



Neonatal Abstinence Syndrome and Maternal Access to Treatment for Opioid Use Disorder in California Counties

NAS Incidence and Driving Distance to Treatment Facilities Offering Medication-Assisted Treatment for Pregnant Women

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September 2018

Nationally, the incidence of maternal opioid use rose sharply after 2000, accompanied by an increase in the rate of neonatal abstinence syndrome (NAS) related to in utero opioid exposure.¹ California is no exception, as NAS incidence increased from a rate of 2.9 per 1,000 delivery hospitalizations in 2008 to 6.4 per 1000 in 2013, according to data from the California State Inpatient Databases.² The standard of care for treatment of pregnant women with opioid use disorder (OUD) is to offer medications (buprenorphine or methadone) in combination with behavioral health therapy (called medication-assisted treatment or MAT).³ This analysis explores county-level NAS incidence rates across California county- and zip-code level access to MAT for opioid use disorder (OUD) for pregnant women.

Despite the steep increases in the rate of NAS at the state-level in California (California Child Welfare Co-Investment Partnership 2017), NAS incidence rates at sub-state levels in California have not been assessed. Further, treatment options are strongly recommended for pregnant women with OUD—specifically those that include pharmacotherapy with methadone or buprenorphine (SAMHSA 2018)⁴—but information about local accessibility of these treatment options in California is not available. To fill the knowledge gap in local area NAS incidence rates and access to treatment for pregnant women with OUD in California, this analysis identifies counties that are “hotspots” for NAS incidence. Additionally, we calculate average driving distances and driving times to OUD treatment providers, including those

that specialize in care for pregnant women, from each county's population center and zip code tabulation area (ZCTA) geographic center.

This brief first describes the data and methods used in the area estimates. Presented in maps and downloadable estimates, these data document incidence rates of NAS at the county level and distances to opioid treatment facilities and buprenorphine-waivered prescribers at the county and ZCTA level in California. This brief then identifies areas with high and low NAS incidence rates and areas where treatment options for pregnant women with OUD require more or less time to access. All data are available for download on the Urban Institute website.

The primary objectives of this study are to understand barriers to treatment that pregnant women face in California by analyzing driving distances to recommended treatment and to assess NAS incidence rates at the county level. This analysis focuses on treatment facilities providing methadone or buprenorphine treatment for OUD, because both are recommended treatment options for pregnant women with OUD (SAMHSA 2018). The data also report on distances to buprenorphine-waivered prescribers, but no data are available to identify which of these prescribers accepts pregnant patients with OUD. Therefore, our estimates are not limited to prescribers who accept pregnant patients and thus might overstate access to buprenorphine treatment for this population.

This analysis aims to provide information to practitioners, policymakers, researchers, and the public and to state groups such as the Statewide Opioid Safety workgroup, led by the California Department of Public Health, and its Maternal/Neonatal Opioid Taskforce with an understanding of unmet need in California related to access to treatment for maternal OUD.

Data and Methods

We collect NAS incidence rates for 2005-16 from patient discharge and emergency department databases hosted at California's Office of Statewide Health Planning and Development (OSHPD). These databases contain records from every inpatient and emergency department discharge in California-licensed hospitals and include patient diagnostic codes that indicate whether physicians identify newborns or infants exhibiting NAS symptoms.⁵ Table 1 documents the diagnostic codes collected:

TABLE 1
Patient Diagnostic Codes Identifying Neonatal Abstinence Syndrome

ICD 9/10 code	Description
ICD 9: 779.5	Drug withdrawal syndrome in newborn
ICD 9: 760.72	Narcotics affecting fetus or newborn via placenta or breastmilk
ICD 10: P96.1	Neonatal drug withdrawal syndrome from maternal use of drugs of addiction
ICD 10: P04.49	Newborn (suspected to be) affected by maternal use of other drugs of addiction

Notes: ICD = International Classification of Diseases. Diagnostic codes for the ninth revision (ICD 9) are in effect from 2005 to September 2015. Diagnostic codes from the tenth revision (ICD 10) are used from October 2015 through December 2016.

We collect records identifying NAS diagnosis by each patient’s county of residence. Data are collected from 2005 to 2016. Incidence counts are aggregated in four-year, six-year, and full-period intervals.⁶ To construct denominators for NAS incidence rates, we use the number of inpatient births in the county and the number of newborn hospitalizations (based on the mother’s county of residence), which are collected from the same data source.⁷

Using data from the 2018 Substance Abuse and Mental Health Services Administration (SAMHSA) treatment locator, we collect the locations of facilities providing methadone or buprenorphine treatment for OUD in California, focusing on facilities also providing pregnancy-specific services.⁸ We collect locations for the following types of treatment facilities offering MAT services: residential facilities, outpatient facilities, and OTPs (Table 2). These facilities are referred to below as OUD treatment facilities. Treatment facility type and whether facilities provided pregnancy-specific services was indicated on the SAMHSA treatment locator for each facility. For each facility type providing pregnancy-specific services, we estimate travel distances and times. These treatment locations are current as of the date of this report. Treatment facility types are not mutually exclusively – for example, of the 32 residential facilities providing MAT services and indicating pregnancy-specific services, 12 sites are also listed as outpatient facilities, 1 site is also listed as an OTP, and 2 sites are also listed as inpatient facilities.

TABLE 2
Treatment provider categories for analysis of OUD treatment

Treatment provider	Description
All OUD treatment facilities offering MAT and pregnancy-specific services	Residential, outpatient, and Opioid Treatment Program (OTPs) facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering MAT services and pregnancy-specific services.
Residential treatment facility offering MAT and pregnancy-specific services	Residential treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering MAT services and pregnancy-specific services.
Outpatient treatment facility offering MAT and pregnancy-specific services	Outpatient treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering MAT services and pregnancy-specific services; excludes OTPs.
Opioid Treatment Program (OTPs) listed as offering pregnancy-specific services	OTP locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering pregnancy-specific services. All OTPs offer methadone.
Buprenorphine-waivered prescribers	Buprenorphine-waivered prescriber locations collected from the Drug Enforcement Agency’s Active Controlled Substances Act Registrants database accessed in February 2018; data does not show which providers treat pregnant women.

Sources: 2018 Substance Abuse and Mental Health Services Administration (SAMHSA) treatment locator; Drug Enforcement Agency’s Active Controlled Substances Act Registrants database 2018.

Finally, using data from the Drug Enforcement Agency's Active Controlled Substances Act Registrants Database from the National Technical Information Service, we obtained the locations of all buprenorphine-waivered prescribers in California. These data do not provide information about whether these prescribers provide services to pregnant patients. The Drug Enforcement Agency's data are current as of February 2018. Where the SAMHSA locator tool lists buprenorphine-waivered prescribers who are publicly listed, the Active Controlled Substances Act Registrants Databases provides locations of all buprenorphine-waivered prescribers in the state.⁹

Using the Census Bureau's Centers of Populations data,¹⁰ we identify the latitude and longitude of county population centers in 2010. We collect ZCTA geographic centers from the Census Bureau's 2010 Gazetteer files.¹¹ ZCTAs are used as the unit of analysis rather than zip codes because ZCTAs are created by the Census Bureau as representations of zip codes, created as standard unit of geography, while zip codes are created by the United States Postal Service as a collection of mail delivery routes.

