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Rural and Appalachian Disparities in Neonatal Abstinence Syndrome Incidence and Access to Opioid Abuse Treatment

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Abstract

Objective—Incidence of Neonatal Abstinence Syndrome (NAS) is increasing due to the rise in opioid use. Rural states like Kentucky have been disproportionately impacted by opioid abuse, and this study determines NAS burden nationally and in Kentucky while quantifying differences in access to care between Appalachian and non-Appalachian counties.

Methods—NAS rates were calculated using national (2013) and Kentucky (2008–2014) National Inpatient Sample discharge data. Births were identified using International Classification of Diseases v9 code 779.5 and live birth codes V30.x–V38.x. Counties were classified as rural, micropolitan, or metropolitan using census data. Proximity analysis was conducted via mapping from ZIP code centroid to nearest opioid treatment facility. Distance to treatment facilities was calculated and then compared using nonparametric testing for counties by rural and Appalachian status.

Results—NAS cases tripled from 2008–2014 in Kentucky counties, with a 2013 NAS rate more than double the national NAS rate. Rural and Appalachian counties experienced a NAS increase per 1,000 births that was 2–2.5 times higher than urban/non-Appalachian counties, with a greater number of NAS births overall in Appalachian counties. All opioid treatment facility types were further from rural patients than micropolitan/metropolitan patients ($P < .001$), as well as further for Appalachians vs non-Appalachians ($P < .001$, all facility types).

Conclusions—NAS burden disparately affects rural and Appalachian Kentucky counties, while treatment options are disproportionately further away for these residents. Policy efforts to increase NAS prevention and encourage opioid abuse treatment uptake in pregnant women should address rural and Appalachian disparities.

Keywords

Appalachia; neonatal abstinence syndrome; opioid abuse; substance abuse; treatment disparities

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The incidence of Neonatal Abstinence Syndrome (NAS), which is caused by *in utero* exposure to prescription and illicit (heroin) opioids, is on the rise in the United States.^{1,2} State and federal policy efforts to combat this increase in opioid abuse appear to have slowed the increase in prescription opioid abuse; however, these policy efforts are hypothesized to have influenced the increase in illicit opioid use as prescriptions become more difficult to obtain.³ The increase in NAS incidence has correlated with the well-documented increase in prescription opioid abuse; however, NAS incidence has not declined as nonmedical prescription opioid use has decreased.³

Recognizing the increase of NAS as a growing problem, bipartisan federal legislation has been signed into law to improve treatment outcomes for neonates with NAS, expand addiction treatment availability options for pregnant women that meet the standard of care, and expand prevention efforts for the avoidance of new nonmedical opioid use.^{4,5} One limitation to the successful implementation of these prevention efforts is the geographical variability and overall rurality of the NAS burden.⁵ According to data from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP), the rate of NAS in rural regions of the United States from 2004 through 2013 was nearly double that of the NAS rate in metropolitan areas, a disparity that has increased over time.⁶ This rural disparity in NAS may be expected, as more rural states have been disparately impacted by the opioid abuse epidemic.^{7,8} In Kentucky, a state hit particularly hard by the epidemic of opioid abuse, the rate of NAS has been observed as more than twice that of the nation as a whole.⁹

The public health community has decried the limited access to subsidized opioid abuse treatment, particularly in rural communities.¹⁰ Increased distance to care may reduce access for substance abuse treatment; however, at least one program that subsidizes transportation has demonstrated that substance abuse treatment utilization increases even for patients living more than 20 miles from the treatment facility when transport is provided.¹¹ This suggests that access to substance abuse treatment may be a multi-faceted problem for patients who abuse opioids during pregnancy; namely, there are physical barriers (distance, transportation), legal barriers (state laws regarding intervention following substance abuse during pregnancy), economic barriers (costs of treatment, opportunity costs of travel), and emotional barriers (stigma). Additionally, there are barriers like access to childcare that can be both physical and economic.¹²⁻¹⁴

This study sought to quantify the burden of NAS and access to opioid treatment centers in one state, Kentucky, where nearly half of Kentucky counties are both rural and in the geographically health disparate Appalachian region. We used national data to also assess the rural burden of NAS and benchmark the observed rate in Kentucky. Previous studies have examined rural and urban disparities in NAS incidence, so the novel contributions of this piece are the additional analysis between NAS incidence rates in Appalachian and non-Appalachian counties, as well as the comparison between distance to nearest treatment facilities by county status.

