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# Characteristics associated with adult non-fatal opioid and stimulant overdose and substance use disorder emergency department visits in Michigan

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## HIGHLIGHTS

- Outcomes were nonfatal opioid or stimulant overdose or substance use disorder ED visits.
- All outcomes had the highest increased risk for ages 28–32 years vs. 18–22 years.
- Medicaid insurance, male sex, and low household income increased risk of overdose.
- These same factors were associated with an increased risk of substance use disorder.
- Opioid and stimulant overdose intentionality modified some associations.

## ARTICLE INFO

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## ABSTRACT

*Background:* Understanding risk factors for emergency department (ED) visits for overdose and substance use disorder (SUD) can inform prevention efforts. Few studies have considered non-fatal opioid overdoses, stimulant overdoses and SUD, and limited data exists by overdose intentionality and by sex.
*Methods:* We conducted a serial cross-sectional study with Healthcare Cost and Utilization Project Michigan (MI) 2019–2020 ED discharge data ($n$=5,716,716). Primary outcomes included non-fatal opioid overdoses, non-fatal stimulant overdoses, and SUD primary diagnoses in a single ED visit. We examined demographic and socio-economic factors associated with study outcomes using binary and multinomial logistic regression (for overdose intentionality) models, which estimated adjusted odds ratios (AOR) and 95 % confidence intervals (CI).
*Results:* Among all MI discharges, 13,908, 1,379, and 23,462 were nonfatal opioid, stimulant, or SUD overdose visits, respectively. Lower median household income (vs. higher income), male sex (vs. female), metropolitan county of residence (vs. small urban/rural), and Medicaid (vs. private insurance) were associated with increased odds of all outcomes. For example, ORs(95 % CIs) for Medicaid were 4.41(4.18,4.65), 2.25(1.95,2.60), and 2.80 (2.70,2.91) for opioid overdoses, stimulant overdoses, and SUD, respectively. All outcomes had the highest increased odds in ages 28–32 years compared to 18–22 years. Stratification by sex and non-fatal overdose intentionality modified some associations, with the strongest associations observed for non-fatal opioid overdoses.

*Abbreviations:* AOR, Adjusted Odds Ratio; AHRQ, Agency for Healthcare Research and Quality; APA, American Psychiatric Association; APA, American Psychological Association; CDC, Centers for Disease Control and Prevention; CI, Confidence Interval; DSM-5, Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; DUD, Drug Use Disorder; ED, Emergency Department; FIPS, Federal Information Processing System; HCUP, Healthcare Cost and Utilization Project; ICD-10-CM, International Classification of Diseases, 10th Revision, Clinical Modification; MI, Michigan; NIDA, National Institute on Drug Abuse; NIH, National Institutes of Health; OR, Odds Ratio; PR, Prevalence Ratio; SEDD, State Emergency Department Database; SAMHSA, Substance Abuse and Mental Health Services Administration; SUD, Substance Use Disorders; US, United States.

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*Conclusions:* Male sex, Medicaid, and race/ethnicity were consistently associated with all outcomes similarly, but other characteristics varied in patterns, strengths of association, and statistical significance by outcome groups, sex, and non-fatal opioid or stimulant overdose intentionality.

## 1. Introduction

Drug overdose and substance use-related health outcomes result in substantial morbidity and mortality globally each year (Castaldelli-Maia et al., 2023; Martins et al., 2015). Data from the National Institute on Drug Abuse (NIDA) (National Institute on Drug Abuse, 2023) showed an upward trend in drug-involved US deaths from just under 20,000 in 1999 to 91,799 and 106,699 in 2020 and 2021, respectively. In the US, from 2013 to 2019, synthetic opioid deaths increased by 1040 %, and psychostimulant deaths increased by 317 % (Mattson et al., 2021). Mattson et al. (2021) reported that the Midwest had the largest increase in psychostimulant-involved deaths from 2016 to 2017 (36.1 %), with over 40 % of deaths involving a psychostimulant as compared to other regions. Specifically, MI showed a statistically significant increase above 50 % in age-adjusted rates of psychostimulant-involved fatalities from 2018 to 2019 (Mattson et al., 2021).

Non-fatal drug-related overdoses are a risk factor for both subsequent non-fatal and fatal drug-related overdoses, making non-fatal drug overdoses an important upstream factor for prevention efforts and a pertinent intervention point (Olfson et al., 2018). In 2016, the Midwest had the second-highest opioid-related hospitalization rate at 360.7 per 100,000 (Weiss et al., 2022). Previous studies have shown that urban or metropolitan counties of residence (Stokes et al., 2023; Xiang et al., 2012), female sex (Pickens et al., 2022; Xiang et al., 2012), lower median household income (Xiang et al., 2012), and younger and middle-aged groups are associated with a higher prevalence of non-fatal overdose ED visits (Stokes et al., 2023; Xiang et al., 2012). The associations of insurance status and ED non-fatal drug-related utilization vary in current literature according to drug type and type of healthcare (Stokes et al., 2023; Xiang et al., 2012).

Another potential upstream intervention point, which also has substantial morbidity associated with it, is substance use disorders (SUD). In 2022, approximately 17.3 % of Americans aged ≥12 years (48.7 million persons) had a SUD (Substance Abuse and Mental Health Services Administration, 2023). Limited research has examined factors associated with overall SUDs, with most studies focusing on specific groups or SUD as a comorbidity. However, some studies using hospital administrative and survey data have shown that urban geographic areas (Armoon et al., 2021; Grant et al., 2016), male sex (Armoon et al., 2021; Grant et al., 2016), younger ages (Armoon et al., 2021; Grant et al., 2016), and lower income (Grant et al., 2016) are associated with an increased prevalence of SUD. Finally, White race/ethnicity has been associated with increased non-fatal overdose ED utilization, but varying races/ethnicities have been associated with increased SUDs (Grant et al., 2016; Stokes et al., 2023).

With the continual increase in fatal opioid and stimulant overdoses, non-fatal opioid and stimulant overdoses and SUDs are important upstream intervention points, particularly in ED settings; however, several limitations exist from the previously cited literature on factors surrounding these encounters. Many studies focused on all drug overdoses or poisonings and did not consider opioid or stimulant-specific overdoses, and almost no studies compared overdose risk factors by intentionality. In addition, few studies have examined risk factors associated with SUD ED visits. As an ED visit is many times the only time an individual living with SUD is seen by healthcare professionals and an important intervention opportunity, it is essential to take advantage of these encounters. To address these gaps, we conducted a comprehensive analysis of demographic and social characteristics in association with non-fatal opioid overdoses, stimulant drug overdoses or SUD among MI adults who were discharged from an ED during 2019–2020. Secondary aims included demographic and social characteristic associations stratified by male versus female sex and non-fatal opioid and stimulant overdoses by intentionality.

## 2. Materials and methods

### 2.1. Data source and study population selection

Data from the Healthcare Cost and Utilization Project (HCUP) State Emergency Department Database (SEDD) for MI from January 1, 2019 to December 31, 2020 were used for this study. SEDD contains ED discharges that do not result in inpatient hospitalization and occur in hospital owned EDs. Any ED visit resulting in an inpatient hospitalization is included in the HCUP State Inpatient Databases (Agency for Healthcare Research and Quality, 2021). The unit of analysis was a discharge record. See Fig. 1 for descriptions of inclusion/exclusion criteria and outcome group formation. The final sample size was n=5,716,716.

Primary outcomes included non-fatal opioid overdoses, non-fatal stimulant overdoses, and SUD primary diagnoses in a single ED visit. All cases were identified using International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) codes in the primary diagnosis field (i.e., first listed diagnosis), indicating the main reason for the ED visit, as defined in the relevant sections below (Pickens et al., 2022; Singh, 2022; Weiss et al., 2022). The CDC, ICD-10-CM Drug Poisoning Indicators Workgroup, and the Council of State and Territorial Epidemiologists published and endorsed standardized ICD-10-CM codes for identification of non-fatal drug overdoses (Vivolo-Kantor et al., 2021), which were used for the identification of overdose outcomes in this study. Further, following the CDC's guidance, only initial encounters were included to reflect active treatment accurately for overdoses in comparison to subsequent or sequala encounters only. In addition, underdosing and adverse effects manners/intentions were excluded to reduce false positives and more accurately reflect actual overdoses (Vivolo-Kantor et al., 2021). The guidelines also recommended looking beyond the primary diagnosis to increase the representation of polydrug overdoses and include cases with a relevant primary ICD-10-CM code external to the included non-fatal drug overdose codes (Vivolo-Kantor et al., 2021). Therefore, secondary diagnosis fields were searched and included for sensitivity analyses.

