Supplementary Appendix for the article: “Sociodemographic factors and social determinants associated with toxicology confirmed polysubstance opioid-related deaths”

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**Substances in toxicology by group:**

1. Opioid toxicology assays included opiates, fentanyl and fentanyl analogs, tramadol, heroin, hydrocodone, morphine, oxycodone, codeine, hydromorphone, or oxymorphone

a. illicit opioids = fentanyl and heroin

b. prescription opioids = opiates, tramadol, hydrocodone, morphine, oxycodone, codeine, hydromorphone, or oxymorphone

c. opiates = uncharacterized opioid

The toxicology testing was conducted by either the Massachusetts State Police Laboratory or sent out to NMS Labs (www.nmslabs.com). Both labs ran routine substance-specific gas chromatography mass spectroscopy testing for codeine, hydrocodone, hydromorphone, morphine, oxycodone, and tramadol. We categorized samples that had a combination of morphine and codeine in the same sample as “heroin.” Whereas those with morphine, but no codeine, were categorized as “morphine” (Harruff, Couper, & Banta-Green, 2015). A subset of 2 toxicology reports included “opiates,” an unknown or uncharacterized opiate found on toxicology.

2. Stimulant toxicology assays included cocaine and amphetamines

3. “Other substance” toxicology assays included benzodiazepines, alcohol, marijuana, gabapentin, or clonidine.

Supplementary Table 1. Definitions of covariables

|  |  |  |
| --- | --- | --- |
| **Covariable** | **Covariable definition** | **Datasets used to derive covariables** |
| Age | Age at time of death was stratified into 3 groups:  (1) 11-24\*, (2) 25-44, and (3) 45+ | RVRS Death Records |
| Sex | Gender recorded at time of death:  (1) Male and (2) Female | RVRS Death Records |
| Race | Race recorded at time of death was categorized in to 4 groups:  (1) White non-Hispanic, (2) Black non-Hispanic, (3) Hispanic, and (4) Others (including Asian/PI non-Hispanic, American Indian or Other) | RVRS Death Records |
| Geographic area of residence | The code for city/town of residence in MA was classified into 2 groups:  (1) non-rural and (2) rural. These distinctions are based on town and the determination is made by the Massachusetts State Office of Rural Health\*\* | Master Demographic |
| HIV status | ICD-10 code for HIV in the study period | APCD |
| Homelessness | One of the following in the study period: 1) a claim with an accompanying ICD-9 V.60 or ICD-10 Z590 code indicating homelessness; 2) a record in the Department of Mental Health (DMH) in which individuals were ever identified as experiencing a loss of housing based on a measure of housing status captured on a monthly basis for all DMH clients; 3) an ambulance record in in which the word “homeless” or “shelter” appeared in the narrative report; or 4) a prescription record in the in which the patient’s address matched that of an emergency shelter (yes= met one of the above conditions, no= did not meet one of the above conditions) | APCD, Case Mix, DMH, MATRIS, PMP |
| Mental health comorbidity | Mental health comorbidity if one of the following ICD9 or ICD10 codes present: an inpatient encounter for depression, bipolar, or schizophrenia, or emergency department visit for depression, bipolar, or schizophrenia, or outpatient observation encounter for depression, bipolar, or schizophrenia in the study period; or ever diagnosed in APCD with these comorbidities | APCD, Case Mix |
| Incarceration in the past 12 months | Record of release from incarceration in either a state prison or jail within 12 months of death | DOC and HOC |
| MOUD in the past 12 months | Record of at least one claim for naltrexone, or encounter for methadone treatment, or prescription of buprenorphine within 12 months of death | BSAS\*\*\*, PMP,  APCD |

RVRS=Registry of Vital Records and Statistics; APCD=All Payer Claims Database; BSAS=Bureau of Substance Abuse Services; DMH=Department of Mental Health; MATRIS=Massachusetts Ambulance Trip Record Information System; PMP=prescription monitoring program; DOC=Department of Corrections (prison); HOC=House of Corrections (jail); MOUD=Medication for Opioid Use Disorder

\*We included persons 11 years and older because: 1) the prevalence of opioid use disorder (OUD) is expanding in persons less than 18 years (Barocas et al., 2018); 2) drug overdose mortality has steadily increased among youth (Hedegaard, 2018); and 3) among individuals in treatment for OUD, 1 in 3 report first using opioids before age 18 (TEDS, 2017).