Methods

Data Sources

National Inpatient Sample (NIS, 2013) data were extracted and evaluated using the Agency for Healthcare Research and Quality's HCUPnet online tool to benchmark the rurality of NAS.⁸ NAS births were identified using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code 779.5 and live births were identified via ICD-9-CM codes V30.x through V38.x, excluding potential iatrogenic NAS cases with a coding algorithm used in other studies.^{15,16} Iatrogenic cases were excluded due to having different causal mechanisms for NAS than those of antenatal exposure. Using diagnosis codes for classification may result in under-identified or overly conservative estimates of NAS cases, but this is a limitation inherent to using administrative data sources. NIS data also provided an additional separation for metropolitan (large metro and suburbs) status designations built in to the HCUPnet online tool and this was included in national level data.

Complete Kentucky state discharge data were used for 2008–2014 provided by the Kentucky Cabinet for Health and Family Services. The sample included all inpatient discharges in the state (whereas NIS data is a random sampling) with any ICD-9-CM diagnosis code of 779.5 for NAS, and V30.x–V38.x for live births, also excluding for iatrogenic NAS cases. Patient ZIP codes for reported residence were cross-walked to a Core-Based Statistical Area code file that linked the ZIP code to US Census Bureau classifications of rural, micropolitan, or metropolitan, which are defined via population thresholds.¹⁷ The Appalachian region was defined based on the Appalachian Regional Commission list of counties and mapped by ZIP codes to patients.¹⁸ NAS rates were calculated per 1,000 live births for national and state-level data for each rural and metropolitan classification as well as for Appalachian and non-Appalachian designation in Kentucky. Calculated NAS rates per 1,000 live births in 2014 were also mapped by county along with the total number of NAS births in each county across all study years in Kentucky using Tableau version 9.3.1 (Tableau Software, Inc., Seattle, Washington).

Several types of treatment facilities were identified in Kentucky using the Substance Abuse and Mental Health Services Administration's National Provider Directory in 2016.¹⁹ Residential opioid treatment centers (N=11), residential treatment centers with programs tailored specifically for pregnant women (N=4), and intensive inpatient opioid treatment centers (N=15) were identified. Treatment centers that only accept private insurance or are cash-only were not included in this analysis; few cash-only treatment centers are present in Appalachian and non-Appalachian rural Kentucky counties.¹⁹ Physicians and clinics licensed to prescribe buprenorphine and/or methadone were identified using Drug Enforcement Agency registries (N=534).

Statistical Analysis

The distance to the identified treatment centers was calculated using facility or provider ZIP codes and the "ZIPCITYDISTANCE" function in SAS version 9.3 (SAS Institute, Inc., Cary, North Carolina), where distance is averaged by each ZIP code centroid (center point) in miles as the starting reference point to the facility or provider address. Proximity analysis

for access to opioid treatment was conducted using mean distance in miles from ZIP code centroid to the nearest opioid addiction treatment center. This was calculated for non-Appalachian and Appalachian counties, and again by county classification of rural, micropolitan, or metropolitan. Aggregation from multiple start points is a common technique in proximity analysis for access to care.^{20,21} Differences in mean distance between the nearest type of treatment center in Appalachian and non-Appalachian counties were tested non-parametrically using a Mann-Whitney U test. Differences in mean distance between the nearest type of treatment center by rural classification status were tested non-parametrically via Kruskal-Wallis testing. A priori significance level was set at 0.05.

Due to reports of substantial wait lists at most of Kentucky's treatment facilities it may not be possible for a patient to access services at the nearest treatment facility. To examine summary data about possible distance to treatment we conducted an aggregate analysis that compared mean distances between all opioid treatment centers and ZIP code centroids. This analysis was conducted by calculating the distance to each treatment facility for every ZIP code centroid and then averaging the resulting distances for each county. Those mean distances to all treatment centers for every county were then averaged by county classification. There are potential problems with skewness resulting from taking averages of averages, so median distance to all treatment centers was also calculated via this method. No testing by county classifications was conducted for the aggregated distance data.

