Drug and Alcohol Dependence 204 (2019) 107505

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

# Trajectories of heroin use: A 15-year retrospective study of Mexican-American men who were affiliated with gangs during adolescence

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ARTICLE INFO

*Keywords:*
Heroin
Trajectories
Mexican Americans
Latino men

ABSTRACT

*Background:* Heroin use is a public health concern in the United States. Despite the unique etiology and patterns of heroin use among U.S. Latinos, long-term heroin trajectories and health consequences among Latinos are not well understood. This study aims to document the distinct heroin use trajectories for a group of street-recruited (non-treatment), young adult Mexican American men living in a disadvantaged community who were affiliated with gangs during their youth.

*Methods:* One-time interviews conducted between 2009–2012 in San Antonio, TX collected retrospective data from a sample of 212 Mexican American young adult men who reported using heroin at least once. Group-based trajectory modeling was applied to determine discrete developmental trajectories of heroin use. ANOVA, Chi square tests, and multinomial logistic regression examined current (past year) social and health indicators among each trajectory group.

*Results:* Five discrete heroin trajectories groups were identified: low use (n = 65); late accelerating (n = 31); early decelerating (n = 26); late decelerating (n = 38); and stably high (n = 52). Varying social and health consequences were found among the trajectory groups.

*Conclusion:* This study describes the unique heroin use trajectories and social and health outcomes among a high-risk subgroup of Mexican American men. The findings suggest that early intervention and intervention available in easy to access non-treatment spaces may be especially useful for groups of people who use relatively less heroin.

## 1. Introduction

While much focus is currently being given to the ongoing opioid epidemic, heroin use has been a public health concern in the United States for decades. People who use heroin have been documented to have the highest levels of persistent use, lasting two to three decades or longer, compared to other drugs (Evans et al., 2013; Genberg et al., 2011; Grella and Lovinger, 2011; Hser et al., 2008). Heroin use has affected and exacerbated health disparities among some U.S. subgroups. For instance, heroin, compared to other illicit substances, has been a longstanding primary drug among some subgroups of Mexican Americans (Bullington, 1977; Casavantes, 1976; Maddux and Desmond, 1981; Moore, 1978; Valdez and Cepeda, 2008; Garcia, 2010). Treatment admissions data show that Latinos are more likely to be treated for heroin use than other race/ethnic groups (Reif et al., 2008). Given that Latinos are the largest racial/ethnic minority group in the U.S., with over half of this group being Mexican-origin (Flores, 2017), understanding the long-term heroin careers of particularly high-risk Mexican Americans is crucial.

Previous research documented the unique etiology and course of drug use, in general, for U.S. Latinos (Amaro et al., 2006; Prado et al., 2008; Valdez et al., 2011; Schinke et al., 2016). Immigration status and acculturation are consistently examined with regard to substance use (Ibanes et al., 2017; Flores et al., 2015; Otiniano Verissimo et al., 2014; Savage and Mezuk, 2014; Blanco et al., 2013). Cultural values, such as *familismo*, *machismo*, and *fatalismo*, often play varying roles as protective and risk factors for substance use (Soto et al., 2011; Prado et al., 2008; Valdez and Cepeda, 2008; Flores et al., 2014). In a study of aging Mexican American men who inject heroin, the influence of family, peer, and community contexts on heroin maintenance processes precluded individuals from “maturing out” after extended periods of injecting (Cepeda et al., 2015). Telzer et al. (2014) suggest that it is in

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https://doi.org/10.1016/j.drugalcdep.2019.06.008
Received 14 November 2018; Received in revised form 4 June 2019; Accepted 5 June 2019
Available online 29 August 2019
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environments of particular disadvantage and conflict that many of these cultural values and family obligations act as risk factors for drug use.

Previous research, although not among Latinos specifically, has begun to identify distinct heroin trajectory groups (Grella and Lovinger, 2011; Mikolajczyk et al., 2014; Prendergast et al., 2008; Teesson et al., 2017). Hser et al. (2007) identified three heroin trajectory groups among a sample recruited from a compulsory drug program over 33 years: people who use heroin at a stably high-level, a late decelerated group, and "early quitters." Similarly, Genberg et al. (2011) documented five distinct trajectory groups among a sample of African-American adults who injected drugs over 20 years, finding that roughly similar numbers of people experienced early, delayed, and late cessation of use, while the largest group had persistent use.

Other research has focused on drug use trajectories, more generally, from adolescence to young adulthood (Forsyth et al., 2017; Cerda et al., 2015; Brunelle et al., 2013; Needham, 2007). Social and individual conditions, such as having a father who was incarcerated (Roettger et al., 2011), are associated with higher illicit drug use in adolescence and early adulthood. Cerda et al. (2015) found that nonmedical use of prescription opioids during childhood and early adolescence predicted heroin use in young adulthood. Yet, a study of high school seniors found that Hispanics were more likely to report heroin use without prior nonmedical opioid use compared to their white counterparts (Palamar et al., 2016).

