

# The association of criminal justice supervision setting with overdose mortality: a longitudinal cohort study

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## ABSTRACT

**Background and Aims** Despite the high prevalence of substance use among people in the US criminal justice system, little is known about the incidence of overdose mortality by use patterns, drug convictions and supervision setting. We examined the associations between these characteristics and overdose mortality. **Design** Retrospective cohort study. **Setting and participants** Individuals sentenced to prison, jail, probation or jail plus probation for a felony conviction in Michigan, USA from 2003 to 2006. **Measurements** Using the National Death Index, we assessed overdose mortality to December 2012. We calculated overdose mortality rates by pre-sentence opioid use, drug convictions and supervision setting. Multivariable analyses were conducted using competing risks regression with time-varying covariates. **Findings** Among 140 266 individuals followed over a mean of 7.84 years [standard deviation (SD) = 1.52], 14.9% of the 1131 deaths were due to overdose (102.8 per 100 000 person-years). Over the follow-up, more than half of overdose deaths occurred in the community (57.7%), nearly a third (28.8%) on probation and 12.8% on parole. The adjusted risk of overdose death was lower on probation [hazard ratio (HR) = 0.71, 95% confidence interval (CI) = 0.60, 0.85] than in the community without probation or parole (HR = 1.00) but not significantly different on parole (HR = 1.13, 95% CI = 0.87, 1.47). Pre-sentence daily opioid use (HR = 3.54, 95% CI = 3.24, 3.87) was associated with an increased risk. Drug possession (HR = 1.11, 95% CI = 0.93, 1.31) and delivery convictions (HR = 0.92, 95% CI = 0.77, 1.09) were not significantly associated with overdose mortality. **Conclusions** Based on the absolute or relative risk, parole, probation and community settings are appropriate settings for enhanced overdose prevention interventions. Ensuring that individuals with pre-sentence opioid use have access to harm reduction and drug treatment services may help to prevent overdose among people involved with the criminal justice system.

**Keywords** Cohort studies, drug overdose, epidemiology, mortality, opioids, prisons.

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## INTRODUCTION

Amid epidemic increases in overdose rates in the United States [1], correctional, addiction treatment, public health and harm reduction agencies have increasingly been working to prevent overdose deaths by providing naloxone and medications for opioid use disorder to people involved in the criminal justice system [2–9]. These efforts have been driven by the substantial proportions of people involved in the criminal justice system due to drug offenses [10,11], the high prevalence of criminal justice contact among

people who use heroin and other opioids [12] and the scale of the system, which supervised 6.6 million people at year-end 2016 [13]. For example, in US jails, which largely detain individuals prior to sentencing or for short sentences, and prisons, which are state or federal facilities that generally incarcerate people serving sentences of more than a year, approximately one-quarter of individuals report past heroin or other opiate use [14]. In the month after release from prison, when individuals are commonly on parole, the fatal overdose risk is heightened [15–20]. Probation settings, which supervised more than 3.7 million

people at year-end 2016, are also important because drug offenses are the most serious offenses for nearly a quarter of people on probation [10], and approximately 6% report past-month heroin or other opioid use [21].

Despite efforts to prevent fatal overdose among people with criminal justice involvement, remarkably little is known about the individual-level drug use characteristics, conviction types and supervision settings associated with highest overdose risks. For example, fatal overdose rates on probation and the independent association of drug possession and delivery convictions with overdose fatalities have not been quantified. In criminal justice settings, data availability is limited compared with traditional health-care settings and public health agencies. Formal opioid use disorder diagnoses, comprehensive overdose histories and biological markers may not be systematically collected, and routine overdose surveillance is not conducted in probation and parole settings [22]. Additionally, medical and behavioral health records may be difficult to access, particularly if health services are contracted to external providers. Nonetheless, commonly available administrative data include basic drug use histories collected during pre-sentence investigations, conviction type and supervision setting over time. Further, data can be linked to state and national vital records to ascertain deaths from overdose.

