OBSTETRICS

Urban-rural differences in pregnancy-related deaths, United States, 2011–2016

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BACKGROUND: The US pregnancy-related mortality ratio has not improved over the past decade and includes striking disparities by race and ethnicity and by state. Understanding differences in pregnancy-related mortality across and within urban and rural areas can guide the development of interventions for preventing future pregnancy-related deaths.

OBJECTIVE: We sought to compare pregnancy-related mortality across and within urban and rural counties by race and ethnicity and age.

STUDY DESIGN: We conducted a descriptive analysis of 3747 pregnancy-related deaths during 2011–2016 (the most recent available data) with available zone improvement plan code or county data in the Pregnancy Mortality Surveillance System, among Hispanic and non-Hispanic White, Black, American Indian or Alaska Native, and Asian or Pacific Islander women aged 15 to 44 years. We aggregated data by US county and grouped counties per the National Center for Health Statistics Urban-Rural Classification Scheme for Counties. We used R statistical software, epitools, to calculate the pregnancy-related mortality ratio (number of pregnancy-related deaths per 100,000 live births) for each urban-rural grouping, obtain 95% confidence intervals, and perform exact tests of ratio comparisons using the Poisson distribution.

RESULTS: Of the total 3747 pregnancy-related deaths analyzed, 52% occurred in large metro counties, and 7% occurred in noncore (rural) counties. Large metro counties had the lowest pregnancy-related mortality ratio (14.8; 95% confidence interval, 14.2–15.5), whereas noncore counties had the highest (24.1; 95% confidence interval, 21.4–27.1), including race and ethnicity and age groups. Pregnancy-related mortality ratio age disparities increased with rurality. Women aged 25 to 34 years and 35 to 44 years living in noncore counties had pregnancy-related mortality ratios 1.5 and 3 times higher, respectively, than women of the same age groups in large metro counties. Within each urban-rural category, pregnancy-related mortality ratios were higher among non-Hispanic Black women than non-Hispanic White women. Non-Hispanic American Indian or Alaska Native pregnancy-related mortality ratios in small metro, micropolitan, and noncore counties were 2 to 3 times that of non-Hispanic White women in the same areas.

CONCLUSION: Although more than half of pregnancy-related deaths occurred in large metro counties, the pregnancy-related mortality ratio rose with increasing rurality. Disparities existed in urban-rural categories, including by age group and race and ethnicity. Geographic location is an important context for initiatives to prevent future deaths and eliminate disparities. Further research is needed to better understand reasons for the observed urban-rural differences and to guide a multifactorial response to reduce pregnancy-related deaths.

Key words: age disparities, maternal death, maternal mortality, metropolitan, noncore, policy, Pregnancy Mortality Surveillance System, pregnancy-related death, racial and ethnic disparities

Introduction

Pregnancy-related complications claim the lives of approximately 700 women annually in the United States; approximately two-thirds of these deaths are preventable.[1,2] Over the past decade, the pregnancy-related mortality ratio (PRMR, the number of pregnancy-related deaths per 100,000 live births) has not improved.[3] There are well-documented disparities in pregnancy-related deaths: non-Hispanic Black women and American Indian or Alaska Native women have a PRMR 2 to 3 times higher than non-Hispanic White women, and the PRMR varies among states, from fewer than 10 to more than 30 deaths per 100,000 births.[4,5]

Rural areas of the United States have unique health challenges. All-cause mortality in rural areas was 18.9% higher than that of urban areas in 2016.[6] As measured by the hospital discharge data from deliveries, the likelihood of severe maternal morbidity and mortality in similar groups is 9% higher in rural areas than that of urban areas.[7] Access to hospital-based and community-based obstetrical care in rural areas declined during 1995–2015, which may have affected pregnancy outcomes.[8–10]

There are large racial and ethnic variations in population distributions in urban and rural areas. Non-Hispanic White individuals make up most rural (79%) and suburban (68%) populations. The proportion of the population who are non-Hispanic Black is twice as large in urban counties (17%) than that of rural counties (8%).[11] The proportion of the population who are Hispanic in urban counties (27%) is twice as large as that of suburban counties (14%) and 3 times as large as that of rural counties (8%).[11] Nearly half of the American Indian or Alaska Native population lives in rural counties.[12]

Despite racial and ethnic disparities in the PRMR, geographic differences in population distributions, and documented health challenges, little is known nationally about potential urban-rural differences in pregnancy-related deaths. Previous studies have focused on subnational geographic areas[13] or were based on death record data[14,15] with documented challenges,[16,17] limiting interpretation. Our study used the national Pregnancy Mortality Surveillance System (PMSS) data to examine

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AJOG at a Glance

Why was this study conducted?

This study aimed to compare pregnancy-related mortality across and within urban and rural counties in the United States by race and ethnicity and age.

Key findings

During 2011−2016, rural counties had the highest pregnancy-related mortality ratio, whereas urban counties had the lowest. Urban-rural disparities in pregnancy-related mortality ratio increased with age. Racial and ethnic disparities mirrored national disparities.

What does this add to what is known?

This study reported on urban-rural disparities in pregnancy-related deaths and used the most recent national data on pregnancy-related deaths from the Pregnancy Mortality Surveillance System. Other studies were subnational, based solely on death record data with documented challenges or hospital discharge data. Finally, the urban-rural disparity was greater among older women than among younger women.

pregnancy-related deaths in urban and rural counties in the United States. Examining geographic variations in pregnancy-related deaths can inform interventions to prevent future pregnancy-related deaths.

Materials and Methods

Numerator

Here, we analyzed 6 years of PMSS data, from 2011 to 2016. The PMSS methodology to identify pregnancy-related deaths has been published previously.[18] Briefly, clinically trained epidemiologists reviewed the death certificates of women who died within a year of pregnancy and matched birth certificates or fetal death reports and other available information (eg, autopsy reports). Deaths were determined to be pregnancy-related if the death occurred during or within 1 year of pregnancy and was caused by a pregnancy complication, a chain of events initiated by pregnancy, or an aggravation of an unrelated condition from the physiological effects of pregnancy. The PMSS receives deidentified records from 52 reporting areas (50 states, New York City, and Washington, DC).

As vital information is recorded in the PMSS data, reviewers abstracted the geographic location data, including the state, county, or zone improvement plan (ZIP) code of residence, when available, from the death certificate and/or other sources (eg, a matching birth or fetal death certificate). County of residence (not recorded in the PMSS until 2015) is unavailable for records from 2011 to 2014. To address this gap, we developed a geocoding process. Because the residence ZIP code, regardless of source, was the most complete geographic location variable available across pregnancy-related PMSS records during 2011−2016 (93% available), it was first used to assign a 5-digit Federal Information Processing System (FIPS) code[19] to each death by using Centrus Desktop.[20] The 5-digit FIPS code is a combination of numeric identifiers for state and county.[21] Next, the state associated with the resulting FIPS code was compared with the state of residence recorded in the PMSS to ensure the accuracy of the geocoding. If the state identified from the FIPS geocode did not match the state in the PMSS, or if the PMSS record did not have a ZIP code to geocode, then the state and county of residence, if available in the PMSS, were coded to a 5-digit FIPS. PMSS records were excluded from analysis if the geocoded FIPS code did not match and the county was missing in PMSS or if the ZIP code and county were unavailable in the PMSS.

