Infant Mortality Across the Rural-Urban Gradient in the United States

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ABSTRACT

Recent research suggests that infant mortality (IM) varies across the US rural-urban gradient. Specifically, IM increases as areas become more rural. While a similar "rural mortality penalty" has been studied in adults, the reason for this gap in IM is unknown. This study seeks to explore this gap by considering the health care, health behavior, and socioeconomic and environmental factors that might contribute to it. Using a combination of descriptive statistics, decomposition analyses, and multilevel regressions, we examine whether IM, the maternal characteristics associated with IM, and birthweight vary across the rural-urban gradient, and examine how much of this variation is explained by rurality. Initial findings suggest that there is variation in the IM rate and characteristics associated with IM by level of rurality. Rural areas also have higher rates of birthweight-specific mortality than other areas.

While the overall US infant mortality (IM) rate has declined since the early 1900s,[1] recent analyses indicate that the IM rate varies significantly by place in the United States. Specifically, a recent report by the National Center for Health Statistics (NCHS) indicates that IM, or death before 1 year of age, increases as areas become more rural, even after accounting for race and maternal age.[2] This mirrors the "rural mortality penalty" found among adults, where, since the 1980s, those living in rural areas have increasingly higher mortality rates at every age than those living in urban areas in the US, due to the fact that rural mortality rates have declined more slowly than urban mortality rates across this period.[3.] While prior research suggests that differential trends in health behaviors, socioeconomic factors, and access to healthcare explain part of the rural-urban mortality gap for adults,[4] the factors driving the rural-urban IM gap are largely unknown.

It is likely that the factors influencing the adult rural mortality gap are also relevant to disparities in IM. For example, the differences in health behaviors that contribute to elevated rural adult mortality almost certainly affect adult health in general, including women's health during the preconception period.[3,5] Poor health and unhealthy behaviors among women in turn shape the course of the pregnancy and may be associated with growth restriction, spontaneous and iatrogenic preterm birth, and risk of sudden unexplained infant death.[6] In addition, women and families living in rural areas may experience poverty but lack access to social services designed to combat it, which could impact IM at and after birth.[7] Finally, women in rural areas have limited access to high quality health care. While access to high quality obstetrical and neonatal care has contributed to the reduction in IM experienced in the US during the last century,[8] access to such care is not equally distributed across the US. Indeed, access to any obstetrical care has fallen in rural areas in recent years.[9]

Because of the complexity of the factors relevant to IM, an examination of the problem requires an approach that considers factors across multiple domains, including health care, health behaviors, and socioeconomic and environmental factors. This study explores rural IM and its potential causes by addressing the following questions:

Question 1: To what extent do IM and the maternal characteristics associated with IM vary across the rural-urban gradient?

Question 2: To what extent does birth-weight specific mortality vary across the rural-urban gradient, and what proportion of the rural-urban differences in IM are explained by the distribution of birthweight?

Question 3: To what extent does rurality contribute to IM after accounting for individual and structural (access to healthcare, area socioeconomic status) factors?

Data and Methods

Our study draws on three sources of data: the NCHS linked (cohort) birth and infant death records (henceforth "birth/death records") for 2005-2014; the 2005-2009 and 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, provided by the National Association for Public Health Statistics and Information Systems (NAPHSIS) through a data use agreement, link the birth and death certificates of each infant that dies within the first year after birth. The dataset includes the mother's county of residence, which we use to link the birth/death records to the ACS. The ACS, administered by the US Census Bureau, replaced the "long-form" census and provides information on county demographic and socioeconomic characteristics. The AHRF includes county-level information on healthcare service availability and access for all US counties. This study was declared exempt by the University of Wisconsin-Madison Institutional Review Board.

Variables
Our primary outcome variable is infant death within the first year of life. To measure rurality and urbanicity, we use the NCHS Urban-Rural Classification Scheme,[10] which categorizes areas by metropolitan or micropolitan classification, population size, and whether the county is part of the metropolitan core. The resulting classification scheme has six categories: large central metro, large fringe metro, medium metro, small metro, micropolitan, and noncore (rural).

We control for individual-level factors available in the birth records that could contribute to IM, including variables accounting for the infant's health and characteristics (e.g., NICU admission, birthweight), the mother's demographic characteristics (e.g., age, race/ethnicity, education), the mother's prenatal health and healthcare for this pregnancy (e.g., adequacy of prenatal care, tobacco use, gestational diabetes diagnosis), the mother's obstetrical history (e.g., parity, prior hypertension), the delivery experience (e.g., method of delivery, transfusion, unplanned hysterectomy), and whether the father's information is included on the birth certificate.