Measuring overdose rates among criminal justice populations and settings may help to inform the design, delivery and evaluation of preventive interventions. Different criminal justice settings present distinct barriers to deliver medications for opioid use disorder and harm reduction services to those most likely to benefit [23,24]. Prisons, for example, may have limited access to medications for opioid use disorder [6,25,26] and naloxone to treat opioid overdoses, and there are few evidence-based guidelines on how to prioritize treatment provision or naloxone distribution. On probation and parole, competing needs, financial constraints and coordination challenges may limit access to community-based services [27–29].

We used data from a state criminal justice system linked with the National Death Index to assess the association between pre-sentence substance use patterns, drug conviction and overdose mortality. We also evaluated overdose mortality rates in prison, parole and probation and among people with prior convictions but living in the community without probation or parole.

## METHODS

### Study design and setting

We conducted a retrospective longitudinal cohort study using data from the Michigan Department of Corrections (MDOC), which has jurisdiction over prisons, felony probation and parole and conducts the pre-sentence

investigations for all individuals convicted of a felony regardless of what setting they are sentenced to. In Michigan, all adults and juveniles sentenced as adults who are convicted of offenses for which the statutory maximum is more than 1 year of incarceration can be sentenced to the MDOC's prisons. Individuals sentenced to less than 1 year of incarceration are sentenced to jail.

The study was approved by the University of Michigan Institutional Review Board with a waiver of consent.

### Study cohort

The study population included individuals aged 15 years and older with new felony sentences in Michigan from 1 January 2003 to 31 December 2006 ( $n = 144\,271$ ). Juveniles aged under 18 years and sentenced as children were not included because they were sentenced in the juvenile system, but juveniles sentenced as adults ( $n = 1785$ ; 1.3%) were included because they were exposed to similar conditions and programming to adults in the MDOC. The focal sentence was the first conviction that led to entry into the cohort. In Michigan, at the time of this study, individuals convicted of a felony offense may have been sentenced to prison, probation, jail, jail plus probation or other sentences (fines or community service). Individuals sentenced to prison were first held in a prison reception and guidance center for intake. Jail sentences were typically of 12 months or less; such individuals were housed in county jails. We included those initially sentenced to jail (7.7% of the study population) and those sentenced to a combination of jail and probation (38.6%).

We did not include short-term jail stays due to probation violations or pre-trial detention. We excluded non-discretionary and identifiable specialty sentences which offered special family or drug services but were too rare to analyze separately, including life sentences ( $n = 2436$ , 1.7%) and specialty courts ( $n = 1659$ , 1.1%). The final cohort included 140 266 individuals, including individuals sentenced to jail ( $n = 10\,788$ ), probation ( $n = 50\,202$ ), jail followed by probation ( $n = 54\,093$ ), prison ( $n = 24\,516$ ) and other sentences such as fines or community service ( $n = 656$ ) during the 4-year baseline period. Follow-up was censored at the time of death or 31 December 2012, whichever came first.

### Exposures

Our primary exposures of interest were criminal justice system setting, pre-sentence opioid use and a felony conviction for drug possession or delivery recorded in the MDOC administrative databases. These databases derive from the pre-sentence investigation and include demographics, body mass index, substance use history, mental health treatment history and prior criminal record. A field agent

typically prepared the pre-sentence investigation report using a process described in an MDOC policy directive [30]. Criminal justice setting indicated whether the individual was in prison, on probation, on parole or in the community not on probation or parole at each day of follow-up, and the cumulative number of admissions and number of months in each setting. Time in the community may have included subsequent jail stays, but these are typically brief (mean of 26 days per stay in 2017 [31]).

Pre-sentence investigation reports provided self-reported use of alcohol, any opioids, marijuana, non-medical stimulants or other drugs at any time before conviction, including never, daily, weekly and occasional (i.e. any use monthly and less) use frequency. We hypothesized that there would be a positive and dose-dependent association between the frequency of opioid use and overdose, with most opioid overdoses occurring among individuals who reported daily opioid use. These hypotheses were not pre-registered and results should be considered exploratory.