Few studies document the social and health consequences of long-term heroin use among subgroups of Mexican Americans. Of the limited research, Torres et al. (2011) found that compared to Hispanic national samples, a community sample of Mexican American males who inject drugs had a higher prevalence of liver diseases, STIs, psychiatric morbidity, and other illicit substance use. In a previous analysis of the current study sample, Mexican American men who used heroin daily had a substantially higher reported prevalence of depressive symptoms and suicidal ideation than men who formerly used heroin (Nowotny et al., 2017).

This study examines trajectories of heroin use over a 15-year period from adolescence to young adulthood in a sample of 212 Mexican American men who reported using heroin at least once in their lifetime. The men in this study, now in their late twenties and early thirties, were recruited from disadvantaged urban neighborhoods that are reflective of Mexican communities across the southwest (Massey et al., 2003; Valdez and Cepeda, 2008; Garcia, 2010) and were originally recruited as part of a study on adolescent gang membership. Gangs continue to be a major social issue (Egley and Ritz, 2006), especially among Latino adolescents with an eight percent cumulative prevalence of gang membership (Pyrooz, 2014) and a longer duration of gang membership compared to other race/ethnic groups (Egley et al., 2006; Sweeten et al., 2013). Local and international gangs have varying levels of organizational relationships with the larger heroin market due, in part, to limited opportunities for disadvantaged youth in the formal sector (Valdez, 2005). Despite this, there is a paucity of research documenting the long-term outcomes for these youth (Decker et al., 2013). Since reductions in current heroin use are associated with overall improvements in risk behaviors, legal problems, and physical and mental health (Teesson et al., 2015), an analysis of long-term heroin use patterns may provide insights into effective intervention time points throughout the life course for youth living in these contexts.

## 2. Methods

### 2.1. Study design and sampling

Data are from a study conducted during 2009–2012 in San Antonio, Texas USA (n = 275). An earlier study, conducted from 1996 to 1998, recruited adolescent Mexican American males who were affiliated with youth street gangs. A multi-stage stratified design was used to randomly select 160 adolescents from rosters representing 26 known Mexican American gangs in this region (Peterson and Valdez, 2005; Yin et al., 1996). Rosters were developed by research staff with the help of gatekeepers and key informants within the gangs. In 2009–2012, a second study was conducted, in which we relocated and enrolled 119 (74.4%) of the original sample and recruited an additional 156 men from the original rosters. Even though data were collected prospectively for some men, we use only data collected crosssectionally and retrospectively during the one-time assessment, and further restrict the sample to only men who reported ever using heroin (n = 212; 77.1%).

The interview protocol was based on the Natural History Interview (NHI) (Hser et al., 2001, 2007). The NHI is designed to collect retrospective, longitudinal data on drug use, criminal involvement, treatment, and other related behaviors over the life course. The administration required the interviewer to work closely with the respondent to structure the interview with the use of memory anchors. Drug use behaviors were then anchored to major life events such as the birth of a child, death of a family member, loss of a job, or incarceration episodes, and mapped onto a calendar timeline. Similar to other life history calendar methods, the NHI has demonstrated high congruence with urinalysis and good test-retest reliability, and has been shown to yield rich information about long-term patterns of drug use (Murphy et al., 2010). For example, DeHart and colleagues (2014) interviewed 115 women in jail ranging in age from 17 to 55 years and collected rich quantitative and qualitative data retrospectively from across the life course (from childhood to the present) to examine how onset of crime and delinquency varied based on mental health status and trauma exposure.

### 2.2. Measures

Using the NHI, retrospective frequency of heroin use per month was collected by recording heroin use, along with memory anchors, on a calendar, which was then entered into a dataset by month. The data were then converted to annual indicators of heroin use, specifically the self-reported number of months of heroin use per year (0–12). Participant characteristics include current measures of age (range 27–36), marital status (married, cohabitating, never married), full-time employment (yes/no), and sources of income (employment; illegal sources including selling drugs, stealing, etc.; friends/family; public sources). We include a measure of housing with three categories: (1) living in own home for most of the past year; (2) living with a parent, partner, or other relative for most of the past year; and (3) unstably housed defined as living on the streets, shelter, or jail for most of the past year or reporting living in three or more places during the past year. Outcome variables include three domains: current behavioral risk, health, and mental health symptomatology.

#### 2.2.1. Behavioral risk

Men self-reported current membership in a Texas prison-based gang (Valdez, 2005), if they had been shot at with a gun in the past year, and any past year criminal activity including participating in any violent behavior (e.g., armed robbery, assault) and property crime-related behavior (e.g., selling drugs, burglary). Additionally, 10 ml of urine was collected at the time of the interview to test for drug metabolites using the iCup AD Panel test to detect opioids, cocaine, and marijuana.

#### 2.2.2. Current health

Current infection was measured using blood samples. Specimens were tested using HIV antibody enzyme linked immunoassay (EIA); Herpes Simplex Virus-Type 2 (HSV-2) specific IgG antibody test with an index ratio > 0.9 (HerpeSelect HSV-2 ELISA, Focus Technologies); and Hepatitis C Virus (HCV) antibody assays using Abbott HCV EIA 3.0 procedure for encoded antigens (recombinant c100-3, HC-31, and HC-34). A positive HCV antibody test may indicate a cleared or ongoing chronic infection. We were unable to conduct HCV RNA tests to confirm

current infection. Only one person out of 195 tested positive for HIV, so this measure was not included in the analysis.