We matched FIPS codes from the geocoded deaths to the 2013 National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme for Counties. This Scheme assigns all US counties to 1 of 6 categories,[22] which are defined as follows: (1) large central metro, metropolitan statistical areas (MSAs) with a population of at least 1 million that contain the entire population of the largest principal city within the MSA, that have their entire population contained in the largest principal city of the MSA, or that contain at least 250,000 inhabitants of any principal city of the MSA; (2) large fringe metro, MSA with a population of at least 1 million that do not fit the definition of large central metropolitan; (3) medium metro, MSA with a population of 250,000 to 999,999; (4) small metro, MSA with a population of less than 250,000; (5) micropolitan, Urban cluster with a population of 10,000 to 49,999; (6) noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

Maternal race or ethnicity was classified as Hispanic (any race) and non-Hispanic White, Black, American Indian or Alaska Native, and Asian or Pacific Islander. Maternal age was considered in 5-year age groups (15−19, 20−24, 25−29, 30−34, 35−39, and 40−44 years).

Denominators

This analysis developed a methodology to estimate county-level counts of births to women aged 15 to 44 years by year and race and ethnicity, which can be used to examine urban-rural differences in pregnancy-related deaths. To estimate PRMRs in this analysis, we used 2 methods to obtain birth denominators depending on the stratification variables (county, year, race and ethnicity, or maternal age). Data came from the National Vital Statistics System (NVSS) via the Centers for Disease Control and Prevention, Wide-ranging Online Data for Epidemiologic Research (CDC WONDER).[23]

The first method to obtain denominators was for county-level estimates of live births by race and ethnicity and year to account for data suppression (NVSS subnational data with fewer than

TABLE 1
Distribution of pregnancy-related deaths by county urban-rural category, United States, 2011–2016

Characteristics	Total	n (%)[a] Large metro	Medium metro	Small metro	Micropolitan	Noncore
Overall	3747	1956 (52)	797 (21)	344 (9)	369 (10)	281 (7)
Race and ethnicity[b]						
White	1524	589 (39)	365 (24)	177 (12)	218 (14)	175 (11)
Black	1384	849 (61)	262 (19)	111 (8)	92 (7)	70 (5)
American Indian or Alaska Native	65	10 (15)	9 (14)	12 (18)	15 (23)	19 (29)
Asian or Pacific Islander	204	144 (71)	36 (18)	9 (4)	9 (4)	6 (3)
Hispanic	570	364 (64)	125 (22)	35 (6)	35 (6)	11 (2)
Age group (y)						
15–19	175	69 (39)	38 (22)	27 (15)	24 (14)	17 (10)
20–24	614	283 (46)	147 (24)	69 (11)	70 (11)	45 (7)
25–29	863	432 (50)	205 (24)	83 (10)	73 (8)	70 (8)
30–34	904	513 (57)	186 (21)	80 (9)	74 (8)	51 (6)
35–39	808	446 (55)	154 (19)	52 (6)	89 (11)	67 (8)
40–44	383	213 (56)	67 (17)	33 (9)	39 (10)	31 (8)

The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, an urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

MSA, metropolitan statistical area.

[a] Percentages may not add to 100 because of rounding; [b] Women identified as White, Black, American Indian or Alaska Native, or Asian or Pacific Islander were not Hispanic. Hispanic women could be of any race.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

10 births were suppressed). We obtained state fertility rates from the NVSS stratified by year, state, and race and ethnicity and multiplied by estimated county population counts of women aged 15 to 44 years from US Census Bureau population data stratified by year, county, and race and ethnicity (Supplemental Online Content; Supplemental Table 1).

We validated our estimate with true births data aggregated by urban-rural category obtained from the NVSS and found close agreement (Supplemental Online Content). As with the numerator data, estimated births were matched to the 2013 NCHS urban-rural classification scheme. However, we cannot use this method to estimate births by county, race and ethnicity, year, and maternal age because nearly 7% of fertility rates stratified by state, race and ethnicity, year, and age were suppressed via CDC WONDER.

A second method was used to obtain the births denominator for urban-rural birth counts stratified by maternal age. For this denominator, we used birth counts from the NVSS aggregated to 2013 NCHS urban-rural classification scheme and maternal age in 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39, and 40–44 years).

Statistical analysis

PRMRs were calculated for each urban-rural category and stratified by year, race and ethnicity, or maternal age. PRMRs based on fewer than 8 deaths were suppressed as they may be unreliable. Furthermore, 8 deaths represented a relative standard error of 35%. We used R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria) and the epitools package[24] to calculate PRMRs, obtain 95% confidence intervals (CIs), and perform exact tests of ratio comparisons using the Poisson distribution. We created race and ethnicity and age group PRMR disparity ratios by dividing the PRMR in 1 group by the PRMR in a reference group. Disparity ratios used non-Hispanic White women and women aged 30 to 34 years as the reference groups, respectively, as these were the groups with the highest number of pregnancy-related deaths. This study did not involve human subjects as defined in 45 CFR 46.102(e) and therefore was not reviewed by an institutional review board.

Results

There were 4076 pregnancy-related deaths recorded in the PMSS during 2011–2016. Furthermore, 5-digit FIPS codes were successfully assigned for 3788 records (92.9%) from ZIP code of residence and for 109 records (0.3%) from county of residence. There were 179 records (4%) excluded from this analysis because of missing ZIP code and county information. Of the 3897 records successfully assigned a 5-digit FIPS, 5 deaths were unable to be matched to the NCHS urban-rural classification scheme because of unresolvable data discrepancies, and 12 deaths had an unknown

TABLE 2
Distribution of live births by county urban-rural category, United States, 2011–2016

Characteristics	Total	n (%)[a]				
		Large metro	Medium metro	Small metro	Micropolitan	Noncore
Overall	23,500,220	13,427,170 (57)	4,905,002 (21)	2,125,202 (9)	1,860,624 (8)	1,182,222 (5)
Race and ethnicity[b]						
White	12,738,577	6,198,217 (49)	2,836,817 (22)	1,461,336 (11)	1,352,185 (11)	890,022 (7)
Black	3,500,990	2,313,354 (66)	650,231 (19)	244,927 (7)	174,346 (5)	118,132 (3)
American Indian or Alaska Native	225,937	53,941 (24)	44,277 (20)	30,643 (14)	46,463 (21)	50,613 (22)
Asian or Pacific Islander	1,562,250	1,198,684 (77)	242,727 (16)	70,743 (5)	39,222 (3)	10,874 (1)
Hispanic	5,472,466	3,662,974 (67)	1,130,950 (21)	317,553 (6)	248,408 (5)	112,581 (2)
Age group (y)						
15–19	1,587,734	747,334 (47)	368,323 (23)	168,658 (11)	179,540 (11)	123,879 (8)
20–24	5,244,997	2,506,440 (48)	1,207,345 (23)	569,330 (11)	568,859 (11)	393,023 (7)
25–29	6,773,408	3,628,200 (54)	1,491,353 (22)	665,686 (10)	594,682 (9)	393,487 (6)
30–34	6,269,593	3,884,903 (62)	1,239,884 (20)	492,814 (8)	401,491 (6)	250,501 (4)
35–39	2,971,425	1,981,441 (67)	541,435 (18)	193,815 (7)	158,398 (5)	96,336 (3)
40–44	653,142	449,665 (69)	113,272 (17)	38,159 (6)	31,999 (5)	20,047 (3)

