



Health Equity

Maternity Care Deserts and Pregnancy-Associated Mortality in Louisiana



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ABSTRACT

Background: Maternal mortality is an issue of growing concern in the United States, where the incidence of death during pregnancy and postpartum seems to be increasing. The purpose of this analysis was to explore whether residing in a maternity care desert (defined as a county with no hospital offering obstetric care and no OB/GYN or certified nurse midwife providers) was associated with risk of death during pregnancy and up to 1 year postpartum among women in Louisiana from 2016 to 2017.

Methods: Data provided by the March of Dimes were used to classify Louisiana parishes by level of access to maternity care. Using data on all pregnancy-associated deaths verified by the Louisiana Department of Health ($n = 112$ from 2016 to 2017) and geocoded live births occurring in Louisiana during the same time period ($n = 101,484$), we fit adjusted modified Poisson regression models with generalized estimating equations and exploratory spatial analysis to identify significant associations between place of residence and risk of death.

Results: We found that the risk of death during pregnancy and up to 1 year postpartum owing to any cause (pregnancy-associated mortality) and in particular death owing to obstetric causes (pregnancy-related mortality) was significantly elevated among women residing in maternity care deserts compared with women in areas with greater access (adjusted risk ratio [aRR] for pregnancy-associated mortality, 1.91; 95% confidence interval [CI], 1.15–3.18; aRR for pregnancy-related mortality, 3.37; 95% CI, 1.71–6.65). A large racial inequity in risk persisted above and beyond differences in geographic access to maternity care (non-Hispanic Black vs. non-Hispanic White aRR for pregnancy-associated mortality, 2.22; 95% CI, 1.39–3.56; aRR for pregnancy-related mortality, 2.66; 95% CI, 1.16–6.12).

Conclusions: Ensuring access to maternity care may be an important step toward maternal mortality prevention, but may alone be insufficient for achieving maternal health equity.

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Maternal mortality is an issue of growing concern in the United States, where incidence of death among women who are pregnant or up to 1 year postpartum continues to increase, in opposition to global trends ([Global, regional, and national levels of maternal mortality..., 2016](#)). Reasons underlying maternal mortality in this country extend beyond clinical risk factors such as maternal age, and are rooted in the social, economic, and geographic conditions that shape uneven access to health-promoting resources and opportunities across the life course ([Ruiz et al., 2015](#)). In particular, the historical and ongoing oppression of Black people—structural racism established at

time of the nation's founding and upheld by present day policies and practices (Bailey et al., 2017)—is reflected in the vast and persistent racial inequity in maternal death. Maternal mortality ratios remain three- to four-fold higher among Black women compared with White women (Benno, Trichilo, Gillispie-Bell, & Lake, 2020; Petersen et al., 2019).

Access to continuous, high-quality maternal health care in the time surrounding pregnancy is key to preventing birth-related complications for women and their children. However, many women encounter barriers to care that prevent them from fully accessing the care that they need to maintain a healthy pregnancy (Derose, Gresenz, & Ringel, 2011). Geographic availability is an important aspect of access and availability of maternal health care, especially for rural women who are greatly affected by the increasing number of hospital closures in their communities (Balasubramanian & Jones, 2016; Hung, Henning-Smith, Casey, & Kozhimannil, 2017). Between 2004 and 2014, rural counties in the United States saw hospital-based obstetric services decrease from 54% to 45%, and this decrease is predicted to continue. A recent study found that loss of hospital-based obstetric services in rural counties not adjacent to urban areas, compared with counties with continual services, is associated with increases in out-of-hospital and preterm births and births in hospitals without obstetric units in the following year (Kozhimannil, Hung, Henning-Smith, Casey, & Prasad, 2018). Concurrently, drawing on the findings from maternal mortality review committees in 13 states from 2013 to 2017, a recent report by the Centers for Disease Control and Prevention identified communities with limited access to clinical care and inadequate receipt of care/care coordination across systems as key factors contributing to rising incidence of maternal mortality and necessitating targeted prevention strategies (Petersen et al., 2019).