Results

In 2013, the rate of NAS births in rural areas of the United States was more than double the rate of NAS births in metro areas (rural = 11.8 NAS births per 1,000 vs metro = 4.5 NAS births per 1,000; $P < .001$; Figure 1), and the overall rate was 7.3 NAS births per 1,000 live births. Between 2008 and 2014, there were 3,892 total NAS cases in Kentucky, which represented an increase from $N=249$ in 2008 up to $N=1,054$ in 2014 (Figure 2). Of these Kentucky cases, 30.1% were in rural areas, 22.8% were in micropolitan areas, and 47.0% were in metropolitan areas. The Appalachian region accounted for 52.0% of all NAS births in Kentucky. In absolute numbers, there were more NAS births in rural and micropolitan areas of Kentucky than in metropolitan areas of Kentucky, and more in the Appalachian region of Kentucky versus the non-Appalachian region (Figure 2). Based on the rate of NAS (Figure 2), these comparisons revealed larger disparities for non-urban and Appalachian areas with rates 2 to 2.5 times higher than metropolitan and non-Appalachian areas.

In 2014, the rate of rural NAS births reached 38.9 per 1,000 live births, which is 5 times higher than the overall US rate from the previous year and 3 times the rate from Kentucky metropolitan areas in that same year. These regional differences in Kentucky are further shown in Figure 3 with a high burden of NAS clustered in the Appalachian area of Kentucky. In rural areas nearly 90% of all NAS births listed Medicaid as the payer source, while less than 80% of NAS births in metropolitan areas had Medicaid.

Proximity analysis of distance to the nearest treatment centers showed that rural/micro and Appalachia areas tended to be further away from treatment when compared to metropolitan and non-Appalachian regions (Table 1.1), and this distance was statistically significant ($P < .$

001, all facility types). The distances to treatment for medication-assisted therapies (methadone, buprenorphine) were particularly concerning because these treatments may require frequent travel for administration. The mean distance to nearest buprenorphine treatment was 6.3 miles in rural counties vs 3.0 miles in urban counties ($P < .001$), and 4.8 miles in Appalachian counties vs 3.6 miles in non-Appalachian counties ($P < .001$). Even more substantial were the distances for methadone therapies, with 22.3 miles to the nearest treatment facility for Appalachian county residents vs 13.1 miles for non-Appalachians ($P < .001$).

The mean and median miles to all treatment facilities or providers were also greater, on average, for rural and Appalachian residences when compared with mean and median miles for metropolitan and non-Appalachian residences (Table 1.2). Pregnancy-specific programs for residents of Appalachian counties were found to be a median of 106.0 miles away vs 71.7 miles for non-Appalachian residents.

Discussion

This analysis demonstrated the large disparity of NAS between residential areas, particularly among Appalachian and non-Appalachian counties in Kentucky. In the case of Kentucky, this is not only a burden of relative rates but also absolute counts given that the number of NAS births is comparable between rural and urban and Appalachian and non-Appalachian regions. This disparity is further exemplified considering the relative lack of access to treatment for pregnant women in the rural and Appalachian areas of Kentucky. The increase in NAS incidence rates in Kentucky Appalachian counties reported in this study are in line with the results of Stabler and associates' analysis of NAS incidence rates in West Virginia from 2007 to 2013.¹⁶ This study identified NAS cases using the same diagnosis-code-based classification framework as Stabler, but this piece used a different data source. Stabler also found disparities in access to treatment programs in West Virginia, and this study expands upon those findings by calculating distances to nearest treatment centers to quantify those disparities.

The Kentucky-specific findings of this piece are also comparable to those of Ko and colleagues' analysis of NAS incidence in 28 states from 1999 through 2013, which also used HCUP data (state inpatient samples) to identify NAS cases.²² Ko reported a change in overall Kentucky NAS incidence rate of 4.7 in 1000 births in 2008 to 15.0 in 1000 births by 2013, which aligns with the findings we have reported in Figure 2. A novel contribution of this study is that Ko's state-level results can now be examined on a more granular level, with our inclusion of rural and Appalachian county designations to view changes in NAS incidence rates as a problem facing Kentucky's geographically distinct population areas with disparate severity. Ko and colleagues' work is also useful for interpreting national trends in NAS incidence, as at least one state from the US's geographically distinct regions is represented in their work.²²