Noncommunicable disease was assessed through self-reported diagnoses of hypertension, diabetes, or heart disease. Self-rated health was measured on a scale of 1–5, 1 being excellent health and 5 being poor health. Respondents were coded as having a serious injury or accident if they responded yes to experiencing any of the following in the past year: shot and injured with a gun, beaten severely, and/or serious car accident. Participants were also asked if they had any problems with skin abscesses.

#### 2.2.3. Mental health

Mental health symptomatology was measured through the Brief Symptom Inventory (Derogatis and Melisaratos, 1983), a 53-item self-report inventory in which participants rate the extent to which they have been bothered (0 = not at all to 4 = extremely) by various symptoms in the past week (overall scale α = 0.98). The scale includes nine subscales: somatization ("faintness or dizziness," 7 items; cut off 0.71; α = 0.87), obsessive compulsive ("having to check and double-check what you do," 6 items; cut off 1.17; α = 0.88), interpersonal sensitization ("feeling inferior to others," 4 items; cut off 1.00; α = 0.81), depression ("feeling no interest in things," 6 items; cut off 0.83; α = 0.90), anxiety ("feeling tense or keyed up," 6 items; cut off 0.83; α = 0.86), hostility ("having urges to break or smash things," 5 items; cut off 0.80; α = 0.83), phobic anxiety ("feeling uneasy in crowds," 5 items; cut off 0.60; α = 0.82), paranoid ideation ("others not giving you proper credit," 5 items; cut off 0.80; α = 0.78), and psychoticism ("the idea that something is wrong with your mind," 5 items; cut off 0.80; α = 0.77) (Schulte-van Maaren et al., 2012). Cut off scores for each subscale were calculated by taking an average of subscale questions (0–4), with higher scores indicating more psychological distress. As to limit the amount of false positives, both symptomatology counts and cut off scores are reported for optimal specificity. Caution should be exercised when using the subscales scores for the BSI (Skeem et al., 2006). Therefore, we also report the Global Severity Index (Derogatis and Melisaratos, 1983), and the subscales suggested by Valera et al. (2015) after examining the discriminate validity of the BSI among men being released from prison. The subscales are as follows: somatization (2 items; α = 0.72), phobic anxiety (4 items; α = 0.81), obsessive compulsive (5 items; α = 0.87), depression (2 items; α = 0.86), suicidal ideation (2 items; α = 0.82), and hostility (4 items; α = 0.78).

### 2.3. Analysis

We applied group-based trajectory modeling (GBTM) to fit longitudinal finite mixture models to identify clusters of persons who use heroin that follow similar progressions of use over time (Jones and Nagin, 2013; Nagin, 2016). This analysis was conducted in Stata 15 using the *traj* command (Jones and Nagin, 2013). Because the outcome is a count of months of heroin use per year, we estimated a Zero-Inflated Poisson (ZIP) model. We also estimated a ZIP model with the outcome specified as the mean monthly frequency of use using a scale of 0: no use to 9: at least 4–9 times a day on most days, and the developmental trajectories looked very similar (see Appendix, Figure A1). We are interested in trajectories of heroin use over the life course, but recognize that the mode of use (e.g., injecting or noninjecting sniffing/smoking) can have different consequences for health. Therefore, we included a time-invariate predictor for lifetime injection history.

We followed a three-step method wherein after establishing the latent class trajectory model for clustering (step 1), we obtained predictions for the trajectory membership (step 2) and subsequently used these predicted scores to assess the relationship between trajectory membership and external variables (step 3). While this approach can lead to severely downward-biased estimates of the strength of the relationships studied in step 3 (Bolck et al., 2004), and there are methods to correct for this bias in LCA models (see Bakk et al., 2013), the use of these weights with GBTM usually does not materially alter the profiles in well-fitting models (Nagin, 2005).

**Table 1**
Fit Statistics for the Final Model.

| | n | $AvePP_j$ | $OCC_j$ | $P_j$ | $\pi_j$ | difference between $P_j$ and $\pi_j$ |
|---|---|---|---|---|---|---|
| 1[a] | 65 | 0.999821 | 12632.54 | 0.306604 | 0.306878 | −0.00027 |
| 2[b] | 31 | 0.999833 | 34941.46 | 0.146226 | 0.146318 | −0.00009 |
| 3[b] | 26 | 0.997314 | 2655.79 | 0.122642 | 0.122312 | 0.00033 |
| 4[b] | 38 | 0.994611 | 845.14 | 0.179245 | 0.180664 | −0.00142 |
| 5[b] | 52 | 0.990173 | 310.04 | 0.245283 | 0.243828 | 0.00145 |

n = sample size for the group; AvePPj = average posterior probability for group j; OCCj = odds of correct classification; $P_j$ = proportion assigned using the maximum probability rule; $\pi_j$ = estimated group probabilities.
[a]linear model.
[b]includes quadratic term.

GBTM assumes that the population is composed of finite distinct groups, but trajectory groups are ultimately just approximations of a more complex reality. Two key decisions when identifying trajectory groups is, first, determining the number of groups that best fit the data and, second, deciding on the highest polynomial order (zero order, first order, etc.) that best characterizes the path the outcome (in this case heroin use) for each trajectory group takes over time. We used the Bayesian information criterion (BIC) and three additional measures of model fit (Nagin, 2005) for model selection (see Appendix). However, this was moderated by a preference for a useful parsimonious model which fitted the data well.

