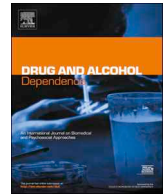


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Full length article

Pregnant women with opioid use disorder and their infants in three state Medicaid programs in 2013–2016

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ABSTRACT

Background: Maternal opioid use disorder (OUD) has serious consequences for maternal and infant health. Analysis of Medicaid enrollee data is critical, since Medicaid bears a disproportionate share of costs.

Methods: This study analyzes linked maternal and infant Medicaid claims data and infant birth records in three states in the year before and after a delivery in 2014–2015 (2013–2016) examining health, health care use, treatment, and neonatal outcomes. Diagnosis and procedure codes identify OUD and other substance use disorders (SUDs).

Results: In the year before and after delivery, 2.2 percent of the sample had an OUD diagnosis, and 5.9 percent had a SUD diagnosis other than OUD. Of the women with OUD, 72.8% had treatment for a SUD in the year before and after delivery, but most had none in an average enrolled month, and only 8.8% received any methadone treatment in a given month. Pregnant women with OUD had delayed and lower rates of prenatal care compared to women with other substance use disorders (SUDs). Infants of mothers with OUD did not differ from infants of mothers with other SUDs in rate of preterm or low birth weight but had higher NICU admission rates and longer birth hospitalizations. Health care costs for women with an OUD were higher than those with other SUDs.

Conclusions: There is an urgent need for comprehensive, evidence-based OUD treatment integrated with maternity care. To fill critical gaps in care, workforce and infrastructure innovations can facilitate delivery of preventive and treatment services coordinated across settings.

1. Introduction

The United States is experiencing an opioid epidemic with serious consequences for maternal and infant health. Women with opioid use disorders face many social and medical complications that can include malnourishment, trauma, sexual assault, domestic violence, hepatitis C, sexually transmitted infections, and death (Substance Abuse and Mental Health Services Administration (SAMHSA, 2018a; Winklbaur et al., 2008). Infants born to women who use opioids in pregnancy frequently experience neonatal abstinence syndrome (NAS, also known as neonatal withdrawal) in the days after birth (Finnegan et al., 1975; Hudak and Tan, 2012). NAS involves the nervous and gastrointestinal systems and is characterized by symptoms that include inconsolable crying, fever, excessive weight loss, and seizures (McQueen and Murphy-Oikonen, 2016). Medicaid is the primary payer for 75% of maternal

hospital stays related to substance use and covers approximately 80% of the \$1.5 billion in annual hospital charges related to NAS (Fingar et al., 2006; Patrick et al., 2015). The epidemic among reproductive aged women has spurred increased efforts to provide evidence-based treatments for pregnant and postpartum women and infants affected by OUD. However, little large-scale, claims-based research has examined prevalence, treatment, outcomes, and expenditures related to OUD among pregnant and parenting women and their infants.

Despite steep increases over the past two decades in both prevalence of opioid use disorder (OUD) among pregnant women and incidence of NAS (Brown et al., 2016; Haight, 2018; Jones et al., 2015; Ko, 2016; Tolia et al., 2015), many pregnant women have barriers to OUD treatment. Because addiction is often regarded as a personal failing or crime rather than an illness, pregnant women may face particular stigma and persecution related to substance abuse, including risk of

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criminal prosecution for child abuse in many states (Angelotta et al., 2016; Paltrow and Flavin, 2013; Saia et al., 2016). Stigma may also lead women to reject treatment entirely; more than 90% of women who meet criteria for treatment for use of illicit drugs but do not receive it believe they do not need treatment (Substance Abuse and Mental Health Services Administration (SAMHSA, 2016).

Another barrier is access. Few opioid treatment programs provide services specific to pregnant women, and approximately one-third of such programs do not accept Medicaid (Smith and Lipari, 2017). Many treatment programs also do not operate according to evidence-based best practices; thus, though medication assisted therapy (MAT) is considered the standard of care for pregnant women, the majority of pregnant women treated for OUD do not receive MAT (Angelotta et al., 2016). Misinformation and stigma surrounding medications to treat OUD may also impede access to treatment, as may the barriers associated with making daily clinic visits if methadone is used.

Evidence-based strategies for managing NAS are often underused as well, particularly non-pharmaceutical strategies such as rooming in and extended skin-to-skin contact with the mother, breastfeeding, swaddling, and quiet low-light environments (ACOG and ASAM, 2017; Comer et al., 2015; Substance Abuse and Mental Health Services Administration (SAMHSA, 2018a), even though they have been shown to reduce hospitalization costs (Grossman et al., 2017; Holmes et al., 2016; MacMillan et al., 2018). Experts on NAS generally agree the “baby’s mother is the best treatment,” but some health care providers carry out punitive practices such as referrals to child protective services even when the mother is receiving MAT and there is no evidence of harm or abuse by the mother (Bishop et al., 2017; Hunt, 2016). Some state governments require such reporting (Angelotta et al., 2016; Saia et al., 2016).