### 2.2. Variable classification/criteria

#### 2.2.1. Non-fatal drug overdose

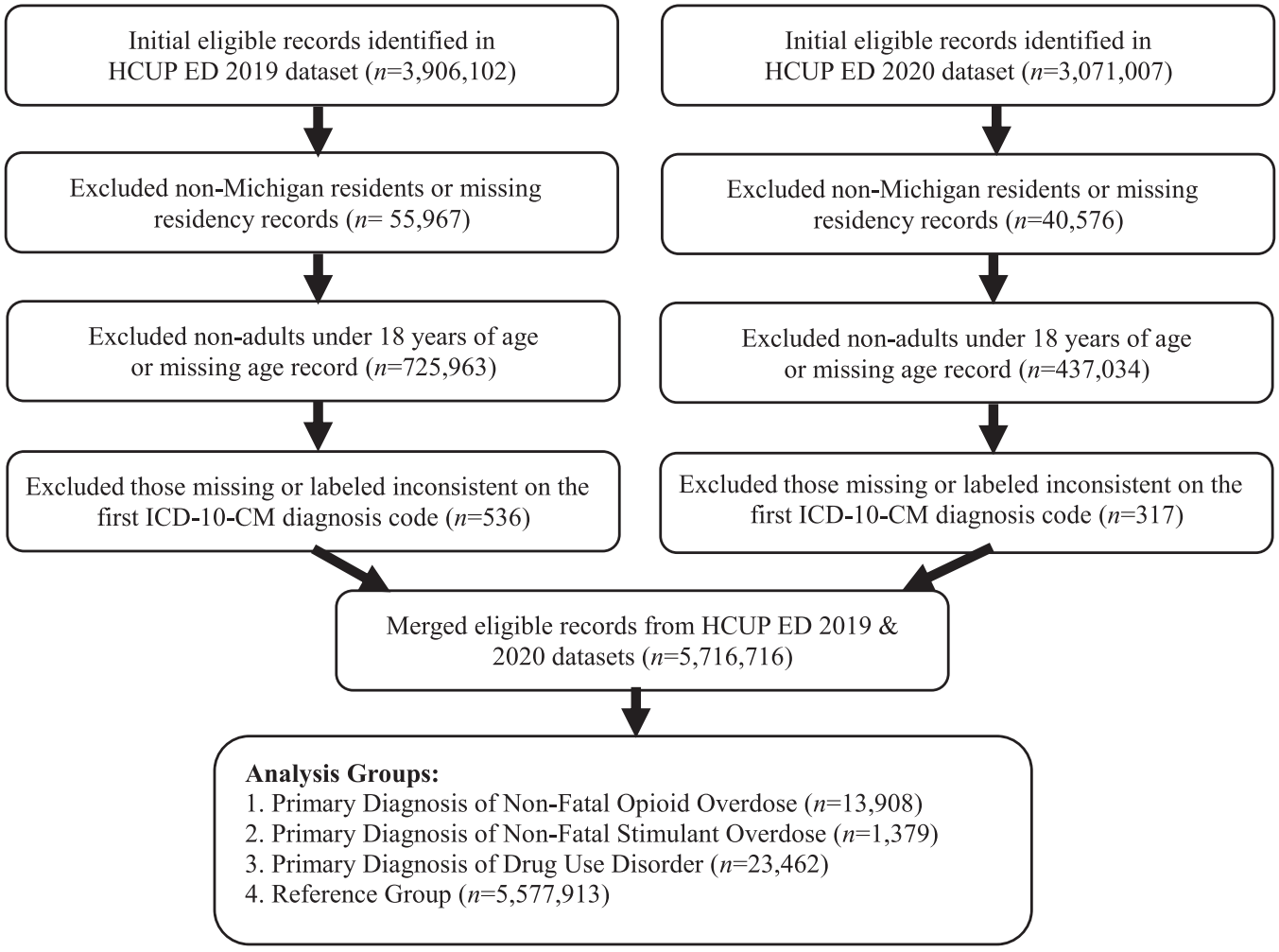
Non-fatal opioid and stimulant overdoses were identified using relevant ICD-10-CM T codes. Opioid-related outcomes included ICD-10-CM codes T40.0x, T40.41, T40.42, T40.49, T40.1x, T40.2x, T40.3x, T40.4x, T40.60, and T40.69. Codes T40.41, T40.42, and T40.49 were added after October 1, 2020. The ICD-10-CM code includes a value for intentionality (1=uintentional; 2=intentional; 3=assault; 4=undetermined intent) (Vivolo-Kantor et al., 2021). Opioid drug subcategories included are as follows: opium, heroin, other opioids, methadone, synthetic narcotics, unspecified narcotics, other narcotics, fentanyl or fentanyl analogs, tramadol, and other synthetic narcotics. Non-fatal stimulant overdoses were identified with ICD-10-CM codes T40.5x, T43.60, T43.61, T43.62, T43.63, T43.64, and T43.69. Stimulant drug subcategories are as follows: cocaine, unspecified psychostimulant, caffeine, amphetamines, methylphenidate, ecstasy, and other psychostimulants.

The corresponding reference group included all other first listed

diagnosis codes besides any first listed diagnosis of any non-fatal drug-related overdoses (T36-T50) and any SUD (F10-F19). The overdose outcomes were dichotomized into the reference group (no) and primary diagnosis codes of non-fatal opioid or stimulant overdose (yes), respectively. The two drug-related outcomes were further categorized by intentionality as follows: reference group (no), unintentional overdose, intentional overdose,and assault/undetermined intent overdose, which were combined due to small counts.

*2.2.2. Substance use disorder*

ICD-10-CM codes (F10-F19) are commonly used to identify SUD (Peterson et al., 2021) and endorsed by the American Psychological Association (APA) (2015) and the American Psychiatric Association (APA) (2017), which publish updates on ICD-10-CM codes for SUD in accordance with the Diagnostic and Statistical Manual of Mental Disorders 5th edition (American Pyschological Association, 2015; American Psychiatric Association 2017). SUD was defined using ICD-10-CM




**Analysis Group Definitions:**

**Non-Fatal Opioid Overdose:** International Classification of Disease, 10th Edition, Clinical Modification (ICD-10-CM) codes T40.0x, T40.41, T40.42, T40.49, T40.1x, T40.2x, T40.3x, T40.4x, T40.60, and T40.69; initial encounters (A) and intentional, unintentional, assault, and undetermined intents (1-4) only.

**Non-Fatal Opioid Stimulant:** ICD-10-CM codes T40.5x, T43.60, T43.61, T43.62, T43.63, T43.64, and T43.69; initial encounters (A) and intentional, unintentional, assault, and undetermined intents (1-4) only.

**Drug Use Disorder:** ICD-10-CM codes F11-F16 and F18-F19. Includes opioid, cannabis, sedative, hypnotic, anxiolytic, cocaine, other stimulant, hallucinogen, inhalant, and other psychoactive substance related use disorders.

**Reference Group:** Any primary diagnosis codes excluding non-fatal drug overdoses (T36-T50) and substance use disorder (F10-F19).

**Fig. 1.** HCUP MI ED 2019–2020 Exclusion/Inclusion Criteria and Analysis Groups Creation.

codes F11-F16 and F18-F19, which includes opioid, cannabis, sedative/hypnotic/anxiolytic, cocaine, other stimulant, hallucinogen, inhalant, and other psychoactive substance-related use disorders, abuse, and dependence related injuries and complications (Peterson et al., 2021). Codes had to be in diagnosis field one for inclusion in the exposure group. Primary diagnosis codes F10 (alcohol use disorder) and F17 (tobacco/nicotine use disorder) were excluded from the exposure group. All other primary diagnosis codes besides any non-fatal drug overdose and SUD in field one were included in the reference group. The final variable was dichotomized into the reference group (no) and a primary diagnosis code of SUD (yes).

#### 2.2.3. ED visit characteristics

Demographics and social factors examined included age, median household income, race/ethnicity, sex, payment type, and county urbanization level. Age at admission was categorized into five-year categories, starting at ages 18–22 years and ending with ages 53–57 years before a final category of ≥58 years. Ages ≥58 years was the final category due to small sample sizes when non-fatal opioid and stimulant overdoses were stratified by intentionality. Median household income in quartiles was based on the patient's on-file zip code for that current year. Any records without zip codes, blank, or others were coded as missing.