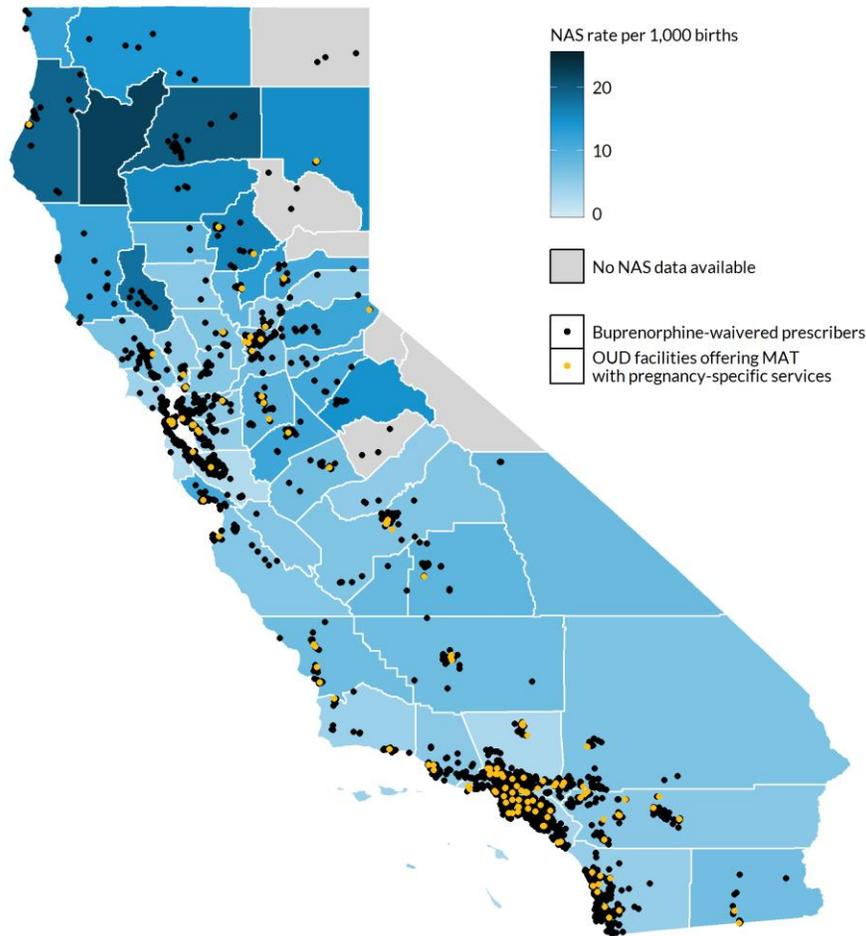
Finally, we calculate average "crow flies" distances, driving distances, and driving times to the three nearest treatment facilities by facility type and separately among facilities that offer pregnancy-specific services, from each county population center and ZCTA.¹² We also calculate these distances and driving times for buprenorphine-waivered prescribers. Driving distances and times were calculated using Google Maps application programming interface software.

Data Highlights

Figure 1 presents a state map that highlights county-level NAS incidence rates in California. Counties with higher NAS incidence rates have darker shades of blue (counties in gray are sparsely populated areas with screened out NAS incidence rates). Figure 1 also includes the locations of all types of OUD treatment facilities that offer MAT and have pregnancy-specific services (yellow dots) and locations of buprenorphine-waivered prescribers (black dots).

FIGURE 1

NAS Incidence Rates, All Treatment Facilities Offering MAT and Pregnancy-Specific Services, and Buprenorphine-Waivered Prescriber Locations, by County



Sources: NAS incidence rates collected from California’s Office of Statewide Health Planning and Development Patient Discharge Data and Emergency Room databases 2005-16. Opioid use disorder treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering medication-assisted treatment services and pregnancy-specific services. Locations of all buprenorphine-waivered prescribers collected from the Drug Enforcement Agency’s Active Controlled Substances Act Registrants database accessed in February 2018.

Notes: MAT = Medication-assisted Treatment. NAS = Neonatal Abstinence Syndrome. NAS incidence is defined using discharges reporting International Classification of Diseases (ICD) 9th revision diagnostic codes 779.5 or 760.72 or ICD 10th revision diagnostic codes P96.1 or P04.49. Treatment facility locations are limited to residential, outpatient, and opioid treatment program facilities providing medication-assisted treatment for opioid use disorders and identifying pregnancy-specific services.

Broadly, NAS incidence rates are greater in the northern regions of the state. OUD treatment centers are centrally located around densely populated centers.

Table 3 provides tabulations of NAS incidence and average driving times to OUD treatment facilities offering MAT and buprenorphine waived prescribers separately for counties with the lowest and highest NAS incidence rates for 2005-16. These tabulations are purely exploratory and do not convey causality.

TABLE 3

NAS rates and Average Drive Times to Treatment Facilities, by Counties with the Lowest and Highest NAS Incidence Rates (2005-2016)

Counties	NAS incidence rate per 1000 births	Average driving time to 3 nearest OUD treatment facility providing MAT and pregnancy services	Average driving time to 3 nearest buprenorphine-waivered prescribers*
Counties with the 5 lowest NAS incidence rates			
	2.9	21 minutes	5 minutes
San Mateo	2.1 (1.8, 2.4)	26	3
Santa Clara	2.3 (2.2, 2.5)	21	4
Los Angeles	2.9 (2.8, 2.9)	11	3
Orange	3.5 (3.3, 3.6)	13	5
Marin	3.8 (3.1, 4.5)	37	8
Counties with the 5 highest NAS incidence rates			
	19.0	118	29
Butte	15.8 (14.3, 17.2)	40	19
Lake	17.9 (15.0, 20.7)	97	20
Humboldt	19.0 (16.9, 20.9)	177	16
Shasta	19.7 (17.9, 21.4)	111	11
Trinity	22.5 (14.1, 30.8)	163	78

Source: NAS incidence rates collected from California’s Office of Statewide Health Planning and Development Patient Discharge Data and Emergency Room databases 2005-16. Opioid use disorder treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering medication-assisted treatment services and pregnancy-specific services. Locations of all buprenorphine-waivered prescribers collected from the Drug Enforcement Agency’s Active Controlled Substances Act Registrants database accessed in February 2018.

Notes: NAS = Neonatal Abstinence Syndrome. NAS incidence is defined using discharges reporting International Classification of Diseases (ICD) 9th revision diagnostic codes 779.5 or 760.72 or ICD 10th revision diagnostic codes P96.1 or P04.49. Treatment facility locations are limited to residential, outpatient, and opioid treatment program facilities providing medication-assisted treatment for opioid use disorders and identifying pregnancy-specific services. Numbers in parenthesis indicate 95% confidence interval of rate estimate based on Poisson distribution.

* Data is not informative about whether these buprenorphine prescribers treat pregnant women.