To-date, there are few estimates showing rates of treatment women with OUD received before, during, and after birth or of the incidence of NICU use and NAS among their infants. Because Medicaid bears a disproportionate share of costs related to women and infants affected by OUD, analysis for Medicaid participants is particularly critical to understanding treatment gaps. Identifying patterns of maternal and infant care, costs, and outcomes related to maternal OUD is critical for designing effective policies to address maternal OUD treatment in multiple settings. This paper aims to fill these research gaps. Our analysis also builds a foundation for causal assessments of outcomes related to different treatment options; the impact of specific state-based policies, such as payment models incentivizing provision of evidence-based care for pregnant women with OUD; and initiatives that are geographically based such as community-level availability of methadone and buprenorphine maintenance treatment providers.

1.1. Goals of the study

This study analyzes maternal and infant Medicaid claims data and infant birth records in three states for the year before and after a birth in 2014 or 2015. Women are categorized as having OUD, other substance use disorders (SUDs), or no SUD. The study seeks to address the following research questions: (1) What share of the women have OUD or other SUDs, and what are the sociodemographic characteristics associated with these disorders? (2) What share of the women received prenatal care, other health care, or SUD treatment of various types, and what is the timing of such care? (3) What share of infants were admitted to the NICU, and what was the duration of the NICU stay and the birth hospitalization? (4) What share of infants are pre-term, low birth-weight, or have an NAS diagnosis? (5) What are the health care costs for women and infants?

2. Methods

2.1. Data and study sample

Using linked Medicaid claims and eligibility records and birth certificate records acquired from three states, we identified a sample of mother-infant dyads from Medicaid-enrolled women who gave birth to a live singleton infant in 2014 or 2015. The data were originally collected and developed into an analytical datafile as part of a larger evaluation of the Strong Start for Mothers and Newborns initiative, which was funded by the Center for Medicare and Medicaid Innovation under Section 1115 A of the Social Security Act and aimed to improve pregnancy outcomes for women and infants covered by Medicaid and the Children’s Health Insurance Program (Hill et al., 2018). The data included any eligibility and claims data for the 24 months surrounding each delivery—the 12 months before the delivery month, the delivery month, and the 11 months after the delivery month—covering the period 2013–2016 depending on the timing of the delivery. Data included women and their infants from a mix of urban and rural counties in the three study states: one northeastern state with data for counties encompassing 66 percent of the state’s population; one southwestern state with data for counties encompassing 78 percent of the state’s population; and one southern state with data for counties encompassing 46 percent of the state’s population. Two states expanded Medicaid in January 2014 under the Affordable Care Act; one did not. Most women in the expansion states who delivered in 2014 were likely not eligible for Medicaid before they were pregnant, while many of those who delivered in 2015 were. Thus, in 2015, a higher proportion of women likely had continuous coverage in the expansion states.

Our initial sample included all women with Medicaid claims data who delivered a live singleton infant in 2014 ($n = 40,172$) or 2015 ($n = 36,696$). We restricted the sample to mother-infant dyads for which the mothers had identified delivery claims and had been enrolled in full-benefit Medicaid for at least one month in the 12 months before the delivery month, the delivery month itself, and/or the 11 months after the delivery month (hereafter referred to as the year before and after delivery). We further restricted our sample to dyads for which there was valid birth weight and gestational age data for the infant. We excluded 2658 sample women from the analysis because they were identified as likely having a SUD using the algorithm described below, but they had no SUD diagnosis and no way to identify their SUD status. The final sample size was 37,782 for 2014 (including samples of 9,379, 11,763, and 16,640 across the three states) and 34,304 for 2015 (including samples of 9,773, 9,548, and 14,983 across the three states). We combined the samples from different years and states to get sufficient sample size. We refer to each individual in the sample, regardless of age or whether she is pregnant or postpartum, as a “woman.” The study was conducted in compliance with [the blinded] Institutional Review Board.

2.2. Substance use disorder status

Within the sample, we classified women as having a SUD based on an adaptation of the Explicit Mention Substance Abuse Need for Treatment in Women (EMSANT-W), a population-based SUD identification tool tailored to women of reproductive age (Derrington et al., 2015), which we applied to International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9) or International Classification of Diseases, 10th Edition, Clinical Modification (ICD-10) codes. Among women identified as having a diagnosed SUD, those with any OUD ($N = 1537$) were identified based on diagnosis codes and/or treatment specific to OUD in claims records (Bouchery et al., 2012). Identification

of infant NAS was not used as a criterion to identify maternal OUD, since NAS diagnosis in the claims was not specific to opioid exposure. Women categorized as “any OUD” could have additional diagnosed SUDs. Women without a diagnosis or treatment specific to OUD but with other diagnosed or unspecified SUDs ($N = 4105$) were categorized as “other SUD,” which included alcohol, cannabis, and other substance use disorders but excluded disorders related to tobacco. Sample women with no SUD-related diagnosis are classified as having no SUD ($N = 63,786$).