Race/ethnicity categories included non-Hispanic Black, non-Hispanic White, Hispanic, and other races/ethnicities (non-Hispanic Asian and Pacific Islander, non-Hispanic Native American, and other races/ethnicities not reported). The other race/ethnicity category was created due to low counts when stratified by outcomes. Available categories for sex, which was self-reported, included the categories of male or female only. All other values (unknown, invalid, non-male, and non-female) were set to missing by HCUP as part of data standardization procedures. Payment type represents the original primary expected payment source for the ED discharge encounter. No charge encounters were minimal (0.01 % of records) and set to missing. Due to low counts after stratification by outcome variables, self-pay, and others, including Worker's Compensation, CHAMPUS, CHAMPVA, Title V, and other government programs, were condensed into one category. Final categories included Medicare, Medicaid, private insurance, and self-pay/others. County urbanization level based on patient county of residence was initially assigned according to rural-urban continuum codes with nine levels. However, due to small counts after outcome variable stratification, it was condensed into a five-category variable (See Supplemental Methods for more details).

### 2.3. Statistical analysis

Univariate analyses of each variable, including counts and percentages, were reported. Bivariate descriptive statistics were also generated, including frequency and percentages for all outcome variables. All cases with missing data were excluded from their respective modeling analysis. In addition, all cell counts and percentages with ≤10 counts were suppressed per the data use agreement with HCUP. Binary logistic regression models were generated for each binary pre-defined group (non-fatal opioid overdose, non-fatal stimulant overdose, and SUD) along with odds ratios (ORs) and 95 % confidence intervals (CIs). Multinomial logistic regression models were generated for analysis of non-fatal opioid and stimulant overdose outcomes by intentionality. In addition, binary logistic regressions were repeated after stratification by male or female sex. Sensitivity analyses were conducted to examine the impact of secondary diagnoses on main findings. The first sensitivity analysis excluded all secondary diagnoses of a non-fatal drug overdose (T36-T50) or SUD (F10-F19) from the reference group in addition to previously described exclusions. The second sensitivity analysis maintained the prior exclusions in the reference group and included all secondary diagnoses of a non-fatal opioid and stimulant overdose and SUD cases in addition to primary diagnoses in the respective categories. P for trend tests were conducted and reported for each ordinal variable in the above models (age, median household income, and county urbanization level). Alpha levels were set to 0.05, and 95 % CIs not containing 1.0 were considered statistically significant. All statistical programming and tests were conducted in SAS version 9.4 (Cary, North Carolina). This study was reviewed and determined as non-human subjects research by the Grand Valley State University Institutional Review Board (# 23–294-H-GVSU, Date: May 23, 2023).

## 3. Results

A total of 5,716,716 cases were eligible for analysis among MI residing adult ED discharges from 2019 to 2020. Table S1 describes the overall population characteristics. Briefly, most of the population were aged ≥58 years (31.1 %), followed by ages 28–32 years (10.7 %), 23–27 years (10.5 %), and 43–47 years (6.9 %). Non-Hispanic White race/ethnicity was most prevalent (67.5 %), followed by non-Hispanic Black (26.4 %) and other races/ethnicities (2.9 %). Medicare (28.4 %), Medicaid (32.4 %), and private insurance (30.3 %) status were relatively equal, but self-pay/other (8.9 %) had the lowest percentage.

After exclusions, 13,908 had a primary diagnosis of a non-fatal opioid overdose, 1,379 a primary diagnosis of a non-fatal stimulant overdose, and 23,462 a primary diagnosis of SUD (Fig. 1). Types of drugs identified in opioid overdoses included heroin (67.7 %), other opioids (14.1 %), and unspecified narcotics (12.7 %) with opium, methadone, synthetic narcotics, other narcotics, fentanyl or fentanyl analogs, tramadol, and other synthetic narcotics specified in <6 % of cases. Types of drugs identified in stimulant overdoses included amphetamines (41.5 %), cocaine (40.8 %), ecstasy (7.2 %), and caffeine (6.2 %) with other and unspecified psychostimulants, and methylphenidate recorded in <5 % of cases. The sample size for study outcomes overall and by intentionality are shown in (Table S2).

As shown in Table 1, all outcomes (non-fatal opioid and stimulant overdoses, SUD) had similar increasing prevalence patterns from ages 18–22 years until ages 28–32 years, which then decreased until the final age category. Non-fatal opioid and stimulant overdoses and SUD had slightly more males in comparison to the reference group, which had slightly more females. All outcomes decreased in prevalence as median household income increased. All outcomes had the highest prevalence among non-Hispanic White, followed by Non-Hispanic Black, and Hispanic groups. Across all outcomes, the payment status with the highest prevalence was consistently Medicaid. Table 2 describes the population characteristics by intentionality for non-fatal opioid and stimulant overdoses. Characteristic patterns were similar to the overall outcomes with some exceptions, mainly seen within the non-fatal stimulant overdoses and intentional and assault/undetermined intents.

Results for the associations of ED visit characteristics and opioid and stimulant overdoses are presented in Table 3 and results for SUD are presented in Table 4. For non-fatal overdoses, all age groups had statistically significant increased odds of a non-fatal opioid overdose as compared to the reference group of ages 18–22 years. For stimulant overdoses, the pattern was different, with statistically significant decreased odds among ages ≥43 years (for example, for ages 43–47 years, OR:0.69, 95 % CI:0.54,0.88). Decreased odds in ages ≥43 years were also observed for SUD discharges (for example, for ages 43–47 years, OR:0.76, 95 % CI:0.71,0.81); however, statistically significant increased odds were seen for younger ages (for example, 23–27 years: OR:1.31, 95 % CI:1.24,1.38). All outcomes had statistically significant increased odds for males as compared to females. In addition, all outcomes had statistically significantly decreased odds for all other races compared to non-Hispanic Whites. The exception was for other races/ethnicities among non-fatal stimulant overdoses, which was not statistically significant (OR:0.89, 95 % CI:0.66,1.20).

All outcomes were associated with increased odds for lower vs. higher median household income; however, only the first quartile (vs. the fourth quartile) was statistically significant across all outcomes. For example, for non-fatal opioid overdoses, the OR for quartile 1 vs.

**Table 1**
MI Adult 2019–2020 ED Discharge Characteristics by Non-Fatal Opioid or Stimulant Overdose or Substance Use Disorder Primary Diagnosis (n=5,616,662).