Births by race and ethnicity groups were estimated by multiplying county-level number of women and stratified by race and ethnicity and year and state fertility rates. Births by age group were obtained from the National Vital Statistics System via CDC WONDER and do not sum to the overall births. The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

CDC WONDER, Centers for Disease Control and Prevention, Wide-ranging Online Data for Epidemiologic Research; *MSA*, metropolitan statistical area.

[a] Percentages may not add to 100 because of rounding; [b] Race and ethnicity groups were defined as Hispanic births (regardless of race) and non-Hispanic White, Black, American Indian or Alaska Native, or Asian or Pacific Islander births.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

race and ethnicity; these were excluded from the analysis. Finally, deaths of women older than 44 years (n=126) and 7 deaths of women younger than 15 years or where age was unknown were excluded because the estimated birth denominator is for women aged 15 to 44 years. The remaining 3747 pregnancy-related deaths were used in this analysis (Table 1 and Supplemental Table 2), representing 92% of all pregnancy-related deaths in the United States that occurred during 2011–2016.

After assigning deaths and births into the 6 NCHS Urban-Rural Classifications, we observed no difference between large central and large fringe metropolitan counties, and we combined these into a single large metro area. More than half of pregnancy-related deaths among Black (61%), Asian or Pacific Islander (71%), and Hispanic (64%) women and 39% of deaths among White women occurred in large metro counties. In contrast, approximately 52% of pregnancy-related deaths among American Indian or Alaska Native women occurred in micropolitan or noncore counties. Urban-rural estimated births (Table 2) closely aligned with true birth counts used for validation, by state, NCHS urban-rural category, and year for Hispanic and non-Hispanic women of all race groups (Supplemental Figures 1 and 2).

The PRMR increased as rurality increased (Figure 1 and Supplemental Tables 3 and 4). The PRMR was higher in micropolitan (19.8; 95% CI, 17.9–22.0) and noncore (23.8; 95% CI, 21.1–26.7) counties than in large metro counties (14.6; 95% CI, 13.9–15.2).

The pattern of increasing PRMR with increasing rurality was observed among most race and ethnicity and age groups; however, age and race- and ethnicity-specific counts were small, resulting in wide overlapping CIs (Table 3). The PRMR among women aged 15 to 24 years was relatively similar by urban-rural category. However, for women in older age groups (ages, 25–29, 30–34, 35–39, and 40–44 years), the disparity between noncore and large metro counties increased with age (Figure 2). Women aged 25 to 29 and 30 to 34 years living in noncore counties had a PRMR 1.5 times higher than women of the same age groups in large metro counties. Comparing noncore counties with large metro counties, women aged 35 to 39 years and 40 to 44 years had 3.1 and 3.3 times higher PRMR, respectively.

Racial and ethnic and age disparities persisted within each county group (Table 4). Black women, regardless of NCHS Urban-Rural Classification, had a PRMR 3 to 4 times higher than White women in the same area. The PRMR of American Indian or Alaska Native women living in small metro, micropolitan, and noncore counties was 2 to 3

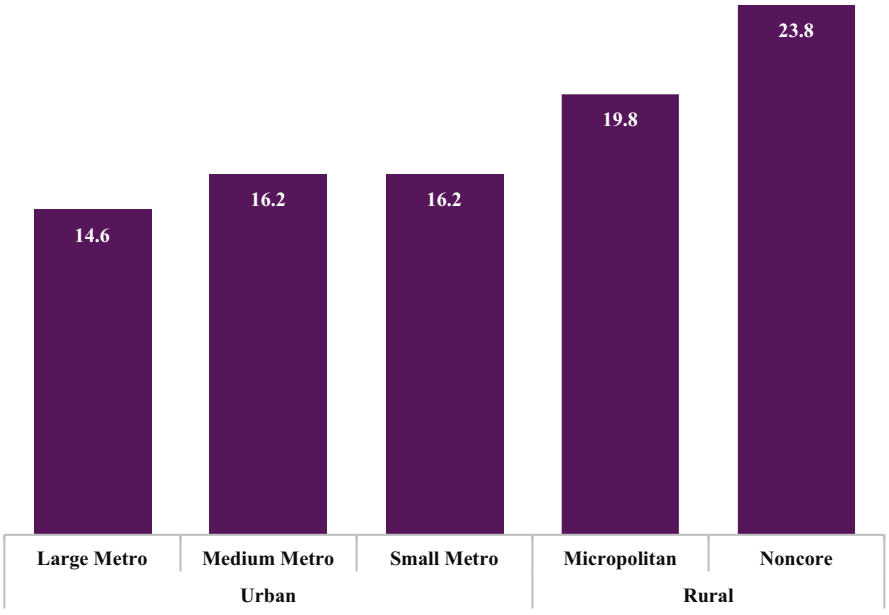
times than that of White women living in these same geographies. The PRMR of non-Hispanic White women was 2 times the PRMR of Hispanic women in noncore counties. In micropolitan and noncore counties, women aged 35 to 39 years had about 3 times PRMR, and women aged 40 to 44 years had 7 to 8 times the PRMR than women aged 30 to 34 years (Table 5).

Comment

Principal findings

The PRMR increased with increasing rurality. Although large metro counties represented 52% of pregnancy-related deaths, they had the lowest PRMR. Noncore and micropolitan counties represented 17% of pregnancy-related deaths but had the highest PRMR. This difference was observed among all non-Hispanic race groupings and in women aged 30 to 44 years. We found that women aged 25 to 29, 30 to 34, 35 to 39, and 40 to 44 years living in noncore counties had higher PRMR than women of the same age groups in large metro counties, and the urban-rural disparity increased among older age groups, signaling that the "exposure" of living in rural areas has a different effect on PRMR for older women compared with younger women.

FIGURE 1
Pregnancy-related mortality ratios by urban-rural category



The PRMR is the number of pregnancy-related deaths per 100,000 live births. The PRMR ratio is highest in rural areas. Rural areas include micropolitan (urban cluster with a population of 10,000—49,999) and noncore (nonmetropolitan counties that did not qualify as micropolitan; most rural areas). Urban areas include large metro ("MSA," with a population of at least 1 million), medium metro (MSA with a population of 250,000—999,999), and small metro (MSA with a population of less than 250,000).