A lack of access to care owing to unavailability of services may impact maternal health outcomes directly by delaying entry into prenatal care or increasing travel time to obtain care, both of which may increase risk for the woman and the neonate (Attar, Hanrahan, Lang, Gates, & Bratton, 2006; Grzybowski, Stoll, & Kornelsen, 2011). Additionally, communities located in areas with limited or no access to health care services may already be at increased risk for adverse health consequences given the co-located burdens of economic hardship, lack of community resources including employment and health insurance coverage, and inadequate transportation and other public service systems (Probst, Moore, Glover, & Samuels, 2004). These factors in turn may be manifestations of structural racism and the intersection of racial and socioeconomic oppression (Williams & Collins, 2001) and therefore more likely to impact maternal morbidity and mortality among women of color and those with low incomes. Importantly, these issues are not exclusive to rural communities, but can occur in urban centers or adjacent areas when hospital closures disrupt continuity of care and exacerbate limitations of public transportation systems (March of Dimes, 2019). A Philadelphia study found that hospital obstetric care units that remained open after many surrounding closures over a nearly 20-year period faced more difficulties in providing complete and continuous maternal care owing to resource strain, causing a brief increase in neonatal mortality (Lorch, Martin, Ranade, Srinivas, & Grande, 2014; Lorch, Srinivas, Ahlberg, & Small, 2013).

The degree to which geographic access to care and the geographic distribution of health-promoting resources may contribute to the current maternal mortality crisis in the United States and exacerbate social inequities in mortality remains unclear. As independent jurisdictions within the United States,

states often make decisions about the distribution of such resources. This may, in part, contribute to the immense variation in risk of maternal death across U.S. states, with Louisiana consistently ranking among those with the highest incidence. The purpose of this study was to explore the relationship between living in counties with limited or no access to maternity care (a maternity care desert) and risk of death during pregnancy and postpartum. We leveraged unique access to linked vital records, which overcome the limitations of ecologic explorations of maternal mortality rates by allowing for the estimation of individual-level risk associated with place of residence in a retrospective cohort of pregnant and postpartum women in Louisiana from 2016 to 2017.

We hypothesized that women residing in areas with limited or no access to maternity care would be at increased risk of death during the pregnancy and postpartum periods relative to those in counties with greater access. We explored this relationship with both pregnancy-associated mortality (death owing to any cause during pregnancy or up to 1 year after the end of pregnancy) and within the subgroup of cases that constitute pregnancy-related mortality (death owing to obstetric causes during pregnancy or up to 1 year since the end of pregnancy). Finally, we used exploratory spatial analytic methods to assess spatial clustering of maternity care deserts within the state.

Methods

Study Population

Data on all verified cases of pregnancy-associated mortality from 2016 to 2017 ($n = 112$) were provided by the Louisiana Department of Health. Deaths were verified as pregnancy-associated (death during pregnancy or up to 1 year postpartum from any cause) if a death record linked to a live birth or fetal death within 1 year and/or via the death record pregnancy checkbox indicating pregnancy status of the decedent. Pregnancy checkbox cases required additional review and verification by the Bureau of Family Health Regional Maternal and Child Health Coordinators. We created a retrospective analytic cohort of pregnant women in Louisiana from 2016 to 2017 by combining all live birth records issued to living women ($n = 125,537$), live birth records with linked maternal death records ($n = 62$), and unlinked maternal death records where no birth record was available because the decedent was pregnant at time of death ($n = 32$) or linkage was not successful ($n = 18$). Reasons for unsuccessful linkages may include data entry errors on the birth or death certificate variables used in the two-stage linkage procedure (maternal social security number, first and last name, and date of birth) or instances where the infant was put up for adoption.