| | Non-Fatal Opioid Overdose | Non-Fatal Stimulant Overdose | Substance Use Disorder[a] | Reference Group[b] |
|---|---|---|---|---|
| **Age at Admission, Years, *n* (%)** | | | | |
| 18–22 | 650 (4.7) | 203 (14.7) | 2593 (11.1) | 532568 (9.6) |
| 23–27 | 1836 (13.2) | 223 (16.2) | 3806 (16.2) | 587600 (10.5) |
| 28–32 | 2692 (19.4) | 259 (18.8) | 4476 (19.1) | 594891 (10.7) |
| 33–37 | 2198 (15.8) | 205 (14.9) | 3509 (15.0) | 481529 (8.6) |
| 38–42 | 1603 (11.5) | 164 (11.9) | 2557 (10.9) | 429856 (7.7) |
| 43–47 | 922 (6.6) | 101 (7.3) | 1503 (6.4) | 384029 (6.9) |
| 48–52 | 847 (6.1) | 79 (5.7) | 1325 (5.7) | 408489 (7.3) |
| 53–57 | 845 (6.1) | 56 (4.1) | 1284 (5.5) | 405541 (7.3) |
| ≥58 | 2315 (16.7) | 89 (6.5) | 2409 (10.3) | 1753410 (31.4) |
| **Median Household Income, *n* (%)** | | | | |
| First Quartile | 6827 (49.3) | 655 (48.0) | 10731 (45.9) | 2379369 (42.8) |
| Second Quartile | 3806 (27.5) | 426 (31.2) | 7037 (30.1) | 1649822 (29.7) |
| Third Quartile | 2271 (16.4) | 200 (14.6) | 4056 (17.4) | 1049831 (18.9) |
| Fourth Quartile | 951 (6.9) | 85 (6.2) | 1549 (6.6) | 475033 (8.6) |
| *Missing* | *53* | *13* | *89* | *23858* |
| **Race/Ethnicity, *n* (%)** | | | | |
| Hispanic | 307 (2.4) | 39 (3.0) | 691 (3.1) | 167113 (3.1) |
| Non-Hispanic Black | 2629 (20.1) | 309 (25.5) | 4799 (21.4) | 1420955 (26.5) |
| Non-Hispanic White | 9887 (75.7) | 919 (70.0) | 16394 (73.1) | 3611235 (67.4) |
| Other[c] | 246 (1.9) | 46 (3.5) | 545 (2.4) | 156757 (2.9) |
| *Missing* | *839* | *66* | *1033* | *221853* |
| **Sex, *n* (%)** | | | | |
| Female | 4599 (33.1) | 479 (34.7) | 9400 (40.1) | 3222856 (57.8) |
| Male | 9308 (66.9) | 900 (65.3) | 14061 (59.9) | 2354891 (42.2) |
| *Missing* | *Suppressed* | *Suppressed* | *Suppressed* | *166* |
| **Primary Payment Type, n (%)** | | | | |
| Medicare | 2054 (14.8) | 136 (9.9) | 3203 (13.7) | 1599251 (28.7) |
| Medicaid | 8189 (58.9) | 737 (53.5) | 13138 (56.1) | 1777907 (31.9) |
| Private Insurance | 1891 (13.6) | 297 (21.6) | 4502 (19.2) | 1699409 (30.5) |
| Self-Pay, Other | 1770 (12.7) | 207 (15.0) | 2597 (11.1) | 495399 (8.9) |
| *Missing* | *Suppressed* | *Suppressed* | *22* | *5947* |
| **County Urbanization Level, n (%)** | | | | |
| Metropolitan, Large | 7479 (53.8) | 567 (41.1) | 9449 (40.3) | 2425758 (43.5) |
| Metropolitan, Medium | 3131 (22.5) | 401 (29.1) | 6653 (28.4) | 1322650 (23.7) |
| Metropolitan, Small | 1963 (14.1) | 183 (13.3) | 3431 (14.6) | 716051 (12.8) |
| Urban, Large | 522 (3.8) | 87 (6.3) | 1646 (7.0) | 386550 (6.9) |
| Small Urban and Rural | 813 (5.9) | 141 (10.2) | 2283 (9.7) | 726904 (13.0) |
| **Total, n** | 13908 | 1379 | 23462 | 5577913 |

*Note*: Counts and percentages were suppressed for cells with ≤10 counts per the data use agreement with HCUP.
[a] Includes opioid, cannabis, sedative, hypnotic, anxiolytic, cocaine, other stimulant, hallucinogen, inhalant, and other psychoactive substance related use disorders.
[b] Includes any other primary diagnosis besides non-fatal drug overdoses (T36-T50) and SUDs (F10-F19).
[c] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and other.

quartile 4 was 1.67 (95 % CI:1.55,1.80). Medicaid consistently had the strongest, statistically significant increased odds as compared to private insurance in all groups with non-fatal opioid overdoses having the strongest increased odds (OR:4.41, 95 % CI:4.18,4.65). County urbanization showed various patterns across outcomes. Non-fatal stimulant overdoses and SUD had the highest odds in medium metropolitan counties as compared to small urban/rural (OR:1.80, 95 % CI:1.46,2.21) and (OR:1.85, 95 % CI:1.76,1.95), respectively. In comparison, non-fatal opioid overdoses had the largest odds in large metropolitan counties (OR:4.32, 95 % CI:3.99,4.67).

Table 5 shows results for associations of interest by intentionality for opioid and stimulant overdoses. For non-fatal opioid overdoses, patterns were similar to overall findings (albeit some ORs were not statistically significant, potentially due to smaller sample sizes) for household income, race/ethnicity, sex, and payment type. One noted difference was for non-fatal opioid intentional overdose for those ages ≥58 years, which had a statistically significant decreased odds compared to ages 18–22 years (OR:0.60, 95 % CI:0.38,0.93). In addition, intentional non-fatal opioid overdoses had the weakest association with county urbanization level with only large metropolitan county of residence associated with elevated odds (OR:1.82, 95 % CI:1.32,2.49). Results for stimulant overdoses by intentionality were similar to overall results for age, household income, race/ethnicity, sex, and payment source. However, small sample sizes resulted in more non-significant findings. The exception was for assault/undetermined and intentional overdoses, which were different for household income, and results for intentional overdoses were different for payment source. In addition, assault/undetermined overdoses were not statistically significantly related to any county urbanization level and only medium metropolitan had statistically significant elevated odds among intentional non-fatal stimulant overdoses (OR:1.73, 95 % CI:1.04,2.88). Unintentional non-fatal stimulant overdoses had the strongest association with medium metropolitan counties (OR:1.85, 95 % CI:1.46,2.34).

Results for associations of interest for opioid and stimulant overdoses and SUD stratified by sex (male, female) are shown included in Tables 6 and 7. The direction of associations were generally similar by sex to overall findings, with main differences in the statistical significance of ORs. One key difference was that Medicare was not associated with stimulant overdoses among males (OR:1.17, 95 % CI:0.87,1.57) but was among females (OR:1.79, 95 % CI:1.22,2.62). In addition, lower household income was not associated with SUD among males, but was among females as shown in Table 7.

Sensitivity analysis results are presented in Tables S3 and S4 for non-fatal opioid and stimulant overdose and Tables S5 and S6 for SUD. The first sensitivity analysis, removing all additional cases with a secondary diagnosis of any non-fatal drug overdoses (T36-T50) and SUDs (F10-F19) among the reference group, had very slight differences in binary logistic regression results. The second sensitivity analysis included

**Table 2**
MI Adult 2019–2020 ED Discharge Characteristics by Primary Non-fatal Opioid or Stimulant Overdose Diagnosis Intentionality.

| | Non-Fatal Opioid Overdose (*n*=13,908) | | | Non-Fatal Stimulant Overdose (*n*=1,379) | | |
|---|---|---|---|---|---|---|
| **Variables** | **Unintentional** | **Intentional** | **Assault/Undetermined** | **Unintentional** | **Intentional** | **Assault/Undetermined** |
| **Age at Admission, Years, n (%)** | | | | | | |
| 18–22 | 582 (4.5) | 45 (8.9) | 23 (5.8) | 154 (13.6) | 40 (21.4) | Suppressed |
| 23–27 | 1704 (13.1) | 72 (14.3) | 60 (15.0) | 181 (16.0) | 32 (17.1) | Suppressed |
| 28–32 | 2531 (19.5) | 87 (17.3) | 74 (18.6) | 215 (19.0) | 33 (17.7) | 11 (18.3) |
| 33–37 | 2060 (15.8) | 76 (15.1) | 62 (15.5) | 171 (15.1) | 27 (14.4) | Suppressed |
| 38–42 | 1485 (11.4) | 71 (14.1) | 47 (11.8) | 135 (11.9) | 25 (13.4) | Suppressed |
| 43–47 | 867 (6.7) | 29 (5.8) | 26 (6.5) | 84 (7.4) | 14 (7.5) | Suppressed |
| 48–52 | 792 (6.1) | 30 (6.0) | 25 (6.3) | 62 (5.4) | Suppressed | Suppressed |
| 53–57 | 799 (6.1) | 25 (5.0) | 21 (5.3) | 51 (4.5) | Suppressed | Suppressed |
| ≥58 | 2185 (16.8) | 69 (13.7) | 61 (15.3) | 79 (7.0) | Suppressed | Suppressed |
| **Median Household Income, n (%)** | | | | | | |
| First Quartile | 6427 (49.6) | 210 (41.8) | 190 (47.9) | 556 (49.5) | 76 (41.5) | 23 (39.0) |
| Second Quartile | 3516 (27.1) | 170 (33.9) | 120 (30.2) | 344 (30.6) | 61 (33.3) | 21 (35.6) |
| Third Quartile | 2110 (16.3) | 97 (19.3) | 64 (16.1) | 155 (13.8) | 34 (18.6) | 11 (18.6) |
| Fourth Quartile | 903 (7.0) | 25 (5.0) | 23 (5.8) | 69 (6.1) | 12 (6.6) | Suppressed |
| **Race/Ethnicity, n (%)** | | | | | | |
| Hispanic | 269 (2.2) | 20 (4.2) | 18 (4.7) | 34 (3.2) | Suppressed | Suppressed |
| Non-Hispanic Black | 2487 (20.4) | 70 (14.6) | 72 (18.8) | 263 (24.5) | 35 (19.1) | 11 (19.0) |
| Non-Hispanic White | 9221 (75.6) | 381 (79.4) | 285 (74.2) | 736 (68.7) | 138 (75.4) | 45 (77.6) |
| Other[a] | 228 (1.9) | 20 (4.2) | 9 (2.3) | 39 (3.6) | Suppressed | Suppressed |
| **Sex, n (%)** | | | | | | |
| Female | 4232 (32.5) | 222 (44.1) | 145 (36.3) | 388 (34.3) | 75 (40.1) | 16 (26.7) |
| Male | 8772 (67.5) | 282 (56.0) | 254 (63.7) | 744 (65.7) | 112 (59.9) | 44 (73.3) |
| **Primary Payment Type, n (%)** | | | | | | |
| Medicare | 1940 (14.9) | 62 (12.3) | 52 (13.0) | 116 (10.3) | 12 (6.4) | Suppressed |
| Medicaid | 7642 (58.8) | 299 (59.3) | 248 (62.2) | 614 (54.3) | 93 (49.7) | 30 (50.0) |
| Private Insurance | 1751 (13.5) | 91 (18.1) | 49 (12.3) | 217 (19.2) | 63 (33.7) | 17 (28.3) |
| Self-Pay, Other | 1668 (12.8) | 52 (10.3) | 50 (12.5) | 183 (16.2) | 19 (10.2) | Suppressed |
| **County Urbanization Level, n (%)** | | | | | | |
| Metropolitan, Large | 7089 (54.5) | 229 (45.4) | 161 (40.4) | 492 (43.5) | 58 (31.0) | 17 (28.3) |
| Metropolitan, Medium | 2907 (22.4) | 118 (23.4) | 106 (26.6) | 310 (27.4) | 69 (36.9) | 22 (36.7) |
| Metropolitan, Small | 1833 (14.1) | 51 (10.1) | 79 (19.8) | 152 (13.4) | 25 (13.4) | Suppressed |
| Urban, Large | 458 (3.5) | 43 (8.5) | 21 (5.3) | 69 (6.1) | 12 (6.4) | Suppressed |
| Small Urban and Rural | 718 (5.5) | 63 (12.5) | 32 (8.0) | 109 (9.6) | 23 (12.3) | Suppressed |