MSA, metropolitan statistical area; *PRMR*, pregnancy-related mortality ratio.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

Results

These findings add to the limited data about urban-rural differences in pregnancy-related deaths in the United States. Our results were consistent with general findings that mortality is higher in rural areas. However, the PRMR in noncore areas was 1.6 times the PRMR in large metropolitan areas, whereas all-cause mortality in rural areas was 1.2 times the all-cause mortality in urban areas.[6] This suggests that there are specific factors present in urban and rural areas that impact pregnancy-related mortality differently than all-cause mortality. An analysis of pregnancy-related deaths in Georgia from 2010 to 2012 found no significant difference in the PRMR by rural, urban, or nonrural classifications or between Black and White women in rural areas.[13] A national-level study using NVSS data during 1990—1992 and 2005—2009 similarly found no difference in maternal mortality between metropolitan and nonmetropolitan areas.[14] We found that the urban-rural PRMR disparity increased with age. Women aged 25 to 29 and 30 to 34 years in noncore counties had a PRMR 1.5 times higher than women in the same age groups in large metro counties; women aged 35 to 39 and 40 to 44 years in noncore counties had a PRMR more than 3 times higher than women of the same age groups in large metro counties. The PRMRs for Black women were significantly higher than that of White women within each urban-rural classification level, which mirror documented national- and state-level disparities.[4] We found that PRMR was lower for Hispanic women than in non-Hispanic White women in noncore counties. Our analysis suggested that the PRMR disparity between American Indian or Alaska Native women and White women observed nationally is driven by disparities in small metro, micropolitan, and noncore counties.

Clinical implications

Differences among geographic location groups might reflect the intersection of age, chronic health conditions, and access to care, including risk-appropriate care. Furthermore, our analysis suggested that increasing rurality affects the PRMR of older women differently compared with the PRMR of younger women. Both the prevalence of delivery hospitalizations of women with substance use disorder and depression[25,26] and the prevalence of smoking,[27] heart disease, hypertension,[28] and obesity[29] were highest among women in rural areas. Infant mortality was highest in

TABLE 3
Pregnancy-related mortality ratio by county urban-rural category and sociodemographic characteristics, United States, 2011–2016

Characteristics	PRMR[a] (95% confidence interval)					
	Total	Large metro	Medium metro	Small metro	Micropolitan	Noncore
Overall	15.9 (15.4–16.5)	14.6 (13.9–15.2)	16.2 (15.1–17.4)	16.2 (14.5–18.0)	19.8 (17.9–22.0)	23.8 (21.1–26.7)
Race and ethnicity[b]						
White	12.0 (11.4–12.6)	9.5 (8.8–10.3)	12.9 (11.6–14.3)	12.1 (10.4–14.0)	16.1 (14.1–18.4)	19.7 (16.9–22.8)
Black	39.5 (37.5–41.7)	36.7 (34.3–39.3)	40.3 (35.6–45.5)	45.3 (37.3–54.6)	52.8 (42.5–64.7)	59.3 (46.2–74.9)
American Indian or Alaska Native	28.8 (22.2–36.7)	18.5 (8.9–34.1)	20.3 (9.3–38.6)	39.2 (20.2–68.4)	32.3 (18.1–53.2)	37.5 (22.6–58.6)
Asian or Pacific Islander	13.1 (11.3–15.0)	12.0 (10.1–14.1)	14.8 (10.4–20.5)	12.7 (5.8–24.2)	22.9 (10.5–43.6)	—[c]
Hispanic	10.4 (9.6–11.3)	9.9 (8.9–11.0)	11.1 (9.2–13.2)	11.0 (7.7–15.3)	14.1 (9.8–19.6)	9.8 (4.9–17.5)
Age group (y)						
15–19	11.0 (9.4–12.8)	9.2 (7.2–11.7)	10.3 (7.3–14.2)	16.0 (10.5–23.3)	13.4 (8.6–19.9)	13.7 (8.0–22.0)
20–24	11.7 (10.8–12.7)	11.3 (10.0–12.7)	12.2 (10.3–14.3)	12.1 (9.4–15.3)	12.3 (9.6–15.5)	11.4 (8.4–15.3)
25–29	12.7 (11.9–13.6)	11.9 (10.8–13.1)	13.7 (11.9–15.8)	12.5 (9.9–15.5)	12.3 (9.6–15.4)	17.8 (13.9–22.5)
30–34	14.4 (13.5–15.4)	13.2 (12.1–14.4)	15.0 (12.9–17.3)	16.2 (12.9–20.2)	18.4 (14.5–23.1)	20.4 (15.2–26.8)
35–39	27.2 (25.3–29.1)	22.5 (20.5–24.7)	28.4 (24.1–33.3)	26.8 (20.0–35.2)	56.2 (45.1–69.1)	69.5 (53.9–88.3)
40–44	58.6 (52.9–64.8)	47.4 (41.2–54.2)	59.1 (45.8–75.1)	86.5 (59.5–121.5)	121.9 (86.7–166.6)	154.6 (105.1–219.5)

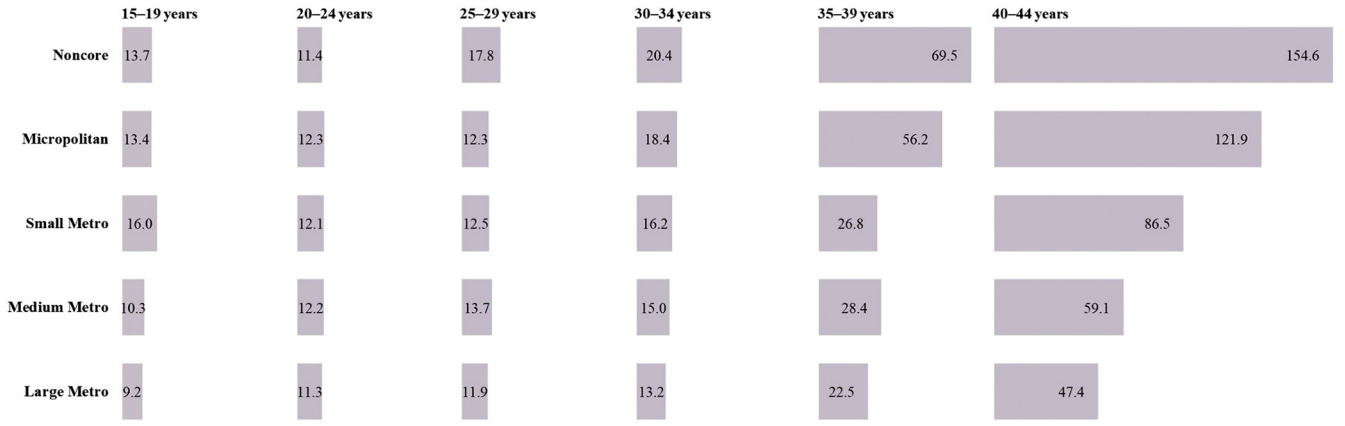
The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

CDC WONDER, Centers for Disease Control and Prevention, Wide-ranging Online Data for Epidemiologic Research; *MSA*, metropolitan statistical area; *PRMR*, pregnancy-related mortality ratio.

