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Association of polysubstance use disorder with treatment quality among Medicaid beneficiaries with opioid use disorder

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ABSTRACT

Introduction: The opioid crisis is transitioning to a polydrug crisis, and individuals with co-occurring substance use disorder (SUDs) often have unique clinical characteristics and contextual barriers that influence treatment needs, engagement in treatment, complexity of treatment planning, and treatment retention.
Methods: Using Medicaid data for 2017–2018 from four states participating in a distributed research network, this retrospective cohort study documents the prevalence of specific types of co-occurring SUD among Medicaid enrollees with an opioid use disorder (OUD) diagnosis, and assesses the extent to which different SUD presentations are associated with differential patterns of MOUD and psychosocial treatments.
Results: We find that more than half of enrollees with OUD had a co-occurring SUD, and the most prevalent co-occurring SUD was for "other psychoactive substances", indicated among about one-quarter of enrollees with OUD in each state. We also find some substantial gaps in MOUD treatment receipt and engagement for individuals with OUD and a co-occurring SUD, a group representing more than half of individuals with OUD. In most states, enrollees with OUD and alcohol, cannabis, or amphetamine use disorder are significantly less likely to receive MOUD compared to enrollees with OUD only. In contrast, enrollees with OUD and other psychoactive SUD were significantly more likely to receive MOUD treatment. Conditional on MOUD receipt, enrollees with co-occurring SUDs had 10 % to 50 % lower odds of having a 180-day period of continuous MOUD treatment, an important predictor of better patient outcomes. Associations with concurrent receipt of MOUD and behavioral counseling were mixed across states and varied depending on co-occurring SUD type.
Conclusions: Overall, ongoing progress toward increasing access to and quality of evidence-based treatment for OUD requires further efforts to ensure that individuals with co-occurring SUDs are engaged and retained in effective treatment. As the opioid crisis evolves, continued changes in drug use patterns and populations experiencing harms may necessitate new policy approaches that more fully address the complex needs of a growing population of individuals with OUD and other types of SUD.

1. Introduction

The opioid crisis, widely recognized as the deadliest drug crisis in history, has gone through several evolutions in terms of the underlying causes of drug overdose mortality. Beginning in the 1990s, prescription opioid analgesics fueled the first wave of the crisis. In 2010, overdose

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deaths increasingly involved illicit opioids, namely heroin; 2013 saw the emergence of highly potent synthetic opioids, primarily fentanyl and fentanyl analogues. More recently, data suggest that the opioid crisis is transitioning to a polydrug use crisis. During 2017 to 2018, 34 % and 12 % of opioid-related deaths involved co-occurrence of cocaine and methamphetamine, respectively (Gladden et al., 2019). Studies have documented similar patterns and rising harms of polysubstance use among nonfatal overdoses treated in emergency departments (Liu et al., 2020; Liu & Vivolo-Kantor, 2020) and among admissions to substance use disorder (SUD) treatment (Jones et al., 2020). A recent survey of adults with opioid use disorder (OUD) found that >90 % reported use of two or more substances, in addition to opioids, in the past year; more than half had a co-occurring SUD (Hassan & Le Foll, 2019).

Rising rates of polydrug use and use disorders have several implications for public health and policy. While significant efforts have tried to expand access to naloxone (Smart et al., 2020), an opioid antagonist capable of reversing the life-threatening effects of opioid overdose, overdoses involving multiple substances are less responsive to naloxone administration (Compton et al., 2020). Similarly, while substantial resources and policy changes have aimed to increase access to medications for opioid use disorder (MOUD) (Barnett et al., 2019; Haffajee et al., 2018; Saloner et al., 2020), currently no FDA-approved medications exist for treatment of stimulant use disorders; thus, individuals with OUD and certain types of co-occurring use disorders may require additional treatment services (McCabe & West, 2017). Finally, individuals with co-occurring SUDs may have a unique set of clinical characteristics or comorbidities that influence engagement in treatment (John et al., 2001), complexity of treatment planning (Krawczyk et al., 2017), as well as treatment retention (Samples et al., 2018).

State Medicaid programs, which are key funders of treatment for OUD, face growing concerns about polysubstance use and co-occurring disorders, in general, and among enrollees with OUD in particular (MACPAC, 2017). While Medicaid covers the plurality of nonelderly adults with OUD (Orgera & Tolbert, 2019), the field knows relatively little about the prevalence of polysubstance use disorder in Medicaid or about how the presence of co-occurring SUDs may complicate treatment of OUD. One recent study (O'Brien et al., 2020) using MarketScan data on Medicaid enrollees aged 18–64 with a primary diagnosis of OUD in 2016 found that half of adult enrollees had an additional SUD diagnosis (most commonly an unidentified other SUD); compared to individuals with OUD-only, those with a co-occurring SUD had significantly lower odds of receiving MOUD. However, since 2016, substantial gains have been made in the prevalence and use of MOUD among Medicaid enrollees (The Medicaid Outcomes Distributed Research Network, 2021), combined with federal and state efforts to promote longer treatment duration to improve patient outcomes (Samples et al., 2020). We know little about whether these encouraging developments have improved treatment utilization and treatment quality among individuals with various OUD-SUD combinations, a population at increased risk for several adverse events and that often requires more complex treatment approaches (O'Brien et al., 2021).

Using Medicaid data for 2017–2018 from four states participating in a distributed research network, this study aims to document the prevalence of specific types of co-occurring SUD among Medicaid enrollees with an OUD diagnosis, describe differences in the demographic and clinical characteristics of these individuals, and assess the extent to which different SUD presentations are associated with differential patterns of MOUD and psychosocial treatments. We build on prior research (O'Brien et al., 2020) through the use of more recent data through 2018, inclusion of adolescents in the study sample, examination of a richer set of individual characteristics (e.g., distinguishing Medicaid expansion from other non-disabled adults, measuring comorbidities that represent medical consequences of injection drug), and evaluation of differential patterns of MOUD (e.g., duration) to better understand how polysubstance use disorders relate to treatment receipt as well as treatment quality. We also evaluate whether variation exists across states in the prevalence and characteristics of co-occurring SUD involvement.

2. Methods

2.1. Study design and setting

This study uses data compiled through the Medicaid Outcomes Distributed Research Network (MODRN). MODRN enables efficient, standardized analyses of multiple states' Medicaid data while ensuring the security of health information. A distributed research network composes multiple organizations using a common data model to support centralized development, but local execution, of analytic programs. Under MODRN, each participating university obtained complete Medicaid data on a census of Medicaid beneficiaries enrolled in their state's Medicaid program at some point during the study period. Each university converted their state's Medicaid data to a MODRN Common Data Model, contributed to a common analytic plan, and conducted analyses locally on their own Medicaid data using standardized code developed by the data coordinating center. Finally, the state-university partners provided aggregate results, not data, to the data coordinating center, which combined the aggregate findings from multiple states for reporting and conducted statistical analyses. Each university participating in this project obtained an exempt determination from their institutional review board.

2.2. Data source and study population

Our study includes Medicaid enrollment, claims, and encounter data from four states (Maryland, Ohio, Pennsylvania, and West Virginia) for the period July 1, 2017 to December 31, 2018. We included all full-benefit, non-dually eligible Medicaid enrollees who were 12–64 years of age for the duration of the measurement period. For two outcomes of interest (continuity of MOUD and receipt of behavioral health counseling with MOUD), we further restrict the sample to individuals continuously enrolled in Medicaid between 30 days prior to an MOUD encounter and 180 days after the MOUD claim.