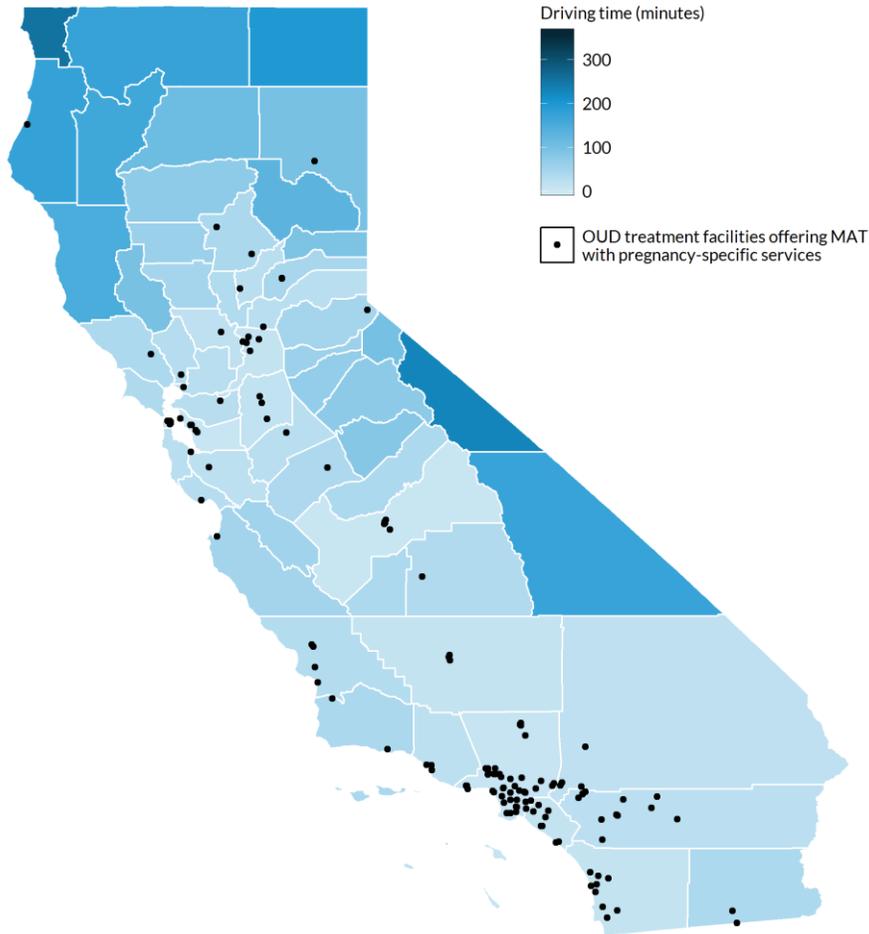
Among counties with the lowest NAS incidence rates,¹³ the average NAS incidence rate is 2.9 cases of NAS diagnosis per 1,000 births. The average driving time to one of the three nearest residential, outpatient, or opioid treatment programs providing pregnancy-specific services is 21 minutes. The average driving time to the three nearest buprenorphine-waivered prescribers is less than 5 minutes.

Among the counties with the highest rates of NAS incidence, the average NAS incidence rate is about 19 cases of NAS diagnosis per 1,000 births, 6.5 times the average among the lowest counties. The average driving time to the three nearest residential, outpatient, or opioid treatment programs providing services to pregnant women is nearly two hours (118 minutes). The average driving time to the three nearest buprenorphine-waivered prescriber is about 29 minutes, about 6 times the average distance among counties with the lowest rates. The rate of NAS incidence has dramatically increased. From 2005 to 2008, about 6,173 newborns were diagnosed with NAS, or 1,541 infants per year. Between 2013 and 2016, 15,616 newborns were diagnosed with NAS, or 3,409 infants per year—more than 2.5 times the rate between 2005 and 2008 (data not shown). Counties with the lowest *rates* of NAS incidence still face large volumes of infants diagnosed with NAS. For example, Los Angeles County has one of the lowest rates of NAS incidence for the full period at 2.9 diagnoses per 1,000 births, but 4,654 infants were diagnosed with NAS between 2005 to 2016 (data not shown).

Figure 2 highlights the average driving time to OUD treatment facilities offering MAT with pregnancy-specific services by county. Areas with longer average driving times are shaded in darker blues.

FIGURE 2

Average Driving Time to Three Closest All Treatment Facilities Offering MAT with Pregnancy-Specific Services, by County



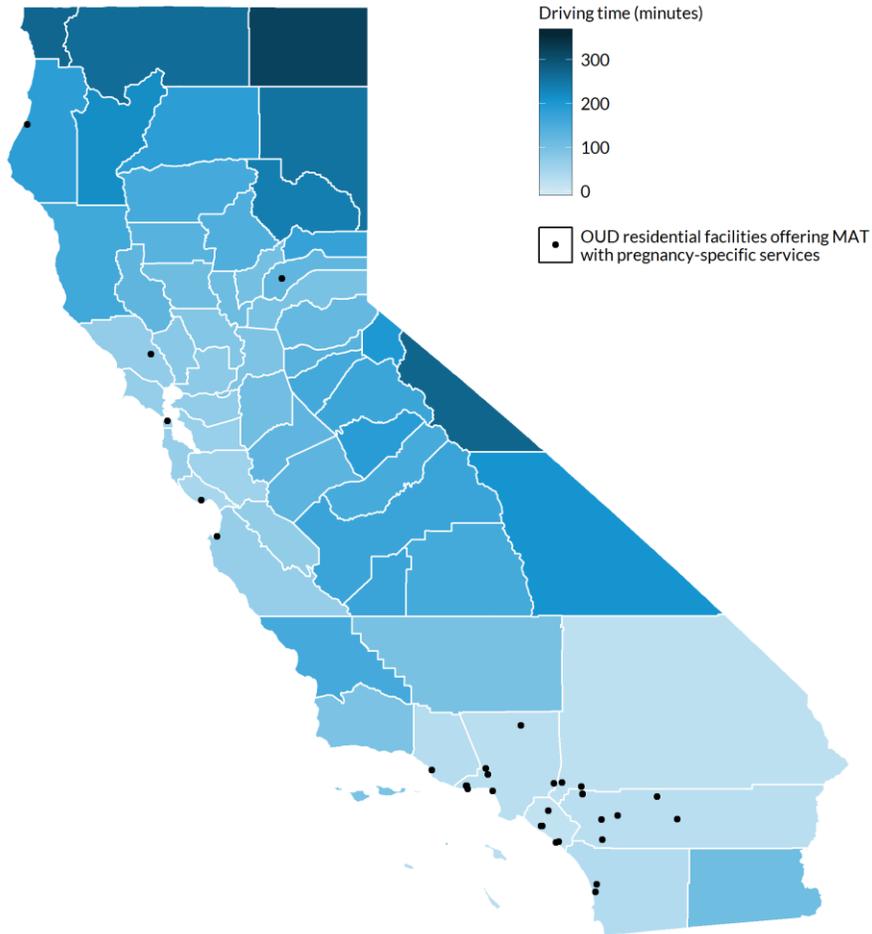
Source: Treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering medication-assisted treatment services and pregnancy-specific services.
Notes: MAT = Medication-Assisted Treatment. Treatment facility locations are limited to residential, outpatient, and opioid treatment program facilities providing medication-assisted treatment for opioid use disorders and identifying pregnancy services.

There are 146 facilities providing pregnancy-specific opioid use disorder treatment services. Most are located in Southern California, particularly around Los Angeles. Correspondingly, average driving times are longer in less urban and less populated regions in the eastern and northern regions of the state. Among counties for which we calculated NAS incidence rates, the counties with the longest average drive times to an OUD treatment facility with pregnancy-specific services are Del Norte (255-minute drive), Humboldt (177 minutes), and Siskiyou (176 minutes). The counties with the shortest average driving times to OUD treatment facilities with pregnancy-specific services are Fresno (9 minutes), Alameda (9 minutes), and Los Angeles (11 minutes). Appendix figure A1 presents these driving times at the zip code level.