2.3. Sociodemographic and health characteristics

We examined the SUD prevalence and characteristics of study women. Women’s sociodemographic and health characteristics from the birth certificate data included age group, race/Hispanic ethnicity, education, marital status, county of residence, number of unique non-prenatal diagnoses, pre-gestational diabetes, pre-gestational hypertension, first time delivery status, and parity. We grouped counties into the following categories: large central metro, large fringe metro, medium metro, and small metro/nonmetropolitan area. We identified any psychiatric diagnosis as having an ICD-9 and/or ICD-10 code in claims for any mood disorder (including major depressive disorder), psychotic disorder, anxiety and stress disorder, personality disorder, or adjustment disorder; we excluded SUDs, developmental disorders, degenerative disorders, and unspecified disorders from psychiatric diagnoses (Bernstein et al., 2015).

2.4. Health care use, SUD treatment, outcome measures, and expenditures

Outcomes of interest included health care utilization and expenditures for women and infants, SUD treatment by type and consecutive months of treatment, and neonatal outcomes.

Our algorithm for identifying SUD treatments relied on procedure and/or diagnostic codes (such as primary diagnosis of SUD) and was developed from published reports (Bouchery et al., 2012; Kotelchuck et al., 2017) and Virginia Department of Medical Assistance Services’ Addiction and Recovery Treatment Services (Virginia Department of Medical Assistance Services, 2017). SUD treatments were classified as: any inpatient treatment, any outpatient therapy, any residential, any partial hospitalization/intensive outpatient, any SUD medication (including unspecified medications with a primary diagnosis of SUD), any methadone, and any indicator of buprenorphine. Because prescription data claims were not available, the buprenorphine indicator is based on identification of lab testing related to buprenorphine treatment. Small sample sizes and limitations in the identification of buprenorphine treatment for OUD precluded separate analysis related to women receiving buprenorphine treatment. Analysis of treatment included estimating the average number of consecutive months enrollees obtained any SUD treatment before and after the birth month. We also estimated the average monthly percent of enrollees with any SUD treatment in the 24 months surrounding birth. We also replicated this analysis among women with any methadone treatment, as methadone accompanied by appropriate therapeutic support is a recommended treatment option throughout the duration of pregnancy and beyond. Among the sample women with OUD, we also compared those with any methadone treatment before birth to those without any treatment to compare the outcomes for those who had at least one month with some recommended treatment to those who had none. Only 39 of the 216 sample women who received methadone treatment prior to delivery had a treatment duration of 6 months or more prior to delivery, so only an analysis of women who received any methadone was done and not an analysis of people who obtained the recommended treatment throughout their pregnancy.

Infant outcomes derived from the birth certificate include low birth weight (< 2500 g), very low birth weight (< 1500 g), pre-term (< 37 weeks gestation), and very pre-term (< 34 weeks gestation). Variables

for admission to the NICU and number of NICU days during the birth hospitalization were derived from a NICU flag provided by one state and claims for the other two states. We used the claims to derive the length of stay of the infant’s birth hospitalization and to categorize infants as having any drug/alcohol related diagnosis including NAS (excluding cases resulting from complications related to neonatal intensive care) or suspicion of exposure to drugs or alcohol via the placenta or breast milk.

Maternal utilization measures derived from the claims include the average beneficiary’s monthly number of hospital stays and emergency department [ED] visits before and after giving birth. We measured trimester in which prenatal care reportedly began using the birth certificate and used claims to classify a small number of people with no report in the birth certificate.

Using expenditures per service from the claims data, we calculated the average enrollee’s monthly expenditures and the average enrollee’s total expenditures over the selected study periods. The three study states all provided complete claims/encounter data for managed care enrollees. We do not distinguish between maternal and infant expenditures in the birth month because often mother and infant are grouped on birth-related claims.

2.5. Estimates

We conducted data analysis using SAS 9.3 (Cary, NC) and STATA 15. Each state was given an equal 1/3 wt in calculating the overall average for our measures. We first used regression analysis to calculate each individual state’s means and standard errors for a given estimate. We then used linear combination to calculate an average of the three state regression coefficients. This same approach was then repeated to estimate and test for differences among the subpopulations. Statistical significance is set at $p\text{-value} \leq 0.05$. In accordance with confidentiality practices set by CMS, we suppress estimates from cell sizes less than 11.

