Adverse Maternal Outcomes Across the Rural-Urban Gradient in the U.S.

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Short Abstract

Rates of maternal mortality and related life-threatening adverse maternal outcomes are rising in the United States. Limitations on the availability of nationally representative data have limited our ability to understand how maternal mortality and adverse maternal outcomes are distributed over the rural-urban gradient across the country. The revised certificate of birth now allows us to evaluate several important adverse outcomes while controlling for individual- and county-level factors across the entire cohort of births to U.S. resident women. In this analysis we examine whether rates of adverse maternal outcomes are higher in rural areas compared to more urban areas, and what factors are associated with increased rates of adverse outcomes. Preliminary findings suggest significant variation in outcomes across the rural-urban gradient and the potential to describe how rurality interacts with other factors to predict life-threatening adverse maternal outcomes.

Background

Maternal mortality and related adverse maternal outcomes are on the rise in the United States (U.S.) (Hirshberg & Srinivas, 2017; Kozhimannil, Hardeman, & Henning-Smith, 2017). In part because maternal mortality is so rare and surveillance data are unreliable, little is known about what demographic and medical factors predict mortality. However, other adverse maternal outcomes that occur at the time of birth can be considered indicators of life-threatening risk to mothers. The revised U.S. certificate of live birth now includes some important measures of both maternal risk and adverse outcomes. Previous to the revised certificate of birth, investigators were limited to state-level linked birth record and hospital discharge data. The availability of data from the revised birth record provide an opportunity for analysis of a near-complete U.S. birth cohort to generate a national picture of adverse maternal outcomes.

Existing research of maternal health in rural areas in the U.S. is limited but suggests that the gradient of rural and urban residence across the U.S. is a significant driver of disparities in maternal outcomes (Kozhimannil et al., 2017).

Rural communities face higher rates of social disadvantage and serious illness across the lifespan. A "rural mortality penalty" has been documented since the 1980s, where those living in rural areas in the U.S. have increasingly higher mortality rates at every age compared to those living in urban areas (James, 2014; Singh & Siahpush, 2014). Sociodemographic factors, health status and behaviors, and access to the healthcare services all present challenges for rural residents and communities. Similarly, neonatal and infant outcomes have been shown to be poor among rural populations. A recent report by the National Center for Health Statistics (NCHS) documented that among all births in the U.S. in 2014, rural counties had higher rates of neonatal mortality than large, urban counties (Ely, Driscoll, & Matthews, 2017). It is plausible that rural women bear a significant share of the increasing maternal morbidity and mortality in the U.S., and that maternity ward closures and inadequate maternity care workforce explain at least some disparities (Hung, Henning-Smith, Casey, & Kozhimannil, 2017; Lisonkova et al., 2016).

While efforts to regionalize perinatal care services have been ongoing for decades, these efforts have focused almost exclusively on improving neonatal outcomes. The American College of Obstetrics and Gynecology (ACOG) and the Society for Maternal Fetal Medicine (SMFM) recently published a new set of guidelines for the designation of *maternal* levels of care, reflecting renewed interest in differentiating patterns of adverse maternal outcomes from neonatal and infant outcomes ("Obstetric Care Consensus No. 2: Levels of maternal care," 2015). These guidelines point to the stark differences in access to obstetric care resources across the rural-urban gradient. Improved understanding of risk for life-threatening adverse maternal outcomes will help inform efforts to regionalize maternal care.

In this analysis we examine whether rates of adverse maternal outcomes documented on the birth record are higher in rural areas compared to more urban areas. Additionally, we examine what factors are associated with increased rates of adverse outcomes, including health behaviors, comorbidities, access to and utilization of health care, and area socioeconomic status.

Methods

Data Sources

To achieve our study aims we use three linked data sources: the 2011-2014 NCHS linked birth and infant death records (henceforth "birth records") for the U.S., the 2010-2014 American Community Survey (ACS) county-level 5-year samples, and the 2016-2017 Area Health Resource File (AHRF). The geocoded birth/death records are provided by the National

Association for Public Health Statistics and Information Systems (NAPHSIS) through a data use agreement. The dataset includes the mother's county of residence, which we use to link the birth/death records to the ACS dataset. The ACS provides county-level demographic and socioeconomic information, and is administered by the U.S. Census Bureau. The AHRF dataset includes county-level information on healthcare service availability including obstetric care for all U.S. counties. This study was declared exempt by the University of Wisconsin-Madison Institutional Review Board.

