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Impact of prenatal substance use policies on commercially insured pregnant females with opioid use disorder

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ABSTRACT

Introduction: States' approaches to addressing prenatal substance use are widely heterogeneous, ranging from supportive policies that enhance access to substance use disorder (SUD) treatment to punitive policies that criminalize prenatal substance use. We studied the effect of these prenatal substance use policies (PSUPs) on medications for opioid use disorder (OUD) treatment, including buprenorphine, naltrexone, and methadone, psychosocial services for SUD treatment, opioid prescriptions, and opioid overdoses among commercially insured pregnant females with OUD. We evaluated: (1) punitive PSUPs criminalizing prenatal substance use or defining it as child maltreatment; (2) supportive PSUPs granting pregnant females priority access to SUD treatment; and (3) supportive PSUPs funding targeted SUD treatment programs for pregnant females.

Methods: We analyzed 2006–2019 MarketScan Commercial Claims and Encounters data. The longitudinal sample comprised females aged 15–45 with an OUD diagnosis at least once during the study period. We estimated fixed effects models that compared changes in outcomes between pregnant and nonpregnant females, in states with and without a PSUP, before and after PSUP implementation.

Results: Our analytical sample comprised 2,438,875 person-quarters from 164,538 unique females, of which 13% were pregnant at least once during the study period. We found that following the implementation of PSUPs funding targeted SUD treatment programs, the proportion of opioid overdoses decreased 45% and of any OUD medication increased 11%, with buprenorphine driving this increase (13%). The implementation of SUD treatment priority PSUPs was not associated with significant changes in outcomes. Following punitive PSUP implementation, the proportion receiving psychosocial services for SUD (12%) and methadone (30%) services decreased. In specifications that estimated the impact of criminalizing policies only, the strongest type of punitive PSUP, opioid overdoses increased 45%.

Conclusion: Our findings suggest that supportive approaches that enhance access to SUD treatment may effectively reduce adverse maternal outcomes associated with prenatal opioid use. In contrast, punitive approaches may have harmful effects. These findings support leading medical organizations' stance on PSUPs, which advocate for supportive policies that are centered on increased access to SUD treatment and safeguard against discrimination and stigmatization. Our findings also oppose punitive policies, as they may intensify marginalization of pregnant females with OUD seeking treatment.

1. Introduction

Opioid misuse, opioid overdose deaths, and opioid use disorder (OUD) are at an alarmingly high level in the United States. These adverse outcomes have also increased among pregnant females, of which an estimated 4.5% self-reported past year opioid misuse in

2018–2019 (SAMHDA, 2021). Among those that reported misuse, 10% met DSM-IV criteria for OUD. The incidence of maternal OUD is on the rise, increasing from 1.1 per 1000 births in 2000 to 8.2 per 1000 births in 2017 (Hirai et al., 2021). Opioid use and use disorder during pregnancy is a major public health concern as opioid exposure can have deleterious impacts not only on mothers but also their newborns. The health impacts

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of in utero exposure to opioids have been well documented in the literature and include higher rates of birth defects, low birth weight, low gestational age, and neonatal drug withdrawal syndrome (Desai et al., 2015; Huybrechts et al., 2018; Maeda et al., 2014 and Patrick et al., 2012).

To address potential adverse effects of prenatal substance exposure, states have implemented punitive and supportive prenatal substance use policies (PSUPs) since the crack cocaine epidemic in the 1980s. Punitive PSUPs either criminalize prenatal substance use, defining prenatal substance exposure as child maltreatment in child welfare statutes or as grounds for termination of parental rights, or utilize other punitive approaches. In contrast to punitive PSUPs, supportive PSUPs are rehabilitative and seek to provide early intervention and substance use disorder (SUD) treatment services in a nondiscriminatory manner. For instance, supportive PSUPs focus on increasing access to SUD treatment by creating or funding targeted SUD treatment programs specifically for pregnant females. Other supportive policies grant pregnant females priority access to SUD treatment programs, which is particularly important if the program has a waitlist (Figdor & Kaeser, 1998; Christian, 2004; Miranda et al., 2015; Angelotta et al., 2016). As such, these PSUPs may have implications for prenatal opioid use and misuse, provider screening and referral, patients' care-seeking behavior, access to SUD treatment, and pregnancy outcomes.

Empirical evidence on PSUPs and their effectiveness remains scarce. The handful of quantitative PSUP studies have focused on infant outcomes, such as neonatal drug withdrawal syndrome and foster care admissions, rather than on maternal outcomes (Atkins & Durrance, 2020; Atkins & Durrance, 2021; Faherty et al., 2019; Faherty et al., 2021; Osterling et al., 2008; Sanmartin et al., 2019; Sanmartin et al., 2020; Maclean et al., 2022; Meinhofer et al., 2022). Notable exceptions are two studies that investigated the impact of PSUPs on admissions to specialty SUD treatment programs among pregnant females using data from the Treatment Episode Data Set Admissions (Atkins & Durrance, 2020; Kozhimannil et al., 2019). Kozhimannil et al. (2019) found that states with criminalizing policies only were associated with a 1 percentage point decline in the proportion of SUD treatment admissions from pregnant females relative to states with no PSUPs. States with multiple concurrent policies (both punitive and supportive) were associated with a 1.3 percentage point increase in the proportion of SUD treatment admissions from pregnant females relative to states with no PSUPs. Atkins and Durrance (2020) found a 1 percentage point decline in the proportion of SUD treatment admissions from pregnant females following the adoption of punitive PSUPs.