Drug convictions for any substance were based on offense descriptions [32]. Because drug possession convictions may reflect the extent of substance use, we hypothesized that individuals with drug possession convictions would be at higher overdose risk than individuals with drug delivery convictions, and that both would be more strongly associated with overdose than no drug convictions. Data also included the date and county of conviction, total offense severity score [33], whether the felony conviction was the person's first, number of prior arrests (0–4, 5–9 and 10+) and time in prison prior to sentencing.

MDOC administrative databases were also the source for other characteristics known to be associated with overdose or all-cause mortality among individuals released from prison [15,34]. These potential confounders or precision variables included age, sex, race (white versus non-white), marital status (single versus ever married), education and pre-sentence employment.

### Study outcomes

We linked identifiers from the MDOC administrative databases to the National Death Index (NDI)-Plus [35], a computerized database of deaths abstracted from death certificates in all 50 states and Puerto Rico [36]. For matches to known decedents, NDI-Plus provided the date, state, and cause of death. International Classification of Disease (ICD)-10 codes were used to classify overdose deaths from any substance(s) and the subset of opioid overdose deaths [15].

To compare death rates between cohort members and the general Michigan population, we used the Centers for Disease Control and Prevention's Wide-ranging OnLine Data for Epidemiologic Research (CDC WONDER) [37] for death counts, population and causes of death for Michigan

residents. Deaths and person-years of cohort members who died in Michigan were deducted from total state deaths reported in CDC WONDER.

### Statistical analysis

For each exposure of interest (criminal justice setting, opioid use and drug conviction), we first calculated crude mortality rates (CMR) as the number of deaths per 100 000 person-years of follow-up with 95% confidence intervals (CI) by exposure status. Person-years were calculated by summing exposure time. Incidence rate ratios (IRR) and 95% CIs were calculated comparing CMRs by exposure status. We also examined crude overdose death rates in the month after prison, parole and probation release. We used indirect standardization to calculate expected deaths in the study cohort based on death rates from the standard population of Michigan residents (i.e. of similar age, gender and race distribution). We present standardized mortality ratios (SMRs), the ratio of observed to expected deaths in the study cohort [38].

Competing-risks regression models were used to examine the independent associations of all three exposures of interest with time-to-death from overdose. Our primary outcome of interest was overdose deaths. However, individuals may have died from other causes which would preclude the primary outcome from occurring. To account for such competing events, we employed competing risks regression to estimate subdistribution hazard ratios (HR) [39]. Standard errors were clustered by county. Opioid overdose mortality was assessed separately as a *post-hoc* analysis using a competing risks model. Models were also adjusted for sex, race, marital status, education, mental health treatment history and body mass index. Age, criminal justice setting and admissions to and months in prison, on probation or on parole since sentencing were treated as time-varying covariates. Sentence length was correlated with sentence type, and therefore not included in the models. With the exception of education, all independent variables had less than 1.2% missingness and the overall number of cells with missing values was 0.3%. Education, however, was missing for 14.8% of the sample, thus we used multiple imputation by chained equations [40] to generate five data sets with imputed values for analysis.

In *post-hoc* analyses, we explored excluding the first month post-release, a time known to be associated with a high risk of death, from IRRs comparing death rates by setting.

## RESULTS

### Cohort characteristics

The cohort ( $n = 140\,266$ ) was 82.9% male and had a mean age of 31.8 [standard deviation (SD) = 11.1,

**Table 1** Characteristics of individuals sentenced for a felony conviction in Michigan and the unadjusted and multivariable association between characteristics and overdose mortality.