For all records, address of residence was geocoded using ArcGIS software (ESRI Inc, Redlands, CA). We successfully identified geographic coordinates for all maternal deaths ($n = 112$) and for more than 80% of births ($n = 101,484$). Those unable to be located included P.O. boxes ($n = 479$), and records with missing or unknown errors in the house number, street name, or zip code variables ($n = 23,574$). For records with missing or incorrect address data, we assigned parish of residence (county equivalent) based on the residential county Federal Information Processing System variable where available on the birth or death record (if discrepant, parish of residence on the birth record took precedence). The final analytic sample with georeferenced data was 124,197 (99% of records).

Among all cases of pregnancy-associated mortality we identified a subgroup of cases consisting of those that were

pregnancy related based on the *International Classification of Diseases 10th revision* codes for underlying cause of death (Chapter XV: Pregnancy, childbirth, and the puerperium). We explored pregnancy-associated and pregnancy-related mortality separately in all analyses.

Maternity Care Deserts

A recent report by the [March of Dimes \(2019\)](#) used data from the 2016–2017 Area Health Resource File to describe availability of maternity care in every U.S. county. Counties were classified by level of access to maternity care: those with access to maternity care, those with limited access to maternity care, and maternity care deserts. Maternity care deserts were counties with no hospitals offering obstetric care and no OB/GYN or certified nurse midwife providers. Counties with limited access to maternity care services had only one hospital providing obstetric services and fewer than 60 obstetric providers per 10,000 births. All other counties were classified as having access to maternity care. We extracted care level classification data from the March of Dimes report for every parish in Louisiana.

Individual-Level Covariates

In adjusted models we included individual-level sociodemographic characteristics known to be associated with reproductive health outcomes and available on the birth record: maternal age (<25, 25–29, 30–34, ≥35), race/ethnicity (non-Hispanic White; non-Hispanic Black; Hispanic, multiple, or other), and educational attainment as an indicator of socioeconomic position (less than high school, high school graduate, more than high school). In cases where only a maternal death record was available ($n = 55$), decedent age, race, and educational attainment variables were coded to match birth record groupings described elsewhere in this article. We additionally controlled for the delivery volume of the birth facility based on the number of births from 2016 to 2017, with more than 1,000 deliveries considered high volume.

Parish-Level Covariates

To control for sociodemographic and geographic differences between parishes that may be associated with both the level of maternity care and other health-promoting resources available to parish residents, we obtained data from the American Community Survey (5-year estimates made in 2017) on parish poverty level and the percentage of the population with health insurance. We additionally controlled for the proportion of births from 2016 and 2017 that were covered by Medicaid (data aggregated across birth records) to capture socioeconomic variation among the maternal population in particular. To characterize distance to neighboring parishes that may differ in level of maternity care or other health-promoting resources we included the geographic area of the parish in square miles (estimates based on the 2010 Census Redistricting Data Summary File) ([U.S. Census Bureau, 2011](#)). We controlled for whether the parish was mostly urban, mostly rural, or completely rural (classifications defined by the 2010 Census Urban and Rural Classification and Urban Area Criteria; [U.S. Census Bureau, 2012](#)), given evidence of health care shortages in rural areas (beyond maternity care) and other structural and social barriers to health ([Probst et al., 2004](#)).

Statistical Analyses

Descriptive statistics characterized the study population and the parishes in which they lived. To preserve confidentiality, we merged maternal characteristic subgroups with less than 10 pregnancy-associated deaths into larger categories before estimating crude mortality ratios and 95% confidence intervals (CI). To estimate the relative risk of death (and 95% CI) associated with living in a maternity care desert, we fit modified Poisson regression models with generalized estimating equations to account for the correlation between women residing in the same parish. We adjusted estimates for both individual- and parish-level covariates.

Finally, we applied exploratory spatial analysis to detect the presence of spatial clustering of maternity care deserts to identify broader regions of the state that may warrant additional concern. A global indicator of spatial autocorrelation (univariate Moran's I) was used to detect the presence of spatial clustering of maternity care deserts. Where the global indicator revealed significant autocorrelation, we ran Local Indicators of Spatial Autocorrelation tests to further identify parishes of limited or no access to maternity care that were surrounded by neighboring parishes with limited or no access to maternity care (i.e., high-high clusters). We used first-order queen contiguity spatial weights and 999 permutations for statistical inference in the Moran's I analysis, conducted in Geoda 1.12.1.161. This study was approved by the Tulane University Institutional Review Board.