The ongoing opioid crisis and its effects on perinatal populations have refocused national attention on PSUPs. In 2016, the Comprehensive Addiction and Recovery Act amended the Child Abuse Prevention and Treatment Act (CAPTA), expanding health care providers' requirements to create plans of safe care for substance-exposed infants and to notify child protective services when identifying substance-exposed infants. States have interpreted these provisions differently—some imposing explicit statutes, regulations, or programs, whereas others have only distributed memorandums to notify providers of new provisions. Understanding the impact of PSUPs on maternal health is a crucial policy question as states seek to alleviate rising rates of OUD in pregnancy and its societal burden, including foster care workloads from parental drug use and neonatal drug withdrawal syndrome (Patrick et al., 2012; Meinhofer and Angleró-Díaz, 2019; Roberts & Pies, 2011; Roberts et al., 2019). Furthermore, states and the federal government continue to enact and revise policies regarding substance use in pregnancy. Advancing this body of research will help to inform the implementation of policies and programs that support well-being among substance-exposed infants and their mothers.

We studied the effect of PSUPs on maternal outcomes, including medications for OUD treatment (MOUD), including buprenorphine, naltrexone and methadone; psychosocial services for SUD treatment; opioid prescriptions; and opioid overdoses among commercially insured pregnant females with OUD. Previous research suggests that about a third of pregnant females with self-reported prescription opioid misuse in the past year are privately insured (Kozhimannil et al., 2017). We evaluated: (1) punitive PSUPs criminalizing prenatal substance use or defining prenatal substance exposure as child maltreatment or as grounds for termination of parental rights or imposing other punitive approaches; (2) supportive PSUPs granting pregnant females priority access to SUD treatment programs; and (3) supportive PSUPs creating or funding targeted SUD treatment programs specifically for pregnant females. We also performed secondary analyses to explore variation in the stringency of punitive PSUPs. We analyzed longitudinal data from the 2006–2019 MarketScan Commercial Claims and Encounters database in 51 states. We estimated fixed effects models that exploited quasi-experimental variation in the staggered implementation of PSUPs to compare changes in outcomes between pregnant and nonpregnant females, in states with and without a PSUP, before and after PSUP implementation.

Our study contributes to the nascent PSUP literature in various ways. First, we are the first to analyze a variety of important maternal outcomes: MOUD, psychosocial services for SUD treatment, prescriptions for opioids, and opioid overdoses. These outcomes capture access to SUD treatment, as well as unequivocal measures of opioid-related adverse health events. Opioid use and misuse during pregnancy, including prescription opioids, have important implications for perinatal health and child welfare outcomes as they are associated with neonatal drug withdrawal syndrome, low gestational age, and foster care placement. Second, our study focuses on OUD populations instead of SUD populations more broadly, along with OUD treatment options that include nonspecialty treatment settings. This focus contrasts with previous literature on the effect of PSUPs on SUD treatment outcomes in specialty SUD treatment settings among pregnant females with SUD using data from the Treatment Episode Data Set Admissions. Third, the fixed effects method we use is a more robust approach, as it can remove bias from unobserved national- and state-level factors affecting outcomes for pregnant and nonpregnant females with OUD. Our study's findings can help to elucidate the real impact and potential unintended consequences of various prenatal substance use policies on pregnant females with OUD, which is necessary for improving the well-being of the mother-infant dyad.

2. Material and methods

2.1. Data sources

We analyzed data from the 2006–2019 MarketScan Commercial Claims and Encounters database. Claims from MarketScan include more than 100 employer-sponsored commercial insurance plans for employees and their dependents through age 64. Data are longitudinal and include information on both inpatient and outpatient encounters and prescriptions dispensed. Between 2006 and 2019, MarketScan comprised 172,636,434 unique individuals with 444,174,378 person-years of follow-up.

2.2. Study population

We identified females of childbearing age (15 to 45 years old) with an OUD diagnosis at least once during the study period of 2006–2019, for a total of 2,438,875 person-quarter observations from 164,538

unique female patients. The study included person-quarters for females enrolled in their insurance plan every day of the quarter. This allowed us to differentiate between lack of utilization of health services and non-enrollment. The study defined presence of OUD by at least two outpatient or one inpatient visit(s) with evidence of OUD as documented with International Classification of Diseases (ICD) version 9 and 10 codes (304.0X, 304.7X, 305.5X, and F11.X), which follows other claims-based analyses in the literature (Howell et al., 2021; Morgan et al., 2018). To identify quarters in which females were pregnant, we first selected those females who had a documented delivery in their medical claims, and then used a validated algorithm to estimate the date of conception, which was based on the date of delivery and whether the infant was premature (Margulis et al., 2013). We identified a total of 20,301 unique females who were pregnant and had an OUD diagnosis at least once during the study period.

2.3. Outcome variables

The outcome variables included indicators of MOUD (buprenorphine prescriptions, naltrexone prescriptions, and methadone), psychosocial services for SUD treatment, opioid prescriptions, and opioid overdoses. The research team made all MOUD indicator variables equal to one if an individual received the specified MOUD for at least one day of the calendar quarter, and zero otherwise. The study identified buprenorphine, naltrexone, and opioid prescriptions using National Drug Codes from filled outpatient pharmacy prescriptions (see Appendix Table 2). The naltrexone variable comprised both available administrations of the drug—pill form and the extended release injectable formulation. Because methadone is administered at opioid treatment programs, the study identified methadone-related claims using Healthcare Common Procedure Coding System (HCPCS) codes (see Appendix Table 5). Methadone estimates are exploratory due to difficulties identifying methadone services in commercial insurance claims. The study then used the number of days dispensed by the pharmacy to calculate the period of buprenorphine, naltrexone, or opioid prescriptions uptake. As injectable naltrexone is administered in-office, we also used the Current Procedural Terminology (CPT) code (J2315) to identify naltrexone; the study set the duration of injectable naltrexone as 28 days per package insert dosing instructions. The study made these indicator variables equal to one if an individual was prescribed the medication for at least one day of the calendar quarter, and zero otherwise. Additionally, the study generated an “any MOUD” indicator to capture OUD treatment with any of the medications: naltrexone or buprenorphine or methadone.