	No. (%)	Unadjusted HR (95% CI)	Adjusted <sup>a</sup> HR (95% CI)
Sex			
Male	116 314 (82.9)	1.00	1.00
Female	23 952 (17.1)	1.37 (1.19–1.58)	1.02 (0.88–1.19)
Race <sup>c</sup>			
White	81 322 (58.0)	1.00	1.00
Non-white	58 662 (41.8)	0.26 (0.23–0.31)	0.28 (0.22–0.36)
Pre-sentence employment	–	0.76 (0.64–0.91)	0.57 (0.45–0.73)
Mental health treatment history	26 830 (19.1)	2.30 (2.03–2.60)	1.65 (1.37–1.98)
Alcohol use			
Never	45 670 (32.6)	1.00	1.00
Occasional	46 162 (32.9)	1.07 (0.92–1.25)	0.79 (0.67–0.94)
Weekly	31 428 (22.4)	1.32 (1.12–1.55)	0.87 (0.75–1.00)
Daily	17 006 (12.1)	1.80 (1.51–2.15)	1.02 (0.84–1.24)
Marijuana use			
Never	53 468 (38.1)	1.00	1.00
Occasional	34 525 (24.6)	1.16 (1.00–1.35)	0.95 (0.84–1.07)
Weekly	23 813 (17.0)	1.25 (1.05–1.46)	1.07 (0.87–1.31)
Daily	28 460 (20.3)	1.06 (0.90–1.25)	0.81 (0.69–0.96)
Opioid use			
Never	124 125 (88.5)	1.00	1.00
Occasional	3673 (2.6)	3.82 (3.01–4.84)	2.65 (2.15–3.26)
Weekly	2741 (2.0)	4.38 (3.39–5.66)	2.99 (2.24–4.00)
Daily	9727 (6.9)	5.90 (5.16–6.76)	3.54 (3.24–3.87)
Stimulant use			
Never	94 700 (67.5)	1.00	1.00
Occasional	18 907 (13.5)	2.27 (1.95–2.63)	1.22 (1.03–1.43)
Weekly	13 099 (9.3)	2.19 (1.84–2.60)	1.10 (0.92–1.32)
Daily	13 560 (9.7)	2.03 (1.71–2.42)	0.94 (0.76–1.16)
Other drug use			
Never	105 363 (75.1)	1.00	1.00
Occasional	30 552 (21.8)	0.83 (0.71–0.97)	0.96 (0.80–1.14)
Weekly	2186 (1.6)	1.75 (1.22–2.51)	0.86 (0.68–1.09)
Daily	2165 (1.5)	2.76 (2.06–3.69)	1.42 (1.03–1.96)
Number of prior arrests			
0–4	66 406 (47.3)	1.00	1.00
5–9	40 797 (29.1)	1.62 (1.40–1.88)	1.43 (1.23–1.66)
10+	33 063 (23.6)	2.44 (2.12–2.81)	1.84 (1.48–2.28)
Drug possession conviction			
No	120 902 (86.2)	1.00	1.00
Yes	19 364 (13.8)	1.85 (1.61–2.13)	1.11 (0.93–1.31)
Drug delivery conviction			
No	118 842 (84.7)	1.00	1.00
Yes	21 424 (15.3)	0.86 (0.72–1.02)	0.92 (0.77–1.09)
Setting			
In the community not on parole or probation	–	1.00	1.00
In prison	–	0.04 (0.02–0.08)	0.03 (0.01–0.07)
On parole	–	1.65 (1.38–1.98)	1.13 (0.87–1.47)
On probation	–	0.84 (0.72–0.98)	0.71 (0.60–0.85)
Cumulative prison months			
0	–	1.00	1.00
1–48	–	0.90 (0.78–1.04)	0.94 (0.75–1.18)
49+	–	0.31 (0.20–0.49)	0.97 (0.57–1.65)
Prison admissions, number	–	0.91 (0.81–1.01)	1.27 (1.00–1.61)
Cumulative probation months	–	1.00 (1.00 <sup>b</sup> –1.00)	1.01 (1.00–1.01)

(Continues)

Table 1. (Continued)