Figures 3, 4, and 5 further disaggregate these driving distances by facility type. Darker blues indicate counties with higher average driving times. Patterns in OUD treatment facility locations in figures 3 through 5 are consistent with those in figure 2. Urban areas near and around Los Angeles, San Diego, San Francisco, and San Jose tend to have higher concentrations of residential facilities, outpatient facilities, and opioid treatment programs. Correspondingly, counties comprising or adjacent to these cities have shorter driving times. Counties in sparsely populated regions in the state's northern and eastern portions have fewer nearby treatment options and require pregnant women to drive further to access treatment for opioid use disorder. For corresponding figures at the ZCTA level, see appendix figures A2-A4.

FIGURE 3

Average Driving Time to Three Closest Residential Facilities Offering MAT with Pregnancy-Specific Services, by County

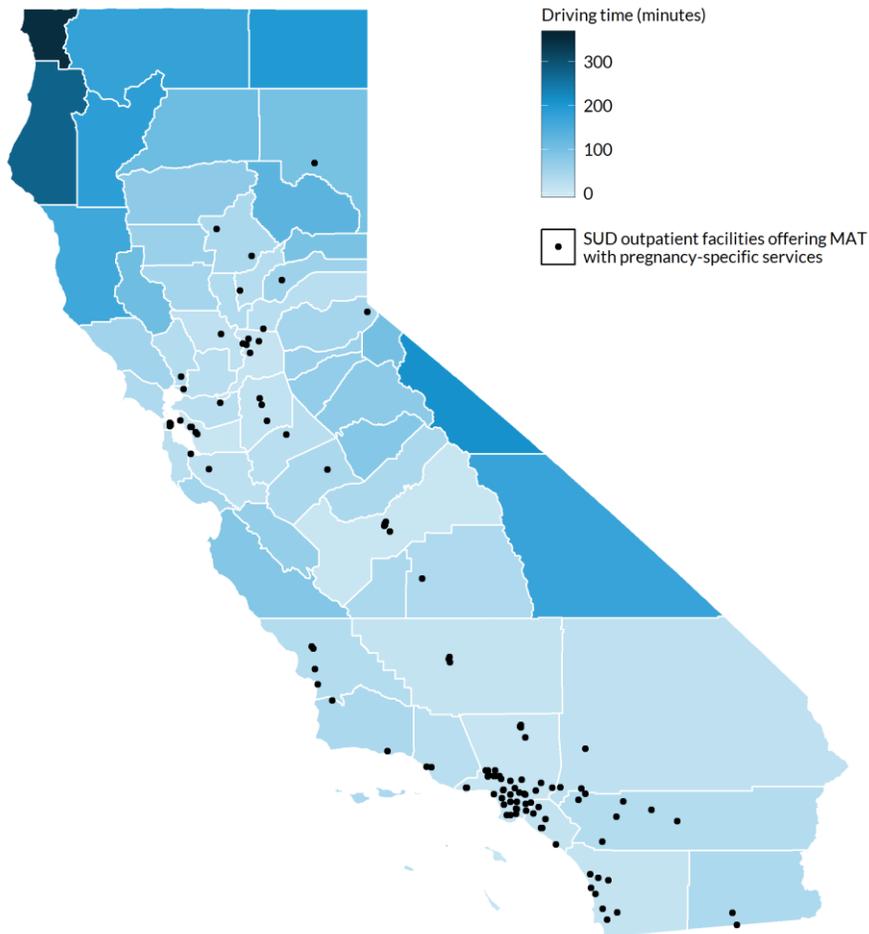


Source: Residential treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering medication-assisted treatment services and pregnancy-specific services.

Notes: MAT = Medication-Assisted Treatment.

FIGURE 4

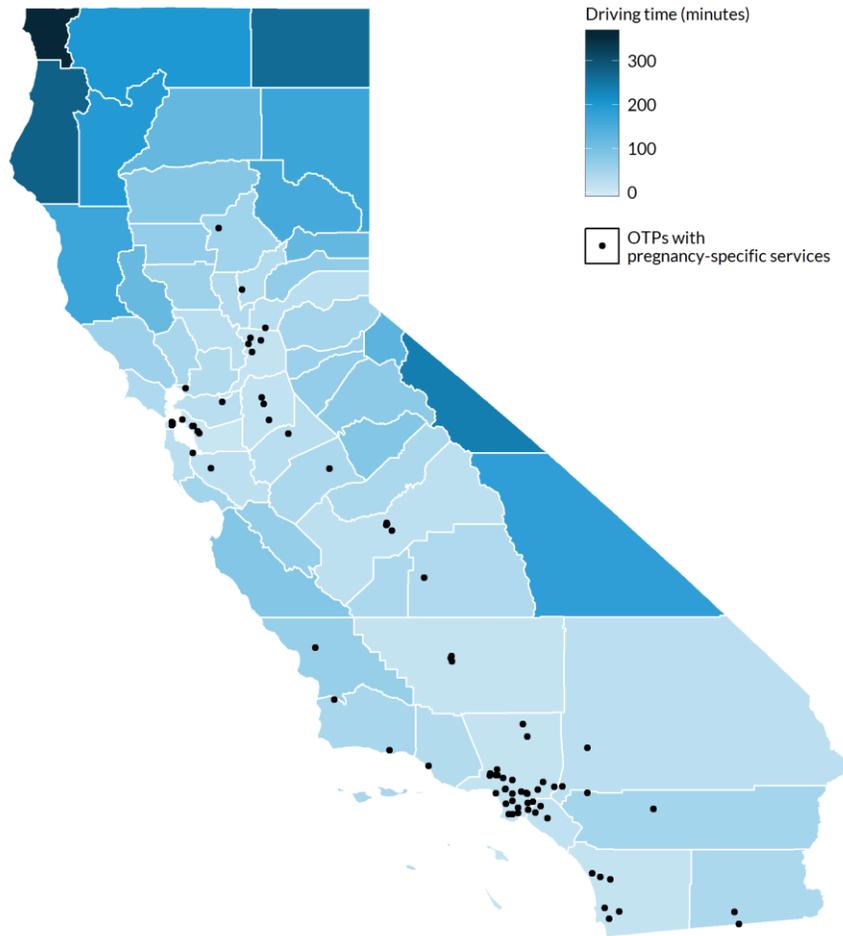
Average Driving Time to Three Closest Outpatient Treatment Facilities Offering MAT with Pregnancy-Specific Services, by County



Source: Outpatient treatment facility locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering medication-assisted treatment services and pregnancy-specific services.

Notes: MAT = Medication-Assisted Treatment.