2.3. Measures

2.3.1. Opioid use disorder

OUD was indicated if enrollees had at least one encounter with any diagnosis (all diagnosis fields) of ICD-10 code F11 in inpatient, outpatient, or professional claims between July 1, 2017, and June 30, 2018 (Index Period). Following prior work (Finlay et al., 2016), we excluded individuals with only ICD-10 F11 codes related to OUD in remission.

2.3.2. Co-occurring substance use disorder

For individuals identified as having an OUD during the study timeframe, we used analogous methods to determine whether they had a co-occurring SUD based on ICD-10 codes. We classified co-occurring SUDs for alcohol (F10), cannabis (F12), cocaine (F14), amphetamine-type stimulants (F15), other psychoactive substances (F19), and an "other" category that included other types of SUD that were relatively infrequent in the data (e.g., sedative/hypnotic/anxiolytic related disorders, hallucinogen-related disorders, any pregnancy related SUD, inhalant-related disorders; see Appendix Table A.1). Unlike the "other" category, other psychoactive substance (F19) is used when the substance is unknown/uncertain, or it is not clear which substance is contributing most to the SUD. As with OUD, we did not count individuals with ICD-10 F codes related to SUD in remission. Individuals without an indicator for one of these other SUDs are classified as OUD-only.

2.3.3. Demographics

To assess whether individuals with co-occurring SUDs differed from those with OUD-only on demographics, we used information based on annual enrollment data from the year of the first OUD diagnosis. This

information includes age (categorical), sex, race and ethnicity, urban/rural residence, and Medicaid eligibility category. We created five standardized, mutually exclusive eligibility groups using information from enrollment files and claims and described in detail elsewhere (The Medicaid Outcomes Distributed Research Network, 2021): 1) pregnant women, 2) youth, 3) adults with disability-related Medicaid eligibility, 4) adults newly eligible under the Affordable Care Act Medicaid expansion (hereafter, expansion), and 5) traditionally eligible nondisabled adults.

2.3.4. Comorbidities

Information on psychological or physical health comorbidities came from claims records during the index period. In line with prior work (O'Brien et al., 2020; Ronan & Herzig, 2016; Serota et al., 2021), these comorbidities included codes related to mental health disorders (anxiety disorders, mood disorders, schizophrenic and other psychotic disorders, post-traumatic stress disorder [PTSD]); infectious disease related to injection drug use or sexual transmission (human immunodeficiency virus [HIV], hepatitis C virus [HCV], hepatitis B virus [HBV]); and other injection-related physiological comorbidities (i.e., intracranial and intraspinal abscess, soft skin tissue infections, osteomyelitis, endocarditis). Appendix Table A.1 lists the codes used to identify comorbidities.

2.3.5. Treatment outcomes

We considered three outcomes related to receipt of treatment. Receipt of any MOUD was indicated if an individual had at least one claim with a National Drug Code (NDC) for buprenorphine or naltrexone within one year after the first diagnosis of OUD or by the end of the measurement period (whichever comes first), or if an individual had a Healthcare Common Procedure Coding System (HCPCS) code for buprenorphine, methadone administration, or extended-release injectable naltrexone. This study does not include claims for oral medications with negative, missing, or zero days' supply.

In addition to receipt of MOUD, we evaluated continuity of pharmacotherapy using National Quality Forum specifications. This measure is an indicator for whether an individual has at least one 180-day period of continuous MOUD treatment (i.e., no more than a 7-day gap) during the two-year analytic period (National Quality Forum, 2021). The MOUD period is determined based on prescription fill dates and days' supply from pharmacy claims, as well as the beginning and end dates of service for office- or facility-based administration of buprenorphine or facility-based dispensing of methadone. For injectable naltrexone, treatment days are assigned assuming a standard 28-day days' supply.

Finally, we obtained information on receipt of behavioral health counseling with pharmacotherapy for OUD based on the existence of behavioral health counseling claims within inpatient, outpatient, and professional claim files. For the counseling and MOUD continuity outcomes, the sample is conditioned on receipt of MOUD. The Appendix provides details on the Current Procedural Terminology (CPT)/HCPCS codes used to identify behavioral health counseling claims, as well as further detail on the construction of each of the treatment indicators.

2.4. Data analysis

We first present descriptive information on the prevalence of different SUDs within the study population, as well as the prevalence of OUD-only and OUD plus specific types of co-occurring SUDs. This article shows descriptive statistics for the pooled population, as well as for each of the four states; we have masked identifying information on state per the terms of our agreements with states. We also describe the characteristics of individuals with OUD-only versus polysubstance use disorders, assessing significance of differences across populations with chi-square tests.

The study evaluated associations between treatment outcomes and co-occurring SUD with OUD using logistic regressions. For each of the three treatment outcomes, the study estimated unadjusted and adjusted odds ratios. The unadjusted models only included the six co-occurring SUD indicators, with OUD-only group as the reference group. The adjusted models controlled for enrollee's characteristics, including demographics and comorbidities during the index period.

Because MODRN prohibits individual-level data sharing across states, regression analyses proceeded in two stages. In stage 1, each state estimated a logistic regression model to evaluate odds of a given treatment outcome based on observed characteristics of the enrollees. In stage 2, random effects meta-analysis generated pooled estimates of associations, with each state's estimates weighted by the inverse of their variances to account for differences in state populations. These analyses used the Hartung-Knapp-Sidik-Jonkman method (Knapp & Hartung, 2003) to estimate between-state variances due to potential heterogeneity across states and to construct valid confidence intervals and 90 % prediction intervals. Cochran's Q test assessed heterogeneity across states with a null hypothesis that coefficients across state are homogeneous (i.e., equal), and the I^2 statistic described the percentage of total variation due to state-to-state variability. Prediction intervals accounted for two sources of randomness, including the state-to-state variability quantified by a robust variance estimation approach (Sidik & Jonkman, 2006) and within-state variability around the target estimates. A prediction interval carries the extra uncertainty in the interested quantity for a single new state population. For this reason, while centered around the same global estimate, prediction intervals are generally wider than confidence intervals and their lengths do not tend to decrease even with more states included in the study. Prediction intervals thus help to assess error when generalizing findings to a new state population, whereas confidence intervals describe the uncertainty in the combined population of interest and we use them to draw study conclusions.

3. Results

Our study population consisted of 5,982,625 full-benefit Medicaid enrollees from the four study states, 5.1 % of whom (n = 305,263) had an indicator for OUD during the index period. Among enrollees with OUD, more than half (52.7 %) had a co-occurring other SUD in 2018, with the percentage varying from 45.2 % to 61.0 % by state. As Fig. 1 shows, the specific type of co-occurring SUDs varied across states, although some similarities occurred. In all four states, the most prevalent co-occurring SUD was for "other psychoactive substances," indicated among about one-quarter of enrollees with OUD in each state and among 45 % to 54 % of all enrollees with OUD and a co-occurring disorder. In three states (States A, B, and C), alcohol, cocaine, and cannabis were the next most common co-occurring SUDs; whereas State D differed in that amphetamine-type SUDs were the second most prevalent co-occurring SUD among enrollees with OUD, with far lower prevalence of co-occurring cocaine use disorder compared to the other states (7 % in State D versus >16 % in all other states).