	No. (%)	Unadjusted HR (95% CI)	Adjusted <sup>a</sup> HR (95% CI)
Probation admissions, number	–	1.20 (1.06–1.37)	1.45 (1.29–1.63)
Cumulative parole months	–	1.02 (1.01–1.02)	1.01 (1.00 <sup>b</sup> –1.02)
Parole admissions, number	–	1.46 (1.32–1.61)	0.93 (0.64–1.36)

HR = hazard ratio. <sup>a</sup>Model adjusted for age (time-varying), marital status, education, body mass index, months in prison prior to sentence, offense severity score, offense severity score squared, first-time felony offense and initial sentence type. <sup>b</sup>< 1.00 before rounding. HR = hazard ratio; CI = confidence interval. <sup>c</sup>0.2% (282) of the cohort had missing race information.

range = 15–94; Table 1]. At baseline, 6.9% of the cohort members reported daily opioid use, with another 2.0 and 2.6% reporting weekly or occasional opioid use, respectively. Among individuals who reported daily opioid use, 74.9% also used alcohol, 70.6% also used marijuana and 65.5% also used stimulants. Opioid use was more common among those who were sentenced to prison (8.3%) or jail (8.8%) than jail plus probation (7.4%) or probation alone (5.4%). In the cohort, 13.8% were sentenced for a drug possession conviction and 15.3% were sentenced for a drug delivery conviction. Most (82.6%) drug possession convictions and 40.3% of drug delivery convictions were for narcotics/cocaine, which include the United States Drug Enforcement Administration Schedule I and II substances, including opioids such as heroin, oxycodone and fentanyl.

### Overdose

Over a mean follow-up of 7.84 years (SD = 1.52) there were 7611 deaths, of which 14.9% ( $n = 1131$ ) were

overdoses (Table 2). One hundred and eleven (9.8%) overdose deaths occurred outside Michigan. More than half of overdose deaths (56.1%,  $n = 634$ ) involved at least one opioid, including natural and semi-synthetic opioids ( $n = 144$ ), heroin ( $n = 333$ ), methadone ( $n = 135$ ) and/or synthetic opioids other than methadone ( $n = 91$ ). Sixty per cent ( $n = 383$ ) of opioid overdoses also involved another substance, such as cocaine (21%), benzodiazepines (14%) or alcohol (12%). The mean age at overdose death was 39.2 years (SD = 10.5).

Overdose mortality rates were 102.8 per 100 000 person-years (95% CI = 97.0, 109.0; Table 3). The overdose mortality rate was 7.0 times (95% CI = 6.6, 7.4) that among state residents. Between 2003 and 2012, the crude overdose death rate for Michigan was 10.8 per 100 000. After subtracting the overdose deaths in our study population from the state numbers, the rate was 9.4 per 100 000. The opioid overdose mortality rate was 57.6 per 100 000 person-years (95% CI = 53.3, 62.3; Supporting information, Table S1).

Table 2 Deaths among cohort members followed to December 2012.

Cause of death [ICD-10 code(s)]	Deaths no. (%) <sup>a</sup>
All causes	7611 (100)
Overdose (X40–49)	1131 (14.9)
Opioid-related (T40.1, T40.2, T40.3, T40.4)	634 (56.1)
Heroin (T40.1)	333 (52.5)
Natural and semi-synthetic opioids (T40.2)	144 (12.7)
Methadone (T40.3)	135 (21.3)
Synthetic opioids other than methadone (T40.4)	91 (8.1)
Cocaine (T40.5)	230 (20.3)
Alcohol (T51.0–T51.9)	141 (12.5)
Benzodiazepines (T42.4)	106 (9.4)
Antidepressants (T43.0, T43.1, T43.2)	30 (2.7)
Psychostimulants (T43.6)	17 (1.5)
Neuroleptics (T43.3, T43.4, T43.5)	17 (1.5)
Toxic gases (T58, T59.0–T59.9)	12 (1.1)
Unspecified drugs, medicaments or substances (T50.9)	478 (42.3)
Other and unspecified narcotics (T40.6) and cannabis (T40.7)	54 (4.8)
Other drugs, medicaments and substances (T39.0–T39.9, T42.0–T42.3, T42.5–T42.9, T44.0–T44.9, T45.0–T45.9) and other psychotropics (T43.8, T43.9)	36 (3.2)

<sup>a</sup>Not mutually exclusive, as deaths can involve more than one substance.