The study identified psychosocial services for SUD treatment with outpatient claims and CPT and HCPCS codes indicative of these services (see Appendix Table 4) (Mutter et al., 2021) along with ICD 9/10 diagnostic codes indicative of an SUD diagnosis in the same claim. The team made the indicator variable equal to one if an individual received psychosocial services for SUD during at least one day of the calendar quarter, and zero otherwise. We identified opioid overdoses (fatal and nonfatal) using ICD 9 and 10 diagnostic codes (see Appendix Table 3). We included evidence of overdose in the outpatient context. Of all claims of opioid overdose, approximately 4% were inpatient admissions. Of the outpatient claims, 68% listed the place of care as “outpatient hospital on campus” and 26% were from the emergency department (Morgan et al., 2019). The study made the indicator variable equal to one if an individual had at least one overdose event in the calendar quarter, and zero otherwise.

2.4. Policy variables

We collected PSUP statutes, effective dates, and repeal dates from various sources, including the Guttmacher Institute’s PSUP statute database, the Children’s Bureau (Administration for Children and Families, 2021; Guttmacher Institute, 2019; Jarlenski et al., 2018), and other studies and reports (Thomas et al., 2018; Faherty et al., 2019; Atkins &

Durance, 2020; Miranda et al., 2015). Some inconsistencies existed in PSUP definitions and effective dates across sources, as previously documented by others (Reddy and Schiff, 2021). We investigated and reconciled these mismatches through original legal research using Westlaw, HeinOnline, and LexisNexis, by contacting state child welfare agencies (Child Welfare Information Gateway, 2021), by reading available documentation in state websites and other official sources, and through consensus across sources (see Appendix Table 1).

We used effective and repeal dates of the policies to generate indicator variables for the implementation of punitive and supportive PSUPs. The study considered two types of supportive PSUPs: (1) policies creating or funding targeted SUD treatment programs specifically for pregnant females—henceforth, “SUD treatment funding”—and (2) SUD treatment priority for pregnant females—henceforth, “SUD treatment priority”. SUD treatment funding PSUPs allocate public funding and resources to expand the capacity of SUD treatment programs and services for pregnant females.¹ SUD treatment priority policies specify pregnant females with SUD as a priority population for access to SUD treatment services, which is particularly important if a waitlist exists. In states with punitive PSUPs, prenatal substance use is criminalized, defined as child abuse or neglect in child welfare statutes, grounds for termination of parental rights, used as evidence to substantiate reports of child abuse or neglect, or may result in being placed in a child protective services registry without initial punishments or repercussions. A same state could have multiple types of PSUPs in the same time period. During our sample period, six states had variation in SUD treatment funding PSUP effective or repeal dates, fifteen states had variation in SUD treatment priority PSUPs effective or repeal dates, and fourteen states had variation in punitive PSUP effective or repeal dates (see Appendix Table 1).

In secondary analyses, we redefined the punitive PSUP indicator by using only variation from the subset of states with more stringent punitive policies. In particular, we stratified stringent punitive PSUPs into (1) criminalizing PSUPs and (2) strong child welfare punitive PSUPs (prenatal substance exposure is defined as child abuse or neglect or grounds for termination of parental rights), and ignored variation from weak child welfare punitive PSUPs. This definition of stringent punitive PSUPs excludes variation from states with weaker punitive PSUPs such as Idaho, in which prenatal drug use cases may result in one’s name added to a child protection registry, without initial punishments or repercussions. It also excludes states such as New Mexico and Rhode Island, where prenatal drug exposure may be used as evidence to substantiate a claim of child abuse or neglect but is not itself defined as abuse or neglect. Of note, stratifications of stringent punitive PSUPs leave us with a limited number of switching policies in each category, making results from these analyses exploratory.

2.5. Statistical analysis

We estimated fixed effects models that compared changes in outcomes between pregnant and nonpregnant reproductive age females with OUD, in states with and without a PSUP, before and after the PSUP became effective. Eq. (1) offers a formal representation of our regression model:

¹ For instance, Illinois’ SUD treatment funding PSUP states that “...the Department shall create or contract with licensed, certified agencies to develop a program for the care and treatment of addicted pregnant women, addicted mothers and their children...” (301/35-5), while Louisiana’s SUD treatment funding PSUP, repealed in 2015, states that “The Department of Health and Hospitals shall establish a program to provide substance abuse services to eligible pregnant women. Such substance abuse services shall ensure the availability of appropriate alcohol and substance abuse treatment programs that do not discriminate against pregnant women or women with young children...” (RS 46:2505).

$$Y_{i,s,t} = \beta_0 + \sum_{p=1}^{p=3} \beta_{1,p} \text{Pregnant}_{i,s,t} \times \text{Policy}_{s,t,p} + \sum_{p=1}^{p=3} \beta_{2,p} \text{Policy}_{s,t,p} + \beta_3 \text{Pregnant}_{i,s,t} + \beta_4 X_{s,t} + \theta_s + \delta_t + \varepsilon_{i,s,t} \quad (1)$$