Table 1 describes the characteristics of our study sample, comparing those with OUD-only to those with OUD and another co-occurring SUD. Relative to enrollees with OUD alone, enrollees with OUD and co-occurring SUD were more likely to be male and eligible for Medicaid through the expansion. Differences in other characteristics between those with OUD alone and those with a co-occurring SUD varied by co-occurring SUD type. Youth and young adults aged 12 to 34 had higher prevalence of OUD and cannabis disorder or OUD and stimulant use disorders (i.e., amphetamine-type or cocaine), whereas adults aged 35 to 64 had higher prevalence of OUD alone or OUD and alcohol use disorder. While generally, enrollees with OUD and a co-occurring SUD were more likely to be of minority race and ethnicity compared to those with OUD only, this was not the case for co-occurring amphetamine-type use disorders, 85 % of which were among non-Hispanic Whites. Similarly, enrollees with OUD and amphetamine-type use disorders had a higher proportion residing in rural areas (29 %) compared to those with other types of co-occurring SUDs (13 %–21 %) or those with OUD only (18 %).

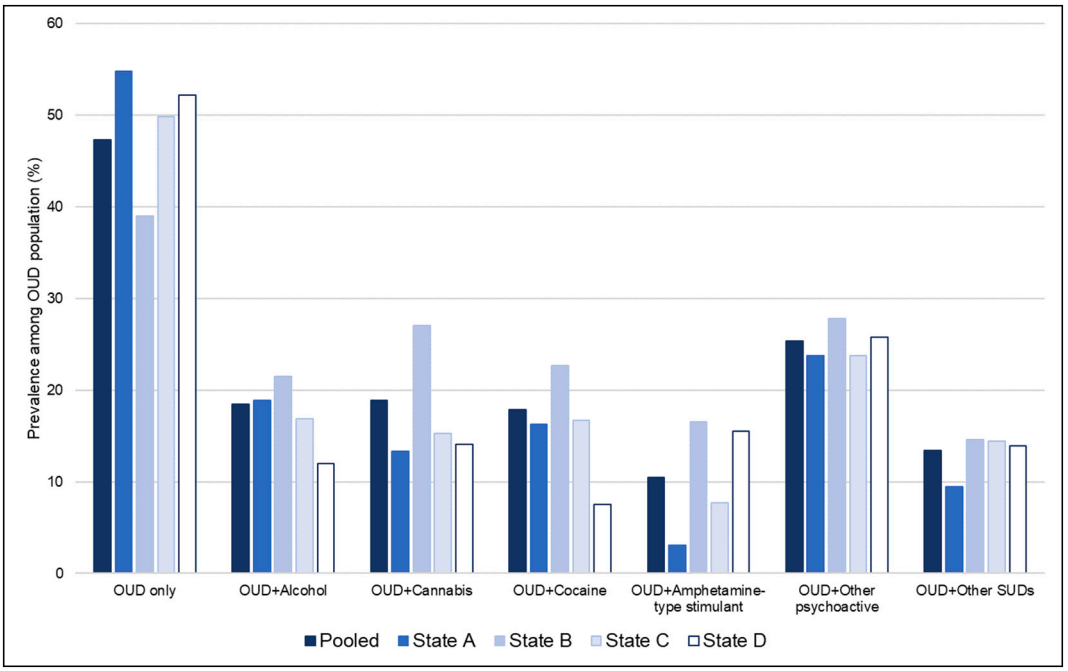

Fig. 1. Prevalence of co-occurring substance use disorder among OUD population, by type.
Notes: OUD = opioid use disorder. SUD = substance use disorder.

Table 1
Characteristics of individuals with OUD only and those with co-occurring substance use disorders.

	OUD only	OUD + other SUD					
		Alcohol	Cannabis	Cocaine	Amphetamine	Other psychoactive	Other
Overall N	144,342	56,395	57,591	54,625	32,062	77,535	40,861
Age %							
12–20	1.2	2.5	5.5	2.0	3.4	2.2	3.5
21–34	42.2	41.7	55.3	47.1	58.7	48.9	60.2
35–44	27.9	25.6	23.2	25.8	25.8	25.7	22.1
45–54	18.6	20.1	11.8	17.8	9.4	15.9	10.3
55–64	10.1	10.0	4.3	7.3	2.7	7.3	4.0
Sex %							
Female	50.5	37.6	41.6	45.0	46.2	46.4	60.3
Male	49.5	62.4	58.4	55.0	53.8	53.6	39.7
Race/Ethnicity %							
Non-Hispanic White	77.5	69.4	70.8	67.6	84.7	73.0	77.4
Non-Hispanic Black	13.6	21.3	19.7	22.6	7.2	17.2	14.0
Hispanic	3.1	2.8	3.3	3.9	1.7	3.8	3.0
Other	5.8	6.5	6.2	5.9	6.4	6.0	5.6
Eligibility %							
Pregnant women	2.9	3.7	7.3	6.0	6.8	7.7	25.2
Children	1.0	2.4	5.0	1.8	3.3	2.0	2.5
Disabled adults	17.1	17.2	13.7	16.5	10.3	16.7	11.6
Non-disabled adults	23.1	13.9	16.6	14.4	17.3	15.2	13.8
Expansion adults	55.9	62.8	57.4	61.3	62.2	58.5	46.8
Living area %							
Urban	82.0	84.0	79.5	86.4	70.7	81.8	82.4
Rural	18.0	16.0	20.5	13.6	29.3	18.2	17.6
Other comorbidities %							
Anxiety disorder	33.8	56.4	55.7	55.9	60.2	57.1	60.3
Mood disorder	35.6	65.0	61.8	65.5	64.5	62.9	63.9
Schizophrenia & other psychotic disorder	3.1	15.8	15.5	16.3	17.6	15.2	13.5
Post-traumatic stress disorder (PTSD)	5.8	17.0	18.1	18.4	19.5	15.5	17.4
Hepatitis C (HCV)	11.2	24.1	22.9	31.4	31.5	33.1	29.0
Human immunodeficiency virus (HIV)	1.0	2.5	1.9	3.4	1.8	3.2	1.9
Hepatitis B (HBV)	0.6	1.9	1.9	2.4	2.7	3.0	1.9
Soft skin tissue infections	12.2	19.2	19.8	25.4	25.8	27.9	20.6
Other injection-related complications[a]	0.8	2.3	2.5	4.0	3.7	5.5	2.5

Notes: OUD = opioid use disorder. SUD = substance use disorder. Co-occurring SUDs are not mutually exclusive (i.e., an individual with OUD can have more than one co-occurring SUD).

[a] Other injection-related complications include intracranial and intraspinal abscess, osteomyelitis, and endocarditis.

The prevalence of comorbidities was substantially higher among enrollees with OUD and a co-occurring SUD. Anxiety disorders and mood disorders were nearly twice as prevalent among those with a co-occurring SUD (e.g., 55–65 % versus 34–36 %), while schizophrenia or other psychotic disorders and PTSD were indicated at rates more than fivefold or threefold, respectively, among those with OUD and a co-occurring SUD compared to among enrollees with OUD alone (e.g., 15–20 % versus 3–6 %). Infectious diseases common in individuals with OUD (HCV, HBV, and HIV), as well as complications of injection drug use, were also more prevalent among those with co-occurring disorders compared to those with OUD alone in all four states. Indicators of injection-related complications were particularly prevalent among those with OUD and a co-occurring stimulant use disorder, who were more than twice as likely to have soft skin tissue infections and five times as likely to have other injection-related comorbidities (e.g., osteomyelitis, endocarditis, and soft skin tissue infections) compared to those with OUD alone. These patterns were consistent across the four study sample states.

