of drugs appear to suggest a persistent pattern of use over a long period of time (e.g., at least for the first 10 years of the addiction careers observed in the current study). This pattern, based on group means, seems to support the chronic nature of addiction of heroin, cocaine, and meth.

The growth mixture modeling results further revealed heterogeneity in patterns of drug use trajectories since initiation. A small subset (approximately 5%) maintained a low level of use and mostly consisted of cocaine and meth users. The two largest groups were the Moderate Use (36%) and High Use (30%) groups; cocaine and meth users were most likely to be found in the Moderate Use group and heroin users in the High Use group. The Increasing Use and Decreasing Use groups each accounted for approximately 14% of the sample, and both included users of all three drug types, except that meth users were slightly overrepresented in the Decreasing Use group. Thus, the mixture modeling results largely confirmed the varying levels of use among the three primary drug types.

Study findings need to be interpreted within the context of study limitations. The samples for the current study were combined from several studies and all subjects came from California. Thus, the study sample may not be representative of dependent heroin, cocaine, or meth users in general. Data used in this study came from self-reported interviews, which may be subject to recall or reporting bias. However, as mentioned earlier, instruments employed in this study have been used in many previous studies among populations of a similar nature. Because we are interested in primary heroin, cocaine, and meth use trajectories, and we generally found

relatively low levels of use of other drugs, our analysis has focused only on the primary drugs used. Future studies should examine how the patterns of these use trajectories shaped or was shaped by the use of other drugs. Finally, a negligible number (less than 0.7%) died within the first 10 years of use; additional studies are planned to explore death rates during the subsequent periods of time.

Despite these limitations, our study findings expand current knowledge in several aspects. The current study is the first to investigate the long-term course, or trajectories, of heroin, cocaine, and meth use and has revealed several interesting findings as summarized above. In addition, by providing empirical descriptions of the use trajectories of the three drug types, the current study also suggests that some individuals (particularly cocaine or meth users) are able either to quit using or maintain low use levels. Interestingly, individuals in the Decreasing Use group, who started off with a high level of use at initiation, were able to gradually decrease their use. These individuals included heroin, cocaine, and meth users and were more likely to be women, white, or both. Importantly, the onset of primary drug and criminality among the Decreasing Use group were all relatively late compared to the other groups, but their engagement in drug treatment was relatively earlier and longer. These findings confirm previous studies showing that early onset of drug use and criminal involvement is associated with more severe and persistent drug use patterns,⁶ and they contribute to the growing body of literature suggesting early intervention is critical to change use trajectories towards more favorable outcomes.

The discussion of long-term disease management or chronic care strategies is most relevant to the High Use and Increasing Use groups who demonstrated long periods of incarceration and short duration in treatment. Prior studies have shown that drug use and crime have mutually reciprocal “multiplier” effects.^{23,24} Criminal activity may be associated with shorter time to relapse, steeper acceleration to regular use, and longer periods of use. Nevertheless, treatment can be effective with criminally involved drug addicts.^{25–27} It has been demonstrated that, given the chronic relapsing nature of addiction, long-term prospects for recovery may be greater for people who re-enter treatment more promptly after relapsing.^{28,29} Longitudinal intervention studies are needed to more effectively adapt treatment strategies suited to the specific life course stages of these drug users and to facilitate long-lasting cessation.^{30–32}

According to the 2000 National Household Survey on Drug Abuse,³³ more males than females abused or were dependent on heroin (53%) or cocaine (58%), but more females abused or were dependent on meth (58%). Additionally, the ethnic distribution for heroin was mostly white (72%) or Hispanic (17%), which was similar to that of meth (71% white, 13% Hispanic) but somewhat contrasted with cocaine (56% white, 25% black, and 14% Hispanic). Conversely, males in California accounted for the majority of treatment admissions for heroin (68%), cocaine (62%), and meth (54%). In addition, considerable ethnic variation was observed in that the majority of heroin or meth admissions were white (44% and 62%, respectively) or Hispanic (37% and 27%, respectively), whereas cocaine admissions were predominantly black (59%). Our sample characteristics closely resemble those observed in the California treatment population. Also notable in our sample is that women were overrepresented in both the Decreasing Use and the Increasing Use groups and Hispanics were overrepresented in the High Use group and underrepresented in the Low Use group. Future studies should examine whether these differences by gender and ethnicity are related to the level, timing, and duration of treatment, incarceration, or self-help participation and suggest optimal conditions for interventions aimed at changing the direction of use trajectories for these groups.

To optimize outcomes, clinical/service policy and practice need to adapt to the specific patterns and needs of users of different drugs. Our life course drug use perspective for examining and contrasting use trajectories of heroin, cocaine, and methamphetamine has provided empirical evidence for both similarities and differences across these drugs. It is important to further

understand what similarities and differences may exist in predictors of and pathways to long-term cessation among users of these different drugs. Examining user characteristics and service exposure (drug treatment, mental health, and criminal justice) associated with use trajectory groupings across primary drug types and identifying factors (including service exposure) associated with distinctive life course drug use patterns will assist in developing more targeted treatment services and policies.