Results

The vast majority of women in this study resided in urban parishes (84%), one-third (33%) were under age 25 at the time of live birth or maternal death before delivery, and most were non-Hispanic White (51.6%) or non-Hispanic Black (36.6%), reflective of the state's overall racial/ethnic composition ([Table 1](#)). Approximately one in four women (24%) resided in a county with limited or no access to maternity care, with 9% residing in a maternity care desert. Among the 112 verified cases of death, pregnancy-associated mortality ratios (per 100,000 live births) were highest among women in both ends of the age distribution, non-Hispanic Black women, those with less than a high school education, those residing in completely rural parishes, and those residing in maternity care deserts, although wide CIs around ratio estimates reflect the small number of deaths occurring at each stratification. The unadjusted pregnancy-associated mortality ratio among non-Hispanic Black women was 2.9 times the mortality ratio among women of all other race/ethnicities (164.9 vs. 56.0 deaths per 100,000 live births, respectively). Fifty-four of the 112 total pregnancy-associated deaths (48.2%) were pregnancy related.

Across Louisiana's 64 parishes, 86% of the population, on average, had health insurance coverage, 17% of families were living below the federal poverty level, and 65% of births in 2016 and 2017 were covered by Medicaid ([Table 2](#)). The average size of a parish was 815 square miles, ranging from 203 to 2,429. [Figure 1A](#) shows Louisiana parishes by level of access to care, with care deserts appearing predominantly—although not exclusively—outside of urban metropolitan areas. Although most of the parishes with access to care were urban (61%), 23% of maternity care deserts ($n = 7$) were also urban parishes ([Table 2](#)).

In the fully adjusted model, residing in a maternity care desert was associated with a 91% increase in risk of pregnancy-associated death relative to parishes with access to maternity care, independent of parish size, urbanicity, sociodemographic

Table 1Descriptive Characteristics of Live Births and Maternal Deaths Owing to Any Cause in Louisiana, 2016–2017 ($n = 124,179$)

Maternal Characteristics	Total Population	Maternal Deaths
	<i>N</i> (%)	Pregnancy-associated Mortality Ratio per 100,000 Live Births (95% Confidence Interval)
Maternal age (y)		
<25	41,364 (33.3)	104.0 (72.9–135.0)
25–29	38,324 (30.9)	67.8 (41.8–93.9)
30–34	29,128 (23.5)	92.7 (57.7–127.6)
≥35	15,363 (12.4)	104.1 (53.1–155.2)
Race/ethnicity		
Non-Hispanic White	64,073 (51.6)	*
Non-Hispanic Black	45,496 (36.6)	147.3 (112.0–182.5)
Hispanic, multiple, or other	14,610 (11.8)	*
Non-Hispanic White, Hispanic, multiple, or other		57.2 (40.5–73.9)
Educational attainment		
Less than high school	19,060 (15.4)	157 (101.1–213.7)
High school graduate	39,412 (31.9)	99.0 (67.9–130.0)
Some college or associates degree	64,994 (52.6)	66.2 (46.4–85.9)
Level of access to maternity care		
Access to maternity care	94,436 (76.1)	90.0 (70.9–109.1)
Limited access to maternity care	18,950 (15.3)	79.2 (39.1–119.2)
Maternity care desert	10,793 (8.7)	111.2 (48.3–174.1)
Residential parish urbanicity		
Mostly urban	104,080 (83.8)	95.1 (76.4–113.8)
Mostly rural	18,045 (14.5)	*
Completely rural	2,054 (1.7)	*
Mostly or completely rural		64.7 (29.5–99.8)
Delivery facility volume		
High (>1000 births)	114,662 (92.3)	
Low (≤1000 births)	9,517 (7.7)	
	Mean (SD)	Mean (SD)
Percentage of residential parish population with health insurance	87.6 (2.0)	87.7 (1.8)
Percentage of residential parish families living below the federal poverty level	15.0 (4.1)	14.7 (3.8)
Residential parish geographic area (square miles)	816.4 (406.4)	796.5 (405.7)
Percentage of residential parish 2016–2017 births covered by Medicaid	62.1 (10.2)	62.8 (9.5)