*Note*: Counts and percentages were suppressed for cells with ≤10 counts per the data use agreement with HCUP. Missing data were excluded from the table. HCUP.

[a] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and others.

retaining the additional exclusion from the reference group noted above while also including any secondary diagnosis of non-fatal opioid overdoses, non-fatal stimulant overdoses, and SUD into the respective outcome groups. Overall findings were similar.

## 4. Discussion

In this large study using HCUP statewide ED data for MI, we identified key factors associated with SUD and overdose outcomes by drug type (opioids, stimulants) and intentionality. Regardless of statistical significance, all outcomes had the highest increased odds for ages 28–32 years (versus 18–22 years), increased odds as median household income decreased (compared to the highest median income category), elevated odds for male sex (versus female), elevated odds for Medicaid insurance (versus private), increased odds for metropolitan counties (versus small urban and rural), and decreased odds for all races/ethnicities compared to non-Hispanic White. Stratification by sex and by non-fatal opioid and stimulant overdose intents altered some associations but not the overall trends reported above for the primary findings. In general, non-fatal opioid overdoses, regardless of stratification, displayed the strongest increased or decreased associations with demographic/social characteristics, ranging as high as 4–5-fold increased odds for specific characteristics such as large metropolitan counties, male sex, and Medicaid insurance.

Previous nationally representative literature recorded slightly different results for age compared to our study, with ages 35–44 years followed by 45–54 recording the highest weighted percentages and rate of ED visits for drug-related poisonings (Xiang et al., 2012), and most recent SAMHSA estimates (SAMHSA, 2023) with the highest SUD prevalence among ages 18–25 years. Of note, Xiang et al. (2012) included all possible drug-related poisonings on a national level, not strictly non-fatal opioid and stimulant overdoses, and SAMHSA reported prevalence of SUDs, not ED encounters, which may account for the differences seen. In addition, the divergence from SAMHSA (2023) could potentially point to differences in seeking, accepting, or needing emergent help among the slightly older ages with SUD. Aligning with our results, urban or metropolitan counties have nationally been associated with higher non-fatal drug-related ED visits (Stokes et al., 2023; Xiang et al., 2012). Limited studies have quantified the association between SUD ED visits and county urbanization level. Our findings correlate with those of Grant et al., who noted higher lifetime Drug Use Disoder (DUD) prevalences and adjusted odds ratios (AORs) among urban compared to rural locations (Grant et al., 2016).

White race/ethnicity has a well-established association with increased non-fatal drug overdoses nationally, but race/ethnicity has a complicated association with drug use and overdose (Stokes et al., 2023). Jalalia et al. notes non-Hispanic White individuals are more likely to be prescribed opioids, providing an initial exposure route (Jalali et al., 2020). On the other hand, disparities in healthcare access/treatment have been noted for racial/ethnic minorities, which may result in undertreated and poorly managed pain, decreasing their exposure to prescription opioid initiation but also their ability to access SUD and drug use treatments (Jalali et al., 2020). The reduced odds of a non-fatal drug overdose ED visit in other racial/ethnic groups compared to non-Hispanic whites do not necessarily mean these groups experience fewer non-fatal drug overdoses but could be more indicative of

**Table 3**
Adjusted Odds Ratios[a] and 95 % Confidence Intervals for the Association of ED Visit Characteristics and Non-Fatal Opioid or Stimulant Overdose Primary Diagnosis, MI 2019–2020.

| Variables | Non-Fatal Opioid Overdose[b] | | Non-Fatal Stimulant Overdose[c] | |
|---|---|---|---|---|
| | Odds Ratio (95 % Confidence Interval) | P for Trend | Odds Ratio (95 % Confidence Interval) | P for Trend |
| **Age at Admission, Years** | | | | |
| 18-22 | 1.00 (Reference) | P<0.001 | 1.00 (Reference) | P<0.001 |
| 23-27 | 2.43 (2.22,2.67) | | 1.03 (0.84,1.25) | |
| 28-32 | 3.32 (3.04,3.62) | | 1.11 (0.91,1.34) | |
| 33-37 | 3.30 (3.01,3.61) | | 1.07 (0.88,1.31) | |
| 38-42 | 2.74 (2.49,3.01) | | 0.96 (0.78,1.19) | |
| 43-47 | 1.83 (1.65,2.03) | | 0.69 (0.54,0.88) | |
| 48-52 | 1.58 (1.42,1.75) | | 0.50 (0.38,0.66) | |
| 53-57 | 1.60 (1.44,1.78) | | 0.37 (0.27,0.50) | |
| ≥58 | 1.27 (1.15,1.40) | | 0.13 (0.10,0.18) | |
| **Median Household Income** | | | | |
| First Quartile | 1.67 (1.55,1.80) | P<0.001 | 1.36 (1.06,1.75) | P<0.001 |
| Second Quartile | 1.32 (1.23,1.43) | | 1.27 (0.99,1.64) | |
| Third Quartile | 1.13 (1.05,1.23) | | 0.95 (0.73,1.24) | |
| Fourth Quartile | 1.00 (Reference) | | 1.00 (Reference) | |
| **Race/Ethnicity** | | | | |
| Hispanic | 0.43 (0.38,0.48) | | 0.54 (0.39,0.75) | |
| Non-Hispanic Black | 0.32 (0.31,0.34) | | 0.53 (0.46,0.61) | |
| Non-Hispanic White | 1.00 (Reference) | | 1.00 (Reference) | |
| Other[d] | 0.37 (0.33,0.42) | | 0.89 (0.66,1.20) | |
| **Sex** | | | | |
| Female | 1.00 (Reference) | | 1.00 (Reference) | |
| Male | 2.97 (2.86,3.08) | | 2.85 (2.54,3.20) | |
| **Payment Type** | | | | |
| Private Insurance | 1.00 (Reference) | | 1.000 (Reference) | |
| Medicare | 1.59 (1.48,1.72) | | 1.35 (1.07,1.71) | |
| Medicaid | 4.41 (4.18,4.65) | | 2.25 (1.95,2.60) | |
| Self-Pay, Other | 2.73 (2.55,2.93) | | 1.82 (1.51,2.20) | |
| **County Urbanization Level** | | | | |
| Metropolitan, Large | 4.32 (3.99,4.67) | P<0.001 | 1.47 (1.20,1.80) | P<0.001 |
| Metropolitan, Medium | 3.00 (2.76,3.25) | | 1.80 (1.46,2.21) | |
| Metropolitan, Small | 3.02 (2.78,3.29) | | 1.39 (1.11,1.75) | |
| Urban, Large | 1.42 (1.27,1.59) | | 1.22 (0.92,1.61) | |
| Small Urban and Rural | 1.00 (Reference) | | 1.00 (Reference) | |

[a] Odds ratios are adjusted for other factors in the table when not the main factor of interest.
[b] Sample Size: *n*=5,340,451. Excludes *n*=251,370 cases missing data.
[c] Sample Size: *n*=5,328,738. Excludes *n*=250,554 cases missing data.
[d] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and others.