$Y_{i,s,t}$ is the outcome of interest for individual i , in state s , and year-quarter t . $\text{Policy}_{s,t,p}$ represents a vector of indicators for each PSUP p : 1) punitive PSUPs, 2) SUD treatment funding PSUPs, and 3) SUD treatment priority PSUPs. The indicator is equal to one if the PSUP p is effective in state s and year-quarter t , and equal to zero otherwise. $\text{Pregnant}_{i,s,t}$ is an indicator equal to one if the individual was pregnant during at least one day in the calendar quarter, and equal to zero otherwise. As such, the same female could be in both the treatment and the comparison group, depending on their pregnancy status in a calendar quarter. Given that the probability of opioid-related outcomes is dependent on opioid utilization or receipt of OUD treatment in previous periods, re-entry of the formerly pregnant female into the study's control group (i.e., non-pregnant group) may attenuate results, biasing the estimation away from finding effects. Nevertheless, we expect the potential for "contamination" of the control group, if any, to be small given the large number of nonpregnant females relative to pregnant females. $\beta_{1,p}$ is the estimate of the effect of PSUP p on outcome $Y_{i,s,t}$ for pregnant females relative to nonpregnant females, captured in the interaction term $\text{Pregnant}_{i,s,t} \times \text{Policy}_{s,t,p}$. $X_{s,t}$ is a vector of state-year varying control variables that include indicators for prescription drug monitoring program operations and mandates, pain clinic laws, the unemployment rate, Medicaid income thresholds for pregnant and postpartum females, and the Affordable Care Act Medicaid expansions (Meinhofer & Witman, 2018; Meinhofer, 2018; Meinhofer et al., 2021; Bullinger and Meinhofer, 2021); θ_s are state fixed-effects that account for time-invariant differences across states; δ_t are year-quarter fixed-effects that account for state-invariant secular trends in outcomes, and $\varepsilon_{i,s,t}$ is the error term. Linear probability models are estimated with least squares regressions and standard errors and 95% confidence intervals account for within state clustering. Because SUD treatment funding PSUPs have variation in a small number of states, we also report 95% confidence intervals based on a wild cluster bootstrap approach for stronger statistical inference when the number of total and treated clusters is small (Roodman et al., 2015; Cameron & Miller n.d.; Conley and Taber, 2011; Cameron et al., 2008).

3. Results

3.1. Descriptive results

Table 1 presents summary statistics. Our analytical sample comprises 2,438,875 person-quarter observations of reproductive age females with OUD, of which 2,352,858 observations correspond to nonpregnant person-quarters and 86,017 to pregnant person-quarters. Among pregnant females, 12% received any MOUD (buprenorphine, naltrexone, or methadone), 11.2% received buprenorphine prescriptions, 0.4% received naltrexone prescriptions, 0.6% received methadone services, 30.9% received opioid prescriptions, and 10.5% received psychosocial services for SUD treatment. Additionally, approximately 0.2% had an opioid overdose. Fig. 1 plots time trends in the proportion of pregnant females receiving any MOUD by PSUP implementation status.

3.2. Regression results

Table 2 reports the main regression results. We found that the proportion of pregnant females with any MOUD increased by 0.0131 (95% CI = 0.001, 0.025), following the implementation of SUD treatment

funding PSUPs. This growth was driven by buprenorphine prescriptions, which increased by 0.0146 (95% CI = 0.003, 0.026). Relative to the sample mean of 0.12 for any MOUD and of 0.112 for buprenorphine, this represented a 11% increase in any MOUD and a 13% increase in buprenorphine prescriptions among pregnant females compared to nonpregnant females. We also found that naltrexone prescriptions decreased by 0.0019 (95% CI = -0.0036, -0.0002) and opioid overdoses decreased by 0.0009 (95% CI = -0.0015, -0.0003), following the implementation of SUD treatment funding PSUPs. Relative to the sample mean of 0.004 for naltrexone and 0.002 for opioid overdoses, this represented a 47.5% decrease in naltrexone prescriptions and a 45% decrease in opioid overdoses among pregnant females compared to nonpregnant females.

Following the implementation of punitive PSUPs, the proportion of pregnant females receiving methadone decreased by 0.0018 (95% CI = -0.0037, 0.0001) and the proportion receiving psychosocial services for SUD decreased by 0.0124 (95% CI = -0.021, -0.004). Relative to the sample mean of 0.006 for methadone and of 0.105 for psychosocial services, this represented a 30% decrease for methadone and a 12% decrease in psychosocial services. We found no statistically significant association between our outcomes and SUD treatment priority PSUPs. Moreover, we found no statistically significant effect between opioid prescriptions and implementation of PSUPs.

Table 3 reports exploratory analyses using variation from stratified stringent punitive PSUPs as described in Section 2.4. We found that following implementation of criminalizing PSUPs, the strongest type of punitive PSUP, a 0.0009 (95% CI = 0.0002, 0.0015) increase in the

Table 1
Summary statistics 2006 to 2019.

	Pregnant	Non-pregnant	Total
	$N =$	$N =$	$N =$
	86,017	2,352,858	2,438,875
Outcome variables			
Buprenorphine	0.112	0.109	0.109
Naltrexone	0.004	0.011	0.011
Methadone	0.006	0.004	0.004
Buprenorphine, naltrexone or methadone	0.120	0.123	0.123
Psychosocial services for SUD	0.105	0.112	0.112
Opioid prescriptions	0.309	0.313	0.313
Opioid overdoses	0.002	0.003	0.003
Prenatal substance use policies			
Punitive	0.429	0.443	0.442
SUD treatment funding	0.631	0.626	0.626
SUD treatment priority	0.315	0.305	0.305
Control variables			
PDMP operations	0.893	0.894	0.894
PDMP mandates	0.325	0.322	0.322
Pain clinic laws	0.262	0.263	0.263
Medicaid income thresholds for pregnant females	2.075	2.085	2.085
Affordable Care Act Medicaid expansions	0.245	0.243	0.243
Unemployment	6.648	6.581	6.583

Source: 2006–2019 MarketScan Commercial Claims and Encounters database.

Notes: The unit of analysis is an individual-quarter.

PDMP = Prescription Drug Monitoring Program. SUD = Substance use disorder.