We determined that the five-group model was the best fitting model because of the optimal fit statistics (Table 1) and because the trajectory groups maintained reasonable size and interpretability, and fit the data well (Nagin, 2016). The model fit statistics for each model (two-group through six-group) with higher order polynomials are available in the Appendix (Table A1). Once we identified the number of groups, we reduced the polynomial orders until the highest order polynomial for each group was significant at the confidence level alpha (α) = 0.05. To examine the outcomes associated with the heroin trajectory groups, we conducted ANOVA or chi square ($\chi^2$) tests to test group differences. Multinomial logistic regression with posthoc testing examined pairwise differences. Bonferroni correction was applied to correct for multiple testing.

## 3. Results

### 3.1. Trajectory groups

We identified five trajectory groups (Fig. 1; Table 2 Panel A). The first group is characterized by men who used heroin at low rates ("low use group") (n = 65, 30.7%). The second group of men is the "late accelerating group" (n = 31, 14.6%), who had a delayed onset of heroin use. The "early decelerating group" (n = 26, 12.1%) used heroin at relatively high levels during adolescence but transitioned to no/low levels of use relatively quickly. The fourth group of men is characterized by "late decelerating use" (n = 38, 18.1%). The fifth group of men, the "stably high group" (n = 52, 24.4%), maintained relatively high levels of use. During adolescence the groups cluster into either high or low using groups. The three groups that consumed heroin at relatively high levels then went on to have very different trajectories of use as they aged. The two groups characterized by relatively low use during adolescence also had very different patterns of use over their life course, with one group maintaining their low/no use over time and the other later increasing their use of heroin. The trajectory groups varied significantly by whether they had ever injected heroin (Table 2 Panel B). Three-quarters of the men (76.9%) in the low/no use group reported

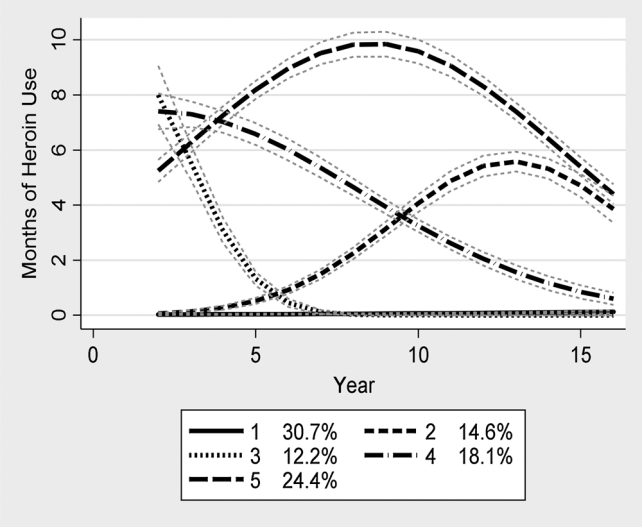


**Fig. 1.** Mean Number of Months of Using Heroin during the Year with 95% Confidence Intervals Presented (n = 212). Group 1 = low use; Group 2 = late accelerating; Group 3 = early decelerating; Group 4 = late decelerating; Group 5 = stably high.
*Note*: Includes men who have ever used heroin, controlling for history of injecting drug use (time invariant).

**Table 2**
Parameter Estimates for Group Based Trajectory Model with Five Heroin Trajectory Groups (n = 212).

| Group | Parameter | Estimate | se | t | p |
|---|---|---|---|---|---|
| Panel A | | | | | |
| 1 | Intercept | −3.76 | 0.38 | −9.78 | < 0.001 |
| | Linear | 0.10 | 0.03 | 3.25 | < 0.001 |
| 2 | Intercept | −4.60 | 0.33 | −13.71 | < 0.001 |
| | Linear | 0.98 | 0.06 | 15.88 | < 0.001 |
| | Quadratic | −0.03 | 0.00 | −13.81 | < 0.001 |
| 3 | Intercept | 2.08 | 0.33 | 6.19 | < 0.001 |
| | Linear | 0.23 | 0.20 | 1.16 | 0.245 |
| | Quadratic | −0.11 | 0.02 | −4.41 | < 0.001 |
| 4 | Intercept | 1.95 | 0.09 | 21.54 | < 0.001 |
| | Linear | 0.05 | 0.03 | 1.61 | 0.107 |
| | Quadratic | −0.01 | 0.00 | −5.67 | < 0.001 |
| 5 | Intercept | 1.21 | 0.06 | 18.07 | < 0.001 |
| | Linear | 0.25 | 0.01 | 14.59 | < 0.001 |
| | Quadratic | −0.01 | 0.00 | −15.58 | < 0.001 |
| Panel B | | | | | |
| 1 | Constant | 0.00 | | | |
| 2 | Constant | 0.46 | 0.33 | 1.41 | 0.156 |
| | Never Injected | −2.43 | 0.52 | −4.65 | < 0.001 |
| 3 | Constant | −0.51 | 0.42 | −1.21 | 0.223 |
| | Never Injected | −0.56 | 0.51 | −1.10 | 0.271 |
| 4 | Constant | 0.85 | 0.31 | 2.74 | 0.006 |
| | Never Injected | −3.66 | 0.67 | −5.45 | < 0.001 |
| 5 | Constant | 1.19 | 0.29 | 4.02 | < 0.001 |
| | Never Injected | −4.41 | 0.78 | −5.64 | < 0.001 |

$BIC_1$ = -7,589.57 (n = 3,180); $BIC_2$ = -7559.78 (n = 212).
Panel A shows model estimates for the five-class solution. Panel B shows the multinomial fixed effects for injection history across the five-classes, with class 1 as the reference group.