Measures

We will evaluate three adverse maternal outcomes that are measured on the revised birth record for all U.S. births. These are postpartum admission to an intensive care unit (ICU), unplanned surgical procedures following delivery, and blood transfusion. Blood transfusion is an often-used proxy measure for significant postpartum hemorrhage.

To measure the rurality and urbanicity, both residence and delivery counties are linked with the 2013 NCHS Urban-Rural Classification Scheme for Counties (Ingram & Franco, 2014). The NCHS classification is based on 2013 Office of Management and Budget delineations of metropolitan or micropolitan statistical areas, with an adjustment from 2012 postcensal estimates of U.S. population. The classification scheme takes into account population size and whether the county is part of a metropolitan core. The resulting scheme has six categories: large central metro, large fringe metro, medium metro, small metro, micropolitan, and noncore or rural.

County-level factors measured will include access to obstetric care as evaluated in the AHRF, socioeconomic status, level of segregation, fertility rate, and region of the U.S. We will also control for individual-level medical risk factors and sociodemographic factors. Individual-level risk factors for adverse outcomes include maternal age, pre-existing or gestational diabetes and hypertension, previous preterm birth, parity, tobacco use during pregnancy, clinical chorioamnionitis, multiple gestation, and mode of delivery (surgical or vaginal). An indicator of delivery in a different county than the county of residence may also be included in regression models. Since the makeup of the U.S. population across the rural-urban gradient differs significantly by race, nativity, and other sociodemographic factors, we will control for maternal race and ethnicity, marital status, nativity status, education level, and insurance coverage type (public, private, self-pay or other). To measure individual-level prenatal care utilization, we will use an indicator of initiation of prenatal care during the first trimester of pregnancy, as well as the Adequacy of Prenatal Care Utilization Index (Kotelchuck, 1994; Osterman & Martin, 2018).

Analysis Plan

To achieve Aim 1 we generate descriptive tables of our key maternal outcomes, comorbidities, health behaviors and socioeconomic risk factors and examine the variability of these outcomes and risk factors over the NCHS rural-urban categories. We will test the association between rural-urban classification and each maternal outcome. We will also examine the variation in mother's sociodemographic and medical risk factors.

In analysis for Aim 2, we use multi-level regression techniques to estimate the influences of individual and county-level factors on the birth outcomes. Our baseline model for each outcome will be a multivariate regression on the individual-level variables including maternal sociodemographic and medical risk factors that may affect maternal outcomes. We may also include a random effect of county into the individual regression analysis before we estimate a full multilevel model. In the full multilevel analysis, we will add county-level sociodemographic factors and access to obstetric services to the county-level equations. We will generate distinct models for the entire sample and compare models for subsamples of each of the NCHS rural-

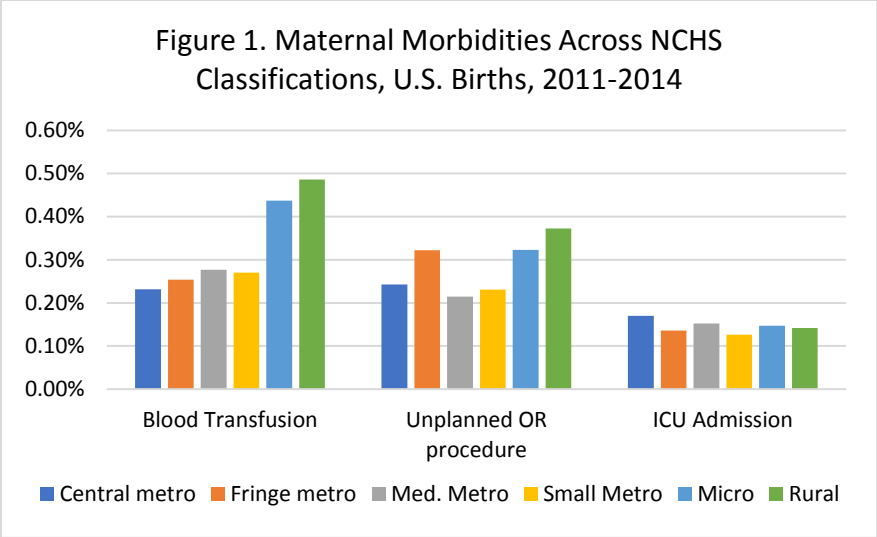
urban classification levels to test the interaction between rural-urban classification and other variables. The comparison may be done by imposing equality constraints on the corresponding coefficients between rural-urban levels. We may use either improvement in goodness of fit (e.g., BIC, AIC...) between unconstrained and constrained models, or the z test for the equality of coefficients (Paternoster, Brame, Mazerolle, & Piquero, 2006).