[a] PRMR denominators (births) for race and ethnicity groups were estimated by multiplying county-level number of women, stratified by race and ethnicity and year and state fertility rates. PRMR denominators (births) for age groups were obtained from the National Vital Statistics System (NVSS) via CDC WONDER; [b] Women identified as White, Black, American Indian or Alaska Native, or Asian or Pacific Islander were not Hispanic. Hispanic women could be of any race; [c] Em dash indicates a PRMR based on fewer than 8 deaths; these results were suppressed because ratios might be unreliable.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

FIGURE 2
Pregnancy-related mortality ratios by age group and urban-rural category



The PRMR is the number of pregnancy-related deaths per 100,000 live births. The PRMR increased in rural areas and among older age groups. Rural areas include micropolitan (urban cluster with a population of 10,000—49,999) and noncore (nonmetropolitan counties that did not qualify as micropolitan; most rural areas). Urban areas include large metro ("MSA," with a population of at least 1 million), medium metro (MSA with a population of 250,000—999,999), and small metro (MSA with a population of less than 250,000).

MSA, metropolitan statistical area; *PRMR*, pregnancy-related mortality ratio.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

rural counties.[30] Compared with urban areas, decreased access to obstetrical care among women in rural areas,[8–10,31] including fewer maternal-fetal medicine subspecialists,[32] further driving distances to access perinatal care,[10] and fewer healthcare providers per capita in rural areas[33] may contribute to disparities among populations by geographic location. Efforts that may help address geographic location disparities include risk-appropriate care,[34] transportation reimbursement policies,[35] statewide participation in perinatal quality collaboratives,[36] and telemedicine or telehealth.[37,38] Differences among groups by geographic location may reflect the intersection of interpersonal racism or implicit bias, such as healthcare provider preferential bias toward White patients,[39] and structural racism manifested in residential or economic segregation, which are linked to poorer health outcomes.[40] Indeed, indicators of structural racism, such as college graduation, employment, and homeownership inequalities, have been shown to differ in their health impacts by urban-rural category.[41] In addition, in rural areas, poverty is highest among Black and

TABLE 4
Disparity ratios within urban-rural category by race and ethnicity, United States, 2011—2016

Urban-rural category	Black-to-White disparity ratio	AI/AN-to-White disparity ratio	A/PI-to-White disparity ratio	Hispanic-to-White disparity ratio
Large metro	3.9[a]	1.9	1.3[a]	1.0
Medium metro	3.1[a]	1.6	1.1	0.9
Small metro	3.7[a]	3.2[a]	1.0	0.9
Micropolitan	3.3[a]	2.0[a]	1.4	0.9
Noncore	3.0[a]	1.9[a]	—[b]	0.5[a]

Disparity ratios were calculated by dividing the PRMR in 1 race and ethnicity group by the PRMR in a reference group. Non-Hispanic White women were the reference group, as they represented the largest racial and ethnic group. The definition are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas). Women identified as White, Black, American Indian or Alaska Native, or Asian or Pacific Islander were not Hispanic. Hispanic women could be of any race.

MSA, metropolitan statistical area; *PRMR*, pregnancy-related mortality ratio.

[a] Denotes statistical significance, $P<.05$; [b] Em dash indicates a PRMR based on fewer than 8 deaths; these results were suppressed because ratios might be unreliable.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

TABLE 5
Disparity ratios within urban-rural category by age group, United States, 2011–2016

Urban-rural category	Age group (y)				
	15–19 to 30–34 disparity ratio	20–24 to 30–34 disparity ratio	25–29 to 30–34 disparity ratio	35–39 to 30–34 disparity ratio	40–44 to 30–34 disparity ratio
Large metro	0.7[a]	0.9	0.9	1.7[a]	3.6[a]
Medium metro	0.7	0.8[a]	0.9	1.9[a]	3.9[a]
Small metro	1.0	0.7	0.8	1.7[a]	5.3[a]
Micropolitan	0.7	0.7[a]	0.7[a]	3.1[a]	6.6[a]
Noncore	0.7	0.6[a]	0.9	3.4[a]	7.6[a]

Disparity ratios were calculated by dividing the PRMR in 1 age group by the PRMR in a reference group. Women aged 30 to 34 years were the reference group, as they represented the largest age group. The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

MSA, metropolitan statistical area; *PRMR*, pregnancy-related mortality ratio.

[a] Denotes statistical significance, $P<.05$.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

American Indian or Alaska Native[42] populations and is associated with lower odds of identifying a steady source of healthcare[43]; furthermore, infant mortality rate is higher among Black and American Indian or Alaska Native populations.[44] In urban areas, American Indian or Alaska Native individuals have higher odds of cost-related barriers to care and of not having a usual place to go when sick than White individuals.[45] Across the nation, Black and American Indian or Alaska Native women with at least some college education have higher PRMRs than White women with less than a high school diploma,[4] which indicates that access to care only partly explains observed urban-rural disparities.[5] Observed differences between non-Hispanic White women and Hispanic women in noncore counties were consistent with findings sometimes referred to as the "Hispanic paradox."[46] However, research also pointed to differences in cardiovascular mortality rates comparing non-Hispanic White individuals with individuals in 3 Hispanic subgroups,[47] evidence of heterogeneity in outcomes based on acculturation,[48,49] and severe maternal morbidity being higher among Hispanic women than non-Hispanic White women.[50,51] Infant mortality data suggested similar associations between mortality and race within Hispanic populations and non-Hispanic populations,[52] which could be examined in future analyses of pregnancy-related deaths.

Research implications

Ultimately, pregnancy-related mortality is a multidimensional issue. Exploring differences in causes of death, timing of death relative to pregnancy, and associations between pregnancy-related deaths and ecologic county-level characteristics, such as access to care, residential segregation, or poverty, may yield additional information about disparities in urban-rural categories.

Strengths and limitations

This analysis has several limitations. By grouping women by age and race and ethnicity, we masked potential intragroup heterogeneity. Although there are documented urban-rural differences in fertility rates,[19] we assumed that race- and ethnicity-specific fertility rates obtained from the NVSS were the same across both urban and rural counties within a state for a given year. Validation checks (Supplemental Online Content) showed that the estimated births closely agreed with data from the NVSS. Vital records, such as those used during PMSS review, can be flawed by misclassifications, including pregnancy checkbox errors on the death certificate[16,17] and race and ethnicity coding inaccuracies. PMSS reviewers use additional information whenever possible to improve the accuracy of pregnancy-related classification.[18] Misclassification of American Indian or Alaska Native mortality data was well documented,[53–55] particularly among urban areas, which tend to have a higher rate of misclassification than rural areas.[56] To reduce racial and ethnic misclassifications, PMSS reviewers obtain self-reported data for race and Hispanic origin from matched birth certificates when available. The PRMR does not include injury deaths (eg, caused by drug overdose, suicide, homicide) or cancer-related deaths,[57] which may skew the results by urban-rural category. Residence ZIP codes in PMSS were abstracted first from the death certificate, but if information were not available, then they were abstracted from other linked sources (eg, the birth or fetal death certificate), which may reduce accuracy if the woman moved since the birth or fetal death certificate was issued. Based on a 10% (n=924) random sample of all PMSS records, 2011–2015, we estimated that 75% of PMSS records contained a ZIP code abstracted from the death certificate.