\*\*A municipality in Massachusetts is considered rural if it meets one of the following criteria: (1) meets at least one of three federal rural definitions at the sub-county level (Census Bureau, OMB, or RUCAs), (2) has a population less than 10,000 people and a population density below 500 people per square mile, (3) has an acute care hospital in the town that meets the state hospital licensure definition of a small rural hospital (SRH), or is a certified Critical Access Hospital (CAH).

\*\*\*Administrative records of admissions to BSAS licensed addiction treatment programs

**Supplementary Table 2. Demographic characteristics of person with opioid-related deaths with and without toxicology, 2014 - 2015**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Opioid-related overdose deaths with toxicology  N = 2244 (77%) | Opioid-related overdose deaths without toxicology  N = 684 (23%) | p value |
| Age |  |  |  |
| 11-24 | 224 (10) | 41 (6) | <0.001 |
| 25-44 | 1279 (57) | 314 (46) |  |
| 45+ | 741 (33) | 329 (48) |  |
| Gender |  |  |  |
| Male | 1674 (75) | 469 (69) | 0.002 |
| Female | 570 (25) | 215 (31) |  |
| Race |  |  |  |
| White, non-Hispanic | 1934 (87) | 571 (82) | <0.001 |
| Black, non-Hispanic | 94 (4) | 44 (6) |  |
| Hispanic | 186 (8) | 48 (7) |  |
| Other | 21 (1) | 30 (4) |  |
| Residence |  |  |  |
| Non-Rural | 2088 (93) | 632 (92) | 0.562 |
| Rural | 156 (7) | 52 (8) |  |

**Supplementary Table 3. Breakdown of type of opioid on toxicology among each opioid-related overdose death categories**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Opioid alone  (N = 389) | Opioids + Other substances without stimulants (N = 1,047) | Opioids +/- Other substances  with stimulants (N = 808) | Total |
| **Opiate alone\*, n (%)** | 0 | 1 (<1%) | 1 (<1%) | 2 (<1%) |
| **Fentanyl/Heroin alone, n (%)**\*\* | 299 (77%) | 722 (69%) | 601 (74%) | 1,601 (72%) |
| **Prescription opioid alone, n (%)** | 35 (9%) | 103 (10%) | 53 (7%) | 191 (9%) |
| **Both Fentanyl/Heroin and Prescription, n (%)** | 55 (14%) | 221 (21%) | 153 (19%) | 429 (19%) |
| \* “Opiate” on toxicology report is an uncharacterized or undetermined opioid from the medical examiner’s report—unknown if it is prescription or illicit  \*\* The proportion is shown as the column percentage. | | | | |

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| **Supplementary Table 4. Multinomial regression model results of opioid-related deaths with accompanying toxicology results in Massachusetts, 2014-2015a** | | |
| **Characteristics** | **Opioid-related death toxicologyb** | |
| Opioids + Other substances, **without stimulants**  vs. Opioids only | Opioids +/- Other substances  **with stimulants**  vs. Opioids only |
| Age |  |  |
| 11-24 | REF | REF |
| 25-44 | 1.18 (0.82-1.70) | 1.84 (1.23-2.76)\* |
| 45+ | 1.32 (0.89-1.97) | 1.70 (1.10-2.64)\* |
| Sex |  |  |
| Male | REF | REF |
| Female | 0.96 (0.72-1.29) | 1.23 (0.91-1.65) |
| Race |  |  |
| White, non-Hispanic | REF | REF |
| Black, non-Hispanic | 0.80 (0.41-1.57) | 1.75 (0.93-3.30) |
| Hispanic | 0.60 (0.38-0.94)\* | 1.31 (0.86-1.99) |
| Other | 0.64 (0.26-1.55) | 0.49 (0.18-1.33) |
| Residence |  |  |
| Non-Rural | REF | REF |
| Rural | 0.73(0.48-1.11) | 0.52(0.33-0.84)\* |
| HIV status |  |  |
| Negative | REF | REF |
| Positive | 1.71 (0.37-7.94) | 2.21 (0.48-10.07) |
| Homelessnessc |  |  |
| No | REF | REF |
| Yes | 1.03 (0.71-1.49) | 1.29 (0.88-1.87) |
| Mental health comorbidity**d** | |  |
| No | REF | REF |
| Yes | 1.83 (1.43-2.36)\* | 1.56 (1.20-2.03)\* |
| Incarceration in past 12 months**e** | |  |
| No | REF | REF |
| Yes | 0.53 (0.36-0.79)\* | 1.05 (0.72-1.53) |
| MOUD in the past 12 months**f** | |  |
| No | REF | REF |
| Yes | 0.93 (0.70-1.24) | 1.16 (0.86-1.55) |
| **a**Odds ratios with 95% confidence intervals  **b**Comparator group for odds ratios is opioid-related deaths with only opioids present on toxicology  cHomelessness during any period of time from 2011-2015  dIncludes depression, bipolar disorder, schizophrenia  eAny release from prison or jail in Massachusetts in the 12 months that preceded the fatal overdose  fMedication for opioid use disorder; includes naltrexone, methadone, or buprenorphine in the 12 months that preceded the fatal overdose  \*Statistically significant with p value <0.05 | | |