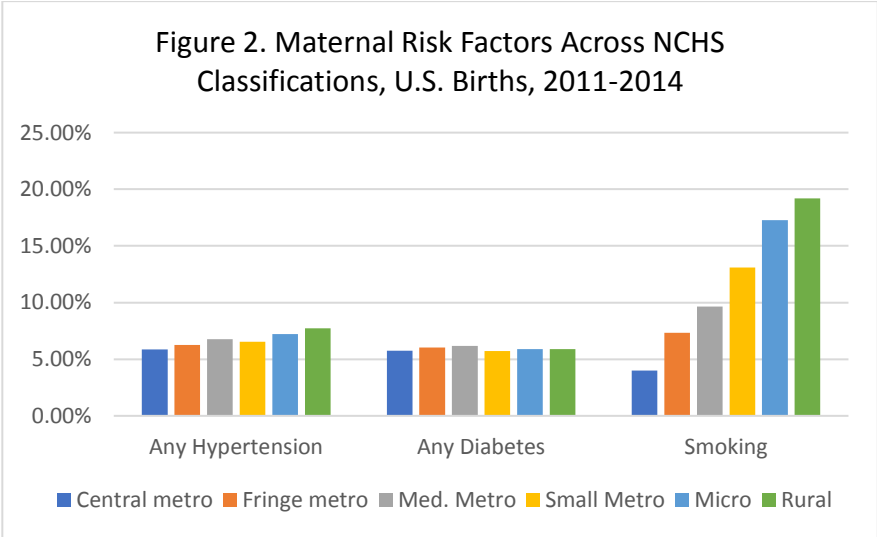
Preliminary Findings and Expected Further Findings

Preliminary analyses address Aim 1 of our study. Our findings confirm that rates of individual-level maternal characteristics vary across the gradient (Table 1). We also find that the adverse maternal outcomes under study do vary across the rural-urban gradient (Figure 1). Specifically, women in more rural counties are more likely to require blood transfusion, and women in fringe metropolitan, micropolitan, and rural counties have higher rates of unplanned surgical procedures. Rates of several important risk factors also vary across place (Figure 2). Rates of smoking and hypertensive disorders increase with increasing rurality. Additionally, women in fringe metropolitan counties have the highest rates of initiating prenatal care during the first trimester, with lower rates among women in central metropolitan and rural counties.

Table 1. Distribution of total births and U.S.-resident maternal characteristics, 2011-2014, by NCHS 2013 Classification.

	Central Metro	Fringe Metro	Med. Metro	Small Metro	Micro	Rural	Total
Total Number of Births							
	5229822 33.04%	3667782 23.17%	3336337 21.08%	1430300 9.04%	1302796 8.23%	859654 5.43%	15826691 100%
Mother's Race and Ethnicity							
NHW	36.43%	59.55%	57.02%	68.16%	72.29%	75.71%	54.08%
NHB	19.38%	14.07%	13.23%	11.85%	8.99%	9.43%	14.78%
Hispanic	32.47%	18.44%	23.74%	15.26%	13.67%	9.06%	23.00%
Other	11.73%	7.94%	6.00%	4.73%	5.05%	5.79%	8.14%
Mother's Education Level							
< High School	18.32%	10.79%	15.24%	13.86%	16.30%	16.31%	16.48%
High School	23.96%	19.06%	22.52%	24.39%	27.14%	27.80%	25.02%
Some College	25.57%	25.12%	27.59%	28.84%	29.79%	29.11%	29.11%
College +	32.14%	32.78%	22.59%	21.64%	17.62%	14.51%	29.39%
Percent Births to Married Mothers							
	57.50%	65.85%	58.25%	58.17%	55.92%	56.06%	59.45%
Percent Births to Foreign-Born Mothers							
	33.43%	23.33%	17.52%	11.92%	9.25%	6.12%	22.32%





Our preliminary findings suggest that the rural-urban gradient is likely significantly associated with life-threatening adverse maternal outcomes. Further analyses of these associations with robust controls as described above will enhance our understanding of which factors drive differences in morbidity rates, and to what extent the rural-urban gradient has an impact on outcomes net of other factors that differ across place. For example, findings suggest that access to and utilization of prenatal care may explain part of the rural-urban variation.

Complete findings from this study will help explain how individual- and county-level risk factors interact to drive outcomes and ultimately identify critical gaps in maternal care needs across the U.S. A better understanding of these complex relationships can help drive resource allocation for continued regionalization of perinatal care across the country, and ultimately contribute to decreasing maternal morbidity and mortality.

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