**Table 4**
Adjusted Odds Ratios[a] and 95 % Confidence Intervals for the Association of ED Visit Characteristics and Substance Use Disorder Primary Diagnosis, MI 2019–2020.

| Variables | Substance Use Disorder[b] | |
|---|---|---|
| | Odds Ratio (95 % Confidence Interval) | P for Trend |
| **Age at Admission, Years** | | |
| 18–22 | 1.00 (Reference) | P<0.001 |
| 23–27 | 1.31 (1.24,1.38) | |
| 28–32 | 1.43 (1.36,1.51) | |
| 33–37 | 1.36 (1.29,1.43) | |
| 38–42 | 1.11 (1.05,1.17) | |
| 43–47 | 0.76 (0.71,0.81) | |
| 48–52 | 0.63 (0.59,0.68) | |
| 53–57 | 0.61 (0.57,0.65) | |
| ≥58 | 0.27 (0.25,0.29) | |
| **Median Household Income** | | |
| First Quartile | 1.15 (1.08,1.22) | P<0.001 |
| Second Quartile | 1.05 (0.99,1.12) | |
| Third Quartile | 0.98 (0.92,1.04) | |
| Fourth Quartile | 1.00 (Reference) | |
| **Race/Ethnicity** | | |
| Hispanic | 0.60 (0.55,0.64) | |
| Non-Hispanic Black | 0.49 (0.47,0.50) | |
| Non-Hispanic White | 1.00 (Reference) | |
| Other[c] | 0.61 (0.56,0.66) | |
| **Sex** | | |
| Female | 1.00 (Reference) | |
| Male | 2.29 (2.23,2.35) | |
| **Payment Type** | | |
| Private Insurance | 1.00 (Reference) | |
| Medicare | 1.68 (1.59,1.78) | |
| Medicaid | 2.80 (2.70,2.91) | |
| Self-Pay, Other | 1.65 (1.57,1.74) | |
| **County Urbanization Level** | | |
| Metropolitan, Large | 1.52 (1.45,1.60) | P<0.001 |
| Metropolitan, Medium | 1.85 (1.76,1.95) | |
| Metropolitan, Small | 1.64 (1.55,1.73) | |
| Urban, Large | 1.42 (1.33,1.51) | |
| Small Urban and Rural | 1.00 (Reference) | |

[a] Odds ratios are adjusted for other factors in the table when not the main factor of interest.
[b] Sample Size: *n*=5,349,759. Excludes *n*=251,616 cases missing data. Includes opioid, cannabis, sedative, hypnotic, anxiolytic, cocaine, other stimulant, hallucinogen, inhalant, and other psychoactive substance related use disorders.
[c] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and others.

healthcare access and medical perceptions among these groups. Conversely, SUD has higher reported national prevalences (SAMHSA, 2023) and increased AORs for lifetime SUD with varying levels of statistical significance among racial/ethnic groups besides White (Grant et al., 2016).

Our findings with elevated odds in MI males compared to females for all outcome groups differ from some national literature but match other national reports. Two studies noted a higher prevalence and rate of females with drug-related US ED visits (Pickens et al., 2022; Xiang et al., 2012). However, these same two studies had a broader definition of drug-related visits and did not look at opioid and stimulant non-fatal overdoses exclusively (Pickens et al., 2022; Xiang et al., 2012). When looking at non-fatal opioid overdoses, one study noted males had higher rates of non-fatal opioid overdoses in 491 US counties from 2018 to 2022 when accounting for emergency medical services in addition to ED visits as increasing numbers of individuals are refusing transportation to and treatment by an ED (Casillas et al., 2022). The conflicting reported sex differences could correspond to help seeking or accepting behavioral differences or type of medical attention accepted between males and females but need further studies to corroborate. Again, few studies have looked at SUD ED visits; however, one study did record a higher lifetime prevalence of DUD among US males as compared to females, aligning with our study results (Grant et al., 2016).

Larger percentages of the population being uninsured or unable to afford insurance have been associated with lower US ED non-fatal drug overdose visits overall, not considering drug type and intentionality (Stokes et al., 2023). An inverse association between household income and overdose outcomes is supported by multiple older nationally representative studies (Grant et al., 2016; Xiang et al., 2012). Our findings indicate that any insurance type and self-pay (versus private insurance), especially Medicaid, had elevated odds for all outcomes. Again, limited studies have looked at SUD diagnosis ED visits and insurance status, but one study did report a high percentage of individuals with SUD having private insurance (58 %) followed by Medicaid (21 %), uninsured (14 %), or other insurance (7 %) (Saunders and Rudowitz, 2022), indicating a high percentage of individuals diagnosed with SUD had some type of insurance. Lower income, having to self-pay for

**Table 5**
Adjusted Odds Ratios[a] and 95 % Confidence Intervals for the Association of ED Visit Characteristics and Non-Fatal Opioid or Stimulant Overdose Primary Diagnosis by Intentionality, MI 2019–2020.