* To preserve confidentiality, cells with small numbers of deaths (<10) were combined with larger categories before mortality ratio estimation (mostly rural combined with completely rural; non-Hispanic White combined with Hispanic, multiple, or other race/ethnicities).

levels, and individual characteristics (adjusted risk ratio [aRR], 1.91; 95% CI, 1.15–3.18). (Table 3) Residence in a maternity care desert was associated with a three-fold risk of pregnancy-related mortality, although imprecision of this estimate owing to fewer cases is evident in the broad CI (aRR, 3.37; 95% CI, 1.71–6.65). Controlling for access to maternity care and all other parish- and individual-level factors did little to reduce the racial disparity in mortality, with a persistent 2.2-fold greater risk among non-

Hispanic Black women compared with White women (aRR for pregnancy-associated mortality, 2.22; 95% CI, 1.39–3.56).

Global Moran's I for parish-level access to care was 0.16 ($p = .02$), indicating significant spatial clustering of maternity care deserts. The tests for local spatial autocorrelation (Local Indicators of Spatial Autocorrelation map) revealed six limited or no access parishes surrounded by other limited or no access parishes (high–high spatial clusters) and five limited or no access

Table 2Descriptive Characteristics of Louisiana Parishes ($N = 64$)

Parish Characteristics	Total ($N = 64$)		Access to Maternity Care ($n = 28$)		Limited Access to Maternity Care ($n = 12$)		Maternity Care Desert ($n = 24$)	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Percent of the population with health insurance	86.3 (3.7)	73.7–93.4	87.4 (1.3)	85.2–90.0	88.0 (1.9)	84.6–91.5	84.2 (5.1)	20.3–88.3
Percentage of families living below the federal poverty level	17.0 (5.8)	7.1–41.8	16.2 (4.1)	8.2–25.1	14.4 (3.7)	9.3–20.4	19.3 (7.4)	7.1–41.8
Parish geographic area (square miles)	815.0 (444.6)	203.0–2429.0	817.9 (417.7)	203.0–2080.0	761.7 (360.5)	303.0–1538.0	838.4 (521.9)	258.0–2429.0
Percentage of 2016–2017 births covered by Medicaid	65.0 (12.8)	20.3–88.3	66.1 (9.5)	47.1–82.4	60.7 (13.9)	34.7–78.0	66.0 (15.5)	20.3–88.3
	<i>n</i> (%)		<i>n</i> (%)		<i>n</i> (%)		<i>n</i> (%)	
Urban/rural classification								
Mostly urban	31 (48.4)		19 (61.3)		5 (16.1)		7 (22.6)	
Mostly rural	24 (37.5)		8 (33.3)		6 (25.0)		10 (41.7)	
Completely rural	9 (14.1)		1 (11.1)		1 (11.1)		7 (77.8)	

Abbreviation: SD, standard deviation.