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FIGURE 1.
Days of drug use per month over 10 years.

FIGURE 2.
Five-group classification of drug use trajectories, based on growth mixture modeling.

TABLE 1 Characteristics by Type of Primary Drug^a (N = 1,797)

	Heroin (n = 629)	Cocaine (n = 694)	Meth (n = 474)	Total (n = 1797)
Male (%) **	89.4	70.6	54.2	72.8
Ethnicity (%) **				
White	35.5	19.9	53.8	34.3
Black	9.2	66.0	13.1	32.1
Hispanic	53.4	10.8	26.6	29.9
Asian/Other	1.9	3.2	6.5	3.6
Primary Drug Use ^b				
Age of First Use ** HC,CM	18.9 (4.7)	23.0 (6.8)	19.6 (5.5)	20.7 (6.1)
Age of First Regular Use ** HC,CM	20.3 (4.6)	26.3 (7.4)	21.1 (6.3)	22.9 (6.9)
Crime ^b				
Age of First Arrest ** HC,HM	15.5 (4.3)	20.2 (7.1)	19.1 (6.8)	18.2 (6.5)
Total Months Incarcerated over the 10 Years ** HC,HM	34.7 (25.9)	6.3 (14.7)	10.5 (19.3)	17.3 (24.1)
Drug Treatment ^b				
Age of First Treatment * CM	26.0 (7.0)	32.6 (7.2)	27.8 (6.9)	28.9 (7.6)
Total Months in Treatment over the 10 Years ** HC,HM	4.8 (12.2)	3.9 (7.5)	4.9 (6.8)	4.5 (9.3)

^a Group differences among three primary drug types were tested.^b Controlling for project.

* p < 0.05.

** p < 0.01.

Significant pairwise comparisons between drugs after controlling for project are indicated by HC (Heroin vs. Cocaine), HM (Heroin vs. Meth) and CM (Cocaine vs. Meth).

Meth = methamphetamine.

TABLE 2

Characteristics by Drug Use Trajectory Type^a (N = 1,797)

Variable	Decreasing Use (n = 254)	High Use (n = 545)	Increasing Use (n = 260)	Moderate Use (n = 638)	Low Use (n = 100)
Primary					
Drug (%) ** DH,DM,HL,ML,HL					
Heroin	32.7	60.2	31.9	20.2	6.0
Cocaine	27.6	20.6	41.5	53.9	60.0
Methamphetamine	39.8	19.3	26.5	25.9	34.0
Male (%) ** DH,DM,DL,ML	62.2	77.3	65.8	75.6	77.0
Ethnicity (%) * DH,HI					
White	42.1	24.9	36.1	34.2	35.0
Black	27.2	23.9	35.7	37.6	46.0
Hispanic	27.6	43.7	24.4	24.1	12.0
Asian/Other	3.2	2.5	3.9	4.1	7.0
Age of First					
Arrest ** DH,HL,ML,IL,ML	19.1 (6.7)	16.3 (5.3)	18.3 (6.3)	19.1 (6.7)	21.1 (8.1)
Age of First Primary Drug					
Use ** DH,DL,ML,DL,HI	22.3 (6.4)	19.5 (5.2)	19.2 (5.4)	21.5 (6.4)	21.8 (7.3)
Age of First					
Treatment ** DL,DL,HL,IL,ML	27.4 (7.2)	27.0 (7.5)	29.5 (7.7)	29.8 (7.1)	35.3 (7.4)
First Treatment in					
Prison (%) ** DL,HL,IL,ML	22.3	44.1	21.1	15.2	2.1
Total Months in Treatment Over					
the 10 Years ** DH,DL,ML,DL,HL,ML	8.6 (12.9)	4.1 (10.1)	2.3 (5.4)	4.5 (8.2)	1.3 (3.8)
Total Months Incarcerated Over					
the 10 Years ** DH,DL,HL,ML,ML	13.1 (16.7)	33.7 (29.4)	11.3 (16.9)	10.2 (18.1)	0.4 (1.9)
Total Months Employed Over					
the 10 Years ** DH,DM,DL,HL,ML,ML	52.3 (39.7)	41.7 (35.6)	58.0 (42.2)	66.0 (41.1)	85.9 (40.4)

^a Group differences among five trajectory classes controlling project effect.**
p < 0.01.*
p < 0.05.

Significant pairwise comparisons between groups are indicated by DH (Decreasing vs. High), DI (Decreasing vs. Increasing), DM (Decreasing vs. Moderate), DL (Decreasing vs. Low), HI (High vs. Increasing), HM (High vs. Moderate), HL (High vs. Low), IM (Increasing vs. Moderate), IL (Increasing vs. Low) and ML (Moderate vs. Low).