Tables 2–4 present meta-analytic results for the associations of co-occurring SUD diagnoses with OUD treatment outcomes, adjusted for enrollee characteristics (see Appendix Table A.2 for unadjusted estimates). For receipt of MOUD (Table 2), the study found a high degree of heterogeneity across states in the extent to which enrollee SUD and other characteristics relate to the likelihood of receiving MOUD. Except for eligibility based on youth age (Cochran's Q test p = 0.25, $I^2 = 40.3$), Cochran Q tests were significant for all model coefficients, and I^2 ranged from 65.4 to 99.8, reflecting significant heterogeneity in estimated associations across states. Examining specific types of co-occurring SUD among the Medicaid population with OUD, enrollees with alcohol use disorder and cannabis use disorder had significantly lower odds of MOUD receipt (for alcohol, odds ratio [OR]: 0.70 and 95 % Confidence Interval [CI]: 0.49–1.02; for cannabis, OR: 0.65 and 95 % CI: 0.47–0.88); while enrollees with co-occurring other psychoactive SUD had significantly higher odds of receiving MOUD (OR: 1.35; 95 % CI: 1.22–1.50). Enrollees with OUD and cocaine use disorder had similar likelihood of receiving MOUD compared to enrollees with OUD alone (OR: 0.99; 95 % CI: 0.86–1.14), whereas associations of OUD and amphetamine-type use disorder were more highly varied.

Several other enrollee characteristics were consistently associated with the likelihood of receiving MOUD treatment within one year of OUD diagnosis. Across all states, compared to non-Hispanic White enrollees, racial/ethnic minority enrollees had significantly lower odds of receiving MOUD, with significant pooled estimates for non-Hispanic Black enrollees (OR: 0.49; 95 % CI: 0.39–0.61) and other non-Hispanic Non-White enrollees (OR: 0.74; 95 % CI: 0.58–0.95). Compared to non-disabled adults, likelihood of MOUD receipt was 16 % lower for expansion adults (95 % CI: 0.72–0.97), 26 % lower for pregnant women (95 % CI: 0.58–0.93), and 53 % lower for children (95 % CI: 0.38–0.59). Finally, most mental and physical health comorbidities had negative or null association with MOUD receipt, with the exception of HCV, which was positively associated with receiving MOUD (OR: 1.69; 95 % CI: 1.33–2.15).

Table 3 presents results for continuity of MOUD treatment, which we consider a proxy indicator for treatment quality given the well-documented relationship between longer treatment duration and better patient outcomes (Samples et al., 2020; Sordo et al., 2017). Again, the study found significant heterogeneity in estimated associations across states, although Cochran Q tests were not significant for co-occurring cocaine use disorder (Cochran's Q test p = 0.66; $I^2 = 26.7$) nor for several other enrollee characteristics (e.g., sex, Hispanic ethnicity). Across all states, conditional on receiving MOUD, enrollees with OUD and a co-occurring SUD had lower odds of OUD medication continuity. From the pooled estimates, compared to enrollees with OUD only, significantly lower odds of MOUD treatment continuity were found for those with co-occurring SUDs involving cocaine (OR: 0.57; 95 % CI: 0.54–0.59; 90 % prediction interval: 0.53–0.60), other psychoactive

Table 2
Meta-analytic results for associations of co-occurring substance use disorder with receipt of MOUD.

		Measures of state-to-state variability		
	Global OR (95 % CI)	Cochran's Q test p-value	I^2	90 % prediction interval of OR
OUD-only	1 [Ref]			
OUD + alcohol	0.70 (0.49–1.02)	<0.001	99.0	0.38–1.29
OUD + cannabis	0.65 (0.47–0.88)	<0.001	98.5	0.39–1.07
OUD + cocaine	0.99 (0.86–1.14)	<0.001	92.2	0.79–1.24
OUD + amphetamine	0.86 (0.44–1.70)	<0.001	99.5	0.28–2.63
OUD + other psychoactive substance	1.35 (1.22–1.50)	<0.001	88.9	1.15–1.58
OUD + other	1.15 (0.81–1.64)	<0.001	98.3	0.65–2.05
Age group				
12–20	1.04 (0.70–1.55)	0.003	79.4	0.57–1.89
21–34	1.96 (1.58–2.43)	<0.001	93.2	1.40–2.75
35–44	1.97 (1.45–2.67)	<0.001	96.6	1.20–3.21
45–54	1.46 (1.25–1.70)	0.004	86.7	1.15–1.85
55–64	1 [Ref]			
Sex				
Female	1 [Ref]			
Male	0.99 (0.88–1.12)	<0.001	93.6	0.82–1.20
Race/ethnicity				
Non-Hispanic White	1 [Ref]			
Non-Hispanic Black	0.49 (0.39–0.61)	<0.001	96.0	0.35–0.69
Hispanic	0.30 (0.03–3.43)	<0.001	99.8	0.01–15.93
Other	0.74 (0.58–0.95)	<0.001	94.9	0.50–1.10
Eligibility				
Non-disabled adults	1 [Ref]			
Expansion adults	0.84 (0.72–0.97)	<0.001	92.4	0.67–1.05
Pregnant women	0.74 (0.58–0.93)	<0.001	90.2	0.51–1.06
Children	0.47 (0.38–0.59)	0.246	40.3	0.36–0.63
Disabled adults	0.50 (0.21–1.18)	<0.001	99.6	0.12–2.05
Living area				
Urban	1 [Ref]			
Rural	0.93 (0.70–1.22)	<0.001	98.2	0.59–1.45
Other comorbidities				
Anxiety disorder	0.88 (0.75–1.04)	<0.001	96.0	0.68–1.14
Mood disorder	0.94 (0.83–1.06)	<0.001	93.3	0.77–1.14
Schizophrenia & other psychotic disorders	0.74 (0.61–0.90)	<0.001	92.5	0.54–1.01
PTSD	1.03 (0.95–1.12)	0.046	65.4	0.91–1.16
HCV	1.69 (1.33–2.15)	<0.001	97.5	1.15–2.50
Soft skin tissue infections	0.90 (0.82–0.99)	<0.001	83.7	0.78–1.04
Other injection-related complications[a]	0.58 (0.45–0.75)	<0.001	84.7	0.40–0.85
Length of follow-up (months)[b]	1.18 (1.13–1.23)	<0.001	98.4	1.10–1.26

Notes: N = 305,263. Number of individuals receiving MOUD is 185,247 (60.7 %). MOUD = medication treatment for opioid use disorder. OUD = opioid use disorder. OR = odds ratio. PTSD = post-traumatic stress disorder. HCV = hepatitis C virus.

[a] Other injection-related complications include intracranial and intraspinal abscess, osteomyelitis, and endocarditis; which were combined due to small cell sizes.

[b] Length of follow-up is defined as the number of months between the first OUD diagnosis and the end of the follow up period (either end of the measurement period or one year after the first diagnosis of OUD).

substances (OR: 0.73; 95 % CI: 0.60–0.88; 90 % prediction interval: 0.66–0.83), and alcohol (OR: 0.66; 95 % CI: 0.51–0.87; 90 % prediction interval: 0.44–1.02). Significantly lower likelihood of MOUD treatment continuity was also shown for male enrollees, enrollees under age 55, and non-Hispanic Black enrollees. Additionally, enrollees with schizophrenia and other psychotic disorders, soft skin tissue infections, or other opioid-related diseases had significantly lower odds of OUD treatment continuity.