3. Results

The vast majority of Medicaid enrolled women in the sample (91.9%) did not have a substance use disorder (SUD) diagnosis of any type in the year before or after giving birth in 2014 or 2015 (Table 1). However, 2.2% of the sample had an opioid use disorder (OUD) diagnosis, and 5.9 percent of the sample had a SUD diagnosis other than OUD. In our study sample, women with OUDs were older, more often white, and from suburban areas (i.e., large fringe and medium metro areas) than women with other SUD diagnoses and without a SUD. Over half of sample women with OUD (52.1%) had a psychiatric diagnosis, an even higher rate than those with another SUD (46.2%); only 9.6% of women without a SUD had a psychiatric diagnosis.

Over three-quarters (72.8%) of sample women with an OUD had claims indicating some form of SUD treatment during the year before and after delivery compared to 52.3% of women with other SUDs (Table 2). However, the average monthly SUD treatment rate among enrollees was low—22.7% among women with an OUD and just 7.9 percent among women with other SUDs. In an average month in the year before and after the birth, enrolled women with OUD were most likely to have claims indicating SUD outpatient therapy (11.8%), partial hospitalization or intensive outpatient (10.9%), or methadone treatment (8.8%). The average number of consecutive months with any SUD treatment for women with an OUD was 3.0 months before the birth month and 3.9 months after the birth month, while women with other SUDs had an average of 1.9 consecutive months of treatment both before and after the birth month. Among the 8.8 percent of women with OUD who were treated with methadone during the 24-month study period, an average of 42.9% received some form of SUD treatment in enrolled months, and 30.0% received methadone. Among women who got methadone treatment before the birth month, that treatment was generally not sustained throughout pregnancy—the average number of

Table 1

Sociodemographic and health characteristics of women who delivered infants in 2014 or 2015 by substance use disorder (SUD) status and type, three state Medicaid programs.

Source: Birth certificates and claims and enrollment data for women and their infants, three state Medicaid programs covering the 24 months surrounding the deliveries (2013–2016). Characteristic estimates are derived from birth certificate data except Strong Start participant, number of unique diagnoses before delivery, and psychiatric diagnosis.

Characteristics	Sample women by status and type of diagnosed SUD ^a		
	Any OUD [ref ^b]	Other SUD (compared to any OUD)	No SUD (compared to any OUD)
Age group			
< =25	31.2%	45.9%***	47.3%***
26–34	57.0%	44.3%***	41.4%***
> =35	11.9%	9.8%**	11.2%
Race/Hispanic ethnicity			
Non-Hispanic white	66.1%	37.9%***	29.7%***
Non-Hispanic black	14.7%	36.9%***	29.2%***
Non-Hispanic other	3.1%	4.8%**	6.5%***
Hispanic	16.1%	20.3%***	34.4%***
Education (from 2 of 3 states)			
Less than high school	26.9%	34.3%***	27.5%
High school	32.5%	36.0%	38.1%***
Some college/Associates	37.5%	27.0%***	28.9%***
College graduate	2.8%	2.4%	5.2%***
Not reported	0.3%	0.3%	0.3%
Married			
Yes	19.3%	15.4%***	32.4%***
No	79.9%	83.6%***	67.1%***
Not reported	0.8%	1.0%	0.4%**
Strong Start participant	4.9%	4.8%	3.0%***
Rural/urban			
Large central metro	39.8%	52.3%***	47.6%***
Large fringe metro	22.4%	18.5%***	21.0%
Medium metro	25.6%	18.4%***	18.9%***
Small metro/nonmetropolitan	12.3%	10.9%**	12.5%
Health characteristics			
Number of unique diagnoses ^b prior to delivery month	5.0	5.0	3.0***
Pre-gestational diabetes	1.0%	1.2%	0.9%
Pre-gestational hypertension	1.7%	3.3%***	1.7%
Any psychiatric diagnosis	52.1%	46.2%***	9.6%***
First time delivery	29.1%	31.4%	36.2%***
Number of previous births, among women who previously delivered	2.2	2.2	1.9***
Total N (%)	1537 (2.2%)	4105 (5.9%)	63,786 (91.9%)

Note. Analysis includes only mothers and their singleton infants who were alive after delivery and had full-benefit eligibility and claims in at least one month in the 24 month study period (i.e., 12 months before the delivery month, the delivery month, and the 11 subsequent months). ***, ** denote statistical significant difference at the .01 and .05 levels for the comparison of group means to the mean for women with OUD within maternal characteristic.

^aDiagnosed SUD defined as having a diagnosis of SUD or SUD treatment in the 12 months leading up to the delivery, during the delivery month, or during the 11 months following delivery. Diagnosed SUD based on HEDIS measure expanded to include people in remission. women of infants diagnosed with fetal alcohol syndrome; people with a diagnosis of drug dependence complicating their pregnancy; people with no observed diagnosis of substance use disorder but who sought or received treatment for a substance use disorder. Treatment algorithm relies on list of treatment codes from Bourchery et al 2012, Virginia Medicaid, and EMSANT-W (Derrington et al., 2015).