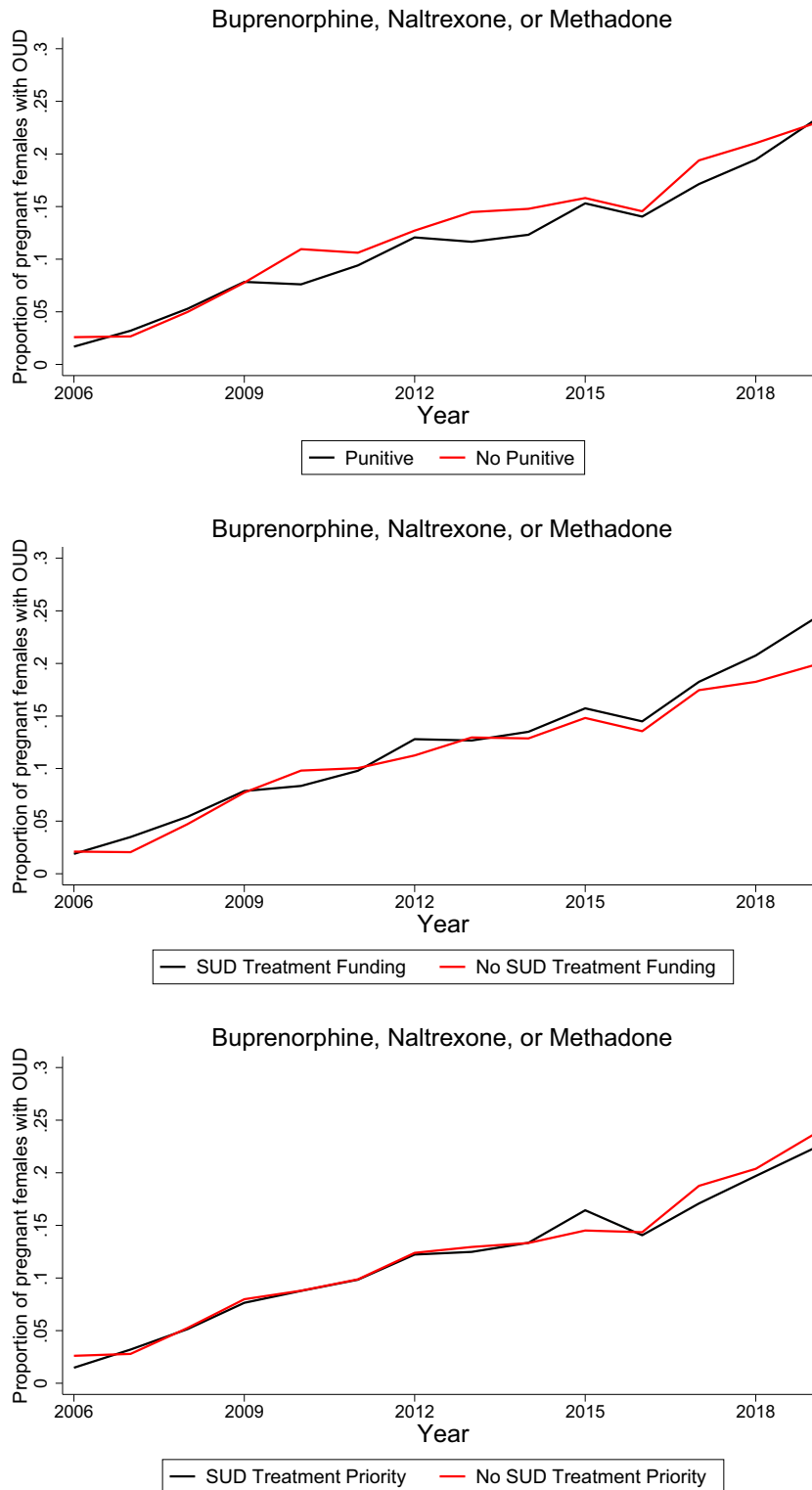


Fig. 1. Trends in medication for opioid use disorder among pregnant females, by prenatal substance use policy implementation status. Source: 2006–2019 MarketScan Commercial Claims and Encounters database. Notes: The unit of analysis is an individual-quarter. OUD = opioid use disorder.

proportion of opioid overdoses occurred. This is a 45% increase in opioid overdoses among the pregnant group relative to the sample mean of 0.002. We also found that the proportion of pregnant females receiving buprenorphine prescriptions decreased by 0.0108 (95% CI = -0.0226, 0.0009), methadone decreased by 0.0018 (95% CI = -0.0038, 0.0001), any MOUD decreased by 0.0133 (95% CI = -0.0244, 0.0022)

and psychosocial services decreased by 0.0140 (95% CI = -0.0224, -0.0056), following implementation of strong child welfare punitive PSUPs. This represented a 9.6% decrease in buprenorphine prescriptions, 30% decrease in methadone prescriptions, 11.1% decrease in any MOUD, and 13.3% decrease in psychosocial services for SUD treatment among the pregnant group. Of note, these stratifications of

Table 2
Impact of prenatal substance use policies on commercially insured pregnant females with opioid use disorder.