Finally, given the importance of psychosocial treatments for addressing non–opioid use disorders—such as alcohol, cannabis, and stimulant use disorders (Dutra et al., 2008)—Table 4 examines results for receipt of behavioral health counseling in combination with MOUD treatment. There is substantial variability in estimated associations across states, with all model coefficients for the co-occurring SUD measures having significant Cochran Q tests and I^2 ranging from 89.1 to 97.5. Pooling across states, the only significant relationships with behavioral health counseling are positive associations estimated for Hispanic ethnicity (OR: 1.31; 95 % CI: 1.13–1.51; 90 % prediction interval: 0.99–1.72); and diagnosis of a mood disorder (OR: 1.56; 95 % CI: 1.35–1.79; 90 % prediction interval: 1.25–1.93), PTSD (OR: 1.75; 95 % CI: 1.42–2.16; 90 % prediction interval: 1.30–2.37), or HCV (OR: 1.24; 95 % CI: 1.08–1.43; 90 % prediction interval: 1.00–1.54).

For all outcomes, variability across states creates a high level of uncertainty in the pooled estimates. Given the substantial heterogeneity across states in the relationships of co-occurring SUDs with OUD treatment outcomes, Fig. 2 presents state-specific estimates of the association of comorbid SUD types with each treatment outcome from adjusted models stratified by state (full results shown in Appendix Tables A.3 to A.5). Several areas exist where the pooled estimates may mask both statistically and substantively important heterogeneity across states. For the outcome of any MOUD receipt, a substantial divergence occurred in the relationship of co-occurring amphetamine-type use disorder with MOUD receipt for one state. Compared to enrollees with OUD-only, enrollees who also had an amphetamine-type use disorder had significantly lower odds of MOUD receipt in three states (OR range from 0.61 to 0.76), but significantly higher odds of MOUD receipt in State A (OR: 1.61; 95 % CI: 1.43–1.81).

Conditioning on enrollees with OUD who received MOUD treatment, the four states generally show the same directionality in the relationship of co-occurring SUD with MOUD continuity and receipt of behavioral counseling, although the magnitudes often vary widely. Compared to enrollees with OUD-only, enrollees who also had an amphetamine-type use disorder had significantly lower odds of continuous MOUD treatment in all four states, but with estimates ranging from 60 % lower odds in State D (OR: 0.38; 95 % CI: 0.34–0.43) to only 10 % lower odds in State A (OR: 0.87; 95 % CI: 0.75–1.00). For the outcome of MOUD combined with behavioral health counseling, the four states generally showed null or positive relationships with co-occurring SUDs. However, the magnitude of these relationships was much larger for State B and State C, where enrollees with OUD and a co-occurring SUD generally had 1.5 or twofold higher odds of receiving counseling compared to enrollees with OUD only.

Table 3
Meta-analytic results for associations of co-occurring substance use disorder with MOUD treatment continuity.

		Measures of state-to-state variability		
	Global OR (95 % CI)	Cochran's Q test p-value	I^2	90 % prediction interval of OR
OUD-only	1 [Ref]			
OUD + alcohol	0.66 (0.51–0.87)	<0.001	95.5	0.44–1.02
OUD + cannabis	0.87 (0.74–1.03)	<0.001	86.7	0.68–1.12
OUD + cocaine	0.57 (0.54–0.59)	0.664	26.7	0.53–0.60
OUD + amphetamine	0.60 (0.35–1.02)	<0.001	98.0	0.25–1.42
OUD + other psychoactive substance	0.73 (0.60–0.88)	<0.001	94.1	0.54–0.99
OUD + other	0.99 (0.76–1.30)	<0.001	94.4	0.65–1.52
Age group				
12–20	0.33 (0.17–0.64)	0.037	77.7	0.12–0.90
21–34	0.51 (0.39–0.67)	<0.001	88.3	0.34–0.78
35–44	0.68 (0.55–0.83)	<0.001	78.8	0.50–0.92
45–54	0.82 (0.73–0.91)	0.183	41.5	0.71–0.94
55–64	1 [Ref]			
Sex				
Female	1 [Ref]			
Male	0.88 (0.85–0.92)	0.458	24.2	0.84–0.92
Race/ethnicity				
Non-Hispanic White	1 [Ref]			
Non-Hispanic Black	0.65 (0.52–0.82)	0.007	90.7	0.45–0.94
Hispanic	0.82 (0.59–1.14)	0.274	86.5	0.44–1.52
Other	0.92 (0.84–1.01)	0.295	37.8	0.81–1.03
Eligibility				
Non-disabled adults	1 [Ref]			
Expansion adults	0.78 (0.71–0.85)	0.022	68.9	0.68–0.89
Pregnant women	1.11 (0.95–1.29)	0.022	62.8	0.89–1.37
Children	0.61 (0.59–1.14)	0.069	70.4	0.25–1.51
Disabled adults	0.89 (0.76–1.05)	0.018	77.8	0.70–1.14
Living area				
Urban	1 [Ref]			
Rural	1.03 (0.76–1.40)	<0.001	96.9	0.63–1.70
Other comorbidities				
Anxiety disorder	1.04 (0.94–1.17)	<0.001	82.7	0.88–1.23
Mood disorder	0.91 (0.83–1.01)	0.001	79.4	0.79–1.06
Schizophrenia & other psychotic disorders	0.87 (0.77–1.00)	0.055	62.9	0.73–1.05
PTSD	1.00 (0.88–1.13)	0.167	71.7	0.83–1.21
HCV	0.98 (0.87–1.12)	<0.001	85.7	0.81–1.20
Soft skin tissue infections	0.80 (0.73–0.88)	0.01	69.2	0.70–0.91
Other injection-related complications[a]	0.74 (0.68–0.81)	0.808	7.3	0.68–0.81
Length of follow-up (months)[b]	1.21 (1.16–1.27)	<0.001	98.7	1.12–1.30

Notes: $N = 160{,}557$. Number of individuals with continuous MOUD is 89,489 (55.7 %). MOUD = medication treatment for opioid use disorder. OUD = opioid use disorder. OR = odds ratio. PTSD = post-traumatic stress disorder. HCV = hepatitis C virus.

[a] Other injection-related complications include intracranial and intraspinal abscess, osteomyelitis, and endocarditis; which were combined due to small cell sizes.

[b] Length of follow-up is defined as the number of months between the index MOUD date and the end of the follow-up period (ranging from 6 to 18 months).

4. Discussion

The use of medications for OUD has seen substantial improvements since 2016 (Shen et al., 2020; The Medicaid Outcomes Distributed Research Network, 2021), but our study of Medicaid data from four states indicates that substantial gaps remain for individuals with OUD and a co-occurring SUD, a group representing more than half of individuals in both our sample and samples from other studies (Hassan & Le Foll, 2019; O'Brien et al., 2020). In most states, enrollees with OUD and alcohol, cannabis, or amphetamine use disorder are significantly less likely to receive MOUD compared to enrollees with OUD only. These disparities are even more pronounced for treatment continuity; those with co-occurring SUDs have 10 % to 50 % lower odds of having a 180-day period of continuous MOUD treatment, an important predictor of better patient outcomes (Samples et al., 2020; Sordo et al., 2017). Our results emphasize the need to improve evidence-based treatment initiation and retention within Medicaid programs for enrollees with OUD and most types of co-occurring SUD. The complicating role co-occurring SUDs play in treatment retention, combined with an absence of medication treatments focused on polysubstance use, highlights a need for further clinical research on polysubstance use. Collaborative care models, which can be designed to help address multiple SUDs, may be a particularly productive setting for evaluating different models of care for patients with polysubstance use.