To account for county-level characteristics that could affect IM, we control for the percentage of the county population that is of reproductive age and the percentage of the population that is non-Hispanic white, non-Hispanic Black, and Hispanic, any race. We also control for the fertility rate, the level of segregation, and the socioeconomic status of the area, as well as access to obstetrical care. We also include a control for region and account for spatial autocorrelation.

Analysis Plan

To address our first question— to what extent do IM and the maternal characteristics associated with IM vary across the rural-urban gradient? —we first examine descriptive statistics of IM overall and by urban/rural classification. We then examine descriptive statistics about IM by time of death (overall, neonatal, and post-neonatal), urban-rural classification, and birthweight-specific mortality.

To address our second question—to what extent does birth-weight specific mortality vary across the rural-urban gradient, and what proportion of the rural-urban differences in IM are explained by the distribution of birthweight?—we use standard (Kitagawa) and adjusted (Blinder-Oaxaca)[11] decomposition methods to estimate the relative contributions of birthweight, birthweight-specific mortality, gestational age and other factors.

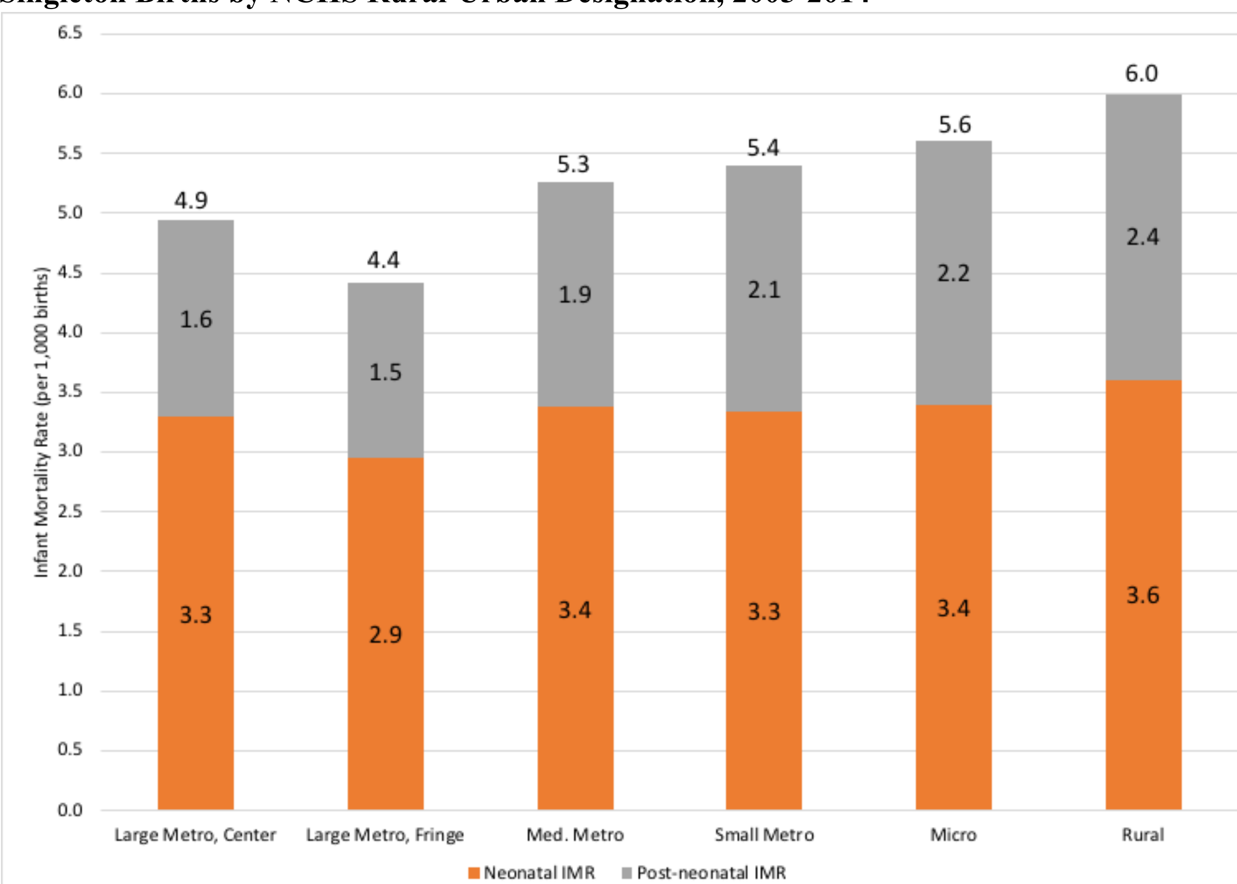
We use multi-level regression to address our third question: To what extent does rurality contribute to IM after accounting for individual and structural (access to healthcare, area socioeconomic status) factors? To assess this, we will take IM as our outcome. With infants at level-1, we will include the controls discussed above for individual factors that could affect IM outcomes, and we will replicate this process with counties at level-2, where we will consider structural factors. We will analyze the entire population, and then will execute separate models for each of the NCHS county classifications to examine the effects of position on the rural-urban gradient. We then will compare coefficients from each model using the *z test for the equality of coefficients*.[12,13]