| | Odds Ratio (95 % Confidence Interval)[b] | | | | | |
|---|---|---|---|---|---|---|
| | Non-Fatal Opioid Overdose[c] | | | Non-Fatal Stimulant Overdose[d] | | |
| **Variables** | **Unintentional** | **Intentional** | **Assault or Undetermined** | **Unintentional** | **Intentional** | **Assault or Undetermined** |
| **Age at Admission, Years** | | | | | | |
| 18–22 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) |
| 23–27 | 2.52 | 1.40 | 2.22 | 1.11 | 0.76 | 1.03 |
| | (2.29, 2.78) | (0.95, 2.05) | (1.35, 3.63) | (0.88, 1.39) | (0.47, 1.21) | (0.40, 2.67) |
| 28–32 | 3.47 | 1.62 | 2.68 | 1.21 | 0.72 | 1.15 |
| | (3.17, 3.81) | (1.12, 2.34) | (1.66, 4.32) | (0.98, 1.51) | (0.45, 1.16) | (0.46, 2.88) |
| 33–37 | 3.45 | 1.68 | 2.71 | 1.18 | 0.74 | 0.83 |
| | (3.14, 3.79) | (1.15, 2.45) | (1.66, 4.41) | (0.94, 1.49) | (0.45, 1.21) | (0.30, 2.29) |
| 38–42 | 2.82 | 1.79 | 2.44 | 1.07 | 0.70 | 0.51 |
| | (2.56, 3.11) | (1.22, 2.63) | (1.47, 4.05) | (0.84, 1.36) | (0.42, 1.18) | (0.15, 1.71) |
| 43–47 | 1.92 | 0.90 | 1.44 | 0.77 | 0.46 | 0.44 |
| | (1.72, 2.14) | (0.56, 1.45) | (0.80, 2.59) | (0.58, 1.02) | (0.24, 0.86) | (0.12, 1.66) |
| 48–52 | 1.64 | 0.92 | 1.40 | 0.53 | 0.26 | 1.06 |
| | (1.46, 1.83) | (0.57, 1.47) | (0.78, 2.51) | (0.39, 0.72) | (0.12, 0.57) | (0.39, 2.88) |
| 53–57 | 1.68 | 0.78 | 1.25 | 0.45 | 0.03 | 0.50 |
| | (1.50, 1.88) | (0.48, 1.29) | (0.68, 2.30) | (0.32, 0.62) | (0.01, 0.24) | (0.15, 1.69) |
| ≥58 | 1.33 | 0.60 | 1.24 | 0.16 | 0.07 | 0.07 |
| | (1.20, 1.47) | (0.38, 0.93) | (0.72, 2.13) | (0.11, 0.22) | (0.03, 0.18) | (0.02, 0.32) |
| P for trend | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| **Median Household Income** | | | | | | |
| First Quartile | 1.67 | 1.80 | 1.55 | 1.44 | 1.11 | 0.81 |
| | (1.55, 1.80) | (1.15, 2.81) | (0.96, 2.49) | (1.09, 1.90) | (0.57, 2.13) | (0.25, 2.56) |
| Second Quartile | 1.31 | 1.92 | 1.28 | 1.30 | 1.18 | 1.01 |
| | (1.21, 1.41) | (1.23, 2.99) | (0.79, 2.07) | (0.98, 1.72) | (0.62, 2.27) | (0.33, 3.15) |
| Third Quartile | 1.12 | 1.67 | 1.14 | 0.94 | 0.98 | 0.82 |
| | (1.03, 1.21) | (1.06, 2.64) | (0.69, 1.88) | (0.70, 1.27) | (0.50, 1.92) | (0.25, 2.67) |
| Fourth Quartile | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) |
| P for trend | <0.001 | 0.045 | <0.001 | <0.001 | 0.788 | 0.739 |
| **Race/Ethnicity** | | | | | | |
| Hispanic | 0.40 | 0.79 | 0.86 | 0.58 | 0.39 | 0.34 |
| | (0.36, 0.46) | (0.50, 1.24) | (0.53, 1.39) | (0.40, 0.83) | (0.14, 1.06) | (0.05, 2.52) |
| Non-Hispanic Black | 0.32 | 0.28 | 0.35 | 0.54 | 0.49 | 0.52 |
| | (0.31, 0.34) | (0.21, 0.38) | (0.27, 0.47) | (0.46, 0.63) | (0.32, 0.75) | (0.24, 1.12) |
| Non-Hispanic White | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) |
| Other[e] | 0.37 | 0.39 | 0.55 | 0.92 | 0.84 | 0.48 |
| | (0.32, 0.42) | (0.20, 0.76) | (0.28, 1.07) | (0.66, 1.27) | (0.37, 1.92) | (0.07, 3.47) |
| **Sex** | | | | | | |
| Female | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) |
| Male | 3.03 | 1.94 | 2.66 | 2.88 | 2.38 | 4.40 |
| | (2.92, 3.15) | (1.62, 2.33) | (2.15, 3.29) | (2.53, 3.27) | (1.76, 3.22) | (2.43, 7.98) |
| **Payment Type** | | | | | | |
| Private Insurance | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) |
| Medicare | 1.62 | 1.11 | 1.52 | 1.53 | 0.59 | 1.73 |
| | (1.50, 1.75) | (0.75, 1.63) | (0.97, 2.40) | (1.18, 1.99) | (0.28, 1.26) | (0.67, 4.44) |
| Medicaid | 4.44 | 3.30 | 5.34 | 2.53 | 1.39 | 1.92 |
| | (4.20, 4.70) | (2.58, 4.23) | (3.86, 7.41) | (2.15, 2.98) | (0.99, 1.96) | (1.02, 3.62) |
| Self-Pay, Other | 2.78 | 1.66 | 3.08 | 2.20 | 0.82 | 0.68 |
| | (2.59, 2.98) | (1.16, 2.37) | (2.04, 4.65) | (1.79, 2.71) | (0.48, 1.40) | (0.23, 2.06) |
| **County Urbanization Level** | | | | | | |
| Metropolitan, Large | 4.59 | 1.82 | 2.69 | 1.68 | 0.89 | 0.61 |
| | (4.23, 4.99) | (1.32, 2.49) | (1.74, 4.15) | (1.33, 2.11) | (0.52, 1.52) | (0.25, 1.50) |
| Metropolitan, Medium | 3.14 | 1.40 | 2.71 | 1.85 | 1.73 | 1.26 |
| | (2.88, 3.42) | (1.00, 1.96) | (1.74, 4.22) | (1.46, 2.34) | (1.04, 2.88) | (0.54, 2.92) |
| Metropolitan, Small | 3.18 | 0.97 | 3.48 | 1.53 | 1.06 | 0.65 |
| | (2.90, 3.48) | (0.66, 1.34) | (2.22, 5.45) | (1.19, 1.98) | (0.59, 1.92) | (0.23, 1.85) |
| Urban, Large | 1.41 | 1.39 | 1.59 | 1.30 | 0.86 | 1.14 |
| | (1.25, 1.59) | (0.93, 2.10) | (0.88, 2.88) | (0.95, 1.78) | (0.41, 1.80) | (0.39, 3.29) |
| Small Urban and Rural | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) | (Reference) |
| | <0.001 | 0.037 | 0.003 | <0.001 | 0.620 | 0.199 |

[a] Odds ratios are adjusted for other factors in the table when not the main factor of interest.
[b] Reference group includes all other primary diagnoses excluding any substance use disorder (F10-F19) or any other non-fatal drug overdose (T36-T50).
[c] Sample Size: *n*=5,340,451. Excludes *n*=251,370 cases missing data.
[d] Sample Size: *n*=5,328,738. Excludes *n*=250,554 cases missing data.
[e] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and others.

**Table 6**
Adjusted Odds Ratios[a] and 95 % Confidence Intervals for the Association of ED Visit Characteristics and Non-Fatal Opioid or Stimulant Overdose Primary Diagnosis by Sex, MI 2019–2020.

| | Odds Ratio (95 % Confidence Interval) | | | |
|---|---|---|---|---|
| | Non-Fatal Opioid Overdose | | Non-Fatal Stimulant Overdose | |
| **Variables** | **Female (*n*=3,090,128)** | **Male (*n*=2,250,323)** | **Female (*n*=3,086,243)** | **Male (*n*=2,242,495)** |
| **Age at Admission, Years** | | | | |
| 18–22 | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| 23–27 | 2.02 (1.75,2.33) | 2.76 (2.44,3.11) | 0.96 (0.70,1.32) | 1.07 (0.83,1.38) |
| 28–32 | 2.53 (2.21,2.91) | 3.89 (3.47,4.37) | 1.15 (0.85,1.55) | 1.08 (0.84,0.39) |
| 33–37 | 2.84 (2.47,3.27) | 3.63 (3.22,4.08) | 0.95 (0.68,1.33) | 1.14 (0.88,1.47) |
| 38–42 | 2.29 (1.97,2.66) | 3.04 (2.69,3.43) | 0.70 (0.48,1.03) | 1.10 (0.84,1.43) |
| 43–47 | 1.97 (1.68,2.32) | 1.79 (1.57,2.05) | 0.63 (0.41,0.96) | 0.72 (0.53,0.97) |
| 48–52 | 1.73 (1.47,2.05) | 1.54 (1.34,1.77) | 0.57 (0.37,0.89) | 0.47 (0.33,0.66) |
| 53–57 | 2.03 (1.72,2.40) | 1.47 (1.28,1.68) | 0.43 (0.26,0.71) | 0.34 (0.23,0.49) |
| ≥58 | 1.08 (0.92,1.27) | 1.41 (1.24,1.60) | 0.10 (0.06,0.17) | 0.15 (0.11,0.22) |
| **Median Household Income** | | | | |
| First Quartile | 2.04 (1.78,2.33) | 1.52 (1.39,1.66) | 1.33 (0.87,2.03) | 1.38 (1.01,1.88) |
| Second Quartile | 1.44 (1.26,1.65) | 1.27 (1.16,1.40) | 1.14 (0.75,1.75) | 1.35 (0.99,1.85) |
| Third Quartile | 1.21 (1.05,1.40) | 1.10 (1.00,1.21) | 0.96 (0.61,1.49) | 0.94 (0.68,1.31) |
| Fourth Quartile | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| **Race/Ethnicity** | | | | |
| Hispanic | 0.34 (0.27,0.41) | 0.49 (0.43,0.56) | 0.59 (0.35,1.00) | 0.51 (0.33,0.79) |
| Non-Hispanic Black | 0.25 (0.23,0.27) | 0.37 (0.35,0.39) | 0.42 (0.33,0.55) | 0.59 (0.50,0.71) |
| Non-Hispanic White | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Other[b] | 0.33 (0.26,0.41) | 0.40 (0.34,0.46) | 0.76 (0.44,1.30) | 0.96 (0.67,1.37) |
| **Payment Type** | | | | |
| Private Insurance | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |
| Medicare | 1.87 (1.63,2.13) | 1.48 (1.35,1.62) | 1.79 (1.22,2.62) | 1.17 (0.87,1.57) |
| Medicaid | 4.53 (4.12,4.98) | 4.38 (4.11,4.67) | 2.06 (1.62,2.61) | 2.36 (1.98,2.83) |
| Self-Pay, Other | 3.19 (2.80,3.64) | 2.56 (2.37,2.78) | 1.83 (1.27,2.62) | 1.83 (1.47,2.29) |
| **County Urbanization Level** | | | | |
| Metropolitan, Large | 4.15 (3.65,4.72) | 4.43 (4.02,4.89) | 1.24 (0.89,1.74) | 1.62 (1.25,2.10) |
| Metropolitan, Medium | 2.95 (2.58.3.37) | 3.03 (2.74,3.36) | 1.58 (1.13,2.20) | 1.94 (1.49,2.52) |
| Metropolitan, Small | 2.60 (2.25,3.00) | 3.27 (2.94,3.64) | 1.17 (0.80,1.70) | 1.54 (1.15,2.06) |
| Urban, Large | 1.43 (1.18,1.72) | 1.42 (1.23,1.64) | 1.22 (0.79,1.90) | 1.21 (0.85,1.73) |
| Small Urban and Rural | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) | 1.00 (Reference) |

[a] Odds ratios are adjusted for other factors in the table when not the main factor of interest.
[b] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and others.

services, or having insurances besides private that are typically associated with reduced earnings (Medicaid), can correlate with reduced ability to afford healthcare or substance use treatment options, resulting in needing emergent healthcare services like an ED for drug-related outcomes.