Interestingly, Kentucky's change in NAS incidence may serve simultaneously as an outlier and a bellwether for other Appalachian states. It is an outlier due to its geographic "split" between the rural Appalachian eastern region, the urban north central region, and the rural

non-Appalachian western regions, all of which make it challenging to apply Kentucky trends nationwide. However, in a regional view Kentucky is a bellwether for not only Appalachian states but also the southeastern and Midwestern United States as a whole due to this geographic split. We would expect to see rates of NAS in Appalachian states like West Virginia similar to those NAS rates in the eastern Appalachian counties of Kentucky, which is what we can confirm by examining Stabler and associates' findings.¹⁶ We also expect to see that NAS rates in non-Appalachian rural Kentucky counties will be similar in non-Appalachian southern and Midwestern states. Ko and colleagues' work using data from 1999 through 2013 would suggest that this is in fact the case: rates of NAS incidence increased in states with significant rural populations like Arkansas (increase in NAS incidence from 1.0 to 2.6 per 1000 births from 2008–2013) but not as fast as in Appalachian states like West Virginia (increase in NAS incidence from 10.2 to 33.4 per 1000 births from 2008–2013).²²

Access to substance abuse treatment continues to be of concern as the opioid abuse epidemic continues. Nationally, it appears the combined policy efforts to reduce the supply of prescription opioids and monitor controlled substance prescribing have tempered the increase in prescription opioid abuse,³ but this does not appear to be the case for NAS nationally or in Kentucky.^{15,23} For pregnant women, there is an associated stigma and unknown legal ramifications with substance abuse while pregnant.^{24,25} Pregnant women with substance abuse disorders have been documented to exhibit evasive behaviors including timing of drug use to avoid “detection” during pregnancy check-ups or by avoiding doctor visits altogether.^{24,26} Thus, it may be likely that treatment seeking is lower in pregnant women compared to other patients, resulting in a non-decreasing trend in NAS. Additionally, only 12 states provide priority access to substance abuse treatment for pregnant women and only 4 states prohibit discrimination against pregnant women seeking treatment.²⁷ The American College of Obstetricians and Gynecologists has recently recommended a practice of “voluntary screening” in pregnant women while reminding providers that NAS diagnoses could result in legal ramifications, or in some cases, the separation of the neonate upon state intervention.²⁷

While past legislation and policies were intent on reducing access (“supply” effect) to prescription medications, increases in illicit opioid abuse appear to minimize the impact of these efforts. New federal legislation appropriating funds for substance abuse treatment must impact the “demand” side of the opioid abuse epidemic. Recent federal legislation, including the “Protecting Our Infants Act” of 2015 and the “21st Century Cures Act” of 2016 have provided funds to increase the access to opioid treatment facilities in light of the ongoing epidemic.^{4,5} States like Kentucky that are hit particularly hard by the opioid abuse epidemic must continue to enforce and supplement policies related to surveillance programs along with subsidizing coverage for substance abuse treatment through state services. The mapping approach of calculating distance to treatment centers would allow policy makers in all states who are considering where to expand their opioid treatment facilities to examine population density, rates of opioid abuse, and proximity of existing treatment options simultaneously to determine where best to expand treatment options. Appalachian counties are facing inequitable access to care for opioid abuse treatment on all of those factors: greater rates of opioid abuse but fewer treatment options within close proximity.

Health care providers can help mitigate pregnant women's fears that increase resistance to treatment by understanding state laws and addressing patient concerns for treatment options.^{26,28} Increasing treatment access for pregnant women in rural areas should be a public health priority and may be bolstered by the engagement of community partners, accessible screening opportunities for substance abuse problems, and innovative use of telehealth for substance abuse treatment.^{26,28,29} Recent reports suggest that only 13% of outpatient-only substance abuse treatment facilities or residential treatment facilities are specifically available to pregnant or post-partum women.³⁰ Due to the tremendous burden of NAS and the potential for lifelong complications for the neonate, tailoring of interventions to pregnant women or women of childbearing age should be a priority within national and state substance abuse policy interventions, and more focus is needed in rural areas that are harder hit by this issue.^{31,32}

