Individual and Community Predictors of Preterm Birth and Low Birthweight Along the Rural-Urban Continuum in Central Pennsylvania

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ABSTRACT: ***Context:*** *Preterm birth and low birthweight remain high priority public health problems and are associated with increased risk of infant mortality as well as long-term health impairments. Although 20% of all births nationally are to rural women, relatively little attention has been paid to pregnancy outcomes in rural areas relative to more urbanized areas.* ***Purpose:*** *This study examines the relationship of individual- and community-level socioeconomic, health care, and health status-related characteristics to preterm birth and low birthweight outcomes among women living in urban and various types of rural communities.* ***Methods:*** *Vital record data on singleton first births to residents of a 28-county region in central Pennsylvania in 2002 (N = 11,546) were merged with zip code-level information from the census and residence in a primary care health professional shortage area. Rural-urban commuting area codes were also appended. Multiple logistic regression analyses were performed to model risks of preterm birth and low birthweight using generalized estimating equations to account for clustering within zip code.* ***Findings:*** *Women residing in large rural city–focused areas had lower adjusted odds of both preterm birth and low birthweight as compared to urban women, controlling for individual risk factors including maternal demographic characteristics, health conditions, and prenatal care use. In contrast, risks of these adverse birth outcomes were not significantly lower among women living in more rural areas relative to those in urban communities.* ***Conclusions:*** *Reduced risks of preterm birth and low birthweight risk are associated with some, but not all types of rural as compared to urban communities.*

Preterm birth and low birthweight remain high priority public health issues that are associated with heightened risk of infant mortality[1] as well as subsequent health and developmental problems.[2] These adverse birth outcomes have been increasing in frequency and also represent some of the most serious and persistent examples of health disparities associated with race/ethnicity,[3] socioeconomic status,[4] and geographic location.[5] Although about 20% of all births nationally are to rural women,[6] much less attention has been paid to pregnancy outcomes in rural communities relative to more urbanized areas.

Various determinants of preterm birth and low birthweight have been described in the literature, including maternal health variables,[7,8] attributes of the psychosocial context,[9] and environmental exposures.[10] One of the most consistent findings of research in this area is the relationship between economic disadvantage and elevated risk for poor birth outcomes.[11,12]

Rural women's disproportionate socioeconomic disadvantage and restricted access to health care resources could be expected to increase their risk of preterm birth and low birthweight. For example, rural women tend to have comparatively higher rates of poverty,[13] lower educational levels,[14] more limited employment opportunities,[15] and more limited access to health insurance[16] and health care service providers.[17] With regard to health care utilization, they receive fewer screening and preventive services,[18] less adequate prenatal care,[19] and make fewer ambulatory

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This research was funded, in part, under a grant with the Pennsylvania Department of Health using Tobacco Settlement Funds. The department specifically disclaims responsibility for any analyses, interpretations, or conclusions. For further information, Contact: Marianne M. Hillemeier, PhD, Department of Health Policy and Administration, Pennsylvania State University, 116 Henderson, University Park, PA 16802; e-mail mmh18@psu.edu.

visits than women in more urbanized areas.[20] The fragmentation of women's health care may be exacerbated in rural areas, due in part to the relative scarcity of obstetrician-gynecologists and to fewer resources on which to establish comprehensive women's health care programs.[21] This has been linked to suboptimal prevention efforts and medical management of chronic disease among rural women, which is particularly salient in view of the increased prevalence of chronic illness and related activity limitation among rural populations.[21]

No studies, to our knowledge, have compared recent patterns of preterm and low birthweight among rural and urban women, and results from older research have been mixed. Using data from the 1991 Linked Birth Death Data Set, Lishner et al[6] reported that women living in nonmetropolitan areas had lower rates of low birthweight than women in metro areas. These findings mirrored earlier results by Larson et al[22] using national data from 1985 to 1987. Larson et al also examined 2 subcategories of rural women, those living adjacent to an urban area, and those in more remote areas. Low birthweight rates among the 2 rural categories were very similar to one another, and both were significantly lower than the urban rate. In contrast, Hulme and Blegen[23] found that Iowa residents delivering by cesarean section who lived in the most remote rural regions not adjacent to urban areas had higher rates of low birthweight and preterm birth than their counterparts living in urban and in rural-adjacent-to-urban communities. These studies underscore gaps in our understanding concerning possible heterogeneity in birth outcomes among women in various types of rural settings.