*never* injecting heroin. Similarly, 65.4% of the men in the early decelerating group reported never injecting heroin, compared to 22.6% in the late accelerating group, 7.9% in the late decelerating group, and 3.9% in the stably high group.

### 3.2. 15-Year outcomes

Table 3 shows significant group level differences in full-time employment and receiving income from illegal sources. For example, the low use group reports significantly higher prevalence of full-time employment compared to the late accelerating, late decelerating, and stably high groups. Among the current measures of behavioral risk, only positive urinalysis for opioid use was significantly different across groups. The differences are quite substantive, as is expected, even though the test data does not overlap with the trajectory data in this analysis. There are no group level differences in marijuana use, cocaine use, and reported prison gang membership, being shot at with a gun, and engagement in illegal activities (violent behavior and property crime behavior) across the different developmental trajectories of heroin use.

There are significant group level differences for experiencing a serious injury or accident and having problems with skin abscesses. Compared to the low use group (16.9%), the late accelerating and late decelerating groups reported a significantly higher prevalence of past year injury (45.2% and 36.5%, respectively). The tested prevalence of HCV varies among the different subgroups as well. Among the low use group, the tested prevalence is 20.6% (24.1% reported ever injecting).

The heroin trajectory groups differed significantly in their symptomatology for depression, anxiety, and psychoticism, with the late accelerating and late decelerating groups generally reporting higher symptomatology than the other groups. Two supplementary analyses were conducted. The first compared the prevalence of clinical indication for mental illness using typical cut-off scores (Table 4). The results are similar to the symptomatology findings. The second used the alternative scoring and documented significant group level differences for phobic anxiety, obsessive compulsive, depression, and hostility (Table 5).

## 4. Discussion

Overall, the findings suggest that the course of heroin use over the transition from adolescence to young adulthood for this high-risk sample varies significantly. In our study, five discrete groups of developmental trajectories of heroin use were identified for Mexican American young adult men who were affiliated with a gang during adolescence and who reported using heroin at least once in their lifetime. About thirty percent of participants were in the stably high group, which is substantively lower than documented by Hser et al. (2007) among men who use heroin and are in treatment (59%).

The men that maintained a relatively low level of use or decreased their use earlier generally reported better outcomes than men that maintained high use or increased their use at a later stage in the life course. Related, the “high risk” developmental trajectory groups (i.e., stably high, late accelerating) had significantly higher prevalences of injection drug use history. This suggests, first, that adolescence may be a key period for intervention, and that early intervention is needed (Sherman et al., 2011). Second, the findings are also supportive of recent calls for treating persons with mild or moderate substance use disorders through the primary care system (Office of the Surgeon General, 2016). Some of the men in our study used at very low rates or decelerated their use at an early stage of the life course. Having treatment or harm reduction intervention within institutional settings that they are likely to come into contact with may help curb some of the long-term consequences of their relatively low use. Given the high prevalence of serious injury, the emergency department may be a useful setting.

The similarity in overall group level differences for marital status, housing, other drug use, and criminal activity suggests a couple of possibilities. First, there may be unmeasured factors or events in the life course that account for these phenomenon. Second, it is possible that these men are socially embedded into supportive family and community-based social networks. For example, over half of the men in each developmental group reported receiving financial assistance from family members, and between one-quarter and one-half are currently

**Table 3**
Current Demographic, Behavioral Risk, Health, and Mental Health Symptomatology associated with Heroin Use Trajectories.