While the negative association of co-occurring SUDs with MOUD receipt has been documented in prior research (O'Brien et al., 2020; The Medicaid Outcomes Distributed Research Network, 2021), we find several novel aspects of heterogeneity across specific types of co-occurring SUD and across states. For all four states, compared to enrollees with OUD-only, enrollees with OUD and other psychoactive SUD were significantly more likely to receive MOUD treatment within one year of OUD diagnosis, in contrast with the generally negative associations found for all other co-occurring SUDs. Why this group has a higher likelihood of MOUD receipt than those with OUD-only is unclear, and whether the conditions of these patients have unique aspects is also unclear. Perhaps practitioners are more inclined to provide MOUD when they are aware of polysubstance exposure, and they believe that OUD is contributing most to the disorders, or when OUD is the only identifiable target that can be addressed because the others are unknown. Demographically, this group appears most like enrollees with OUD and cocaine use disorder, but they have fewer psychiatric comorbidities and higher rates of physiological comorbidities. Given that OUD with other psychoactive SUD was the most prevalent comorbid SUD in all four states, further insights may be gained by future research that conducts a more detailed analyses or case note review to better understand these patients and to assess whether their relatively higher likelihood of MOUD receipt reflects unique aspects of this patient population versus, for example, an artifact of certain types of providers tending to use these diagnosis codes.

Our results also highlight the importance of considering between-state heterogeneity in Medicaid treatment processes and outcomes for individuals with multiple SUDs compared to those with OUD alone. Although prior analysis has found Medicaid enrollees with OUD and stimulant disorders are less likely than those with OUD only to receive MOUD (O'Brien et al., 2020), our state-specific analyses reveal that the relationship of treatment outcomes with co-occurring OUD and

Table 4
Meta-Analytic results for associations of co-occurring substance use disorder with behavioral health counseling and MOUD.

		Measures of state-to-state variability		
	Global OR (95 % CI)	Cochran's Q test p-value	I^2	90 % prediction interval of OR
OUD-only	1 [Ref]			
OUD + alcohol	1.54 (0.93–2.54)	<0.001	97	0.68–3.48
OUD + cannabis	1.46 (0.89–2.38)	<0.001	96.8	0.66–3.24
OUD + cocaine	1.46 (0.83–2.57)	<0.001	97.5	0.58–3.67
OUD + amphetamine	1.28 (0.63–2.58)	<0.001	97.3	0.41–4.00
OUD + other psychoactive substance	1.08 (0.78–1.50)	<0.001	96.6	0.63–1.84
OUD + other	1.20 (0.91–1.58)	<0.001	89.1	0.78–1.85
Age group				
12–20	1.27 (0.71–2.26)	0.153	57.3	0.57–2.84
21–34	1.10 (0.90–1.35)	0.006	70.8	0.83–1.48
35–44	1.02 (0.80–1.29)	<0.001	77.9	0.72–1.45
45–54	1.00 (0.83–1.21)	0.017	64.6	0.77–1.30
55–64	1 [Ref]			
Sex				
Female	1 [Ref]			
Male	1.04 (0.93–1.17)	<0.001	78.8	0.88–1.23
Race/ethnicity				
Non-Hispanic White	1 [Ref]			
Non-Hispanic Black	1.02 (0.60–1.72)	<0.001	96.9	0.44–2.35
Hispanic	1.31 (1.13–1.51)	0.776	38.7	0.99–1.72
Other	0.96 (0.82–1.13)	0.034	61.6	0.77–1.20
Eligibility				
Non-disabled adults	1 [Ref]			
Expansion adults	1.20 (0.89–1.62)	<0.001	95.9	0.74–1.95
Pregnant women	0.97 (0.81–1.18)	0.025	63.4	0.75–1.27
Children	0.96 (0.38–2.39)	0.009	78.5	0.24–3.76
Disabled adults	1.08 (0.72–1.62)	<0.001	94.9	0.56–2.07
Living area				
Urban	1 [Ref]			
Rural	0.87 (0.61–1.25)	<0.001	97	0.49–1.57
Other comorbidities				
Anxiety disorder	1.14 (0.79–1.64)	<0.001	97.7	0.63–2.06
Mood disorder	1.56 (1.35–1.79)	<0.001	85.1	1.25–1.93
Schizophrenia & other psychotic disorders	1.01 (0.61–1.66)	<0.001	93.2	0.46–2.24
PTSD	1.75 (1.42–2.16)	0.02	70	1.30–2.37
HCV	1.24 (1.08–1.43)	0.002	79.4	1.00–1.54
Soft skin tissue infections	1.01 (0.91–1.12)	0.082	61.7	0.87–1.16
Other injection-related complications[a]	0.64 (0.49–0.85)	0.085	58.4	0.44–0.95
Length of follow-up (months)[b]	1.17 (1.11–1.24)	<0.001	94.5	1.07–1.29

Notes: N = 160,557. Number of individuals receiving behavioral health counseling is 133,464 (83.1 %). MOUD = medication treatment for opioid use disorder. OUD = opioid use disorder. OR = odds ratio. PTSD = post-traumatic stress disorder. HCV = hepatitis C virus.

[a] Other injection-related complications include intracranial and intraspinal abscess, osteomyelitis, and endocarditis; which were combined due to small cell sizes.

[b] Length of follow-up is defined as the number of months between the first OUD diagnosis and the end of the follow up period (either end of the measurement period or one year after the first diagnosis of OUD).

stimulant (i.e., cocaine or amphetamine-type) use disorders exhibits substantive variability across states. Unlike for co-occurring alcohol or cannabis use disorders, different states appear to have varied success in initiating MOUD treatment among enrollees with co-occurring OUD and stimulant use disorders as well as for linking these individuals with behavioral health counseling. Given the stark rise in illicit stimulant availability, use, and use disorders in recent years (Hoots et al., 2020; Jones et al., 2020), evaluating the reasons underlying this state-level variation may facilitate development of tailored treatment approaches that can address the combination of health, economic, and social care issues commonly needed among the population with stimulant use disorder (O'Donnell et al., 2019).

Finally, while few enrollee characteristics were consistently associated with treatment receipt and retention, non-Hispanic Black enrollees had half the odds of receiving MOUD compared to non-Hispanic White enrollees. Restricting to the set of individuals who received MOUD, non-Hispanic Black enrollees still had significantly lower odds of having a 180-day period of continuous MOUD treatment compared to White enrollees. These findings, which were consistent across all four states, align with similar patterns of racial disparities in OUD treatment that have been documented in previous studies (Administration & Substance Abuse Mental Health Services Administration, 2020; Hollander et al., 2021; Schiff et al., 2020; The Medicaid Outcomes Distributed Research Network, 2021; Tiako, 2021).

4.1. Limitations

This exploratory study has several limitations. First, as with any analysis of claims data, SUD diagnoses codes have inaccuracies and missingness (Howell et al., 2021) that may produce misclassification bias. Claims data also contain little information on illness severity or provider and patient preferences, which may drive some of the observed associations. Second, our study data are restricted to Medicaid enrollees from four relatively geographically concentrated states. While it is unclear whether our study findings may generalize to other state Medicaid programs, the consistency of our results with some other research (O'Brien et al., 2020) using other Medicaid samples lends some support to generalizability. Third, we found substantial heterogeneity across states, reflected in wide prediction intervals, which limits generalizability to other states. This finding highlights the importance of state-specific analyses and supports further analysis with a wider sample of states to study this heterogeneity directly. Fourth, although our ability to capture methadone treatment through OTPs and psychosocial treatment improves over studies relying on pharmacy claims data (Meinhofer et al., 2019; Saloner et al., 2017), we cannot capture medication or psychosocial treatment not paid for by Medicaid. Last, our data end in 2018; given the continued evolution of the opioid crisis, particularly in the context of the COVID-19 pandemic (Alexander et al., 2020), these associations may have changed by 2021.