Examining differences in birth outcomes across different types of rural settings also requires consideration of community-level variables other than rurality. Communities arrayed along the rural-urban continuum also are likely to differ with respect to population characteristics (eg, average household income, percentage of minority population) and community resources (eg, presence of health care facilities, physician-to-population ratio). Rural areas, for example, are likely to have fewer health care resources relative to more urbanized areas, which could affect women's health care utilization patterns, their health status before or during pregnancy, and the frequency or quality of their care during pregnancy. Controlling for such community-level variables is important in order to assess the impact of rurality and to understand the implications for practice and policy.

The objective of this study is to examine the relationship of individual- and community-level socioeconomic, health care, and health status-related characteristics to preterm birth and low birthweight outcomes among rural and urban women. Because a simple dichotomous rural-urban classification is likely to ignore potentially important variation among rural women living in diverse types of settings, we employ a multidimensional classification system using rural-urban commuting area (RUCA) codes to examine differences among residents of various rural community types.[24]

Methods

Singleton first births to women residing in a 28-county region of central Pennsylvania in 2002 were analyzed (N = 11,546). This region is diverse in terms of socioeconomic status indicators and race/ethnic composition. Poverty rates in these counties ranged from 6.6% to 18.8% of the population in the 2000 Census, and median household incomes varied from just over $30,000 to around $47,000. County populations range from 1.8% to 24.4% non-white, with African American women residing primarily in the Harrisburg area (Dauphin County), and Latinas predominantly located in Lancaster and Lebanon counties.

Data. Vital record data files for all births in 2002 to residents of the study region were obtained from the Pennsylvania Department of Health. Individual-level files for a substantial proportion of the rural births of interest were not otherwise available due to restrictions on data availability in counties with total population sizes under 100,000. For these analyses, we selected the singleton first births in order to examine risks associated with a first adverse outcome and to remove the effects of multiple gestations on the outcomes of interest.

Regarding community context, zip code-level sociodemographic data were obtained from US Census files in 2000 and appended to the data file. In addition, zip codes in primary care health professional shortage areas were identified.

Each of the variables included in the analyses is described below, along with identification of the corresponding data source.

Maternal Characteristics. These characteristics of the mother were included because they reflect maternal risk for adverse pregnancy outcomes based on sociodemographic characteristics, health status, or health behaviors previously identified in the literature.

Age Group. Maternal age at the time of birth was obtained from birth records. Each record was assigned one of the following maternal age categories: $\leq$19 years, 20-24 years, 25-29 years, 30-34 years, and 35 years and older. A set of 4 dummy variables for maternal age was created, with 25-29 years as the omitted category.

Educational Attainment. Birth records include information on highest level of schooling completed by the mother. This information was dichotomized into 2 educational categories: less than a high school graduate and high school graduate or greater educational attainment.

Marital Status. A yes/no variable indicating whether the mother was married at the time of birth was created from birth record information.

Race/ethnicity. Self-reported data from mothers on birth records include items related to Spanish/Hispanic/Latina background and race. This information was used to assign each mother in one of the following mutually exclusive categories: non-Hispanic white, non-Hispanic black, Hispanic, or other. In the analyses, a set of 3 dummy variables for race/ethnicity were included, with the omitted category being non-Hispanic white.

Tobacco Use. Self-report information about cigarette smoking during each trimester of pregnancy as well as the 3 months prior to pregnancy is included on the birth record. A single dichotomous variable was created categorizing women as either having reported or not having reported tobacco use during any of these time periods.