	Buprenorphine	Naltrexone	Methadone	Buprenorphine, naltrexone or methadone	Psychosocial services	Opioid prescriptions	Opioid overdoses
Punitive × pregnant	−0.0051 (0.0063) [−0.018,0.008] {−0.019,0.009}	−0.0009 (0.0008) [−0.002,0.001] {−0.003,0.001}	−0.0018* (0.0009) [−0.0037,0.0001] {−0.0039,0.0001}	−0.0079 (0.0061) [−0.020,0.004] {−0.021,0.006}	−0.0124*** (0.0041) [−0.021,−0.004] {−0.021,−0.003}	−0.0052 (0.0085) [−0.022,0.012] {−0.025,0.013}	0.0002 (0.0003) [−0.0004,0.0009] {−0.0005,0.0009}
SUD Tx funding × pregnant	0.0146** (0.0056) [0.003,0.026] {0.003,0.026}	−0.0019** (0.0009) [−0.0036,−0.0002] {−0.0036,−0.0000}	0.0002 (0.001) [−0.002,0.002] {−0.002,0.002}	0.0131** (0.0058) [0.001,0.025] {0.001,0.025}	−0.0033 (0.0041) [−0.012,0.005] {−0.013,0.006}	0.0038 (0.0083) [−0.013,0.020] {−0.014,0.023}	−0.0009*** (0.0003) [−0.0015,−0.0003] {−0.0016,−0.0002}
SUD Tx priority × pregnant	0.0082 (0.0082) [−0.008,0.025] {−0.010,0.026}	0.0000 (0.0008) [−0.002,0.002] {−0.002,0.002}	−0.0006 (0.0008) [−0.002,0.001] {−0.002,0.001}	0.0076 (0.0081) [−0.009,0.024] {−0.011,0.025}	−0.0039 (0.0046) [−0.013,0.005] {−0.015,0.007}	−0.0128 (0.0105) [−0.034,0.008] {−0.036,0.013}	0.0002 (0.0003) [−0.0003,0.0007] {−0.0004,0.0007}
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,438,875	2,438,875	2,438,875	2,438,875	2,438,875	2,438,875	2,438,875
States	51	51	51	51	51	51	51

Source: 2006–2019 MarketScan Commercial Claims and Encounters database.

Notes: Fixed effects models are estimated with least squares and include controls listed in Table 1, state fixed effects and year-quarter fixed effects. The unit of analysis is an individual-year-quarter. State clustered standard errors are in parentheses and 95% confidence intervals are in brackets. Wild cluster bootstrapped 95% confidence intervals are in curly brackets. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.1$.

SUD Tx = Substance use disorder treatment. FE = fixed effect. Year-Qtr = Year-quarter.

Table 3
Impact of prenatal substance use policies on commercially insured pregnant females with opioid use disorder, stringent punitive PSUPs.

	Buprenorphine	Naltrexone	Methadone	Buprenorphine, naltrexone or methadone	Psychosocial services	Opioid prescriptions	Opioid overdoses
Criminalizing × pregnant	0.0368 (0.0282) [−0.020,0.093] {−0.726,0.245}	0.000 (0.0011) [−0.002,0.002] {−0.018,0.047}	−0.0008 (0.0014) [−0.0037,0.0020] {−0.0365,0.0124}	0.0351 (0.0274) [−0.020,0.090] {−0.769,0.214}	−0.0047 (0.0086) [−0.022,0.013] {−0.076,0.247}	−0.0136 (0.0336) [−0.081,0.054] {−0.505,1.423}	0.0009*** (0.0003) [0.0002,0.0015] {−0.0004,0.0082}
Strong child welfare punitive × pregnant	−0.0108* (0.0059) [−0.023,0.001] {−0.023,0.003}	−0.0007 (0.0008) [−0.002,0.001] {−0.003,0.001}	−0.0018* (0.001) [−0.0038,0.0001] {−0.0039,0.0001}	−0.0133** (0.006) [−0.024,−0.002] {−0.025,−0.001}	−0.0140*** (0.0042) [−0.022,−0.006] {−0.023,−0.004}	−0.0025 (0.0085) [−0.020,0.015] {−0.024,0.015}	0.000 (0.0003) [−0.0005,0.0006] {−0.0006,0.0007}
SUD Tx funding × pregnant	0.0129** (0.0053) [0.002,0.024] {0.001,0.025}	−0.0019** (0.0008) [−0.0036,−0.0002] {−0.0037,0.0001}	0.0001 (0.001) [−0.0019,0.0022] {−0.0021,0.0023}	0.0113** (0.0056) [0.000,0.023] {−0.001,0.023}	−0.0036 (0.0041) [−0.012,0.005] {−0.012,0.005}	0.0042 (0.0081) [−0.012,0.020] {−0.012,0.022}	−0.0009*** (0.0003) [−0.0015,−0.0003] {−0.0016,−0.0002}
SUD Tx priority × pregnant	0.0074 (0.0073) [−0.007,0.022] {−0.010,0.024}	0.000 (0.0008) [−0.0016,0.0015] {−0.0017,0.0017}	−0.0006 (0.0008) [−0.0022,0.0010] {−0.0023,0.0012}	0.0067 (0.0071) [−0.008,0.021] {−0.011,0.023}	−0.0041 (0.0044) [−0.013,0.005] {−0.015,0.006}	−0.013 (0.0105) [−0.034,0.008] {−0.037,0.015}	0.0002 (0.0002) [−0.0003,0.0007] {−0.0004,0.0007}
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,438,875	2,438,875	2,438,875	2,438,875	2,438,875	2,438,875	2,438,875
States	51	51	51	51	51	51	51

Source: 2006–2019 MarketScan Commercial Claims and Encounters database.

Notes: Fixed effects models are estimated with least squares and include controls listed in Table 1, state fixed effects and year-quarter fixed effects. The unit of analysis is an individual-year-quarter. Stratifications of stringent punitive PSUPs into criminalizing PSUPs and strong child welfare punitive PSUPs leave us with a limited number of switching policies in each category, making results from these analyses exploratory. State clustered standard errors are in parentheses and 95% confidence intervals are in brackets. Wild cluster bootstrapped 95% confidence intervals are in curly brackets. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.1$.

SUD Tx = Substance use disorder treatment. FE = fixed effect. Year-Qtr = Year-quarter.

stringent punitive PSUPs leave us with a limited number of punitive PSUPs in each category, making results from Table 3 exploratory.