| | Group 1: Low Use (n = 65) | Group 2: Late Accelerating (n = 31) | Group 3: Early Decelerating (n = 26) | Group 4: Late Decelerating (n = 38) | Group 5: Stably High (n = 52) | $F/x^2$ | p |
|---|---|---|---|---|---|---|---|
| Age | 31.3 | 31.1 | 30.9 | 31.5 | 31.2 | 0.23 | 0.922 |
| Marital Status | | | | | | | |
| Married | 24.6% | 6.5%$^{+}$ | 23.1% | 18.4% | 5.8%$^{+}$ | 10.9 | 0.028 |
| Cohabitating | 21.5% | 32.3% | 34.6% | 31.6% | 23.1% | 3.00 | 0.558 |
| Single (Not Married) | 32.3% | 45.2% | 26.9% | 29.0% | 44.2% | 4.80 | 0.308 |
| Employed Full-Time | 38.5% | 16.1%$^{+}$ | 42.3% | 10.5%$^{+\$}$ | 15.4%$^{+}$ | 18.55 | < 0.001* |
| Source of Income | | | | | | | |
| Income from Illegal Sources | 23.1% | 51.6%$^{+}$ | 19.2% | 31.6% | 59.6%$^{+\$}$ | 23.58 | < 0.001* |
| Income from Family/Friends | 52.3% | 54.8% | 53.9% | 86.8%$^{+\hat{}\$}$ | 65.4% | 14.24 | 0.007 |
| Income from Public Services | 26.2% | 25.8% | 7.7% | 10.5% | 26.9% | 7.79 | 0.099 |
| Housing Status | | | | | | | |
| Live in Own Home | 44.6% | 32.3% | 26.9% | 13.2%$^{+}$ | 21.2%$^{+}$ | 14.02 | 0.007 |
| Live with Parent/Partner/Relative | 24.6% | 32.3% | 50.0%$^{+}$ | 31.6% | 53.9%$^{+}$ | 13.23 | 0.010 |
| Unstably Housed | 30.8% | 35.5% | 23.1% | 55.3%$^{+}$ | 25.0%$^{\#}$ | 11.31 | 0.023 |
| Behavioral Risk (Past Year) | | | | | | | |
| Marijuana Use (urinalysis)[a] | 43.8% | 51.7% | 54.6% | 55.9% | 50.0% | 1.68 | 0.794 |
| Cocaine Use (urinalysis) [a] | 39.1% | 58.6% | 31.8% | 32.4% | 47.8% | 6.39 | 0.172 |
| Opioid Use (urinalysis) [a] | 21.9% | 75.9%$^{+}$ | 9.1%$^{\hat{}}$ | 52.9%$^{+}$ | 78.3%$^{+\$}$ | 57.11 | < 0.001* |
| Member of Prison Gang | 28.6% | 44.8% | 40.0% | 39.5% | 45.1% | 4.09 | 0.393 |
| Shot at with Gun | 6.2% | 19.4% | 7.7% | 2.6% | 21.2%$^{+}$ | 11.93 | 0.018 |
| Illegal Activities | | | | | | | |
| Violent Behavior | 53.9% | 61.3% | 50.0% | 52.6% | 61.5% | 1.68 | 0.795 |
| Property Crime Behavior | 24.6% | 32.3% | 19.2% | 42.1% | 53.9%$^{+\$}$ | 14.90 | 0.005 |
| Current Health | | | | | | | |
| Self-Reported Poor Health | 44.3% | 54.8% | 16.7%$^{+\hat{}}$ | 39.4% | 56.4%$^{\$}$ | 11.47 | 0.022 |
| Serious Injury or Accident | 16.9% | 45.2%$^{+}$ | 15.4%$^{\hat{}}$ | 7.9% | 36.5%$^{+\#}$ | 20.31 | < 0.001* |
| Skin Abscesses[b] | 0.0% | 3.2% | 0.0% | 10.5% | 19.2% | 20.0 | < 0.001* |
| Hepatitis C (tested)[a] | 20.6% | 67.9%$^{+}$ | 21.7%$^{\hat{}}$ | 81.8%$^{+\$}$ | 82.2%$^{+\$}$ | 64.36 | < 0.001* |
| Herpes Simplex Virus-2 (tested)[a] | 33.3% | 53.6% | 21.7% | 33.3% | 28.9% | 6.88 | 0.143 |
| Mental Health Symptomatology [c] | | | | | | | |
| Global Severity Index | 0.61 (0.44, 0.77) | 0.99 (0.72, 1.27) | 0.39 (0.22, 0.57)$^{\hat{}}$ | 0.73 (0.49, 9.6) | 1.04 (0.82, 1.26)$^{+\$}$ | 5.36 | < 0.001* |
| Somatization (range 0-23) | 3.2 (2.0, 4.5) | 5.1 (2.9, 7.2) | 2.3 (0.9, 3.6) | 3.4 (2.1, 4.8) | 5.9 (4.5, 7.2)$^{+}$ | 3.63 | 0.007 |
| Obsessive Compulsive (range 0-23) | 5.0 (3.7, 6.2) | 7.9 (5.7, 10.1)$^{+}$ | 3.7 (2.2, 5.3)$^{\hat{}}$ | 5.3 (3.7, 6.9) | 7.6 (6.1, 9.2)$^{+\$}$ | 4.21 | 0.003 |
| Sensitization (range 0-13) | 2.3 (1.6, 3.1) | 3.5 (2.2, 4.8) | 1.5 (0.6, 2.4) | 2.1 (1.4, 2.8) | 3.8 (2.8, 4.8)$^{+\$}$ | 3.71 | 0.006 |
| Depression (range 0-24) | 3.0 (2.0, 4.0) | 6.3 (3.9, 8.6)$^{+}$ | 1.4 (0.2, 2.5)$^{\hat{}}$ | 4.4 (2.4, 6.3) | 6.6 (5.0, 8.1)$^{+\$}$ | 6.45 | < 0.001* |
| Anxiety (range 0-24) | 3.1 (2.1, 4.2) | 5.1 (3.4, 6.8) | 2.0 (1.2, 2.8) | 4.5 (2.7, 6.3) | 6.0 (4.5, 7.5) $^{+\$}$ | 4.53 | < 0.001* |
| Hostility (range 0-20) | 3.4 (2.4, 4.3) | 5.6 (4.0, 7.1)$^{+}$ | 2.5 (1.3, 3.8) | 4.1 (2.7, 5.5) | 5.5 (4.4, 6.7) $^{+\$}$ | 4.16 | 0.003 |
| Phobic Anxiety (range 0-17) | 2.5 (1.5, 3.4) | 3.2 (1.9, 4.5) | 1.1 (0.5, 1.7) | 2.8 (1.6, 3.9) | 4.1 (2.8, 5.4)$^{\$}$ | 2.87 | 0.024 |
| Paranoid Ideation (range 0-20) | 4.3 (3.3, 5.3) | 6.8 (5.0, 8.5)$^{+}$ | 3.0 (1.7, 4.3)$^{\hat{}}$ | 4.7 (3.5, 6.0) | 5.9 (4.7, 7.0)$^{\$}$ | 3.89 | 0.005 |
| Psychoticism (range 0-18) | 2.8 (2.0, 3.7) | 5.3 (3.9, 6.7)$^{+}$ | 1.5 (0.6, 2.4)$^{\hat{}}$ | 3.7 (2.3, 5.0) | 5.4 (4.1, 6.6)$^{+\$}$ | 6.45 | < 0.001* |