5. Conclusions

The opioid crisis is transitioning to a polydrug crisis, and early indicators from the COVID-19 pandemic suggest particularly stark increases in use, availability, and harms associated with alcohol, stimulants, and synthetic opioids (DiGennaro et al., 2021; Palamar et al., 2021; Roberts et al., 2021). Current efforts to increase access to and quality of evidence-based treatment for OUD need renewed focus and attention to ensure that individuals with co-occurring SUDs are engaged and retained in effective treatment. Continued changes in drug use

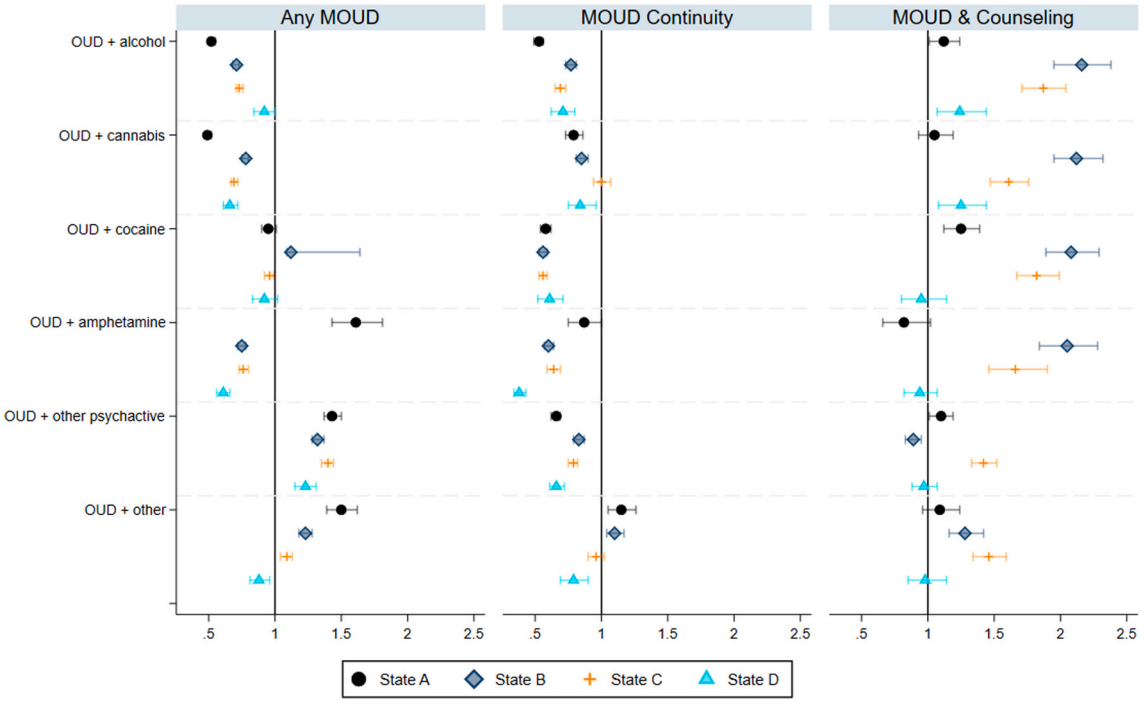

Fig. 2. State-specific results for associations of co-occurring substance use disorder with treatment outcomes, odds ratios and 95% confidence intervals relative to individuals with OUD only.

Notes: OUD = opioid use disorder. MOUD = medication for OUD. Figures shows odds ratios (ORs) and 95% confidence intervals (CIs) from regression models adjusted for demographic and other characteristics of enrollees shown in Table 1.

patterns, supply sources, and populations experiencing harms may necessitate new policy approaches that are not narrowly focused on opioid use or OUD but those that more fully address the complex needs of a growing population of individuals with OUD and other types of SUD.

CRediT authorship contribution statement

Rosanna Smart: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Joo Yeon Kim:** Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing. **Susan Kennedy:** Conceptualization, Project administration, Writing – review & editing, Funding acquisition. **Lu Tang:** Methodology, Software, Formal analysis, Writing – review & editing. **Lindsay Allen:** Conceptualization, Writing – review & editing. **Dushka Crane:** Conceptualization, Writing – review & editing. **Aimee Mack:** Conceptualization, Writing – review & editing. **Shamis Mohamoud:** Conceptualization, Writing – review & editing. **Nathan Pauly:** Conceptualization, Writing – review & editing. **Rosa Perez:** Conceptualization, Writing – review & editing. **Julie Donohue:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration, Funding acquisition.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsat.2022.108921.

References

Administration, S. A. M. H. S., & Substance Abuse Mental Health Services Administration. (2020). *The opioid crisis and the black/african american population: an urgent issue*.

Alexander, G. C., Stoller, K. B., Haffajee, R. L., & Saloner, B. (2020). An epidemic in the midst of a pandemic: Opioid use disorder and COVID-19. *Annals of Internal Medicine, 173*(1), 57–59.

Barnett, M. L., Lee, D., & Frank, R. G. (2019). In rural areas, buprenorphine waiver adoption since 2017 driven by nurse practitioners and physician assistants. *Health Affairs, 38*(12), 2048–2056.

Compton, W. M., Valentino, R. J., & DuPont, R. L. (2020). Polysubstance use in the US opioid crisis. *Molecular Psychiatry*, 1–10.

DiGennaro, C., Garcia, G.-G., Stringfellow, E., Wakeman, S., & Jalali, M. S. (2021). *Changes in characteristics of opioid overdose death trends during the COVID-19 pandemic. medRxiv*.

Dutra, L., Stathopoulou, G., Basden, S. L., Leyro, T. M., Powers, M. B., & Otto, M. W. (2008). A meta-analytic review of psychosocial interventions for substance use disorders. *American Journal of Psychiatry, 165*(2), 179–187.

Finlay, A. K., Harris, A. H., Rosenthal, J., Blue-Howells, J., Clark, S., McGuire, J., Timko, C., Frayne, S. M., Smelson, D., & Oliva, E. (2016). Receipt of pharmacotherapy for opioid use disorder by justice-involved US veterans health administration patients. *Drug and Alcohol Dependence, 160*, 222–226.

Gladden, R. M., O'Donnell, J., Mattson, C. L., & Seth, P. (2019). Changes in opioid-involved overdose deaths by opioid type and presence of benzodiazepines, cocaine, and methamphetamine—25 states, July–December 2017 to January–June 2018. *Morbidity and Mortality Weekly Report, 68*(34), 737. https://doi.org/10.15585/mmwr.mm6834a2

Haffajee, R. L., Bohnert, A. S., & Lagisetty, P. A. (2018). Policy pathways to address provider workforce barriers to buprenorphine treatment. *American Journal of Preventive Medicine, 54*(6), S230–S242.

Hassan, A. N., & Le Foll, B. (2019). Polydrug use disorders in individuals with opioid use disorder. *Drug and Alcohol Dependence, 198*, 28–33.

Hollander, M. A., Chang, C.-C. H., Douaihy, A. B., Hulsey, E., & Donohue, J. M. (2021). Racial inequity in medication treatment for opioid use disorder: Exploring potential facilitators and barriers to use. *Drug and Alcohol Dependence, 227*, Article 108927.

Hoots, B., Vivolo-Kantor, A., & Seth, P. (2020). The rise in non-fatal and fatal overdoses involving stimulants with and without opioids in the United States. *Addiction, 115*(5), 946–958.

Howell, B. A., Abel, E. A., Park, D., Edmond, S. N., Leisch, L. J., & Becker, W. C. (2021). Validity of incident opioid use disorder (OUD) diagnoses in administrative data: A chart verification study. *Journal of General Internal Medicine, 36*(5), 1264–1270.