**Table 3** Overdose mortality rates (deaths per 100 000 person-years) among cohort members ( $n = 140\,266$ ) followed to 2012 and comparisons in overdose mortality rates by pre-sentence opioid use, drug conviction and setting.

	Overdose deaths no. (%)	Crude overdose mortality rate (95% CI)	IRR (95% CI)
Full cohort	1131	102.8 (97.0–109.0)	
Setting			
In the community not on probation/parole	653 (57.7)	121.7 (112.7–131.4)	(Reference)
In prison	< 10 <sup>a</sup>	–	–
On parole	145 (12.8)	199.9 (169.9–235.2)	1.64 (1.36–1.97)
On probation	326 (28.8)	98.9 (88.7–110.2)	0.81 (0.71–0.93)
Opioid use			
Never	688 (60.8)	70.4 (65.3–75.8)	(Reference)
Occasional	76 (6.7)	268.4 (214.3–336.0)	3.81 (2.97–4.84)
Weekly	64 (5.7)	307.4 (240.6–392.8)	4.37 (3.33–5.65)
Daily	303 (26.8)	414.2 (370.1–463.5)	5.89 (5.13–6.75)
Drug conviction <sup>b</sup>			
None	732 (64.7)	92.5 (86.0–99.4)	(Reference)
Drug possession	257 (22.7)	171.8 (152.1–194.2)	1.86 (1.61–2.15)
Drug delivery	142 (12.6)	89.4 (75.8–105.4)	0.97 (0.80–1.16)
Initial sentence <sup>c</sup>			
Jail only	129 (11.4)	153.7 (129.4–182.7)	(Reference)
Jail with probation	475 (42.0)	112.0 (102.4–122.6)	0.73 (0.60–0.89)
Prison	150 (13.3)	76.6 (65.3–90.0)	0.50 (0.39–0.64)
Probation	374 (33.1)	95.5 (86.3–105.7)	0.62 (0.51–0.76)

IRR = incidence rate ratio; CI = confidence interval. <sup>a</sup>If both a drug possession and drug delivery conviction, classified as drug possession. <sup>b</sup>Other sentences suppressed due to low counts cell (< 10). <sup>c</sup>Suppressed due to low counts cell (< 10).

More than half (57.7%) of the overdose deaths occurred in the community while not on probation or parole, 28.8% occurred on probation and 12.8% occurred on parole (Table 3). Fewer than 10 overdoses occurred in prison. Compared with being in the community not on probation or parole, overdose rates were highest on parole [incidence rate ratio (IRR) = 1.64, 95% CI = 1.36, 1.97] and lower on probation (IRR = 0.81, 95% CI = 0.71, 0.93) and in prison. In the first month after prison release, there were 11 overdose deaths (25.6% of deaths in the first month) and the overdose mortality rate was 259.0 per 100 000 person-years (95% CI = 143.4, 467.6). Even after excluding the first month after release (Supporting information, Table S2), the IRRs were similar (parole versus community: IRR = 1.65, 95% CI = 1.36, 1.99; probation versus community: IRR = 0.82, 95% CI = 0.71, 0.93). In the first month after probation or parole ended, the overdose mortality rates were 194.0 per 100 000 person-years (95% CI = 114.9, 326.7) and 119.2 per 100 000 person-years (95% CI = 29.8, 476.6), respectively. The first month after probation ended was associated with a significantly higher overdose mortality rate than other periods on probation (IRR = 1.96, 95% CI = 1.06–3.34), but there was no significant association for first month after parole ended (IRR = 0.60; 95% CI = 0.07, 2.19) compared with other periods on parole.