Initial Results

Initial analyses suggest preliminary answers to our first two research questions. First, important maternal and socioeconomic characteristics do vary across the rural-urban gradient. Protective factors, such as being married and having a college education, are much more prevalent among mothers in fringe metros, which have the lowest IM rates, while risk factors are much more likely in micropolitan and rural areas (results not shown). In particular, mothers in rural areas are the least likely to have college degrees, have private insurance, and to be foreign-born, and are the most likely to be covered by Medicaid, to smoke, and to have children before the age of 24.

Figure 1 and Table 1 show differences in IM by timing of death and by birthweight-specific mortality, respectively, for singleton births from 2005-2014 by NCHS rural-urban designation.

Figure 1: Total, Neonatal, and Post-Neonatal Infant Mortality for Resident Mothers' Singleton Births by NCHS Rural-Urban Designation, 2005-2014



The figure shows total, neonatal, and post-neonatal IM by NCHS category, while the table shows the birthweight-specific mortality by NCHS classification, as well as total IM by NCHS classification, total IM by birthweight, and the ratio of rural IM to large metro fringe IM.

As the tables and figures demonstrate, the IM rate does vary across the rural-urban gradient, with infants faring the best in large metro fringe (suburban) counties, and worst in rural counties. There is also variation in birthweight-specific mortality. When comparing the areas with the worst overall outcomes—rural counties—to the areas with the best outcomes—large metro fringe counties—the birthweight-specific mortality is higher in rural areas in all but one instance (250-499 g). These findings suggest that further analyses are warranted.

Table 1: Birthweight-Specific Mortality Rate for Resident Mothers' Singleton Births by NCHS Rural-Urban Designation, 2005-2014

Birthweight	Large Metro, Center	Large Metro, Fringe	Med. Metro	Small Metro	Micro	Rural	Total	Ratio: Rural to Fringe
< 250 g	840.0	841.7	904.4	849.4	853.3	876.1	858.5	1.04
250-499 g	832.2	841.2	852.6	848.5	821.0	823.2	13570.9	0.98
500-749 g	411.7	413.1	424.4	430.1	424.6	443.7	12092.4	1.07
750-999 g	129.0	133.2	135.2	147.3	150.2	150.8	4192.0	1.13
1000-1249 g	62.2	65.0	68.5	77.3	74.2	87.3	2118.0	1.34
1250-1499 g	42.0	40.9	49.0	48.8	48.9	55.2	1581.9	1.35
1500-1749 g	31.5	30.9	32.8	35.9	38.1	41.7	1632.4	1.35
1750-1999 g	20.5	21.8	23.9	25.9	27.1	29.2	1766.8	1.34
2000-2249 g	13.6	14.2	15.7	16.1	18.4	17.6	2179.5	1.24
2250-2499 g	8.1	7.6	9.0	9.7	10.5	10.8	3136.2	1.43
2500-2749 g	4.5	4.4	5.4	5.9	6.1	6.3	4089.2	1.43
2750-2999 g	2.7	2.6	3.2	3.8	4.1	4.2	5306.1	1.58
3000-3249 g	1.9	1.8	2.2	2.5	2.9	3.0	5727.0	1.64
3250-3499 g	1.4	1.3	1.7	1.9	2.2	2.4	4794.2	1.75
3500-3749 g	1.2	1.1	1.5	1.7	1.8	2.0	3279.4	1.79
3750-3999 g	1.1	1.0	1.2	1.5	1.6	1.7	1809.1	1.65
4000-4249 g	1.1	1.1	1.3	1.3	1.6	2.0	846.4	1.86
4250-4499 g	1.0	0.9	1.1	1.7	1.4	1.8	323.9	1.94
4500+ g	1.1	1.0	1.5	1.1	1.7	2.5	46.6	2.40
Total	4.9	4.4	5.3	5.4	5.6	6.0	5.0	

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