Chronic Hypertension. A variable indicating whether or not the mother reported prepregnancy hypertension was created from birth record data.

Diabetes. Birth record data concerning a history of prepregnancy diabetes was captured in a yes/no indicator variable.

Prenatal Care. The adequacy of prenatal care utilization was included because previous research indicated an association between poor birth outcomes and failure to complete the recommended schedule of prenatal care visits.[25]

Adequacy of Prenatal Care Utilization. Birth records contain information on the date of the first prenatal care visit as well as the total number of prenatal care visits made during the pregnancy. Using this information, prenatal care receipt was characterized according to Kotelchuck's Adequacy of Prenatal Care Utilization index[26] as either inadequate, intermediate, adequate, or adequate plus. The adequate plus category includes instances when a greater than expected number of prenatal visits were made, which tends to be indicative of a pregnancy complicated by chronic medical conditions or other problems. In the analyses, a set of 3 dummy variables for prenatal care utilization was included, with adequate care designated as the omitted category.

Contextual Characteristics. These zip code-level variables included a measure of rurality as well as selected measures of population composition and availability of health care resources. The variables listed below are those that were selected from a longer list after preliminary analyses assessing bivariate associations with the outcomes and multicolinearity.

Rural-Urban Classification. Mothers' residential zip codes from birth records were categorized according to RUCA version 2.0 zip code approximation codes. The RUCA taxonomy is a classification system based on the sizes of cities and towns and work commuting flows.[24] The schema includes 33 codes that can be aggregated to suit specific research and policy needs. We followed the recommendation of the WWAMI (Washington, Wyoming, Alaska, Montana, and Idaho) Rural Health Research Center for health-related research in using a 4-level residential categorization as follows: (1) urban-focused area (RUCA codes = 1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1), (2) large rural city–focused/town–focused area (RUCA codes = 4.0, 4.2, 5.0, 5.2, 6.0, 6.1), (3) small rural town–focused area (RUCA codes = 7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2), and (4) isolated small rural town–focused area (RUCA codes = 10.0, 10.2, 10.3, 10.4, 10.5, 10.6). This definition identifies the split between urban and rural in approximately the same way as does the Office of Management and Budget metropolitan definition, and additionally at the sub county level, it divides rural areas into 3 categories relevant for health-related research. Large rural cities/towns, for example, may have a population of 30,000 with many medical providers, while small rural town–focused areas have comparatively fewer resources, and isolated small rural towns may have under 1,000 residents and very limited or no medical provider availability.

Percent High School Graduates in Zip Code. Mother's zip code of residence from the birth record was matched to 2000 Census information to determine the percent of adults who are high school graduates. A dichotomous variable was created indicating that the population percentage was either less than or equal to 80% or alternatively was greater than 80%. The 80% cut-point corresponded to the median of the distribution in the sample.

Percent Below Poverty in Zip Code. Similarly, proportion of the population in the mother's zip code of residence below poverty level was identified in 2000 Census data. A dichotomous variable was created, divided at the median of the poverty rate distribution, to indicate whether this proportion was greater than 8% or was less than or equal to 8%.

Residence in primary care health professional shortage area. A yes/no variable was created indicating whether maternal zip code of residence from the birth record was located in a primary care

health professional shortage area as identified by the US Centers for Medicaid and Medicare Services in 2005.[27]

Outcome Variables.

Preterm Birth. Gestational age was computed from birth record information concerning date of mother's last menstrual period. A yes/no variable was created indicating whether the birth occurred at less than 37 weeks gestation.

Low Birthweight. Weight at birth from the birth record was used to create a yes/no variable indicating whether the infant's birthweight was less than 2,500 g.

Methods of Analysis. A series of 2 multiple logistic regression models was estimated for each of the outcomes of interest, preterm birth, and low birthweight. In model 1, only the individual-level variables—maternal characteristics and prenatal care—were included. model 2 included the individual-level characteristics from model 1 as well as the contextual variables previously described. The generalized estimating equations method was used to account for clustering of individuals within zip code.