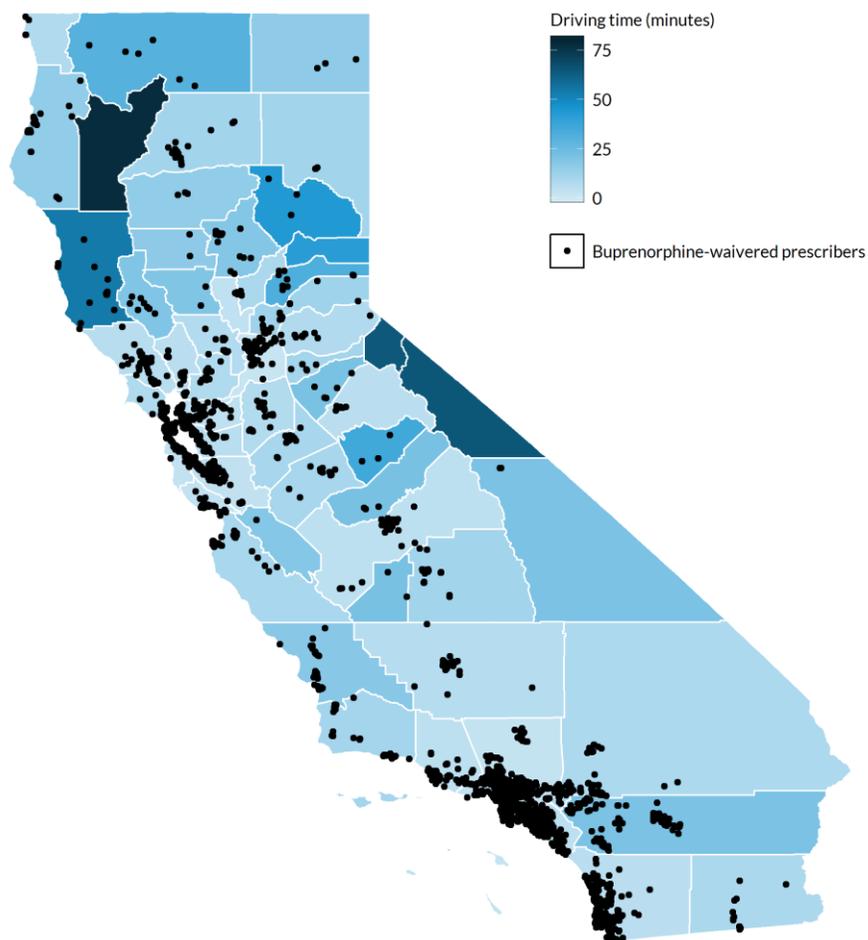
FIGURE 5
Average Driving Time to Three Closest Opioid Treatment Program (OTPs) Facilities Indicating Offer of Pregnancy-Specific Services, by County



Source: Opioid Treatment Program locations collected from the Substance Abuse and Mental Health Services Administration treatment locator tool, accessed in 2018, filtered by those offering medication-assisted treatment services and pregnancy-specific services.

Figure 6 presents driving times and locations of buprenorphine-waivered prescribers in February 2018. There are 3,052 listed prescribers in our data. However, there are no public data indicating which of these prescribers offer services to pregnant women.

FIGURE 6
Average Driving Time to Three Closest Buprenorphine-Waivered Prescribers, by County



Source: Buprenorphine-waivered prescriber locations collected from the Drug Enforcement Agency's Active Controlled Substances Act Registrants database accessed in February 2018.

Notes: Data is not informative about whether these buprenorphine prescribers treat pregnant women.

Limitations

The data have several limitations. First, NAS incidence rates reflect cases between 2005 and 2016, while treatment locations collected from the SAMHSA treatment locator tool are informative about treatment options in 2018 and buprenorphine-waivered prescribers reflect locations as of 2018. Historical trends in treatment access to facilities or buprenorphine-waivered prescribers are not available.

Second, buprenorphine-waivered prescribers are not restricted to those accepting pregnant patients. The average drive times and distances should be thought of as lower-estimates of treatment accessible to pregnant women with opioid use disorders. While data from the Drug Enforcement Agency's active controlled substance act Registrants Database list all buprenorphine-waivered prescribers, not all of these prescribers are publicly listed. Thus, the distance to an available provider is likely to be greater than the distances reported here.

Third, driving distances in county-level analyses are based on county population centers. If there is wide heterogeneity in within-county population locations or within-county distances to treatment options, distances from population centers to treatment options do not necessarily reflect true distances women with opioid use disorder must travel.

Fourth, the collected data from SAMHSA and the data from the Drug Enforcement Agency's Active Controlled Substances Act Registrants Database are not informative about treatment capacity at each site. If facilities are at or near full capacity, the effective travel distances and times for obtaining treatment are likely longer than these estimated travel times and distances.

Fifth, while our data solely present measures of treatment access based on driving distance and driving time, we note that there are many other measures of barriers to treatment (such as facility capacity, income, and transportation) that are not reported in the data. These factors may play a critical role in determining access to OUD treatment for pregnant women.

Sixth, SAMHSA data are not informative about the location of off-site MAT treatment available from each facility type. If off-site MAT services are prevalent, our estimates may overestimate the driving distance and time to the nearest facilities.

Seventh, the International Classification of Diseases diagnosis codes switched from its 9th revision to its 10th revision between 2015 and 2016. As noted in Table 1, the 10th revision diagnostic codes identifying NAS do not fully correspond to the 9th revision diagnostic codes. However, our data are aggregated beyond single-year analyses. We therefore cannot assess any structural break in NAS trends from 2015 to 2016. This is likely to most affect the quality of our four-year interval estimates from 2013 to 2016.

Finally, while the data reported here suggest that lower access to MAT for pregnant women is associated with higher incidence rates of NAS, we caution that this is a purely descriptive analysis and does not convey information on the underlying causal relationship between these factors. MAT with

methadone or buprenorphine treatment for pregnant women has been previously shown to be associated with NAS incidence, with approximately half of infants treated for NAS (SAMHSA 2018). However, guidance from SAMHSA and others strongly supports MAT for OUD during pregnancy since the benefits outweigh the risks of untreated OUD (SAMHSA 2018). In fact, experts have observed that in the case of established maternal OUD, the incidence of NAS is likely unchanged regardless of whether MAT treatment is received (Brown and Talbert 2017). Further research investigating the causal relationship between treatment access and NAS incidence requires that researchers control for various confounding factors (such as neighborhood poverty rates, unemployment rates, MAT treatment options for women of reproductive age, among others) that are not observed in the data presented here.