^bExcludes prenatal-related diagnoses.

consecutive months with methadone treatment before the birth month was only 2.8 months. Among those with any methadone treatment after the birth month, the average number of consecutive months of any methadone treatment was 5.0.

During the 12 months before the birth month, sample women with an OUD had delayed prenatal care, lower rates of prenatal care, and higher rates of hospital and ED use compared to both other groups in the study (Table 3). This was generally truer among women with OUD who had any methadone treatment before delivery than their counterparts with no treatment of any kind. In the 12 months before delivery, sample women with an OUD also had over three times the rate of hospital stays and over twice the rate of ED visits of women without a SUD.

Perinatal outcomes such as rate of preterm or low birth weight did not differ between infants of mothers with OUD or other SUDs (Table 4). However, infants of mothers with an OUD, and especially those whose mothers were treated with methadone, had higher rates of admission to NICU during the birth hospitalization, longer birth hospitalizations, and more infant drug/alcohol diagnosis compared to infants of mothers with other SUDs. The NAS rate among infants of mothers treated with any methadone was double the rate observed among infants of mothers with OUD who received no treatment before delivery (52.5% versus 25.0%), which may be related to higher rates of NAS screening among infants of mothers treated with methadone. The number of days in the NICU, if admitted, was also longer for infants of mothers treated with methadone compared to infants of mothers with OUD who received no treatment before delivery (22.1 days versus 16.9 days) with even larger differences in overall length of birth hospitalization. However, there was no statistically significant difference between the two groups in terms of the rate of preterm or low birth weight.

Health care costs for sample women with an OUD were higher than those with other SUDs and were generally twice as high or more than costs for those without a SUD (Table 5), a pattern consistent across measures (i.e., average monthly and total health care expenditures) and study periods (i.e., before and after delivery and delivery month expenditures). For example, delivery month and delivery hospitalization expenditures were \$22,485 for women with an OUD compared to \$16,171 for those with another SUD and \$11,196 for those without a SUD. Costs for women with an OUD were particularly high relative to the other groups in the period after the birth hospitalization. Among women with an OUD, health care costs before and at delivery were higher for women with methadone treatment than for women with OUD and no treatment of any kind before the birth month. Higher costs may be related to the treatment itself or because these women were experiencing higher health care needs. There was no statistically significant difference in costs between the two groups after birth.

4. Discussion

Current rates of maternal OUD and NAS point to a need for maternal access to comprehensive, effective, and sustained OUD treatment. Pervasive treatment gaps revealed through analysis of these three states' Medicaid administrative and birth certificate data can inform initiatives for expanding access to prenatal and postpartum treatment for Medicaid-enrolled women with OUD and other SUDs.

Over the course of 24 months, nearly three in four women with OUD in our sample had at least some treatment related to substance use. However, treatment was not continuous, and in an average month most of those enrolled did not have any SUD-related services. Clinical guidelines recommend that pregnant women with OUD in stable treatment with opioid agonist such as methadone should remain in treatment throughout the pregnancy (Substance Abuse and Mental Health Services Administration (SAMHSA, 2018a). Methadone or buprenorphine treatment is currently the standard of care for opioid use disorder treatment in pregnancy (ACOG and ASAM, 2017), and clinical studies show that infants of mothers on methadone treatment have better outcomes than infants of mothers with untreated OUD or who have medication-assisted withdrawal during pregnancy (Lund et al., 2012; Winklbaur et al., 2008). However, among sample women with

Table 2

Percent with SUD-related treatment among women with a diagnosed SUD who delivered an infant in 2014 or 2015 by type of SUD, type of treatment, and consecutive months of treatment before and after delivery, in three state Medicaid programs.

Source: Birth certificates and claims and enrollment data for women and their infants, three state Medicaid programs covering the 24 months surrounding the deliveries (2013–2016). SUD-related treatment estimates are derived from the claims data.

SUD-Related Treatment ^b	Sample women by status and type of diagnosed SUD ^a	
	Any OUD [ref*]	Other SUD
Percent of sample with any SUD-related treatment during the 24 months surrounding their delivery	72.8%	52.3%***
Average monthly percent of enrollees with any SUD-related treatment, 24 months surrounding their delivery	22.7%	7.9%***
Any inpatient	0.9%	0.4%***
Any outpatient therapy	11.8%	6.0%***
Any residential	0.9%	0.1%***
Any partial hospitalization or intensive outpatient	10.9%	2.0%***
Any SUD-related medication	9.4%	0.1%***
Any methadone	8.8%	0.0%***
Any buprenorphine ^c	1.3%	0.0
Average # of consecutive months with any SUD-related treatment		
In the 12 months before delivery month	3.0	1.9***
In the 11 months after delivery month	3.9	1.9***
Percent of enrollees with any SUD-related treatment, average of 24 months surrounding their delivery among those ever treated with methadone	42.9%	n/a
Any inpatient	1.1%	n/a
Any outpatient therapy	20.3%	n/a
Any residential	1.8%	n/a
Any partial hospitalization or intensive outpatient	19.7%	n/a
Any SUD-related medication	31.0%	n/a
Any methadone	30.0%	n/a
Any buprenorphine ^c	4.0%	n/a
Average # consecutive months with methadone treatment		
In the 12 months before delivery month	2.8	n/a
In the 11 months after delivery month	5.0	n/a
Total N	1537	4105