Limitations

This study has limitations inherent to using inpatient discharge data. These data rely on accurate coding practices that may vary between hospitals. In the case of NAS, it is likely to be underdiagnosed;³³ thus, our counts may be underestimated. The ICD-9-CM code 779.5 used for case identification may also capture neonatal withdrawal caused by other, non-opioid substances. Trends in NAS may be influenced by increased awareness and diagnosis over time; however, this would not account for the differences between rural and urban areas. We used ZIP codes to determine the distance to nearest treatment. This proximity analysis strategy is limited to calculating the distance from the geographic center of each ZIP code to the next, which may over- or underrepresent the true distance for patients based on their exact residential location. Lastly, studies conducting proximity analysis using ZIP code centroid methods are additionally susceptible to underestimating distance required for travel in rural areas due to the assumption that distance can be equally converted to travel time regardless of road density, quality, and availability of public transportation options.²⁰ Therefore, our proximity analysis is likely conservative in its estimation of treatment distance for rural areas, ie, the disparity between urban and rural areas is likely larger than what is shown here.

Conclusions

This is the first study to show a large disparity in NAS in the United States by Appalachian status. Using Kentucky as a case example, disparities in NAS burden correspond with disparities in treatment access for opioid abuse. Policy interventions are needed to address the disparities in access to treatment for those in non-urban areas to halt the increase in NAS and the tremendous humanistic and economic burden it poses.

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References

1. Patrick, S., Schumacher, R., Benneyworth, B., Krans, E., McAllister, J., Davis, M. Neonatal abstinence syndrome and associated health care expenditures; JAMA: The Journal of the American Medical Association. 2012. p. 307<http://dx.doi.org/10.1001/jama.2012.3951>
2. Hudak ML, Tan RC. COMMITTEE ON DRUGS, COMMITTEE ON FETUS AND NEWBORN, American Academy of Pediatrics. Neonatal drug withdrawal. Pediatrics. 2012; 129(2):e540–e560. DOI: 10.1542/peds.2011-3212 [PubMed: 22291123]
3. Dart RC, Surratt HL, Cicero TJ, et al. Trends in opioid analgesic abuse and mortality in the united states. N Engl J Med. 2015; 372(3):241–248. DOI: 10.1056/NEJMsa1406143 [PubMed: 25587948]
4. McConnell M. Protecting our infants act of 2015. *S 799*. 2015(114th Congress).
5. Bonamici S. 21st century cures act. 12/13/2016;HR.34(114th Congress (2015–2016)).
6. Villapiano NL, Winkelman TN, Kozhimannil KB, Davis MM, Patrick SW. Rural and urban differences in neonatal abstinence syndrome and maternal opioid use, 2004 to 2013. JAMA Pediatr. 2016; doi: 10.1001/jamapediatrics.2016.3750
7. Keyes KM, Cerda M, Brady JE, Havens JR, Galea S. Understanding the rural-urban differences in nonmedical prescription opioid use and abuse in the united states. Am J Public Health. 2014; 104(2):e52–e59. DOI: 10.2105/AJPH.2013.301709 [PubMed: 24328642]
8. Agency for healthcare research and quality. [Accessed February 12, 2016] HCUPnet. <http://hcupnet.ahrq.gov/>
9. Brown JD, Doshi PA, Pauly NJ, Talbert JC. Rates of neonatal abstinence syndrome amid efforts to combat the opioid abuse epidemic. JAMA Pediatrics. 2016; 170(11):1110–1112. <http://dx.doi.org/10.1001/jamapediatrics.2016.2150>. [PubMed: 27669331]
10. Dick AW, Pacula RL, Gordon AJ, et al. Increasing potential access to opioid agonist treatment in U.S. treatment shortage. Health Affairs. 2015; 34(6):1028–1034. DOI: 10.1377/hlthaff.2014.1205 [PubMed: 26056209]
11. Whetten R, Whetten K, Pence BW, Reif S, Conover C, Bouis S. Does distance affect utilization of substance abuse and mental health services in the presence of transportation services? AIDS Care. 2006; 18(Supplement 1):S27–S34. [PubMed: 16938672]
12. Jackson A, Shannon L. Barriers to receiving substance abuse treatment among rural pregnant women in kentucky. Maternal and child health journal. 2012; 16(9):1762–1770. [PubMed: 22139045]
13. Greenfield S, Brooks A, Gordon S, et al. Substance abuse treatment entry, retention, and outcome in women: A review of the literature. Drug and alcohol dependence. 2007; 86(1):1–21. [PubMed: 16759822]
14. Carr C, Xu J, Redko C, et al. Individual and system influences on waiting time for substance abuse treatment. Journal of substance abuse treatment. 2008; 34(2):192–201. [PubMed: 17512159]
15. Patrick SW, Schumacher RE, Benneyworth BD, Krans EE, McAllister JM, Davis MM. Neonatal abstinence syndrome and associated health care expenditures: United states, 2000–2009. JAMA. 2012; 307(18):1934–1940. DOI: 10.1001/jama.2012.3951 [PubMed: 22546608]
16. Stabler M, Long D, Chertok I, Giacobbi P, Pilkerton C, Lander L. Neonatal abstinence syndrome in west virginia substate regions, 2007–2013. J Rural Health. 2017; 33(2):92–101. [PubMed: 26879950]
17. [Accessed December 10, 2016] United states census bureau: 2010 metropolitan and micropolitan statistical areas- main. <https://www.census.gov/population/metro/>
18. Appalachian regional commission. [Accessed May 10, 2016] counties in appalachia. <http://www.arc.gov/counties>
19. Substance abuse and mental health services administration. [Accessed October 4, 2016] national directory of mental health treatment facilities. 2015. <http://www.samhsa.gov/data/mental-health-facilities-data-nmhss/reports?>
20. McDonald YJ, Goldberg DW, Scarinci IC, et al. Health service accessibility and risk in cervical cancer prevention: Comparing rural versus nonrural residence in new mexico. J Rural Health. epub ahead of print: August 24, 2016.