3.3. Robustness checks

We tested the sensitivity of estimates in various ways and found these all to be generally stable. The wild cluster bootstrap confidence intervals included in Tables 2 and 3, which account for a small number of total and treated groups, show no considerable changes in 95% confidence intervals when using this approach for statistical inference. One exception are 95% confidence intervals for criminalizing PSUPs, which become considerably wider; although, this does not affect conclusions from our findings. We also conducted robustness checks to explore the potential effect of PSUPs on selection into the treatment group and into the sample (Appendix Tables 6 and 7). First, we estimated the impact of PSUPs on the probability of becoming pregnant, using our sample of reproductive age females ever diagnosed with an OUD. Results indicate that neither of the PSUPs predicts the probability of becoming pregnant (Appendix Table 6). Second, using the full sample of pregnant females, regardless of ever being diagnosed with an OUD, we estimated the impact of PSUPs on OUD diagnoses. In particular, we estimated the impact of PSUPs on OUD diagnoses using a sample that includes all year-quarters of ever pregnant females, and a sample that includes only pregnant year-quarters. Appendix Table 7 reports results from these analyses, which show that PSUPs do not predict the probability of being included in the sample due to an OUD diagnosis among pregnant females. Appendix Table 8 reports estimates based on regressions that exclude control variables. Robustness of our study's stratifications of punitive PSUPs is further explored in Appendix Table 9, which combines both stringent punitive policies (criminalizing and strong child welfare) into one indicator as described in Section 2.4. Appendix Table 10 reports estimates based on PSUP definitions that ignore repeats, which assumes that physicians and patients maintain similar behaviors to when the policies were effective. Appendix Table 11 reports estimates based on a sample that drops individuals observed for less than one year to examine the role of compositional changes in our sample. Appendix Table 12 reports estimates based on regressions using pregnancy-year fixed effects, instead of year-quarter fixed effects. This allows for differential time trends for pregnant and nonpregnant groups. Appendix Table 13 reports estimates based on regressions that control for individual fixed effects, instead of state fixed effects. Appendix Tables 14–16 report estimates based on regressions where only one PSUP (punitive, SUD Tx Funding or SUD Tx Priority) is included at a time, instead of including all three policies at the same time in the model. Appendix Table 17 reports estimates based on regressions where pregnant and postpartum females are in the treated group instead of pregnant females only. Appendix Table 18 includes estimates from regressions that account for state-year fixed effect interactions, while Appendix Table 19 accounts for state-year fixed effect interactions and pregnancy-year fixed effect interactions. Last, Appendix Table 20 reports estimates based on regressions that control for pregnancy-year fixed effect interactions, state-year fixed effect interactions, and individual fixed effects. We find that estimates are robust to specifications with interactive terms.

4. Discussion

Elucidating the impacts of state prenatal substance use policies on pregnant females with SUD is key, as these policies have potential to mitigate or exacerbate some of the adverse effects of prenatal substance use in perinatal populations. Our study is one of the first to generate quasi-experimental evidence linking such policies with the health and health care outcomes of pregnant females with OUD. Using fixed effects methods, we documented three key findings.

First, we found that the proportion of any MOUD increased 11% and the proportion of opioid overdoses decreased 45% following the adoption of PSUPs creating or funding targeted SUD treatment programs

specifically for pregnant and postpartum females. Previous research documents that specialty SUD treatment facilities with targeted programs for pregnant and postpartum females are more likely to offer buprenorphine, methadone, and ancillary services, such as child care, housing, employment, social services, and domestic violence assistance, relative to specialty SUD treatment facilities without such targeted programs (Meinhofer et al., 2020). Previous research also documents that pregnant females receiving SUD treatment in specialized programs exhibit higher rates of treatment retention, illicit drug abstinence, and report fewer barriers to care (Niccols et al., 2012; Grella, 1999; Hser et al., 2011; Ashley et al., 2003). Therefore, decreases in opioid overdoses and increases in buprenorphine prescriptions could be driven, at least partially, by increases in access and utilization of OUD medications and other evidence-based comprehensive services following implementation of these supportive PSUPs. Additionally, SUD treatment funding PSUPs may help to mitigate discrimination and other barriers to SUD treatment among pregnant females. For example, a recent cross-sectional study found that pregnant females were less likely than nonpregnant females with OUD to be given an appointment with an OUD treatment clinician (Patrick et al., 2020). Policies that promote SUD treatment availability for pregnant patients could potentially reduce such barriers in the health care system and improve outcomes.

SUD treatment funding PSUPs were also associated with decreases in naltrexone prescriptions. The lower utilization of naltrexone may reflect greater access to gold standard OUD treatment medications, resulting in improved care for pregnant patients with OUD. Naltrexone, buprenorphine, and methadone are the only medications approved by the Food and Drug Administration to treat OUD. However, for pregnant females with OUD, only methadone and buprenorphine are currently recommended by leading medical organizations. Recent clinical data have supported naltrexone's safety in pregnancy (Towers et al., 2020), but these data are sparse. Obstetric society guidelines suggest that in some cases providers may choose to continue naltrexone for patients who are already stabilized on the drug and subsequently become pregnant (ACOG, 2017). As naltrexone is not a controlled substance, it is easier to prescribe than methadone or buprenorphine and not subject to burdensome licensing requirements. The creation of SUD treatment programs specifically for pregnant and postpartum females may have increased the availability of SUD treatment providers who are both licensed to prescribe methadone or buprenorphine and trained on care for pregnant patients, resulting in substitution away from naltrexone.

Second, we found that SUD treatment priority PSUPs were not associated with statistically significant changes in maternal outcomes or increased dispensing of OUD medications. While SUD treatment priority PSUPs should reduce access barriers for patients seeking care at SUD treatment facilities with waitlists, other facility- or patient-level barriers may still persist and limit such policies' ability to improve participation and engagement in treatment (Seay et al., 2017). In addition, federal law already requires that pregnant persons receive priority access at SUD treatment facilities that are opioid treatment programs or at facilities that receive federal substance use block grants, possibly making SUD treatment priority PSUPs less binding in the context of pregnant females with OUD. More research should elucidate whether SUD treatment priority PSUPs are effective in the context of pregnant females with other SUDs.