Note. Analysis includes only mothers and their singleton infants who were alive after delivery and had full-benefit eligibility and claims in at least one month in the 24 month study period (i.e., 12 months before the delivery month, the delivery month, and the 11 subsequent months). ***, ** denote statistical significant difference at the .01 and .05 levels for the comparison of group means to the mean for women with OUD within maternal characteristic.

n/a: not applicable.

^a See notes to Table 1.

^b SUD treatment defined as any inpatient treatment, outpatient therapy, residential, partial hospitalization/intensive outpatient, or medication with a diagnosis related to SUD plus some additional treatments that are exclusive to SUD; see text for more details.

^c Identified through toxicology testing for buprenorphine levels.

Table 3

Maternal health care utilization rates during the 12 months before delivery month among women with a diagnosed substance use disorder (SUD) who delivered infants in 2014 or 2015 by SUD status and type for three state Medicaid programs.

Source: Birth certificates and claims and enrollment data for women and their infants, three state Medicaid programs covering the 24 months surrounding the deliveries (2013–2016). Prenatal care estimates derived from birth certificate data except in cases where there was no report in which case we looked for a Medicaid claim. Numbers of hospital stays and ED visits are from the claims data.

Maternal health care utilization measure	Sample women by status and type of diagnosed SUD ^a			
	Any Opioid Use Disorder (OUD)			Other SUD (compared to any OUD)
	All [ref*]	No Treatment Before Delivery [ref*]	Any Methadone Treatment Before Delivery (compared to no treatment)	
Trimester in which prenatal care began				
First trimester	45.4%	44.1%	37.0%	50.2%***
Second trimester	34.9%	33.4%	42.8%^^	33.9%
Third trimester	13.7%	13.4%	18.9%	11.7%
No prenatal care	4.5%	6.5%	1.1%^^	3.2%***
Not reported in birth certificate and no Medicaid claim found	1.5%	2.5%	0.3%	1.0%
Monthly rate while enrolled^b during the 12 months before delivery month				
# Hospital stays	0.04	0.02	0.05^^	0.03**
# Emergency department (ED) visits	0.25	0.29	0.20	0.23
Total N	1537	838	216	4105

Note. Analysis includes only mothers and their singleton infants who were alive after delivery and had full-benefit eligibility and claims in at least one month in the 24 month study period (i.e., 12 months before the delivery month, the delivery month, and the 11 subsequent months). ***/^^, **/^^ denote statistical significant difference at the .01 and .05 levels for the comparison of group means to the mean for women with OUD within maternal characteristic.

^a See notes to Table 1.

^b Calculated by dividing the total number of stays/visits by the total number of enrolled months for each person before delivery and then averaging across the sample. People with 0 enrolled months before delivery are excluded from the average.

Table 4

Infant health care utilization and infant outcomes for infants with women with a diagnosed substance use disorder (SUD) who delivered infants in 2014 or 2015 by SUD status and type for three state Medicaid programs.

Source: Birth certificates and claims and enrollment data for women and their infants, three state Medicaid programs covering the 24 months surrounding the deliveries (2013–2016). NICU, number of hospital days, and drug/alcohol related diagnoses are from the claims data. Other estimates are from the birth certificate data.

	Infants of sample women by status and type of diagnosed maternal SUD				
	Any Opioid Use Disorder (OUD)			Other SUD (compared to any OUD)	No SUD (compared to any OUD)
	All [ref*]	No Treatment Before Delivery [ref*]	Any Methadone Treatment Before Delivery (compared to no treatment)		
All sample infants					
NICU during birth hospitalization ^b	38.9%	35.4%	49.2% ^{***}	17.5% ^{***}	10.2% ^{***}
# NICU days, if any NICU	17.2	16.9	22.1 ^{^^}	15.3	11.9 ^{***}
# Hospital days during birth hospitalization	10.8	9.5	17.9 ^{^^}	5.2 ^{***}	3.4 ^{***}
Preterm (< 37 weeks)	14.8%	16.3%	19.1%	14.3%	8.0% ^{***}
Very preterm (< 34 weeks)	4.0%	4.7%	7.1%	4.2%	2.0% ^{***}
Low birth weight (less than 2500 grams)	15.2%	16.0%	16.9%	13.6%	6.9% ^{***}
Very low birth weight (less than 1500 grams)	2.1%	2.3%	4.5%	2.0%	1.0% ^{***}
Any infant drug/alcohol related diagnosis	45.8%	36.6%	65.7% ^{^^}	11.6% ^{***}	0.0% ^{***}
Neonatal Abstinence Syndrome (NAS)	32.2%	25.0%	52.5% ^{^^}	4.7% ^{***}	0.0% ^{***}
Suspicion of exposure to drugs/alcohol via placenta or breast milk	24.0%	17.8%	31.4% ^{^^}	7.7% ^{***}	0.0% ^{***}
Total N	1537	838	216	4105	63,786