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| **Supplementary Table 5. Results of the secondary analysis multinomial regression model of opioid-related deaths with accompanying toxicology results in Massachusetts, 2014-2015†** | | | |
| **Characteristics** | **Opioid-related death toxicology** | | |
| Opioids + **stimulants**, but no other substances  vs. opioids only**‡** | Opioids + other substances, **without stimulants**  vs. opioids only **‡** | Opioids + other substances + **stimulants**  vs. opioids only**‡** |
| Age |  |  |  |
| 11-24 | REF | REF | REF |
| 25-44 | 1.56 (0.86-2.83) | 1.18 (0.82-1.71) | 1.95 (1.26-3.02)\* |
| 45+ | 1.67 (0.88-3.16) | 1.32 (0.89-1.97) | 1.71 (1.07-2.75) \* |
| Sex |  |  |  |
| Male | REF | REF | REF |
| Female | 1.06 (0.70-1.60) | 0.96 (0.72-1.29) | 1.28 (0.94-1.75) |
| Race |  |  |  |
| White, non-Hispanic | REF | REF | REF |
| Black, non-Hispanic | 2.18 (1.01-4.70)\* | 0.80 (0.41-1.56) | 1.60 (0.83-3.11) |
| Hispanic | 1.14 (0.70-2.19) | 0.60 (0.38-0.94) \* | 1.33 (0.86-2.07) |
| Other | 0.74 (0.19-2.88) | 0.64 (0.26-1.54) | 0.41 (0.13-1.27) |
| Residence |  |  |  |
| Non-Rural | REF | REF | REF |
| Rural | 0.32(0.13-0.79)\* | 0.73(0.48-1.11) | 0.59(0.36-0.96)\* |
| HIV status |  |  |  |
| Negative | REF | REF | REF |
| Positive | 2.72 (0.48-15.32) | 1.71 (0.37-7.93) | 2.02 (0.42-9.73) |
| Homelessness\*\* |  |  |  |
| No | REF | REF | REF |
| Yes | 1.85 (1.15-2.98)\* | 1.03 (0.71-1.49) | 1.12 (0.75-1.68) |
| Mental health comorbidity**††** | |  |  |
| No | REF | REF | REF |
| Yes | 1.26 (0.87-1.82) | 1.84 (1.43-2.36)\* | 1.68 (1.27-2.21)\* |
| Incarceration in past 12 months**‡‡** | |  |  |
| No | REF | REF | REF |
| Yes | 1.27 (0.77-2.07) | 0.53 (0.36-0.79)\* | 0.97 (0.65-1.45) |
| MOUD in the past 12 months**‡‡‡** | |  |  |
| No | REF | REF | REF |
| Yes | 1.29 (0.87-1.92) | 0.93 (0.70-1.24) | 1.11 (0.82-1.51) |
| **†**Odds ratios with 95% confidence intervals  **‡**Comparator group for odds ratios is opioid-related deaths with only opioids present on toxicology  \*Statistically significant with p value <0.05  \*\*Homelessness during any period of time from 2011-2015  ††Includes depression, bipolar disorder, schizophrenia  ‡‡Any release from prison or jail in Massachusetts in the 12 months that preceded the fatal overdose  ‡‡‡Medication for opioid use disorder; includes naltrexone, methadone, or buprenorphine in the 12 months that preceded the fatal overdose | | | |

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