Conclusions

Noncore and micropolitan counties represented 17% of pregnancy-related deaths and had the highest pregnancy-related mortality ratios. Disparities in

pregnancy-related mortality ratios in urban-rural categories indicate that geographic location is an important context for efforts to prevent pregnancy-related deaths. Urban-rural disparities may stem from differences in population health status, access to or quality of care, causes and timing of death, and other socioenvironmental characteristics and exposure to bias and structural racism. A better understanding of these factors' interaction is needed as 1 piece of a multifactorial response to guide and improve effective policy and program interventions to prevent pregnancy-related deaths. ■

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Supplemental Online Content

Method used to calculate pregnancy-related mortality ratio denominator (live births)

To generate approximate counts of county-level births, including counties where Centers for Disease Control and Prevention, Wide-ranging Online Data for Epidemiologic Research (CDC WONDER) suppresses data (all subnational data with fewer than 10 births) from the National Vital Statistics System (NVSS),[1] we used the following method to estimate births per county for each year from 2011 to 2016 and for each included race and ethnicity (Hispanic births and non-Hispanic White, Black or African American, American Indian or Alaska Native, and Asian or Pacific Islander births): (1) state fertility rates, we acquired fertility rates (number of births/number of women aged 15 to 44 years in a specified population) from the NVSS and stratified by year, state, and race and ethnicity. This included all women identified as Hispanic and all non-Hispanic women in bridged-race categories of White, Black or African American, American Indian or Alaska Native, and Asian or Pacific Islander; (2) county population size, we acquired estimates of the number of women aged 15 to 44 years from US Census Bureau population data stratified by year, county, and race and ethnicity. Race and ethnicity groups were the same as those used in acquiring state fertility rates; (3) county-level births, for each year and race and ethnicity subgroup, we multiplied state fertility rates by estimated county population counts of women aged 15 to 44 years to calculate county-specific counts of births.

Validating estimated counts

Births by race and ethnicity and year were calculated for each county. We assumed that this method would yield estimated births that were comparable to actual births by county, year (2011−2016), and race and ethnicity (identified as Hispanic births and all non-Hispanic births for bridged-race categories of White, Black or African American, American Indian or Alaska Native, and Asian or Pacific Islander). To validate this assumption, we considered the following 3 questions.

Do estimated county births sum to true births when aggregated to National Center for Health Statistics urban-rural classification scheme?

In Supplemental Figure 1, we compared the sum of county-specific estimated birth counts from 2011 to 2016 to see how closely they match the counts of "true" births obtained from the NVSS via CDC WONDER (race and ethnicity groups included Hispanic births and births by bridged-race categories of White, Black or African American, American Indian or Alaska Native, and Asian or Pacific Islander), aggregated to the 2013 National Center for Health Statistics-Urban-Rural Classification Scheme.[2] We log-transformed the axes of Supplemental Figure 1 to permit closer attention to small count regions. The red diagonal line of equality shows close alignment between estimated births (y-axis) and true births (x-axis) in each urban-rural category, year, and race and ethnicity group. This is evident in large and small count urban-rural categories.

Do estimated county births correlate with true state births?

In Supplemental Figure 2, we compared true state births by race and ethnicity (limited to 4 largest groups for which data were not suppressed in CDC WONDER: non-Hispanic White, non-Hispanic Black, non-Hispanic Asian or Pacific Islander, and Hispanic) and year (2011−2016) to estimated county births by race and ethnicity groups and years. We log-transformed the axes to allow for closer comparison of low birth counts. The red line of equality shows close alignment between the logs of estimated (y-axis) and true births (x-axis) summed to each state. This is evident in large and small count states.

Is there agreement between true births and estimated births?

One approach to quantifying the agreement between 2 sets of continuously measured values based on the same unit is the concordance correlation coefficient (CCC).[3] The CCC evaluates the interrate agreement. Values of the CCC range from 0 to 1, with 1 indicating perfect agreement. We estimated the CCC of log-transformed estimated vs true birth counts for each year (2011−2016) and race and ethnic group (limited to 4 largest groups for which data were not suppressed via CDC WONDER: non-Hispanic White, non-Hispanic Black, non-Hispanic Asian or Pacific Islander, and Hispanic) and found an agreement of at least 0.99 for all categories in each year.

Supplemental References

1. Centers for Disease Control and Prevention. Data use restrictions. Available at: https://wonder.cdc.gov/datause.html. Accessed April 8, 2020.