*Group test significant at the $\alpha < 0.05$ with a Bonferroni correction for multiple testing.
+ indicates a significant difference from Group1. ^ indicates a significant difference from Group 2. $ indicates a significant difference from Group 3. # indicates a significant difference from Group 5. P-values are corrected for multiple testing using the Bonferroni method.
[a]The sample for biological testing (blood/urine) is reduced to n = 195. The corresponding sample sizes for the trajectory groups are 64, 29, 22, 34, and 46. A standard urinalysis window for opioids is 3 days, marijuana is 3–30 days (depending on how much is consumed), and cocaine is 3 days.
[b]Multinomial logistic regression model not stable due to small prevalence rates across groups.
[c]Mean and 95% confidence interval presented for symptomatology scores.

**Table 4**
Mental Health Symptomatology using Typical Cut-off Scores.

| | Group 1: Low Use (n = 65) | Group 2: Late Accelerating (n = 31) | Group 3: Early Decelerating (n = 26) | Group 4: Late Decelerating (n = 38) | Group 5: Stably High (n = 52) | $F/x^2$ | p |
|---|---|---|---|---|---|---|---|
| Somatization Cut-off | 21.5% | 41.9%$^{+}$ | 19.2% | 26.3% | 57.7%$^{+\$\#}$ | 21.92 | < 0.001* |
| Obsessive Compulsive Cut-off | 24.6% | 41.9% | 19.2% | 23.7% | 44.2% | 9.84 | 0.043 |
| Sensitization Cut-off | 27.7% | 45.2% | 11.5% | 26.3% | 46.2%$^{+\$}$ | 13.23 | 0.010 |
| Depression Cut-off | 29.2% | 45.2% | 7.7%$^{+\hat{}}$ | 31.6% | 53.9%$^{+\$}$ | 19.09 | < 0.001* |
| Anxiety Cut-off | 24.6% | 41.9% | 11.5% | 29.0% | 51.9%$^{+\$}$ | 17.3 | < 0.001* |
| Hostility Cut-off | 33.9% | 58.1%$^{+}$ | 30.8% | 36.8% | 59.6%$^{+}$ | 13.00 | 0.011 |
| Phobic Anxiety Cut-off | 29.2% | 45.2% | 19.2% | 34.2% | 44.2% | 7.17 | 0.127 |
| Paranoid Ideation Cut-off | 46.2% | 67.7%$^{+}$ | 34.6% | 55.3% | 65.4%$^{+\$}$ | 10.64 | 0.031 |
| Psychoticism Cut-off | 30.8% | 58.1%$^{+}$ | 15.4%$^{\hat{}}$ | 31.6% | 55.8%$^{+\$}$ | 19.68 | < 0.001* |

*Group test significant at the $\alpha < 0.05$ with a Bonferroni correction for multiple testing.
+ indicates a significant difference from Group1. ^ indicates a significant difference from Group 2. $ indicates a significant difference from Group 3. # indicates a significant difference from Group 5. P-values are corrected for multiple testing using the Bonferroni method.