Results

Characteristics of Rural and Urban Residential Areas. The urban-focused population in the sample lived in moderate-size metropolitan areas ranging in total population from 119,000 to 517,500. This group of women tended to be older, more highly educated, more ethnically diverse, and less likely to live in poverty than those living in the 3 types of rural areas. At the other end of the spectrum, the isolated small rural areas in the sample are located outside of urban places and have no primary work flows over 5% to any urban place. Women in these isolated areas were the youngest and least educated of the 4 types of areas and were most likely to be located in a primary care health professional shortage area. Those women in large rural city–focused areas (residing or with substantial work flow to an urban cluster with a population 10,000-49,000) and small rural town–focused areas (residing or with substantial work flow to a small urban cluster with a population of 2,500-9,999) tended to be intermediate between the 2 extremes in terms of sociodemographic characteristics. There were no statistically significant differences found in preterm birth or low birthweight rates among births to women in the 4 types of residential areas.

Multiple Logistic Regression Results. Adjusted odds ratios calculated from multiple logistic regression models predicting low birthweight are presented in Table 1. The "maternal variables only" column contains results from a model, which includes only individual-level variables. As would be expected based on prior research, a number of maternal characteristics are significantly associated with low birthweight risk.

Table 1. Multiple Logistic Regression Results Using Generalized Estimating Equations to Model Low Birthweight Risk, Singleton First Births, 2002*†

	Maternal Variables Only	Maternal Plus Community Variables
	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Maternal variables		
Age category		
≤19 versus 25-29 y	1.07 (0.82, 1.40)	1.08 (0.82, 1.41)
20-24 versus 25-29 y	0.95 (0.78, 1.15)	0.95 (0.79, 1.16)
30-34 versus 25-29 y	1.25 (1.01, 1.55)	1.25 (1.00, 1.55)
≥35 versus 25-29 y	1.37 (1.01, 1.87)	1.36 (1.00, 1.85)
Race/ethnicity		
Non-Hispanic black versus non-Hispanic white	1.65 (1.26, 2.17)	1.51 (1.14, 2.02)
Hispanic versus non-Hispanic white	1.09 (0.80, 1.48)	1.01 (0.74, 1.37)
Other versus non-Hispanic white	1.43 (0.99, 2.05)	1.35 (0.93, 1.96)
Not married versus married	1.30 (1.09, 1.55)	1.30 (1.09, 1.56)
Not high school graduate versus HS graduate	1.08 (0.87, 1.33)	1.08 (0.87, 1.34)
Smoker versus nonsmoker	1.84 (1.54, 2.21)	1.83 (1.53, 2.20)
Chronic hypertension versus no chronic hypertension	1.76 (1.06, 2.94)	1.79 (1.07, 3.00)
Diabetes versus no diabetes	0.79 (0.54, 1.16)	0.78 (0.54, 1.15)
Prenatal care utilization		
Inadequate versus adequate	1.78 (1.37, 2.30)	1.72 (1.33, 2.24)
Intermediate versus adequate	0.83 (0.62, 1.11)	0.80 (0.60, 1.07)
Adequate plus versus adequate	3.57 (2.99, 4.27)	3.62 (3.03, 4.33)
Community variables		
Rural-urban classification		
Large rural city versus urban focused		0.73 (0.60, 0.89)
Small rural town versus urban focused		0.96 (0.70, 1.31)
Isolated small rural versus urban focused		0.75 (0.55, 1.03)
≤80% versus >80% HS graduates		1.09 (0.94, 1.27)
>8% versus ≤8% individuals below poverty		0.96 (0.82, 1.13)
Primary care health professional shortage area		1.55 (0.92, 2.61)

*OR, odds ratio; CI, confidence interval; HS, high school
†N = 11,546 births.