John, D., Kwiatkowski, C. F., & Booth, R. E. (2001). Differences among out-of-treatment drug injectors who use stimulants only, opiates only or both: Implications for treatment entry. *Drug and Alcohol Dependence, 64*(2), 165–172.

Jones, C. M., Bekheet, F., Park, J. N., & Alexander, G. C. (2020). The evolving overdose epidemic: synthetic opioids and rising stimulant-related harms. *Epidemiologic Reviews, 42*(1), 154–166. https://doi.org/10.1093/epirev/mxaa011

Jones, C. M., Underwood, N., & Compton, W. (2020). Increases in methamphetamine use among heroin treatment admissions in the United States, 2008–2017. *Addiction, 115*(2), 347–353.

Knapp, G., & Hartung, J. (2003). Improved tests for a random effects meta-regression with a single covariate. *Statistics in Medicine, 22*(17), 2693–2710.

Krawczyk, N., Feder, K. A., Saloner, B., Crum, R. M., Kealhofer, M., & Mojtabai, R. (2017). The association of psychiatric comorbidity with treatment completion among clients admitted to substance use treatment programs in a US national sample. *Drug and Alcohol Dependence, 175*, 157–163.

Liu, S., Scholl, L., Hoots, B., & Seth, P. (2020). Nonfatal drug and polydrug overdoses treated in emergency departments—29 states, 2018–2019. *Morbidity and Mortality Weekly Report, 69*(34), 1149.

Liu, S., & Vivolo-Kantor, A. (2020). A latent class analysis of drug and substance use patterns among patients treated in emergency departments for suspected drug overdose. *Addictive Behaviors, 101*, Article 106142.

MACPAC. (2017). Chapter 2: medicaid and the opioid epidemic Medicaid and CHIP Payment and Access Commission (MACPAC). https://www.macpac.gov/wp-content/uploads/2017/06/Medicaid-and-the-Opioid-Epidemic.pdf.

McCabe, S. E., & West, B. T. (2017). The three-year course of multiple substance use disorders in the united States: A national longitudinal study. *The Journal of Clinical Psychiatry, 78*(5), Article e537.

Meinhofer, A., Williams, A. R., Johnson, P., Schackman, B. R., & Bao, Y. (2019). Prescribing decisions at buprenorphine treatment initiation: do they matter for treatment discontinuation and adverse opioid-related events? *Journal of Substance Abuse Treatment, 105*, 37–43.

National Quality Forum. (2021). Continuity of pharmacotherapy for opioid use disorder (OUD). *Centers for Medicare & Medicaid Services.* Retrieved October 12, 2021 from https://cmit.cms.gov/CMIT_public/ViewMeasure?MeasureId=5881.

O'Brien, P., Henke, R. M., Schaefer, M. B., Lin, J., & Creedon, T. B. (2020). Utilization of treatment by medicaid enrollees with opioid use disorder and co-occurring substance use disorders. *Drug and Alcohol Dependence, 217*, Article 108261.

O'Brien, P., Henke, R. M., Schaefer, M. B., Lin, J., & Creedon, T. B. (2021). Adverse events among adult medicaid enrollees with opioid use disorder and co-occurring substance use disorders. *Drug and Alcohol Dependence, 221*, Article 108555.

O'Donnell, A., Addison, M., Spencer, L., Zurhold, H., Rosenkranz, M., McGovern, R., Gilvarry, E., Martens, M. S., Verthein, U., & Kaner, E. (2019). Which individual, social and environmental influences shape key phases in the amphetamine type stimulant use trajectory? A systematic narrative review and thematic synthesis of the qualitative literature. *Addiction, 114*(1), 24–47.

Orgera, K., & Tolbert, J. (2019). *The opioid epidemic and Medicaid's role in facilitating access to treatment.* Kaiser Family Foundation. Retrieved August 11, 2022:.

Palamar, J. J., Le, A., Carr, T. H., & Cottler, L. B. (2021). Shifts in drug seizures in the united States during the COVID-19 pandemic. *Drug and Alcohol Dependence, 221*, Article 108580.

Roberts, A., Rogers, J., Mason, R., Siriwardena, A. N., Hogue, T., Whitley, G. A., & Law, G. R. (2021). Alcohol and other substance use during the COVID-19 pandemic: A systematic review. *Drug and Alcohol Dependence, 109150*.

Ronan, M. V., & Herzig, S. J. (2016). Hospitalizations related to opioid abuse/dependence and associated serious infections increased sharply, 2002–12. *Health Affairs, 35*(5), 832–837.

Saloner, B., Daubresse, M., & Caleb Alexander, G. (2017). Patterns of buprenorphine-naloxone treatment for opioid use disorder in a multistate population. *Medical Care, 55*(7), 669–676. https://doi.org/10.1097/MLR.0000000000000727

Saloner, B., Lin, L., & Simon, K. (2020). Geographic location of buprenorphine-waivered physicians and integration with health systems. *Journal of Substance Abuse Treatment, 108034*.

Samples, H., Williams, A. R., Crystal, S., & Olfson, M. (2020). Impact of long-term buprenorphine treatment on adverse health care outcomes in medicaid: the impact of longer treatment on health care outcomes for opioid use disorder within a key population of medicaid enrollees. *Health Affairs, 39*(5), 747–755.

Samples, H., Williams, A. R., Olfson, M., & Crystal, S. (2018). Risk factors for discontinuation of buprenorphine treatment for opioid use disorders in a multi-state sample of medicaid enrollees. *Journal of Substance Abuse Treatment, 95*, 9–17.

Schiff, D. M., Nielsen, T., Hoeppner, B. B., Terplan, M., Hansen, H., Bernson, D., Diop, H., Bharel, M., Krans, E. E., & Selk, S. (2020). Assessment of racial and ethnic disparities in the use of medication to treat opioid use disorder among pregnant women in Massachusetts. *JAMA Network Open, 3*(5), e205734. e205734.

Serota, D. P., Bartholomew, T. S., & Tookes, H. E. (2021). Evaluating differences in opioid and stimulant use-associated infectious disease hospitalizations in florida, 2016–2017. *Clinical Infectious Diseases, 73*(7), e1649–e1657.

Shen, K., Barrette, E., & Dafny, L. S. (2020). Treatment of opioid use disorder among commercially insured US adults, 2008–17: Study examines how medicare rural add-on payments affected the number of home health agencies serving rural counties. *Health Affairs, 39*(6), 993–1001.

Sidik, K., & Jonkman, J. N. (2006). Robust variance estimation for random effects meta-analysis. *Computational Statistics & Data Analysis, 50*(12), 3681–3701.

Smart, R., Pardo, B., & Davis, C. S. (2020). Systematic review of the emerging literature on the effectiveness of naloxone access laws in the united states. *Addiction, 116*(1), 6–17. https://doi.org/10.1111/add.15163

Sordo, L., Barrio, G., Bravo, M. J., Indave, B. I., Degenhardt, L., Wiessing, L., Ferri, M., & Pastor-Barriuso, R. (2017). Mortality risk during and after opioid substitution treatment: systematic review and meta-analysis of cohort studies. *BMJ, 357*.

The Medicaid Outcomes Distributed Research Network. (2021). Use of medications for treatment of opioid use disorder among US medicaid enrollees in 11 states, 2014–2018. *Journal of the American Medical Association, 326*(2), 154–164.

Tiako, M. J. N. (2021). Addressing racial & socioeconomic disparities in access to medications for opioid use disorder amid COVID-19. *Journal of Substance Abuse Treatment, 122*, Article 108214.