### 4.1. Strengths and limitations

Several strengths exist for this study. This study had a large sample size of over five million discharges to create exposure groups and was representative of all MI non-federal hospital associated EDs. ICD-10-CM codes for non-fatal opioid, stimulant, and any drug overdoses were based on standardized definitions, allowing for more direct comparison with other previous research. Sensitivity analyses were also performed with only slight differences from the original results, adding to the strength and quality of the study.

Limitations exist within this study. Diagnosis codes could be present from older visits and not pertain to the current visit, codes could be added for insurance or various other reasons not pertaining to the medical encounter, and diagnosis codes are not all inclusive and descriptive, with some not accurately representing the true visit reason or drug type involved. All of these could result in information bias. There is also the potential for provider bias, where each ED could have different reporting and diagnosing standards. To account for this, we looked at the primary diagnosis codes only, the most relevant code for the ED encounter, and conducted sensitivity analyses including secondary diagnoses, which showed minimal differences. However, it is worth noting this does not account for all possible polysubstance use and polysubstance non-fatal overdoses, which may bias some associations like sex differences. It is also worth noting that a previous study using latent class analysis to identify groups of patients based on drug types in ED data found that polysubstance use was more common among women (Liu and Vivolo-Kantor, 2020). Another limitation, as also noted by Pickens et al., is that EDs do not reliably conduct toxicology testing; therefore, diagnosis codes may be flawed in drug type identification or only record unspecified drug involvement (Pickens et al., 2022). This could result in potential underrepresentation or misidentified drug-specific encounters. Another limitation is that HCUP SEDD does not include non-fatal overdoses that did not result in ED visits, it only includes discharged ED encounters, and only MI data was utilized, which may affect generalizability. Further, individuals treated at Veterans Administration healthcare centers are not included in HCUP data. Therefore, this study may underrepresent non-fatal overdoses in some high-risk populations and settings. It is also worth noting that the onset of the COVID-19 pandemic occurred during the study years, which may have altered associations, and this study may not fully represent the most recent substance use trends, which continue to change over time.

## 5. Conclusions

We found that Medicaid insurance (vs. private), male sex (vs. female), low household income (vs. high), and metropolitan counties (vs. rural/small urban) had increased odds and Hispanic, non-Hispanic Black, and all other races/ethnicities (vs. non-Hispanic White) had reduced odds for all study outcomes. The exception was for SUD, where only the lowest household income category was associated with increased odds of SUD. In addition, analyses by sex and non-fatal overdose intentionality revealed more specific demographic/social characteristic variation for at-risk population identification. However, results for non-fatal opioid and stimulant overdoses by intentionality

**Table 7**
Adjusted Odds Ratios[a] and 95 % Confidence Intervals for the Association of ED Visit Characteristics and Substance Use Disorder Primary Diagnosis by Sex, MI 2019–2020.

| | Odds Ratio (95 % Confidence Interval) | |
|---|---|---|
| **Variables** | **Female (*n*=3,094,770)** | **Male (*n*=2,254,989)** |
| **Age at Admission, Years** | | |
| 18–22 | 1.00 (Reference) | 1.00 (Reference) |
| 23–27 | 1.18 (1.09,1.28) | 1.40 (1.31,1.50) |
| 28–32 | 1.35 (1.25,1.45) | 1.48 (1.39,1.58) |
| 33–37 | 1.34 (1.24,1.46) | 1.35 (1.26,1.44) |
| 38–42 | 1.21 (1.11,1.32) | 1.03 (0.95,1.11) |
| 43–47 | 0.94 (0.85,1.04) | 0.64 (0.58,0.70) |
| 48–52 | 0.77 (0.69,0.85) | 0.55 (0.50,0.60) |
| 53–57 | 0.74 (0.66,0.83) | 0.53 (0.48,0.58) |
| ≥58 | 0.28 (0.26,0.32) | 0.25 (0.23,0.28) |
| **Median Household Income** | | |
| First Quartile | 1.29 (1.17,1.42) | 1.07 (0.99,1.15) |
| Second Quartile | 1.14 (1.03,1.25) | 1.01 (0.94,1.09) |
| Third Quartile | 1.09 (0.99,1.20) | 0.92 (0.85,1.00) |
| Fourth Quartile | 1.00 (Reference) | 1.00 (Reference) |
| **Race/Ethnicity** | | |
| Hispanic | 0.49 (0.43,0.56) | 0.68 (0.61,0.74) |
| Non-Hispanic Black | 0.42 (0.40,0.45) | 0.53 (0.51,0.56) |
| Non-Hispanic White | 1.00 (Reference) | 1.00 (Reference) |
| Other[b] | 0.62 (0.54,0.71) | 0.60 (0.53,0.67) |
| **Payment Type** | | |
| Private Insurance | 1.00 (Reference) | 1.00 (Reference) |
| Medicare | 2.00 (1.84,2.17) | 1.47 (1.37,1.58) |
| Medicaid | 2.61 (2.46,2.76) | 2.97 (2.84,3.11) |
| Self-Pay, Other | 1.89 (1.73,2.07) | 1.55 (1.46,1.65) |
| **County Urbanization Level** | | |
| Metropolitan, Large | 1.37 (1.27,1.48) | 1.65 (1.54,1.77) |
| Metropolitan, Medium | 1.63 (1.51,1.76) | 2.03 (1.89,2.16) |
| Metropolitan, Small | 1.45 (1.33,1.58) | 1.79 (1.66,1.92) |
| Urban, Large | 1.41 (1.28,1.56) | 1.41 (1.29,1.55) |
| Small Urban and Rural | 1.00 (Reference) | 1.00 (Reference) |

[a] Odds ratios are adjusted for other factors in the table when not the main factor of interest.
[b] Includes Non-Hispanic Asian and Pacific Islander, Non-Hispanic Native American, and others.

had varied statistical significance and patterns, most likely due to small sample sizes, and future research with large sample sizes are warranted.

ED visits for drug-related concerns represent a time to connect with individuals about available resources for substance use. The ability to identify at-risk groups by outcome and specific key factors may help to inform and direct limited resources more effectively and efficiently. Some potential ED initiated interventions previously studied and reported include buprenorphine medication for opioids with continuation in the primary care setting (D'Onofrio et al., 2017), opioid and naloxone education/kits (Dwyer et al., 2015), peer recovery specialists and training programs (Waye et al., 2019), and screening, brief intervention, and referral programs (Bernstein et al., 1997; Pringle et al., 2018; D'Onofrio & Degutis, 2010). Public health and related stakeholders' intervention efforts would benefit from more targeted research and the ability to quickly identify at-risk groups during key intervention points to reverse the increasing negative drug-related health outcomes.

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## CRediT authorship contribution statement

**Olivia Martin:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Harriet Bird:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Sarah Nechuta:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

## Declaration of Competing Interest

None.

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### *Contributors*

All authors contributed to the design of the study, development of the research question, and/or analysis design for this secondary data analysis. Sarah Nechuta acquired the data for the study and the IRB approval. The analysis was conducted by Olivia Martin and replicated by Sarah Nechuta. Olivia Martin wrote the first draft of the manuscript. All authors contributed to manuscript writing. All authors read and approved the final manuscript for publication.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.dadr.2024.100290.

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