These characteristics include older maternal age, non-Hispanic black race/ethnicity, being unmarried at the time of the infant's birth, current smoking, presence of chronic hypertension, and receipt of an inadequate number of prenatal care visits. Receipt of more than the recommended number of prenatal care visits (adequate plus), which tends to be associated with the presence of medical problems requiring extraordinarily frequent monitoring prior to delivery, was also associated with low birthweight risk.

The second model contains the individual-level variables from the first model plus community variables including rural-urban residence classification and zip code characteristics related to educational attainment, percent of the population below poverty, and location in a primary care health professional shortage area. In the full model, the only community characteristic that proved to be statistically significant was rural-urban residence classification. Compared with women living in urban-focused areas, those in large rural city–focused areas had significantly lower adjusted odds of low birthweight. In contrast, low birthweight risk among women living in small town–focused and isolated small rural–focused areas were not significantly different from those of urban women.

Results of identical multiple logistic regressions modeling risk of preterm birth are presented in Table 2. The pattern of results is generally quite similar to that seen in the low birthweight analyses. Individual-level characteristics found to be statistically significant in the first model include older maternal age, presence of chronic hypertension, and inadequate or more than adequate prenatal care utilization. Community characteristics were added in the full model, with rural-urban classification representing the most significant community variable. Women in large rural cities were found to have lower preterm birth risk relative to urban women, although the result in this instance was only marginally statistically significant ($P = .07$). As was the case in the low birthweight models, women living in the other types of rural communities had preterm birth risks comparable to urban women.

Table 2. Multiple Logistic Regression Results Using Generalized Estimating Equations to Model Preterm Birth Risk, Singleton First Births, 2002*†

	Maternal Variables Only	Maternal Plus Community Variables
	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Maternal variables		
Age category		
≤19 versus 25-29 y	1.11 (0.83, 1.49)	1.10 (0.82, 1.49)
20-24 versus 25-29 y	0.95 (0.77, 1.17)	0.95 (0.77, 1.18)
30-34 versus 25-29 y	1.24 (1.01, 1.51)	1.25 (1.02, 1.53)
≥35 versus 25-29 y	1.53 (1.12, 2.08)	1.54 (1.13, 2.10)
Race/ethnicity		
Non-Hispanic black versus non-Hispanic white	1.23 (0.95, 1.60)	1.20 (0.93, 1.55)
Hispanic versus non-Hispanic white	0.81 (0.50, 1.30)	0.72 (0.43, 1.19)
Other versus non-Hispanic white	0.91 (0.60, 1.36)	0.87 (0.57, 1.33)
Not married versus married	1.04 (0.87, 1.24)	1.06 (0.88, 1.27)
Not high school graduate versus HS graduate	1.16 (0.95, 1.42)	1.17 (0.95, 1.42)
Smoker versus nonsmoker	1.18 (0.98, 1.43)	1.18 (0.98, 1.43)
Chronic hypertension	1.73 (1.08, 2.79)	1.68 (1.03, 2.73)
Diabetes	1.24 (0.93, 1.65)	1.21 (0.91, 1.61)
Prenatal care utilization		
Inadequate versus adequate	2.24 (1.70, 2.95)	2.25 (1.70, 2.98)
Intermediate versus adequate	0.96 (0.73, 1.24)	0.94 (0.72, 1.23)
Adequate plus versus adequate	5.91 (4.96, 7.04)	6.01 (5.05, 7.16)
Community variables		
Rural-urban classification		
Large rural city versus urban focused		0.82 (0.67, 1.02)
Small rural town versus urban focused		0.81 (0.54, 1.21)
Isolated small rural versus urban focused		1.03 (0.78, 1.35)
≤80% versus >80% HS graduates		1.07 (0.90, 1.28)
>8% versus ≤8% individuals below poverty		0.96 (0.79, 1.16)
Primary care health professional shortage area		0.83 (0.46, 1.52)

*OR, odds ratio; CI, confidence interval; HS, high school.
†N = 11,546 births.