**Table 5**
Mental Health Symptomatology Using Alternative Scoring[a].

| | Group 1: Low Use (n = 65) | Group 2: Late Accelerating (n = 31) | Group 3: Early Decelerating (n = 26) | Group 4: Late Decelerating (n = 38) | Group 5: Stably High (n = 52) | $F/x^2$ | p |
|---|---|---|---|---|---|---|---|
| Somatization (range 0-4) | 0.55 (0.34, 0.77) | 1.00 (0.63, 1.37)$^{+}$ | 0.52 (0.18, 0.86) | 0.67 (0.41, 0.93) | 1.03 (0.76, 1.30)$^{+}$ | 2.97 | 0.021 |
| Phobic Anxiety (range 0-14) | 0.40 (0.23, 0.58) | 0.45 (0.22, 0.68) | 0.15 (0.01, 0.29) | 0.53 (0.27, 0.80) | 0.87 (0.60, 1.13)$^{+\$}$ | 4.54 | 0.002* |
| Obsessive Compulsive (range 0-19) | 0.79 (0.57, 1.00) | 1.24 (0.87, 1.61)$^{+}$ | 0.49 (0.25, 0.72)$^{\wedge}$ | 0.83 (0.54, 1.12) | 1.23 (0.96, 1.50)$^{+\$}$ | 4.35 | 0.002* |
| Depression (range 0-8) | 0.64 (0.42, 0.86) | 1.32 (0.86, 1.79)$^{+}$ | 0.39 (0.09, 0.68)$^{\wedge}$ | 1.00 (0.61, 1.40) | 1.43 (1.10, 1.76)$^{+\$}$ | 6.45 | 0.001* |
| Suicidal Ideation (range 0-8) | 0.35 (0.16, 0.55) | 0.50 (0.17, 0.83) | 0.10 (-0.01, 0.21) | 0.46 (0.14, 0.78) | 0.68 (0.41, 0.96) | 2.20 | 0.070 |
| Hostility (range 0-15) | 0.89 (0.67, 1.11) | 1.51 (1.15, 1.88)$^{+}$ | 0.76 (0.45, 1.07)$^{\wedge}$ | 1.08 (0.80, 1.36) | 1.35 (1.11, 1.59)$^{+}$ | 4.41 | 0.002* |

*Group test significant at the $\alpha < 0.05$ with a Bonferroni correction for multiple testing.
+ indicates a significant difference from Group1. ^ indicates a significant difference from Group 2. $ indicates a significant difference from Group 3. # indicates a significant difference from Group 5. P-values are corrected for multiple testing using the Bonferroni method.
Means and 95% confidence intervals presented.
[a]Alternative scoring from Valera et al., 2015.

living with parents or other relatives. This suggests that their social networks are comprised of family members that are instrumental in providing social support and a safety net that prevents more deleterious consequences. Men may remain integrated into their families and communities, in what Garcia (2010) describes as the "dynamics of connectedness". Bourgois et al. (2006) study of older street-recruited men who used heroin documented a similar experience for African American men, while most of the white men were expelled from their families when they began engaging in drug-related crime. Despite the potential benefits for the men in this study, we cannot speak to the potential stress or other negative consequences for their family members and other relations. Previous research among this sample documents complex romantic relationships with women that are shaped by variations in illicit drug use and incarceration across the life course (Valdez et al., 2019).

A major strength of this study is the detailed collection of retrospective life histories with a non-treatment "street-based" sample from a particularly disadvantaged community. Nevertheless, there are several limitations. First, data was collected from retrospective self-report. Life history calendar methods have been found to facilitate recall more effectively and measure temporal ordering, co-occurring events, and other complicated data more accurately than traditional survey methods (Sutton et al., 2011; Yoshihama et al., 2005; Morris and Slocum, 2010), especially for respondents with unstable lives and cognitive difficulties (Sutton, 2010), however, the possibility of recall bias and survivor bias (six men from the first study were determined to be deceased) should be considered. Second, the findings are not generalizable to all Mexican American men. At most, they are characteristic of a high-risk hard to reach population: non-institutionalized Mexican American male youth living in an urban disadvantaged neighborhood, who are affiliated with youth gangs and engaging in illicit drug use as they transition to adulthood. This is a specific subset of the population, but their experiences may be representative of other urban gang-involved youth. Third, the analysis relies on the "three-step" method and bivariate analyses. While the men in this study are fairly homogenous demographically, there is still the possibility of unmeasured confounders and omitted variable bias. Including time-varying covariates and adolescent specific time-invariant predictors in a multiple variable model would help address this concern as well as other temporal issues. Last, it should be acknowledged that the sample size is relatively small and may have been insufficient to detect additional existing groups.

In sum, we show how heroin use can evolve over the life course during the transition from adolescence to adulthood in different ways, regardless of levels of use reported during adolescence. That is, some men who reported high levels of use during adolescence gradually lowered their use, while some men who engaged in low levels of use during adolescence gradually increased their use. Dynamic models examining how life course events and other age-graded changes influence these developmental trajectories of heroin use, and how they co-occur with other illicit drug use and illegal activities, would strengthen our understanding of key intervention points. Nevertheless, findings suggest that heroin use into adulthood, even for persons with low levels of use in adolescence, can have detrimental health consequences. Yet, embeddedness into supportive social networks may potentially help buffer some of these effects.

## Contributors

KM Nowotny was responsible for the analysis and contributed to all sections of the paper. J. Frankeberger was responsible for the developing the background and framing for the paper. A Cepeda and A Valdez contributed to the overall conceptualization of the study, interpretation of the findings, and development of the discussion.

## Funding

This study was supported by the National Institutes of Health, National Institute on Drug Abuse (R01 DA023857). Additional support was provided to the lead author by the Lifespan/Brown Criminal Justice Research Training (CJRT) Program on Substance Use, HIV, and Comorbidities funded by NIDA (R25 DA037190). The NIH and NIDA had no role in the collection or analysis of these data, or in the development of this manuscript.

## Declaration of Competing Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2019.06.008.

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