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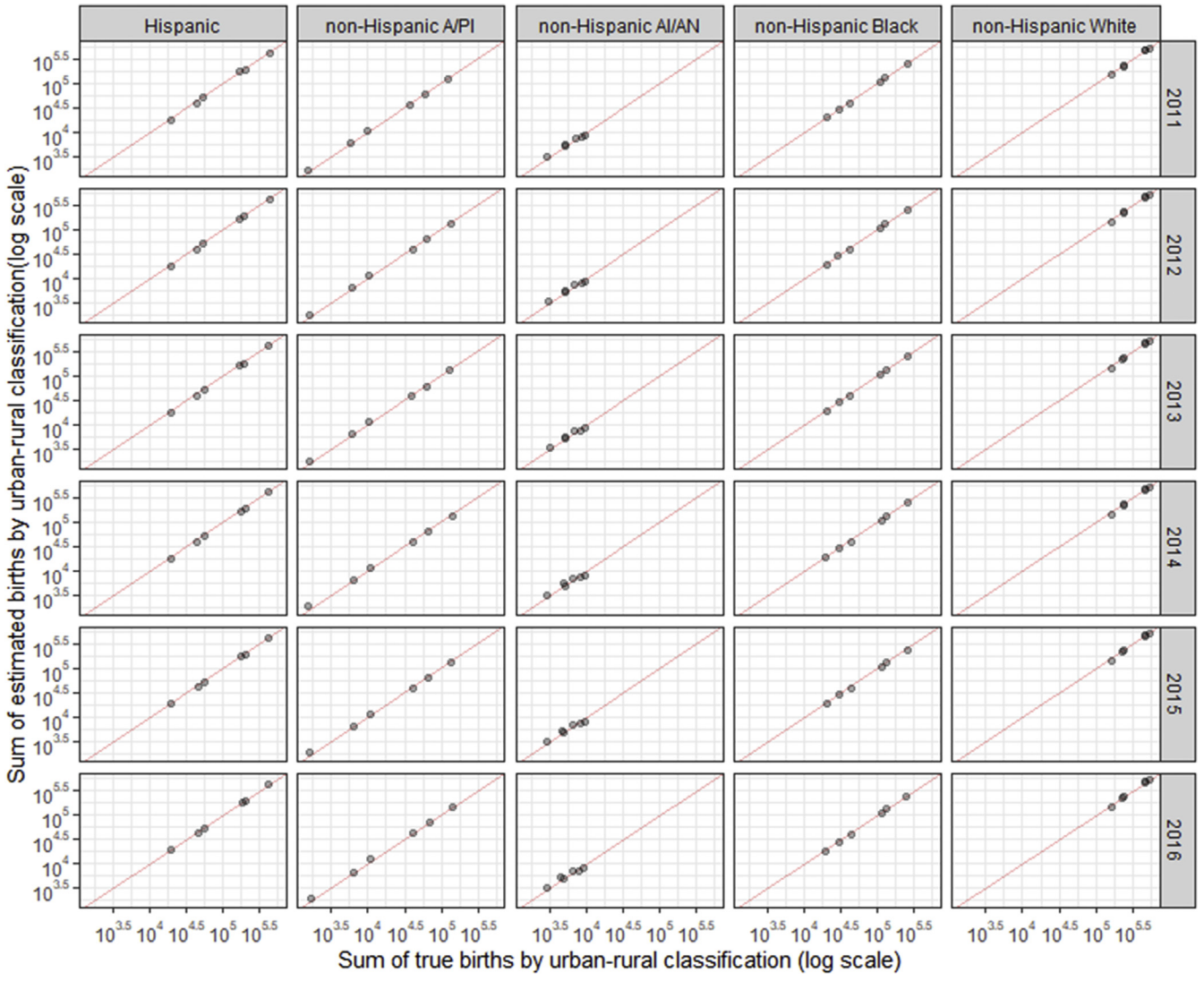
SUPPLEMENTAL FIGURE 1

True births compared to estimated births summed to National Center for Health Statistics urban-rural classification (United States, 2011–2016)

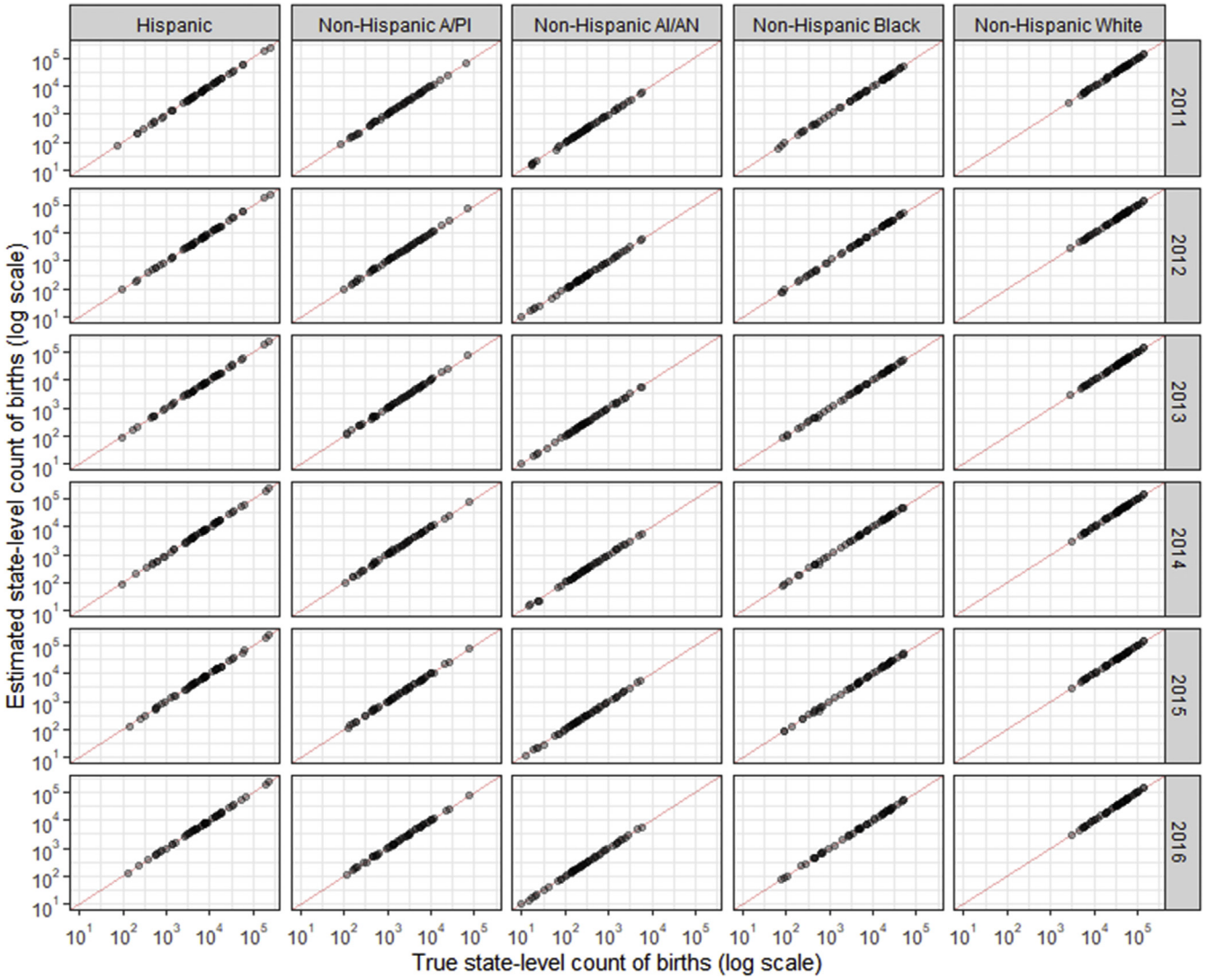


The figure shows a close alignment between estimated births (y-axis) and true births (x-axis) in each urban-rural category, year, and race and ethnicity group.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

SUPPLEMENTAL FIGURE 2

True births compared to estimated births summed by US state, 2011–2016



The figure shows a close alignment between the logs of estimated births (y-axis) and true births (x-axis) summed to each state.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

SUPPLEMENTAL TABLE 1
Distribution of live births by county urban-rural category and year, United States, 2011–2016

		n (%)[a]				
Year	Total	Large metro	Medium metro	Small metro	Micropolitan	Noncore
2011	3,919,509	2,231,805 (57)	818,038 (21)	354,626 (9)	314,104 (8)	200,936 (5)
2012	3,915,553	2,233,816 (57)	816,336 (21)	354,394 (9)	312,245 (8)	198,762 (5)
2013	3,900,280	2,225,360 (57)	814,339 (21)	353,155 (9)	310,120 (8)	197,306 (5)
2014	3,940,369	2,253,114 (57)	821,926 (21)	356,534 (9)	311,171 (8)	197,624 (5)
2015	3,924,710	2,245,436 (57)	819,577 (21)	355,066 (9)	308,983 (8)	195,648 (5)
2016	3,899,799	2,237,639 (57)	814,786 (21)	351,427 (9)	304,001 (8)	191,946 (5)

Births by year were estimated by multiplying county-level number of women, stratified by race and ethnicity (defined as Hispanic, regardless of race, and non-Hispanic White, Black, American Indian or Alaska Native, or Asian or Pacific Islander) and year, and state fertility rates. The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan: urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

MSA, metropolitan statistical area.