Discussion

Our results indicate that next to individual maternal characteristics, rural-urban residence is an important predictor of preterm birth and low birthweight. In fact, rural-urban residence was the only community-level variable with statistically significant effects in these analyses. Because several types of rural communities were considered rather than a single rural-urban dichotomy, it was possible to differentiate level of risk

along a continuum of rurality. Women living in the 2 most rural types of communities were shown to experience risks of poor birth outcomes as great as those found among women living in urban-focused communities. Stated another way, the protective effects on birth outcome commonly ascribed to rural residence appear to hold only for those living in more densely populated rural areas.

General perceptions of a comparative advantage in low birthweight risk among rural residents may have stemmed from previous studies comparing crude low birthweight rates among rural and urban women. Lishner et al's[6] analysis of total births in the 1991 Linked Birth Death Data Set, for example, found that women living in nonmetropolitan counties had a significantly lower rate of low birthweight births relative to those in metropolitan counties (6.8% vs 7.2%, $P = .01$). Similarly, Larson et al[22] studied US singleton births from 1985 through 1987, finding similar birth outcome patterns with a nonmetropolitan rate of 5.6% in contrast to a metropolitan rate of 5.9% ($P = .01$). As in the present study, Larson et al also examined variation within types of rural areas. In their study, rural births were dichotomized by whether or not the mother lived in a rural county that was adjacent to 1 or more metro counties in terms of physical location and commuting patterns. Low birthweight rates were shown to be similar in the 2 types of rural counties (5.6% in each).

Larson et al also went beyond comparison of crude rates to include multivariate logistic regression analyses. In contrast to findings in the present study, they found no significant differences in low birthweight risk among metropolitan counties and either of the 2 groups of rural counties. The differences in results between the 2 studies might be attributable to several factors. Most saliently, the data used by Larson et al was gathered in the mid-1980s. Since that time, changes such as enhanced employment opportunities and quality of life, rising educational attainment, improved transportation infrastructure, and modifications in the organization, financing, and availability of medical and prenatal care may have conferred a relative advantage to women living in more densely populated rural areas adjacent to urban areas, while those in less populous and more isolated rural areas experienced no comparative risk reduction. It may also be the case that the more refined system of rurality classification afforded by the 3 categories of rural zip code-based RUCA codes used in the present analyses permitted the detection of differences among rural area types that were obscured in the dichotomous, county-based classification system used in the earlier study.

The present analyses also cast doubt on the commonly held assumption that the sole problem related to pregnancy outcomes among rural women is reduced access to medical care. While health care access is certainly a salient issue and one that must be addressed in rural areas, in the present analyses, rural residence remained a significant predictor even after controlling for prenatal care receipt and the availability of physicians in the community. It appears that other aspects of residence in the most rural types of communities are also relevant in determining preterm birth and low birthweight risk.

The present study has several limitations, which should be borne in mind. Most importantly, it relies heavily on data from birth records, which are limited in scope and contain some self-reported items, such as smoking status during pregnancy, that are subject to measurement error. Additional information including objective indicators of maternal health status would improve the accuracy of adverse outcome risk estimation. Also, while the Central Pennsylvania region studied provides a range of different rural community types, it does not include the most heavily urbanized type of urban community, and therefore, the analyses do not include the full continuum of RUCA codes.

In conclusion, the study findings underscore the need to more fully identify the mechanisms that underlie risks of preterm birth and low birthweight among rural women. What is it about living in the most remote types of rural communities that is disadvantageous? It may be that elevated psychosocial stress, which has recently been implicated in adverse birth outcome risk,[28,29] is a relevant concern among rural women. While life in rural areas is typically envisioned as idyllic and relatively stress free, results of a recent survey of women in the Central Pennsylvania region indicate that rural women experience stressors equal to and in some cases greater than those reported by other women.[30] Future research among rural women should consider psychosocial stress levels, and other factors related to rurality in addition to health care access in explicating reproductive risk and targeting interventions.

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