Note. Analysis includes only mothers and their singleton infants who were alive after delivery and had full-benefit eligibility and claims in at least one month in the 24 month study period (i.e., 12 months before the delivery month, the delivery month, and the 11 subsequent months). ^{***}/^{^^}, ^{**}/^{^^} denote statistical significant difference at the .01 and .05 levels for the comparison of group means to the mean for women with OUD within infant outcome.

^aSee notes to Table 1.

^bIncludes infants readmitted if readmission occurred the same day as discharge from the delivery hospitalization or the day after discharge from the delivery hospitalization.

Table 5

Maternal and infant health care expenditures among women with a diagnosed substance use disorder (SUD) who delivered infants in 2014 or 2015 by SUD status and type for three state Medicaid programs.

Source: Birth certificates and claims and enrollment data for women and their infants, three state Medicaid programs covering the 24 months surrounding the deliveries (2013–2016). Expenditure estimates were derived from the claims data.

Health care expenditures ^b	Sample women by status and type of diagnosed SUD ^a				
	Any Opioid Use Disorder (OUD)			Other SUD (compared to any OUD)	No SUD (compared to any OUD)
	Any OUD [ref*]	No treatment before delivery [ref*]	Any methadone treatment before delivery (compared to no treatment)		
Average monthly expenditures during enrolled months					
During the 12 months before delivery month	\$821	\$617	\$1168 ^{^^}	\$633 ^{***}	\$325 ^{***}
During the 11 months following delivery month and hospitalization					
Maternal	\$721	\$790	\$782	\$396 ^{***}	\$190 ^{***}
Infant	\$488	\$619	\$406	\$355 ^{**}	\$255 ^{***}
Total expenditures during enrolled months					
During the 12 months before delivery month	\$6646	\$4310	\$11,321 ^{^^}	\$5335 ^{***}	\$2510 ^{***}
In the delivery month and hospitalization (maternal and infant)	\$22,485	\$20,257	\$34,885 ^{^^}	\$16,171 ^{***}	\$11,196 ^{***}
During the 11 months following delivery month and hospitalization					
Maternal	\$6225	\$6093	\$8127	\$3457 ^{***}	\$1321 ^{***}
Infant	\$5019	\$6413	\$3657 ^{**}	\$3582	\$2488 ^{***}
Total N	1537	838	4105	216	63,786

Note. Analysis includes only mothers and their singleton infants who were alive after delivery and had full-benefit eligibility and claims in at least one month in the 24 month study period (i.e., 12 months before the delivery month, the delivery month, and the 11 subsequent months). ^{***}/^{^^}, ^{**}/^{^^} denote statistical significant difference at the .01 and .05 levels for the comparison of group means to the mean for women with OUD within infant outcome.

^a See notes to Table 1.

^b Expenditures are summed for enrollees defined as people enrolled for any length of time during the period.

OUD who obtained any methadone treatment, the monthly rate of methadone treatment was only 30 percent, and the average number of consecutive months with methadone treatment before birth was 2.8. Treatment that does not meet standards of care is less likely to be effective. We suspect that lack of recommended standard of methadone care is one reason why outcomes for mothers with methadone treatment were no better than outcomes for women with no OUD treatment. Because access to medication treatment in this population is so limited, we also suspect that those treated with methadone might have been more severe cases that are not representative of a broader group of pregnant women with OUD, and thus these women would have had higher health care costs regardless of treatment. The infants of these mothers may have higher costs due to higher medical needs during the birth hospitalization. However, their costs may also be higher as a result of NICU and pharmacological treatment overuse, potentially increasing costs without improving outcomes (Devlin et al., 2017; Holmes et al., 2016; MacMillan et al., 2018). This is an important area for future research.