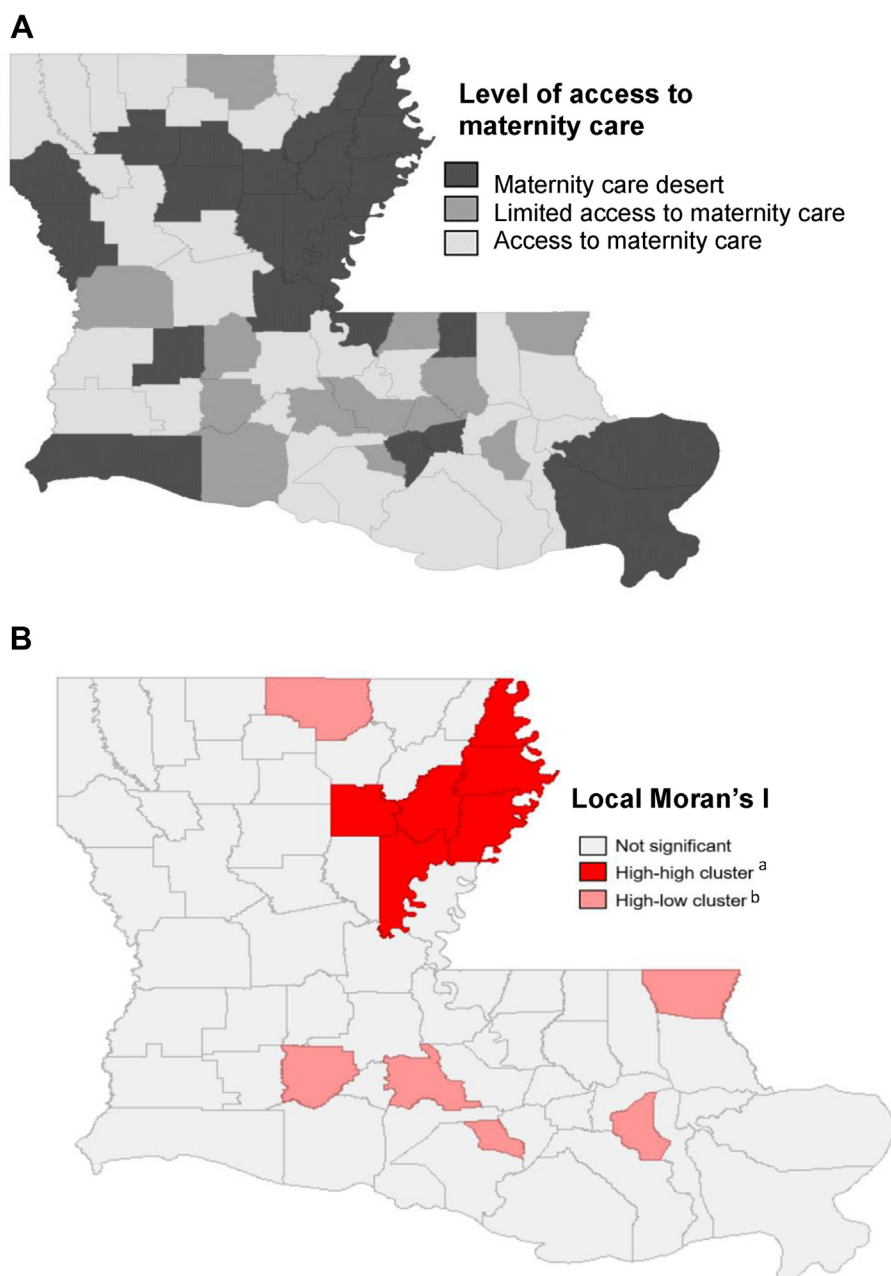


Figure 1. Maternity care access by Louisiana Parish and Local Moran's I (Local Indicators of Spatial Autocorrelation) test for spatial autocorrelation of maternity care deserts, 2016–2017. (A) Level of maternity care access by Louisiana parish, 2016–2017. (B) Local Moran's I (Local Indicators of Spatial Autocorrelation) test for spatial autocorrelation of maternity care deserts, Louisiana 2016–2017. (A) High–high indicates parishes with limited or no access to maternity care surrounded by other parishes with limited or no access to maternity care. (B) High–low indicates parishes with limited or no access to maternity care surrounded by parishes with access to maternity care.

parishes surrounded by parishes with access (high–low spatial outliers) (Figure 1B).