21. Rosenblum A, Cleland CM, Fong C, Kayman DJ, Tempalski B, Parrino M. Distance traveled and cross-state commuting to opioid treatment programs in the united states. *Journal of Environmental and Public Health*. 2011; 10:1–10. DOI: 10.1155/2011/948789
22. Ko J, Patrick S, Tong V, Patel R, Lind J, Barfield W. Incidence of neonatal abstinence syndrome- 28 states: 1999–2013. *MMWR Morb Mortal Wkly Rep*. 2016; 65:799–802. [PubMed: 27513154]
23. Patrick SW, Davis MM, Lehmann CU, Cooper WO. Increasing incidence and geographic distribution of neonatal abstinence syndrome: United states 2009 to 2012. *J Perinatol*. 2015; 35(8): 650–655. DOI: 10.1038/jp.2015.36 [PubMed: 25927272]
24. Stone R, Banwell C, Bammer G. Pregnant women and substance use: Fear, stigma, and barriers to care. *Health & Justice*. 2015; 3(1):2.
25. Murphy A. A survey of state fetal homicide laws and their potential applicability to pregnant women who harm their own fetuses. *Indiana Law J*. 2014; 89(2):847.
26. Jones HE, Martin PR, Heil SH, et al. Treatment of opioid-dependent pregnant women: Clinical and research issues. *J Subst Abuse Treat*. 2008; 35(3):245–259. DOI: 10.1016/j.jsat.2007.10.007 [PubMed: 18248941]
27. Terplan M, Minkoff H. Neonatal abstinence syndrome and ethical approaches to the identification of pregnant women who use drugs. *Obstet Gynecol*. 2017; 129(1):164–167. DOI: 10.1097/AOG.0000000000001781 [PubMed: 27926654]
28. Shainker SA, Saia K, Lee-Parritz A. Opioid addiction in pregnancy. *Obstet Gynecol Surv*. 2012; 67(12):817–825. DOI: 10.1097/OGX.0b013e3182788e8c [PubMed: 23233054]
29. Benavides-Vaello S, Strode A, Sheeran BC. Using technology in the delivery of mental health and substance abuse treatment in rural communities: A review. *J Behav Health Serv Res*. 2013; 40(1): 111–120. DOI: 10.1007/s11414-012-9299-6 [PubMed: 23093443]
30. Smith, K., Lipari, RN. The CBHSQ Report. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration; Rockville, MD: 2017. Women of childbearing age and opioids. https://www.samhsa.gov/data/sites/default/files/report_2724/ShortReport-2724.html [Accessed: April 17, 2017]
31. Patrick SW. The triple aim for neonatal abstinence syndrome. *J Pediatr*. 2015; 167(6):1189–1191. DOI: 10.1016/j.jpeds.2015.09.047 [PubMed: 26454574]
32. Jones HE, Kaltenbach K. Neonatal abstinence syndrome. *JAMA*. 2012; 308(8):762–763. author reply 763. DOI: 10.1001/jama.2012.8595 [PubMed: 22910747]
33. Burns L, Mattick RP. Using population data to examine the prevalence and correlates of neonatal abstinence syndrome. *Drug Alcohol Rev*. 2007; 26(5):487–492. 781267171 [pii]. [PubMed: 17701511]