Improving access to treatment involves ensuring sufficient resources, including trained providers, to offer care for all eligible pregnant and postpartum women. The data reveal that many women engaged in some form of treatment at some point in the year before and/or the year after birth, suggesting that many pregnant and parenting women want treatment. The low monthly rates of maternal treatment suggest an urgent need for comprehensive, high-quality, evidence-based OUD treatment, development of targeted workforce (e.g., prenatal care providers who have training in addiction medicine and are waived to prescribe buprenorphine) and infrastructure (e.g., co-location of MAT and prenatal care, optimal use of technology to improve care and to facilitate and track care coordination), and coordinated efforts to facilitate delivery of preventive and treatment services to maternity care patients across multiple settings. Efforts to train physicians and other providers to prescribe medications as part of MAT are underway (Substance Abuse and Mental Health Services Administration (SAMHSA, 2018b) but may need to be expanded further among those with expertise in maternity care. Though most advance practice nurses are currently eligible to train to provide MAT under the Comprehensive Addiction and Recovery Act (American Society of Addiction Medicine (ASAM, 2018), certified nurse midwives are not (American College of Nurse-Midwives (ACNM, 2018).

Our results also point to broader contextual issues including a critical need for treatment engagement across multiple settings and linkages to community and family services to support treatment retention and recovery. Addressing stigma and misinformation among women, their family and peers, maternity care and neonatal providers, and the general population is also essential to provision and uptake of appropriate treatment. Ensuring that seeking treatment is not a cause for women to be separated from their infants may also be a key element for initiation and continuation of OUD treatment for pregnant and postpartum women.

Our sample of women with OUD in these three states tended to be white, older, and residing in suburban areas. There may be efficiencies associated with targeting treatment and overdose prevention interventions by state or locality, such as by identifying specific areas needing more pregnancy-specific OUD care. In addition, our findings suggest that pregnant women and mothers with OUD and other SUDs have a high rate of mental health comorbidities that may complicate OUD or SUD or act as a trigger for recurrence of use. Thus, in addition to therapeutic interventions that are part of MAT, many of these women may need psychiatric treatment for other mental health needs (Dugosh et al., 2016).

Nearly 40 percent of infants of women with OUD had a NICU stay with an average stay over 17 days. Because many NICUs do not offer rooming in, such stays can mean a lengthy period of unnecessary separation between mother and infant. NICU care, as opposed to rooming-in with the mother, has been shown to correlate with

substantial increases in the length of pharmaceutical treatment for NAS, such as morphine, rather than evidence-based non-pharmacological techniques, such as skin-to-skin contact and breastfeeding, which have been shown to reduce length of stay and costs (Grossman et al., 2017; Holmes et al., 2016; MacMillan et al., 2018). The high cost of health care use among women with OUD and their infants compared to other groups is likely driven in part by differences in NICU use.

This study has limitations. Some are inherent to the use of administrative health care data, including lack of data from additional payers and poor data quality. In some cases, limitations arise from the lack of detail in the claims data; for example, codes related to medication administration for a SUD diagnosis do not identify the medication. We did not have access to the full prescription drug data to fill in these gaps. In many cases, the procedure codes did identify medication treatment. For example, methadone treatment for OUD is not prescribed—it is dispensed at Opioid Treatment Facilities (also known as methadone clinics), whose claims data are included in this study. However, the other key medication treatment for maternal OUD, buprenorphine, is prescribed. Buprenorphine treatment was identified using claims and diagnosis codes for laboratory testing related to buprenorphine treatment, so our study may undercount buprenorphine treatment and instead count those people as receiving intensive outpatient or other types of SUD treatment. In addition, we are not able to observe key treatment characteristics such as medication dose and any SUD treatment not covered by Medicaid. Inference from these findings is limited because we cannot identify the specific states, and eligibility and treatment policies vary across states. The study is based on just three states, and although the states vary widely geographically and in the characteristics of their Medicaid programs, their health care infrastructure—particularly for substance use treatment—limits the generalizability of the findings to other states. The “other SUD” group could include individuals with unspecified or undiagnosed OUD, particularly since it includes those with unspecified SUD. The data we accessed for this study excluded women or infants who died before delivery or at delivery, precluding examination of mortality outcomes. Lastly, the non-experimental nature of our study design precludes causal interpretations.

5. Conclusions

This study reveals the critical need for interventions to improve access to comprehensive, evidence-based treatment for mothers with OUD and other SUDs. The lack of sustained treatment or use of MAT indicates inadequate treatment for women before, during, and after birth. If a patient is not already in treatment when she gives birth, outreach to initiate and support evidence-based, ongoing treatment during the birth hospitalization could improve outcomes for mothers and their infants. Such interventions will likely require changes in provider and patient attitudes and knowledge about effective treatment for substance use during and after pregnancy. Federal, state, and local investments could support changes in culture and expansions of the delivery infrastructure that would expand availability and delivery of effective treatment.

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Contributors

Dr. Clemans-Cope had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Clemans-Cope, Lynch, Howell, Hill. Acquisition of data: Holla, Morgan, Johnson. Analysis and interpretation of data: All authors. Drafting of the manuscript: Clemans-

Cope, Lynch, Howell, Cross-Barnet, Thompson. Study supervision: Clemans-Cope. All authors contributed to and approved the final version of the manuscript.

Conflict of interest

No conflicts declared.

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