Discussion

The results from this analysis of all verified pregnancy-associated deaths in Louisiana from 2016 to 2017 highlight the importance of place as a significant contributor to risk of death among pregnant and postpartum women. We find that women living in parishes that lack access to maternity care experience a 91% increase in risk of death during pregnancy and up to 1 year

postpartum, independent of the woman's age, race/ethnicity, socioeconomic position, and whether she lived in a parish that was urban or rural, impoverished, or underinsured. The association was larger in magnitude for pregnancy-related mortality compared with pregnancy-associated mortality, likely reflecting the importance of timely clinical treatment and care in obstetric emergencies. However, the significant albeit smaller magnitude of association with pregnancy-associated mortality suggests the importance of maternity care throughout pregnancy as a critical window of opportunity for prevention of nonobstetric causes of death as well. For many women who may not otherwise be in

Table 3

Adjusted Relative Risks and 95% Confidence Intervals (CIs) for Maternal Death in Association with Residence in a Maternity Care Desert, Louisiana 2016–2017

Independent Variables	Pregnancy-Associated Mortality	Pregnancy-Related Mortality
	Relative Risk (95% CI)	Relative Risk (95% CI)
Level of access to maternity care		
Access to maternity care	Reference	
Limited access to maternity care	1.37 (0.83–2.28)	0.79 (0.28–2.24)
Maternity care desert	1.91 (1.15–3.18)	3.37 (1.71–6.65)
Residential parish urbanicity		
Mostly urban	Reference	Reference
Mostly rural	0.40 (0.21–0.74)	0.60 (0.24–1.49)
Completely rural	1.36 (0.49–3.74)	0.41 (0.14–1.19)
Maternal age (y)		
<25	Reference	Reference
25–29	0.81 (0.50–1.32)	1.80 (0.84–3.83)
30–34	1.25 (0.73–2.12)	2.17 (0.95–4.92)
≥35	1.48 (0.91–2.41)	4.03 (1.79–9.08)
Race/ethnicity		
Non-Hispanic White	Reference	Reference
Non-Hispanic Black	2.22 (1.39–3.56)	2.66 (1.16–6.12)
Hispanic, multiple, or other	0.52 (0.22–1.22)	0.64 (0.19–1.50)
Educational attainment		
Less than high school	2.39 (1.50–3.81)	2.90 (1.35–6.21)
High school graduate/GED	1.43 (0.92–2.22)	1.83 (0.86–3.90)
More than high school	Reference	Reference
Percent of the population with health insurance*	1.06 (0.96–1.17)	1.29 (1.05–1.60)
Percentage of families living below the poverty level*	0.93 (0.88–0.97)	0.84 (0.78–0.91)
Parish geographic area (risk per 100 square miles)	0.99 (0.96–1.04)	1.00 (0.96–1.06)
Percentage of births covered by Medicaid*	1.04 (1.01–1.07)	1.07 (1.02–1.13)
Delivery facility volume		
Low	Reference	
High	1.22 (0.70–2.31)	1.14 (0.36–3.64)

* Per 1-unit increase.

contact with services, maternity care visits may represent a rare opportunity to receive intimate partner violence screening and prevention, mental health and substance use screening and treatment, or education on healthy behaviors and practices (e.g., seat belt use). These components of care encounters are critically important because homicide, suicide, and transport accidents remain leading causes of pregnancy-associated mortality in the United States (Palladino, Singh, Campbell, Flynn, & Gold, 2011; Wallace, Crear-Perry, Mehta, & Theall, 2020; Wallace, Hoyert, Williams, & Mendola, 2016).

Of concern, we did not find a substantial decrease in the large racial inequity in maternal death between Black and White women after controlling for level of access to maternity care and parish- and individual-level sociodemographic characteristics. Previous research found that counties with larger numbers of non-Hispanic Black women had higher odds of losing all hospital obstetric services (Hung et al., 2017). This finding is alarming, because the loss of hospital-based delivery services in communities already experiencing multiple forms of oppression are likely to aggravate persisting racial disparities in obstetric care and subsequently contribute to already severe racial inequities in maternal and birth outcomes (Grobman et al., 2015). Our finding of a persistent two-fold greater risk experienced by Black women independent of their residential status (whether living in a maternity care desert or not) further implicates differential quality of care issues increasingly noted in the literature (Creanga et al., 2014; Fiscella & Sanders, 2016; Howell, Egorova, Balbierz, Zeitlin, & Hebert, 2016; Novick, 2009). Historically embedded racism acting across multiple levels—individual health care provider bias, systemic racism within health care delivery systems, and structural racism within U.S. society that engenders racially segregated hospitals, the distribution of resources they receive