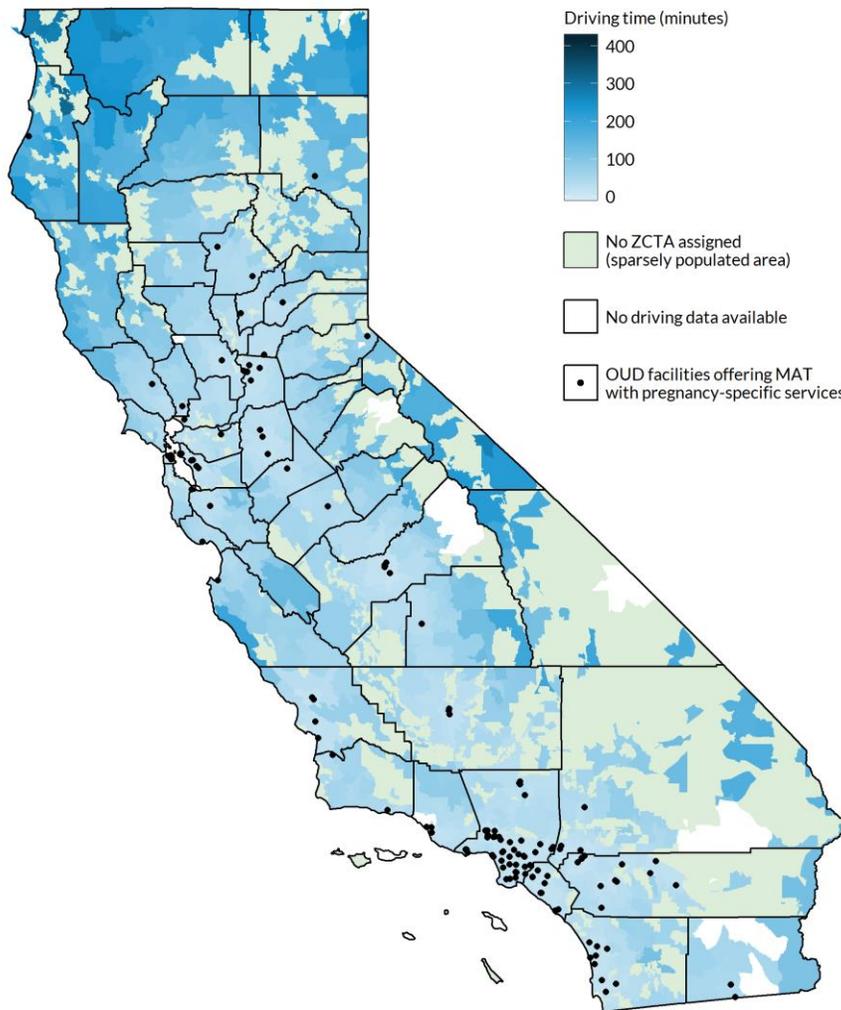
Discussion

We report previously undocumented NAS incidence rates and distances to OUD treatment facilities providing methadone or buprenorphine treatment for OUD and pregnancy-specific services, as well as buprenorphine-waivered prescribers throughout counties in California. The data reflect that NAS incidence rates are greater in rural counties in the state's northern and eastern regions. These areas also tend to be farther from treatment facilities providing methadone or buprenorphine treatment to pregnant women and from buprenorphine-waivered prescribers. These patterns are consistent with a similar analysis of NAS incidence and distance to treatment in Kentucky.¹⁴ Though our analysis does not identify a causal relationship, these findings suggest that proximity to methadone or buprenorphine treatment for pregnant women, proximity of buprenorphine-waivered prescribers, and NAS incidence are correlated.

Appendix: Zip Code Tabulation Area Maps of Driving Times

FIGURE A1

Average Driving Time to Three Closest Treatment Facilities Offering MAT with Pregnancy-Specific Services, by Zip Code Tabulation Area (ZCTA)

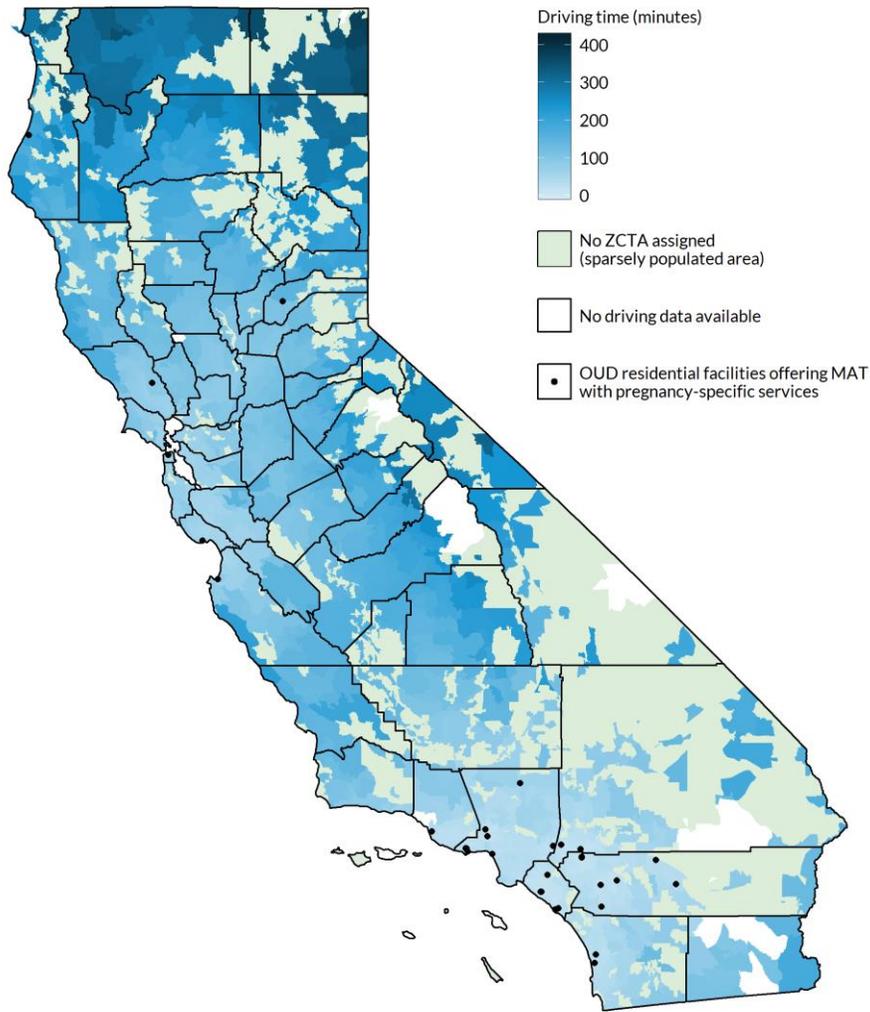


Source: Treatment facilities locations collected from SAMHSA treatment locator tool accessed in 2018.

Notes: MAT = Medication-assisted treatment. Treatment facilities locations are limited to residential, outpatient, and opioid treatment program facilities providing medication assisted treatment for opioid use disorders and identifying pregnancy services. Black lines outline county boundaries.

FIGURE A2

Average Driving Time to Three Closest Residential Facilities Offering MAT with Pregnancy-Specific Services, by Zip Code Tabulation Area (ZCTA)