The mean sentence length was 153.3 days (SD = 121.8; median = 122 days, 25th to 75th IQR = 45–

243 days) for people sentenced to jail or jail and probation.

Individuals who used daily opioids had a nearly sixfold higher crude overdose mortality rates (IRR = 5.89, 95% CI = 5.13, 6.75) than individuals who did not use opioids. Daily opioid use was associated with a significantly higher overdose mortality rate (414.2 per 100 000 person-years, 95% CI = 370.1, 463.5) than occasional use (268.4 per 100 000 person-years, 95% CI = 314.3, 336.0).

Individuals with a drug possession conviction had a 1.86 times higher overdose mortality rate (95% CI = 1.61, 2.15) than individuals without a drug conviction, but the rate was not higher among individuals with a drug delivery conviction (IRR = 0.97, 95% CI = 0.80, 1.16).

Approximately 60% of overdose deaths occurred among individuals reporting no opioid use prior to their first sentence, and more than half of these (51.3%,  $n = 353$ ) were opioid-related. Thirty-nine per cent ( $n = 247$ ) of those with an opioid overdose neither reported opioid use nor had a drug conviction.

#### The association between setting, opioid use and drug possession conviction and overdose

Compared with being in the community not on parole or probation, being in prison or on probation were associated with reduced risks of overdose mortality in adjusted models

(prison: HR = 0.03, 95% CI = 0.01, 0.07; probation: HR = 0.71, 95% CI = 0.60, 0.85), but not being on parole (HR = 1.13, 95% CI = 0.87, 1.47; Table 1). Cumulative probation months and number of probation admissions were significantly associated with overdose mortality. Individuals who reported daily, weekly or occasional opioid use had elevated risks of overdose mortality relative to no use (daily HR = 3.54, 95% CI = 3.24, 3.87; weekly HR = 2.99, 95% CI = 2.24, 4.00; occasional HR = 2.65, 95% CI = 2.15, 3.26). Daily other drug use (HR = 1.42, 95% CI = 1.03, 1.96) was associated with increased risks of overdose mortality, but marijuana (HR = 0.81, 95% CI = 0.69, 0.96) was protective and alcohol (HR = 1.02, 95% CI = 0.84, 1.24) and stimulant use (HR = 0.94, 95% CI = 0.76, 1.16) were not associated.

In adjusted analyses, drug possession (HR = 1.11, 95% CI = 0.93, 1.31) and delivery convictions (HR = 0.92, 95% CI = 0.77, 1.09) were not associated with overdose mortality (Table 1).

#### Post-hoc analyses

Daily opioid use was associated with a greater than fourfold risk in opioid overdose (HR = 4.61, 95% CI = 3.75, 5.67; Supporting information, Table S3).

Among people without prior opioid use (Supporting information, Table S4), drug possession was not associated with overdose mortality (HR = 1.14; 95% CI = 0.87–1.50). Supporting information, Table S5 lists the leading causes of death among individuals with a drug possession conviction.

## DISCUSSION

In this criminal justice population, overdose accounted for nearly 15% of all deaths over almost 8 years of follow-up. Opioids were involved in more than half of overdose deaths, consistent with national and state-wide trends. The highest overdose mortality rate occurred while people were on parole but, over the entire follow-up, the highest proportion of overdoses occurred while people were no longer involved with parole or probation and were in the community. Transitional periods after prison and probation were high-risk. Daily opioid use identified during pre-sentencing investigations was associated with a greater than threefold risk of overdose. Drug possession and delivery convictions were not significantly associated with overdose in adjusted models.