Third, we found that punitive PSUPs were associated with statistically significant reductions in the proportion of pregnant females receiving psychosocial services for SUD and methadone. Other MOUD outcomes were statistically insignificant, although coefficients were negative. When stratifying stringent punitive policies into criminalizing PSUPs and strong child welfare PSUPs, we found that criminalizing PSUPs, the strongest type of punitive PSUP, were associated with increases in opioid overdoses. The adoption of strong child welfare PSUPs was associated with decreases in MOUD and psychosocial services. Fear of punitive consequences associated with substance use during pregnancy may represent a barrier to accessing OUD care (Figdor & Kaeser,

1998; Jessup et al., 2003; Leech et al., 2020). Punitive PSUPs may discourage pregnant patients with OUD from accessing SUD treatment or other health care services due to the stigma and risk of separation of mother and infant. Similarly, criminalizing PSUPs may dampen naloxone uptake, an argument for making naloxone over the counter (Murphy et al., 2019; Walsh & Bratberg, 2021). Previous research has demonstrated that punitive PSUPs negatively impact admissions to specialty SUD treatment programs among pregnant females and worsen perinatal health (Atkins & Durrance, 2020; Faberty et al., 2019; Kozhimannil et al., 2019). Further research on opioid mortality and other health care outcomes not observed in our analysis, such as analysis inclusive of both commercially insured and Medicaid beneficiaries, are needed to further inform policymakers.

Although we did not find a statistically significant association between opioid prescriptions and the implementation of any PSUP, 30.9% of the pregnant group had opioid prescriptions in at least one quarter. Given the high rate of opioid prescriptions among pregnant females with OUD and their association with opioid misuse and adverse newborn outcomes, further research should evaluate the effect of PSUPs on opioid prescriptions among pregnant females.

This study is subject to various limitations. First, as our data are based on a sample of commercially insured individuals, our estimates may not generalize to other populations. Research using hospital data suggests that the majority of pregnant females with OUD at delivery are Medicaid beneficiaries (77%) (Hirai et al., 2021); however, research using nationally representative survey data suggests that nearly a third of pregnant females with self-reported prescription opioid misuse in the past year are privately insured (Kozhimannil et al., 2017). More generally, a large proportion of reproductive-age females with self-reported opioid misuse in the past year (51%) or with OUD in the past year (38%) are privately insured (SAMHDA, 2015-2018). As such, studying the impact of PSUPs on this population is important because a sizable proportion of commercially insured pregnant and nonpregnant reproductive-age females misuse opioids. Second, methadone for OUD in insurance claims may not properly reflect actual methadone use. Methadone for OUD is often not covered by commercial insurers and administration is restricted to opioid treatment programs that are largely separate from other health care services. Identification of methadone administration using billed procedure codes is challenging due to bundled payments or cash payments. More generally, some commercially insured patients may be receiving OUD treatment services that are financed through other payers or self-paid, and, thus, may not be accurately reflected in our data or measures. Third, state PSUPs and their scope of implementation and/or enforcement are likely to vary among states. These differences might be difficult to capture with a binary policy indicator. While we do stratify stringent punitive PSUPs in an effort to consider these differences, these stratifications leave us with a limited number of punitive PSUPs in each category, making results from Table 3 exploratory. This is especially true for criminalizing PSUPs, which exploit variation from three switching states. Last, MarketScan data do not allow for stratifications by race and ethnicity, which are important to consider as PSUPs may exacerbate or mitigate existing disparities in access to OUD medications.

Taken together, our findings suggest that supportive approaches may enhance SUD treatment utilization and improve health outcomes among commercially insured pregnant females with OUD, while punitive PSUPs may not improve maternal outcomes and possibly worsen them in some cases. Findings from our study support recommendations made by major medical and public health organizations, which emphasize greater access to treatment and medication for OUD and the repeal of punitive measures (ACOG, 2017; Ecker et al., 2019).

5. Conclusion

To create systems of care that improve well-being for pregnant females with substance use disorders, we must understand the

implications of PSUPs. Our findings suggest that among commercially insured pregnant females with OUD, supportive PSUPs that create or fund SUD treatment programs specifically for pregnant females may increase MOUD and decrease opioid overdoses. In contrast, punitive PSUPs may have harmful effects by increasing the proportion of opioid overdoses and decrease SUD treatment utilization. Our findings add to the limited empirical research available on PSUPs and their effectiveness at improving perinatal health outcomes. Additionally, our findings highlight the nation's trend toward more punitive PSUPs as a cause of concern, as our findings suggest that some punitive policies may negatively impact perinatal health outcomes. Our findings support the recommendations made by leading medical organizations who oppose punitive policies and emphasize efforts that focus on rehabilitation and treatment to minimize adverse health outcomes associated with substance use disorder.

CRedit authorship contribution statement

Nadia Tabatabaepour – Conceptualization, Software, Investigation, Project administration, Validation, Visualization, Roles/Writing - original draft, Writing - review & editing.

Jake R. Morgan – Data curation, Formal analysis, Software, Investigation, Resources, Validation, Writing - review & editing.

Ali Jalali – Investigation, Methodology, Roles/Writing - original draft.

Shashi N Kapadia – Investigation, Roles/Writing - original draft, Writing - review & editing.

Angélica Meinhofer – Conceptualization, Formal analysis, Software, Project administration, Funding acquisition, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Roles/Writing - original draft, Writing - review & editing.

Declaration of competing interest

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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.2022.108800>.

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