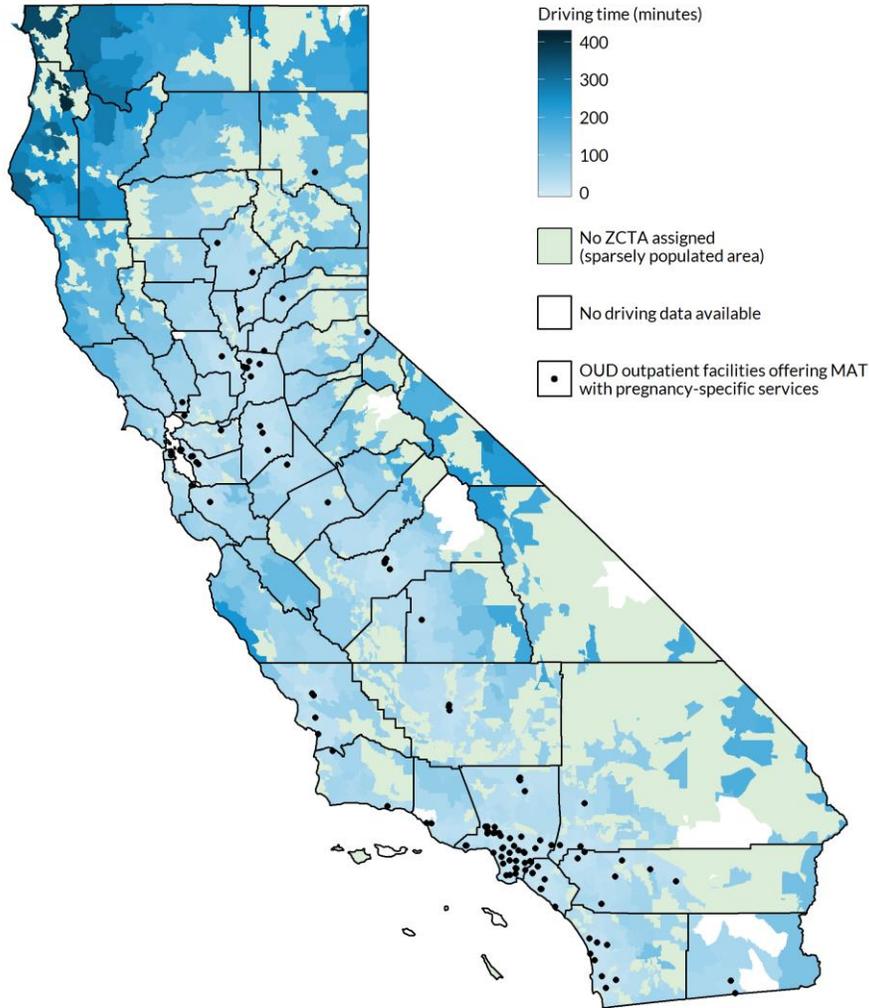


Source: Treatment facilities locations collected from SAMHSA treatment locator tool accessed in 2018.

Notes: MAT = Medication-assisted Treatment. Treatment facilities locations are limited to residential facilities providing medication assisted treatment for opioid use disorders and identifying pregnancy services. Black lines outline county boundaries.

FIGURE A3

Average Driving Time to Three Closest Outpatient Facilities Offering MAT with Pregnancy-Specific Services, by Zip Code Tabulation Area (ZCTA)

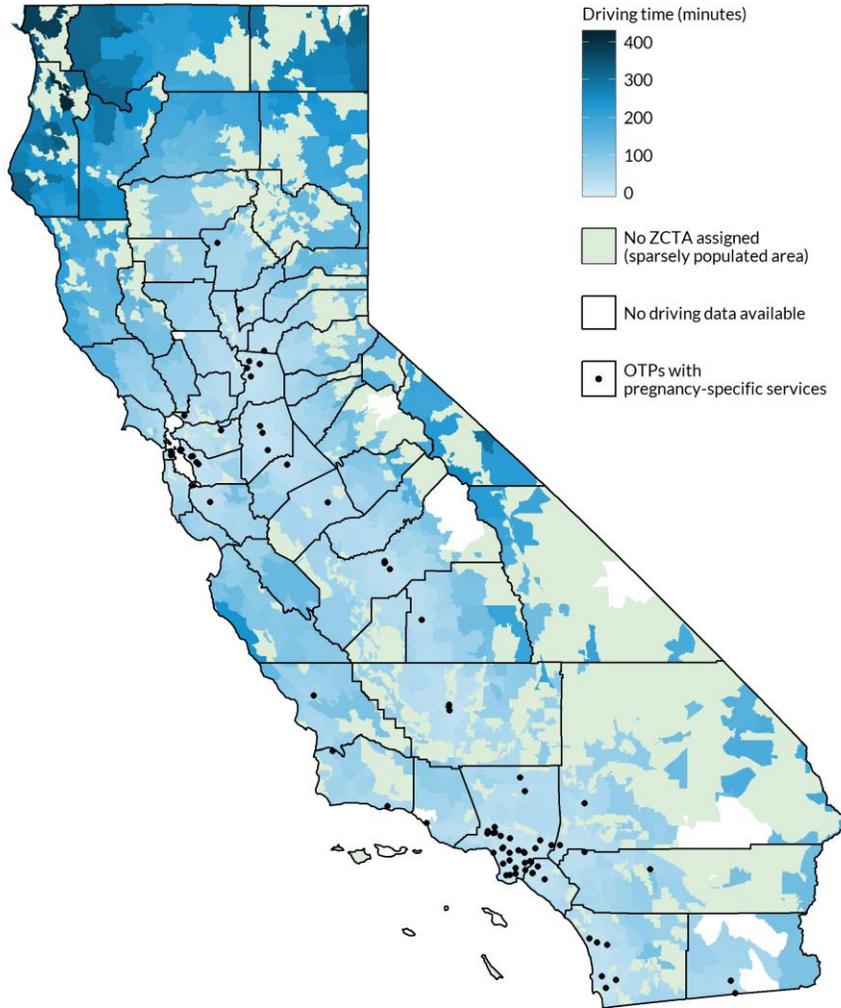


Source: Treatment facilities locations collected from SAMHSA treatment locator tool accessed in 2018.

Notes: MAT = Medication-assisted Treatment. Treatment facilities locations are limited to outpatient facilities providing medication assisted treatment for opioid use disorders and identifying pregnancy services. Black lines outline county boundaries.

FIGURE A4

Average Driving Time to Three Closest Opioid Treatment Programs (OTPs) Indicating Offer of Pregnancy-Specific Services, by Zip Code Tabulation Area (ZCTA)

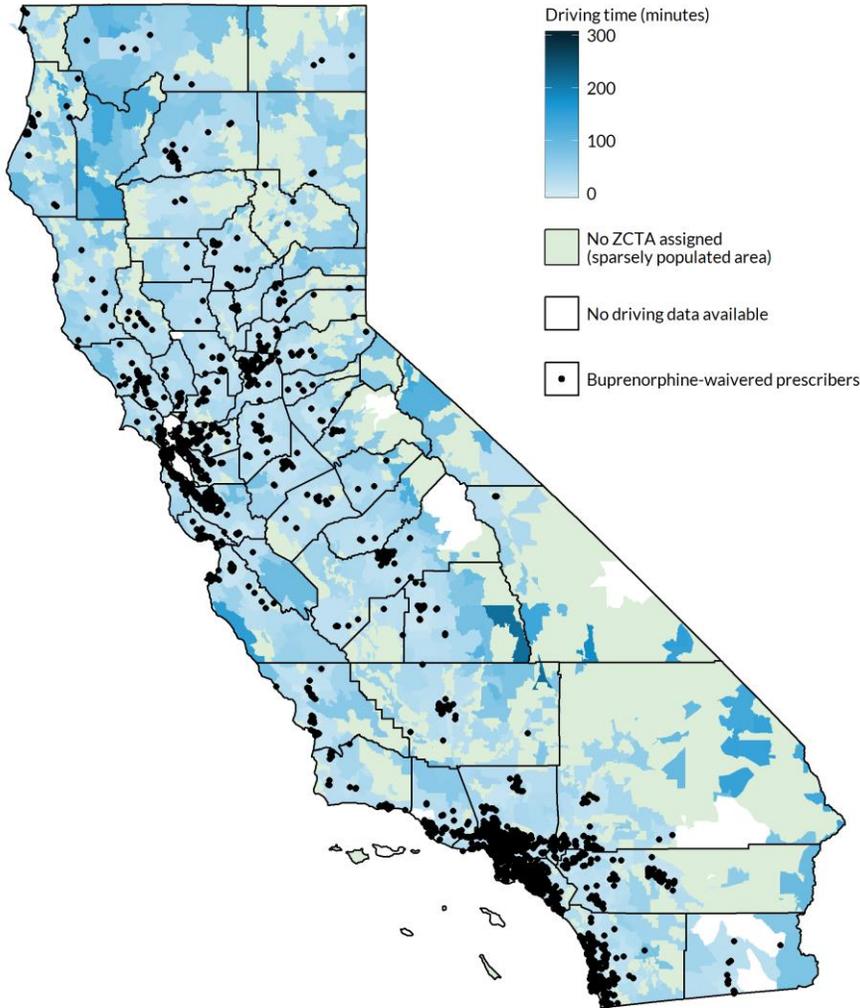


Source: Treatment facilities locations collected from SAMHSA treatment locator tool accessed in 2018.