Based on our findings, reducing barriers and enhancing access to medications for opioid use disorder and naloxone may be beneficial for individuals with prior opioid use in community, parole and probation settings. Our findings also suggest that the transition from parole and probation to the community may be an important juncture for such

interventions, perhaps because individuals lose access to ancillary services provided by parole or probation and are no longer monitored. More than a third of opioid overdose deaths were among individuals who did not have a history of opioid use prior to their sentence, suggesting that this indicator may not be adequately sensitive. Some individuals may not have reported opioid use during pre-sentence investigations, whereas others probably initiated opioid use later. Thus, additional indicators will be needed to identify all those could benefit from prevention interventions. In New York City, one study targeted overdose education and naloxone to individuals visiting jails [41]. Further studies could identify additional indicators and develop and test formal overdose predictive models among criminal justice populations to help inform public health intervention targeting. Alternatively, universal, rather than targeted, approaches to screening for substance use disorders and offering treatment and naloxone in parole and probation settings may be needed. Additional services, such as patient navigation [42], may help reduce barriers to treatment and services during high-risk transitions.

We identified significant differences in overdose mortality rates throughout criminal justice settings. The overdose mortality rate was low in prison, consistent with an 'incapacitation effect' [43,44] related to restricted access to prescribed and illicit opioids in prisons. Individuals are subject to monitoring in prison, and there may be opportunities to intervene before an overdose becomes fatal. While treatment for opioid use disorders in prisons and naloxone provision at release are associated with reduced mortality risks after release [3,45–47], individuals in the United States frequently cannot access medications for opioid use disorder during incarceration [6,25,48].

Our findings highlight the high risk of overdose among criminal justice populations in community settings, including parole, probation and after supervision has been completed. Some barriers are similar across parole and probation settings. Parole and probation offices generally do not have medical staff or pharmacy services and are not required to provide access to medications for opioid use disorder or naloxone to prevent opioid overdose deaths. Judges and parole and probation officers may not support the use of medications for opioid use disorder. A lack of insurance coverage can also be a barrier to treatment [49]. However, there may be differences in parole and probation that impact overdose risk. While people on parole and probation may experience social instability, individuals on parole may have more housing insecurity, lower social and family support and fewer employment options than individuals on probation due to the challenges associated with re-entry [50]. Further research could be used to identify differences in barriers to treatment and overdose prevention between probation and parole settings and effective interventions to reduce the risks in each setting.

This study was conducted in a single US state, which may not be generalizable to other states and countries. Based on the limitations of available criminal justice data, we did not have information about ethnicity, opioid use patterns, opioid use disorder diagnoses and treatment, severity of mental health disorder, receipt of prescriptions for opioids over time, urine toxicology or stays in local jails after the initial sentence [51]. Given that treatment for opioid use disorder, including prison-based treatment, is known to be associated with reductions in mortality [47], treatment availability might have influenced the mortality rates we observed. We may not have identified all overdose deaths, including deaths outside the United States, and some heroin and fentanyl overdoses may have been inaccurately categorized [52–55]. Since 2012, heroin and fentanyl overdose rates have increased [1], not captured in our results. However, our study is one of the largest studies of overdose deaths in any longitudinally observed denominator population; this allowed us to examine subgroups not previously examined and adjust for more potential confounders. Information on risk and protective factors in this cohort should be used to generate hypotheses for future general population overdose studies.

Based on the absolute or relative risk, parole, probation and community settings are appropriate settings for enhanced overdose prevention interventions. Ensuring that individuals with pre-sentence opioid use have access to harm reduction and drug treatment services may help to prevent overdose among people involved with the criminal justice system.

#### Declaration of interests

I.A.B. receives royalties from Uptodate for educational content related to the clinical care of incarcerated adults.

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### Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Table S1** Crude mortality rates (deaths per 100 000 person-years) from opioid overdose among cohort members ( $N = 140\,266$ )

**Table S2** Crude mortality rates (deaths per 100 000 person-years) from overdose among cohort members excluding first month post-release

**Table S3** The unadjusted and multivariable association between baseline and time-varying characteristics and opioid overdose mortality

**Table S4** The multivariable association between baseline and time-varying characteristics and overdose mortality by opioid use history

**Table S5** Leading causes of death among individuals with a drug possession conviction.