[a] Percentages may not add to 100 because of rounding.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

SUPPLEMENTAL TABLE 2
Distribution of pregnancy-related deaths by county urban-rural category and year, United States, 2011–2016

		n (%)[a]				
Year	Total	Large metro	Medium metro	Small metro	Micropolitan	Noncore
2011	680	371 (55)	125 (18)	54 (8)	72 (11)	58 (9)
2012	570	280 (49)	142 (25)	53 (9)	56 (10)	39 (7)
2013	643	338 (53)	132 (21)	58 (9)	58 (9)	57 (9)
2014	654	338 (52)	142 (22)	69 (11)	67 (10)	38 (6)
2015	607	317 (52)	136 (22)	55 (9)	63 (10)	36 (6)
2016	593	312 (53)	120 (20)	55 (9)	53 (9)	53 (9)

The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

MSA, metropolitan statistical area.

[a] Percentages may not add to 100 because of rounding.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

SUPPLEMENTAL TABLE 3

Pregnancy-related mortality ratio by county urban-rural category and year, United States, 2011–2016

	Pregnancy-related mortality ratio[a] (95% confidence interval)					
Year	Total	Large metro	Medium metro	Small metro	Micropolitan	Noncore
2011	17.3 (16.1–18.7)	16.6 (15.0–18.4)	15.3 (12.7–18.2)	15.2 (11.4–19.9)	22.9 (17.9–28.9)	28.9 (21.9–37.3)
2012	14.6 (13.4–15.8)	12.5 (11.1–14.1)	17.4 (14.7–20.5)	15.0 (11.2–19.6)	17.9 (13.5–23.3)	19.6 (14.0–26.8)
2013	16.5 (15.2–17.8)	15.2 (13.6–16.9)	16.2 (13.6–19.2)	16.4 (12.5–21.2)	18.7 (14.2–24.2)	28.9 (21.9–37.4)
2014	16.6 (15.3–17.9)	15.0 (13.4–16.7)	17.3 (14.6–20.4)	19.4 (15.1–24.5)	21.5 (16.7–27.3)	19.2 (13.6–26.4)
2015	15.5 (14.3–16.7)	14.1 (12.6–15.8)	16.6 (13.9–19.6)	15.5 (11.7–20.2)	20.4 (15.7–26.1)	18.4 (12.9–25.5)
2016	15.2 (14.0–16.5)	13.9 (12.4–15.6)	14.7 (12.2–17.6)	15.7 (11.8–20.4)	17.4 (13.1–22.8)	27.6 (20.7–36.1)

The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

MSA, metropolitan statistical area.

[a] Pregnancy-related mortality ratio denominator (births) for year were estimated by multiplying county-level number of women, stratified by race and ethnicity (defined as Hispanic, regardless of race, and non-Hispanic White, Black, American Indian or Alaska Native, or Asian or Pacific Islander) and year, and state fertility rates.

Merkt et al. Urban-rural differences in pregnancy-related deaths. Am J Obstet Gynecol 2021.

SUPPLEMENTAL TABLE 4

Pregnancy-related mortality ratio by county urban-rural category and sociodemographic characteristics, United States, 2011–2016

Characteristics	Pregnancy-related mortality ratio[a] (95% confidence interval)		
	Total	Urban	Rural
Overall	15.9 (15.4–16.5)	15.1 (14.6–15.7)	21.4 (19.8–23.1)
Race and ethnicity[b]			
White	12.0 (11.4–12.6)	10.8 (10.2–11.4)	17.5 (15.8–19.3)
Black	39.5 (37.5–41.7)	38.1 (36.0–40.1)	55.4 (47.2–64.6)
American Indian or Alaska Native	28.8 (22.2–36.7)	24.1 (16.3–34.1)	35.0 (24.3–48.9)
Asian or Pacific Islander	13.1 (11.3–15.0)	12.5 (10.8–14.4)	29.9 (16.8–49.4)
Hispanic	10.4 (9.6–11.3)	10.3 (9.4–11.2)	12.7 (9.3–17.0)
Age group (y)			
15–19	11.0 (9.4–12.8)	10.4 (8.7–12.4)	13.5 (9.7–18.3)
20–24	11.7 (10.8–12.7)	11.7 (10.7–12.7)	12.0 (9.9–14.4)
25–29	12.7 (11.9–13.6)	12.4 (11.6–13.4)	14.5 (12.2–17.0)
30–34	14.4 (13.5–15.4)	13.9 (12.9–14.9)	19.2 (16.0–22.8)
35–39	27.2 (25.3–29.1)	24.0 (22.2–25.9)	61.2 (52.0–71.6)
40–44	58.6 (52.9–64.8)	52.1 (46.5–58.2)	134.5 (104.8–169.9)
Year			
2011	17.3 (16.1–18.7)	16.2 (14.8–17.6)	25.2 (21.1–30.0)
2012	14.6 (13.4–15.8)	14.0 (12.7–15.3)	18.6 (15.0–22.7)
2013	16.5 (15.2–17.8)	15.6 (14.3–16.9)	22.7 (18.7–27.2)
2014	16.6 (15.3–17.9)	16.0 (14.7–17.4)	20.6 (16.9–25.0)
2015	15.5 (14.3–16.7)	14.9 (13.6–16.2)	19.6 (15.9–23.9)
2016	15.2 (14.0–16.5)	14.3 (13.1–15.6)	21.4 (17.5–25.9)

Urban areas include large, medium, and small metropolitan counties. Rural areas include micropolitan and noncore counties. The definitions are as follows: large metro, an MSA with a population of at least 1 million; medium metro, an MSA with a population of 250,000 to 999,999; small metro, an MSA with a population of less than 250,000; micropolitan, urban cluster with a population of 10,000 to 49,999; and noncore, nonmetropolitan counties that did not qualify as micropolitan (most rural areas).

MSA, metropolitan statistical area.

[a] Pregnancy-related mortality ratio denominator (births) for year were estimated by multiplying county-level number of women, stratified by race and ethnicity (defined as Hispanic, regardless of race, and non-Hispanic White, Black, American Indian or Alaska Native, or Asian or Pacific Islander) and year, and state fertility rates; [b] Women identified as White, Black, American Indian or Alaska Native, or Asian or Pacific Islander were not Hispanic. Hispanic women could be of any race.

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