Figure 1. Neonatal abstinence syndrome (NAS) in the United States by patient residence status, 2013

Error bars indicate 95% confidence intervals. Data from 2013 National Inpatient Sample, classifications of metro/suburbs/rural residence status from Agency for Healthcare Research and Quality HCUPnet online tool.

Figure 2. Number and rate of NAS births by residence status in Kentucky, 2008–2014

Metropolitan classifications based on Core-Based Statistical Area codes mapped to 5-digit patient zip codes in discharge data. Appalachian region defined by Appalachian Regional Commission county list linked to ZIP codes.

Figure 3. Map of NAS birth rate per 1,000 live births by Kentucky county, 2014

Appalachian region defined by Appalachian Regional Commission county list linked to ZIP codes. Rates are color coded, absolute numbers are within each county in text.

Table 1.1

Distance in Miles From ZIP Code Centroid to Nearest Opioid Addiction Treatment Center for Pregnant Women in Kentucky in 2016 by Urban/Rural and Appalachian County Classification

County Classification	Methadone ^a		Buprenorphine ^b		Residential ^c		Inpatient ^d		Pregnancy-specific ^e	
	Nearest Treatment	P value ^f	Nearest Treatment	P value	Nearest Treatment	P value	Nearest Treatment	P value	Nearest Treatment	P value
Rural	21.4	< .001	6.3	< .001	32.2	< .001	29.8	< .001	39.3	< .001
Micro-politan	27.7		3.7		49.2		23.1		30.9	
Metropolitan	10.9		3.0		11.4		11.8		10.8	
Appalachia	22.3	< .001	4.8	< .001	36.8	< .001	24.3	< .001	29.5	< .001
Non-Appalachia	13.1		3.6		15.9		14.9		9.8	

^a All methadone clinics in Kentucky (N=16).

^b Includes all physicians (N=534) licensed to prescribe buprenorphine according to Drug Enforcement Agency registries. May include inactive prescribers.

^c Includes all residential treatment centers that are publicly funded and have opioid-specific treatment protocols (N=11).

^d Hospital-based inpatient opioid locations (N=15).

^e Publicly funded residential treatment centers with programs specifically tailored for pregnant women (N=4).

^f P-value calculated via Kruskal-Wallis test for rural, micro-politan, and metropolitan classifications and via Mann Whitney U test for Appalachia vs Non-Appalachia.

Table 1.2

Distance in Mean and Median Miles From ZIP Code Centroid to all Opioid Addiction Treatment Centers^g for Pregnant Women in Kentucky in 2016 by Urban/Rural and Appalachian County Classification

County Classification	Methadone		Buprenorphine		Residential		Inpatient		Pregnancy-specific	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Rural	126.7	114.6	124.4	116.3	129.4	123.2	124.6	121.8	120.2	218.4
Metropolitan	116.7	101.4	110.3	97.7	121.2	110.5	104.0	96.8	113.9	99.4
Appalachia	106.4	94.5	98.6	87.4	99.7	88.9	93.2	84.1	70.3	70.4
Non-Appalachia	118.6	104.9	114.7	104.6	120.9	113.2	112.7	108.7	107.8	106.0
	111.2	98.9	103.5	90.1	106.2	94.1	97.6	85.8	82.9	71.7

^gDistance in miles from every zip code centroid to each opioid treatment center was calculated, then those distances to all centers were averaged by county classification. Due to skewness from taking an average of an average, median distances by county classifications were also calculated.