and the quality of care they deliver—may be the most fundamental cause of this inequity (Prather, Fuller, Marshall, & Jeffries, 2016; Rosenthal & Lobel, 2011). Advancing our understanding of why the persistence of racial inequity in pregnancy-associated death extends beyond access to health care will require qualitative approaches to reveal the lived experiences of Black women, with particular attention to the complex and contextually dependent barriers to their achieving optimal health before, during, and after pregnancy (Lawson & Marsh, 2017). Equally urgent is the need for research that identifies the ways in which structural racism continues to exclude Black people from access to power and resources, engendering population health inequities.

Through the conduct of exploratory spatial analysis, we identified a cluster of maternity care deserts within the northern region of the state that warrants further investigation. Longitudinal trends in maternal mortality in the northern region, or an exploration of severe maternal morbidity (which occurs at substantially greater incidence than mortality), may reveal significant maternal population health harms associated with living in this cluster of maternity care deserts.

This analysis has a number of limitations. First, this study is cross-sectional, and prohibits drawing causal conclusions or exploring the impact of changes in the health care access landscape on trends in maternal mortality over time. We have attempted to rule out alternative explanations for the apparent association between maternity care deserts and maternal death by adjusting estimates for differences between parishes that may be common causes of both. Still, we acknowledge the possibility of residual confounding by factors we are unable to measure (e.g., chronic disease prevalence or maternal social support). Second, we used a single address of residence based on location at time of live birth (or death where no live birth record was

available), and therefore we cannot explore or account for mobility and the possibility that women may have moved residences during the course of their pregnancy and postpartum periods. Because our data are limited to the state of Louisiana, we are also unable to spatially diagnose and account for the influence of surrounding counties located in other states, an issue that may be particularly important in the Mississippi delta region where a number of limited or no access Louisiana parishes share borders with counties in Mississippi. Finally, given the rarity of pregnancy-associated death in the study's two-year period, we had limited power to explore sub-groups of death by cause or by sociodemographic characteristics. Even grouping those that were pregnancy-related yielded imprecise estimates. Additional years of data would increase analytic power, although would require careful consideration of the rapidly changing health care access landscape (hospital closures, insurance program expansions) that may occur when combining multiple years of data to yield more stable rates.

Implications for Practice and/or Policy

Unequal geographic access to maternity care is an issue of concern not only for Louisiana, but for states across the United States. Our findings support increased access to maternity care in the time surrounding pregnancy for prevention of pregnancy-related mortality and, although to a lesser extent, pregnancy-associated mortality. This may require greater coordination and resource sharing across hospital systems and settings to ensure complete geographic coverage; initiatives that provide logistical and financial support for women needing to travel for care; innovative interventions that incorporate technology, telemedicine, and novel models of supportive and preventive care delivery; and increased access to affordable, high-quality health care for women before, during, and after pregnancy. In 2018, the state's perinatal regionalization system—a hospital classification system to ensure provision of risk-appropriate maternal care—began identifying obstetric levels of care specifically, although previously neonatal intensive care and maternal care were jointly considered. This system should help to facilitate transfer of women with high-risk conditions to facilities that are equipped to provide the appropriate levels of specialty care regardless of where they may be living (*Levels of Maternal Care...*, 2019). Concurrently, improved access to care alone may be insufficient to reduce the deep and persistent racial inequity in maternal death. Future work should explore how additional health care system factors such as quality of care and respectful care interactions, continuity of care, and implementation of patient safety protocols may prevent future deaths. Moreover, broader examination of context beyond health care systems may continue to reveal social, structural, and policy determinants that may be at play. Critically needed are interventions that begin to dismantle structural racism and remediate the harmful social contexts underlying pregnancy-associated mortality in the United States.

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