Notes: Treatment facilities locations are limited to opioid treatment programs providing medication assisted treatment for opioid use disorders and identifying pregnancy services. Black lines outline county boundaries.

FIGURE A5

Average Driving Time to Three Closest Buprenorphine-Waivered Prescribers, by Zip Code Tabulation Area (ZCTA)



Source: Buprenorphine-waivered prescriber locations collected from the Drug Enforcement Agency's Active Controlled Substances Act Registrants database accessed in February 2018.

Notes: Black lines outline county boundaries. Data is not informative about whether these buprenorphine prescribers treat pregnant women.

Notes

- ¹ See Ko et al. (2016), Patrick et al. (2012), Villapiano et al. (2017), Winkelman et al. (2018), and Ko (2016).
- ² See California Child Welfare Co-Investment Partnership (2017)
- ³ See, for example, this statement from the American College of Obstetricians and Gynecologists: <https://www.acog.org/About-ACOG/News-Room/Statements/2016/ACOG-Statement-on-Opioid-Use-During-Pregnancy>
- ⁴ In a 2018 report, a SAMHSA expert panel concluded that although extended-release injectable naltrexone is approved for the treatment of OUD, information about the safety of the medication during pregnancy was insufficient to recommend it as a treatment option for pregnant women. We therefore do not include naltrexone as a treatment option in this analyses.
- ⁵ See www.oshpd.ca.gov/documents/HID/Data_Request_Center/2017_Nonpublic_DataDictionary_PDD.pdf for more information on OSHPD Patient Discharge Data. See www.oshpd.ca.gov/documents/HID/Data_Request_Center/2017_Nonpublic_DataDictionary_EDAS.pdf for more information on OSHPD Emergency Department Data.
- ⁶ OSHPD does not release data at cell sizes less with incidence cases of less than 11. To avoid excluding many counties due to this rule, we combined data across these wider time periods of 4, 6, and 12 years.
- ⁷ Users can also use an alternative denominator, the number of newborn hospitalizations, to assess these NAS incidence rates.
- ⁸ We included facilities that offered one or more of the following services: buprenorphine maintenance, buprenorphine maintenance for predetermined time, buprenorphine detox, methadone maintenance, methadone maintenance for predetermined time, methadone detox, outpatient methadone/buprenorphine or naltrexone, methadone used in treatment, buprenorphine used in treatment, methadone, buprenorphine subdermal implant (Probuphine®), buprenorphine with naloxone (Suboxone®), buprenorphine without naloxone.
- ⁹ As a point of references, the number of estimated buprenorphine-waivered prescribers in SAMHSA treatment locator indicates 2,086 listed locations.
- ¹⁰ See <https://www.census.gov/geo/reference/centersofpop.html>
- ¹¹ See <https://www.census.gov/geo/maps-data/data/gazetteer2010.html>
- ¹² We estimated driving distances and times using the *gmapsdistance* package for R statistical software, which accesses the Google Maps application programming interface. To feasibly estimate distances from a restricted list of facilities for each county and ZCTA, we limited estimating driving distances and times to the 20 nearest facilities by crow-fly distances.
- ¹³ We note that small area estimates may sensitive due to smaller denominators (i.e. fewer births or fewer newborn observations). While using confidence intervals based on Poisson distributions mechanically yield wider confidence intervals in lower populated regions, alternative approaches to estimating incidence rates may provide useful insights on the sensitivity of these estimates. Downloadable data estimates include separate estimates for each denominator (i.e. number of births or number of newborn hospitalizations), which will permit users to implement alternative approaches to rate estimation such as implementing Bayesian hierarchical models (for example, see: https://www.cdc.gov/nceh/tracking/conf04/pdfs/thu/ses3A/s_richardson.pdf).
- ¹⁴ See Brown, Goodin, and Talbert (2018).

References

Brown, Joshua D., Amie J. Goodin, and Jeffery C. Talbert. 2018. "Rural and Appalachian Disparities in Neonatal Abstinence Syndrome Incidence and Access to Opioid Abuse Treatment: Neonatal

- Abstinence Syndrome: Rural Disparities.” *The Journal of Rural Health* 34 (1): 6–13. <https://doi.org/10.1111/jrh.12251>.
- Brown, Joshua D., and Jeffery C. Talbert. 2017. “Treatment of Opioid Use Disorder During Pregnancy May Increase Cases of Neonatal Abstinence Syndrome—Reply.” *JAMA Pediatrics* 171 (7): 707. <https://doi.org/10.1001/jamapediatrics.2017.0863>.
- California Child Welfare Co-Investment Partnership. 2017. “A Matter of Substance: Challenges and Responses to Parental Substance Use in Child Welfare.” *Insights, Volume XIII*, 16.
- Ko, Jean Y. 2016. “Incidence of Neonatal Abstinence Syndrome – 28 States, 1999–2013.” *MMWR. Morbidity and Mortality Weekly Report* 65. <https://doi.org/10.15585/mmwr.mm6531a2>.
- Patrick, Stephen W., Robert E. Schumacher, Brian D. Benneyworth, Elizabeth E. Krans, Jennifer M. McAllister, and Matthew M. Davis. 2012. “Neonatal Abstinence Syndrome and Associated Health Care Expenditures: United States, 2000–2009.” *JAMA* 307 (18): 1934–40. <https://doi.org/10.1001/jama.2012.3951>.
- SAMHSA. 2018. “Clinical Guidance for Treating Pregnant and Parenting Women With Opioid Use Disorder and Their Infants.” <https://store.samhsa.gov/product/Clinical-Guidance-for-Treating-Pregnant-and-Parenting-Women-With-Opioid-Use-Disorder-and-Their-Infants/SMA18-5054>.
- Villapiano, Nicole L. G., Tyler N. A. Winkelman, Katy B. Kozhimannil, Matthew M. Davis, and Stephen W. Patrick. 2017. “Rural and Urban Differences in Neonatal Abstinence Syndrome and Maternal Opioid Use, 2004 to 2013.” *JAMA Pediatrics* 171 (2): 194–96. <https://doi.org/10.1001/jamapediatrics.2016.3750>.
- Winkelman, Tyler N. A., Nicole Villapiano, Katy B. Kozhimannil, Matthew M. Davis, and Stephen W. Patrick. 2018. “Incidence and Costs of Neonatal Abstinence Syndrome Among Infants With Medicaid: 2004–2014.” *Pediatrics* 141 (4): e20173520. <https://doi.org/10.1542/peds.2017-3520>.

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Acknowledgments

This brief was funded by the California Health Care Foundation. We are grateful to them and to all our funders, who make it possible for Urban to advance its mission.

The views expressed are those of the authors and should not be attributed to the Urban Institute, its trustees, or its funders. Funders do not determine research findings or the insights and recommendations of Urban experts. Further information on the Urban Institute's funding principles is available at www.urban.org/support.

The authors appreciate the helpful suggestions of Bowen Garrett, Kelly Pfeifer, Eileen Yamada, James Gasper, Jeff Talbert, Mike Curtis, David Reynen, Jennifer Troyan, and members of California's Maternal and Neonatal Task Force.